

## 1.0 INTRODUCTION

### 1.1 Objectives and Organization of the Report

The main objectives of this report are to describe the technical basis for the Florida Keys Carrying Capacity Study (FKCCS) and its accompanying Carrying Capacity/Impact Assessment Model (CCIAM), to report results of the initial test runs, and to discuss model refinements based on test results. The first draft of this report (November 2001) reported results generated for two scenarios used to test the model. This Test Model Report includes the following elements:

- A description of the technical basis of each component of the study and the model.
- A description of inputs and outputs for each module, and the processes that link these variables.
- An overview of data management activities, including data acquisition, suitability analyses, intermediate data management, and data quality assessments.
- Results of two test scenario runs.
- A discussion of assumptions, uncertainties, and results of preliminary sensitivity testing.
- A discussion of refinements made to the model based on the results of the test runs.

The FKCCS, including the CCIAM and this report, has greatly benefited from comments and observations made on the November 2001 draft version of this report. The National Research Council (NRC) provided an independent review of the CCIAM (NRC 2002) commissioned by the U.S. Army Corps of Engineers (USACE) and the Florida Department of Community Affairs (DCA). The following agencies and organizations also provided written comments on the November 2001 draft report: U.S. Environmental Protection Agency (EPA), Florida Fish and Wildlife Conservation Commission (FWC), Florida Department of Environmental Protection (DEP), Florida Keys Aqueduct Authority (FKAA), 1,000 Friends of Florida, The Ocean Conservancy and World Wildlife Fund (jointly), the South Florida Water Management District (SFWMD), the Florida Keys Citizens Coalition (FKCC), and the Environmental & Land Use Center, Inc., writing on behalf of five non-governmental organizations (NGOs). In addition, the technical Contractor attended a productive meeting with the NRC review committee on January 17, 2002.

The remainder of Section 1 presents background information regarding the context, history, and scope of the FKCCS. Section 2 briefly describes the CCIAM. Sections 3 through 10 describe each of the main components of the study and the model. Section 11 discusses the

results of the CCIAM test, including lessons learned and refinements necessary to finalize the study. Appendices include all the interim reports that serve as building blocks for the FKCCS, a summary of comments on the draft report, and a list of coefficients, formulas, and indicators of carrying capacity that constitute the CCIAM. Additionally, appendices include maps, a list of acronyms, and a glossary.

## **1.2 Background and Legal Mandate**

The Florida Keys were designated as an Area of Critical State Concern in 1974. Broad goals of this ruling were "...to conserve and protect the natural, environmental, historical and economic resources, the scenic beauty, and the public facilities within the Area of Critical State Concern." The Area of Critical State Concern designation transferred all local Monroe County review and approval rights to the state land planning agency, the DCA.

In 1986, a new comprehensive plan and corresponding land development regulations were approved for Monroe County. They were developed in response to the Area of Critical State Concern designation, as well as to comply with State of Florida regulations and to maintain a high quality of life in the region. In 1991, the Monroe County Board of Commissioners ratified the *Monroe County Year 2010 Comprehensive Plan* (the Plan).

The Plan was revised in 1993 following several legal challenges initiated by the DCA and other private organizations. Ongoing legal proceedings prompted a 1995 Final Order and Recommendation by a Hearing Officer, which resulted in further revisions and final adoption of the Plan in 1996. During final revisions of the Plan, a "carrying capacity approach" to growth management was adopted.

The Florida Administrative Code (FAC) issued an Executive Order in 1996 calling for the preparation of a "carrying capacity analysis" for the Florida Keys. The FKCCS fulfills a portion of the state and local government requirements as outlined in Florida Administration Commission Rules. Sections 28-20.100 and 28-19.100 FAC state:

*"The [carrying capacity] analysis shall be based upon the findings adopted by the Administration Commission on December 12, 1995, or more recent data that may become available in the course of the study, and shall be based upon the benchmarks of, and all adverse impacts to, the Keys land and water natural systems, in addition to the impacts of nutrients on marine resources. The carrying capacity analysis shall consider aesthetic, socioeconomic (including sustainable tourism), quality of life and community character issues, including the concentration of population, the amount of open space, diversity of habitats, and species richness. The analysis shall reflect the interconnected nature of the Florida Keys' natural systems, but may consider and analyze the carrying capacity of specific islands or groups of islands and specific ecosystems or habitats, including distinct parts of the Keys' marine ecosystem."*

Section 528(b) (3) of the Water Resources Development Act of 1996 authorizes the USACE to cooperate with a non-Federal sponsor to complete the FKCCS, a critical project under the Everglades and South Florida Restoration Programs. The U.S. Congress passed the Water Resources Development Act of 1996, which included legislation directing the Secretary of the Army, through the USACE, to complete a series of Critical Projects associated with the Central and South Florida Restoration Study. The Critical Project authorization requires that the project provide independent, immediate, and substantial benefits to the South Florida ecosystem. In conjunction with the South Florida Ecosystem Restoration Task Force and the Governor's Commission for a Sustainable South Florida, the FKCCS consistently ranked 4th out of about 35 Critical Projects nominated and prioritized.

The goal of the FKCCS, excerpted from FAC Rule 28-20.100, reads as follows:

*“The carrying capacity analysis shall be designed to determine the ability of the Florida Keys ecosystem, and the various segments thereof, to withstand all impacts of additional land development activities.”*

Additionally, Rule 28-20.100 establishes that the carrying capacity study will be implemented by “...the adoption of all necessary [comp] plan amendments to establish a rate of growth and a set of development standards that ensure that any and all new development does not exceed the capacity of the county's environment and marine system to accommodate additional impacts. Plan amendments will include a review of the County's Future Land Use Map series and changes to the map series and the “as of right” and “maximum” densities authorized for the plan's future land use categories based upon the natural character of the land and natural resources that would be impacted by the currently authorized land uses, densities and intensities.”

Therefore, the FKCCS will provide the state and local jurisdictions with an analytical tool and an evaluation of a series of land development scenarios that will support comprehensive plan amendments and revise development standards for the Florida Keys.

### **1.3 Development of the Florida Keys Carrying Capacity Study Scope of Work**

The development of the Scope of Work (SOW) for the FKCCS began with a cooperative agreement between the DCA and USACE in August 1996. A Steering Committee (SC) and a Technical Advisory Committee (TAC), charged with developing the SOW, included the participation of 38 agencies and 3 individuals. The SC and TAC included those agencies on the Florida Keys National Marine Sanctuary (FKNMS) Water Quality Protection Program (WQPP), area business leaders, and intervenors involved in the legal challenges to the Monroe County Comprehensive Plan. Members of the SC and TAC provided knowledge about issues affecting Monroe County.

The TAC met for the first time in September 1996 to develop a definition of the purpose, goals and objectives, concept and approach, and review a “straw man” outline for the FKCCS SOW. Utilizing input from the TAC, three iterations of drafts and revisions of the SOW were

completed between September 1996 and October 1997. In March/April 1998, the third draft of the SOW underwent a peer review of 18 experts of differing disciplines from government agencies, academia, and private industry. Based upon the peer review, the SOW was finalized in September 1998.

The peer review identified some outstanding issues and uncertainties regarding species, ecosystems, relationship of land development activities and their impact on the marine environment, water circulation and water quality modeling and ecosystem modeling. To keep the FKCCS process moving forward, the project sponsors, USACE and DCA, invited a group of 65 technical experts for a technical workshop series to address the uncertainties and refine the study approach in the following areas:

1.	Conceptual Framework	May 1999
2.	Mobilization Workshop	June 1999
3.	Ecosystems	July 1999
4.	Species of Concern	August 1999
5.	Wastewater	August 1999
6.	Stormwater	September 1999
7.	Water Circulation/Water Quality Modeling	October 1999
8.	Carrying Capacity Analysis Model Framework	November 1999
9.	Scenario Development	January 2000

The workshop reports are included on the FKCCS website at <http://www.saj.usace.army.mil/projects>.

#### **1.4 User Needs Assessment**

Both the State of Florida and the local government jurisdictions will use the results of the FKCCS to support comprehensive plan amendments and revise development standards for the Florida Keys. Therefore, an assessment of the users' needs was conducted in 2000 (see Appendix A). The assessment included the following activities:

- Identifying the users of the FKCCS.
- Developing of a questionnaire regarding current development dynamics, planning/regulatory activities, planning issues/community concerns, and information technology/Geographic Information Systems (GIS).
- Scheduling and performing interviews with the users.
- Developing a prototype graphic user interface for the CCIAM.
- Convening and facilitating a workshop with the users to discuss the findings of the User Needs Assessment.

The primary users of the study are DCA, Monroe County, Village of Islamorada, City of Layton, City of Key Colony Beach, City of Marathon, City of Key West, and the South Florida Regional Planning Council. Others may benefit from the background data compilation, databases, literature reviews, research, and interim reports.

Although the primary users represented a range of interests and concerns regarding their needs and expectation about the FKCCS, all parties agreed in the following areas:

- Planning priorities in Monroe County continue to emphasize population and growth issues. Priorities are also focusing on quality of life issues, redevelopment, and revitalization activities.
- The importance of hurricane evacuation clearance times, including the potential widening of U.S. Highway 1 (U.S. 1) and the resulting impacts this action might have on the Keys in general, and on each of the municipalities in particular.
- The importance of the cost of implementing the Comprehensive Plan/Five-Year Program, especially in relation to concurrency management, infrastructures provisions, and land acquisition funding.
- That maintenance and updating of data generated by the FKCCS is a critical issue.

While most agencies were interested in the regional answers that the model could provide, it was generally recognized that these Keys-wide answers might be of limited use to local planners in their day-to-day work. The concept of providing access to all data used and generated in the FKCCS through an Internet application was borne from this realization. This Internet application was coined the “Routine Planning Tool” (RPT). A by-product of the study, the RPT will allow users to view GIS data and perform basic GIS function using a web browser. At the end of the study, a technology transfer will occur, which will focus on the use of the RPT by the local planners. The specifications of the RPT will be described in the final FKCCS report.

## **1.5 Technical Review and Public Input**

### **1.5.1 Technical Review**

The FKCCS and CCIAM have been under intense scrutiny from scientists, planners, government agencies, NGOs, and the public. In addition to the input gathered during the three years from the development of the SOW through the Technical Workshops (discussed in Section 1.3), interested parties have had opportunity to comment on the study through technical experts’ review of interim FKCCS reports, periodic meetings with local planners, two series of public meetings, study team presentations to local groups, access to a project website, and a two-day technical wrap-up workshop which included over 65 experts as well as members of the NRC Review Committee.

Government Study Team members reviewed every FKCCS interim report (included in Appendix A). Most reports were also submitted to external technical experts for review. For example, the research on existing data on terrestrial and marine ecosystems and species was submitted to several experts in order to cover the variety of subjects involved in the research. In every case, reports were revised before being accepted as final.

From the inception of the study, a Working Group convened periodically to discuss project progress and, in particular, to track how the study and CCIAM responded to the users needs. The Working Group included the Government Study Team (USACE, DCA), the Technical Contractor (URS Corporation), Monroe County, Village of Islamorada, City of Key Colony Beach, City of Layton, City of Marathon, City of Key West, and the South Florida Regional Planning Council. All meetings were open to the public. The Florida Marine Research Institute (FMRI) is performing the Database Management Work for the FKCCS. As part of this work, they led a GIS Coordinating Committee that initially reviewed and approved all GIS-related activities in the FKCCS.

In January 2001, the study team hosted a workshop entitled “Technical Wrap-Up Workshop” in Key Largo. The Technical Wrap-Up Workshop reconvened the experts who had participated in the Technical Workshop series discussed in Section 1.3, as well as the NRC Review Committee, which had already been engaged to provide an independent technical review of the study. Over 65 experts from around the country gathered to critique the study and model progress to date and provide thorough commentary on the study.

The NRC Review Committee reviewed the November 2001 draft of this report and submitted 153 questions to the Contractor in early January 2002. The Contractor provided written responses to all questions and met with the NRC committee on January 17, 2002, to address the committee’s questions.

### **1.5.2 Public Input**

The study team reported on project progress during three series of public meetings held in July 2000, March 2001, and April 2002. On every occasion, public meetings were held at Upper, Middle, and Lower Keys locations. In addition, members of the study team made 33 presentations to local trade, civic, or environmental organizations. A web site for the project, which the USACE maintains, includes all project reports, public meeting information, public comments, NRC Interim Review of the FKCCS, a searchable literature database, and other pertinent information. The URL address for the study is: <http://www.saj.usace.army.mil/projects> (double click on FKCCS on the left side of the screen). Both the NRC and FMRI have project information in their website.

As the study progressed, the study team gave due consideration to the numerous comments, observations, suggestions, and criticism offered by the diverse group of scientists, government agencies, NGOs, and the public. The input has helped refine the study but has also shown that diverse expectations remain regarding the study and the CCIAM.

## **1.6 Scope of the Study and Stakeholders Expectations**

### **1.6.1 Scope of the Study**

The FKCCS has focused on establishing the relationship between “land development activities” and indicators of carrying capacity in order to determine the ability of the Florida Keys ecosystems to withstand all impacts of additional land development. Simultaneously, it has considered socioeconomic issues, quality of life, amount of open space, diversity of habitats, and species richness. The study has been carried out with the understanding that the state and local governments will use it to assist them in adopting all necessary comprehensive plan amendments to establish a rate of growth and a set of development standards that “ensure that any and all new development does not exceed the capacity of the county’s environment and marine system to accommodate additional impacts.” (FAC Rule 28-20.100).

In order to address the carrying capacity of the Florida Keys ecosystems and provide support in making countywide comprehensive plan amendments, relationships and results are assessed at the FKNMS scale. Level of effort for the study was apportioned among five key disciplines: terrestrial and marine ecosystems and species, human infrastructure, socio-economics, fiscal, and water issues. Finally, all of the data, relationships, and carrying capacity indicators were integrated using state-of-the-art GIS technology in order to build an automated computer model.

With few exceptions, the study team attempted to establish the relationships between development and the environment based upon the findings adopted by the Administration Commission on December 12, 1995 and other data that became available since then. The identification and assimilation of relevant existing data to address the goal of the study, which is documented in Sections 3 through 10 and Appendix A, revealed a paucity of specific, peer reviewed scientific information that could support the establishment of defensible carrying capacity criteria or of clear predictive relationships between land development activities and some of the study parameters. For example, while a voluminous and rapidly growing body of scientific literature addresses the marine environment in the Florida Keys (for a recent review, see Porter and Porter 2002), virtually no study shows undisputable connections between development in the Keys and water quality in the FKNMS, the distribution and health of benthic communities, or fisheries productivity in the Florida Keys (discussion in Section 10).

Overall, the current peer-reviewed scientific information proved insufficient to develop a comprehensive carrying capacity framework that would allow for undisputable determinations of whether future development scenarios fall within the carrying capacity of the Florida Keys (discussion in NRC 2002). Yet the study and the impact analysis model clearly document the effects of development on the environment in the Florida Keys and will provide solid technical support for decisions on comprehensive plan amendments and development standards in the Keys. Therefore, the computer model that is the main analysis tool produced in the study has been re-termed CCIAM.

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### 1.6.2 Stakeholders Expectations

Some stakeholders' expectations have contrasted with the study methods, progress, and findings. Many of the conflicting expectations are related to the regional scale of the study, the level of detail that has resulted from the required allocation of time and effort to a variety of disciplines (each of which could be the subject of detailed studies), and the almost exclusive use of existing data. Five examples illustrate stakeholder expectations that contrast with the study's framework and intent:

- During the user needs assessment, local planners expressed that the model should allow them to determine the impacts of individual development projects as part of their daily activities. Yet, because of its regional scale, the CCIAM is not intended to assist in individual permitting decisions. Several stakeholders, such as 1,000 Friends of Florida (letter to DCA, dated January 30, 2002), as well as recent newspaper articles (e.g., The Key West Citizen, editorial dated March 15, 2002) have expressed similar expectations. A GIS-based Internet application will serve the FKCCS data to the public and local planners. This decision was a direct result of the study team's work in the user needs assessment early on in the project. In addition, a prototype Internet application was demonstrated at the January 2001 technical wrap-up workshop.
- During the technical workshops and in the review of interim FKCCS reports, technical experts expressed expectations or recommended actions for which data do not exist or exceeded the level of effort that could be allocated in this study. For example, water circulation was identified as necessary to evaluate water quality and experts called for the preparation of a hydrodynamic model for the study area. However, the development of such a detailed model is costly and time consuming; therefore, this recommendation could not be accommodated within the scope of the study. The study team attempted to adapt and use existing data and knowledge to develop a useful circulation approach (discussion in Section 10).
- Technical experts advocated the use of population viability analysis (PVA) techniques as a means to evaluate whether development would jeopardize threatened and endangered species. A thorough literature search confirmed that PVAs required detailed population data (Appendix A), which is lacking for virtually every species in the Florida Keys. Two exceptions include the Lower Keys marsh rabbit (*Silvilagus palustris hefneri*) and the Florida Key deer (*Odocoileus virginianus clavium*). A PVA model was developed for the Lower Keys marsh rabbit in the mid-1990s (Forys and Humphrey 1999). For the Key deer, a three-year study recently completed (Lopez 2001) yielded a state-of-the-art PVA model, which is being used to support a Habitat Conservation Plan for Big Pine and No Name Keys sponsored by the Florida Department of Transportation (FDOT), DCA, and Monroe County.

- Recent comments have criticized the inclusion of socioeconomic parameters in the study (Environmental & Land Use Center, Inc. letter to DCA and USACE, dated February 12, 2002). The legal mandate for the study, discussed in Section 1.2, required that the study consider socioeconomic issues.
- Several reviewers and stakeholders, including the NRC (NRC 2002) and the FKCC (letter from Curtis Kruer to DCA and the USACE dated March 30, 2002), criticize the omission of local knowledge, anecdotal data, and expert opinion in the technical basis of the model. The Study Team assimilated and recognized the value of local knowledge and expert opinion in the FKCCS. However, in many cases the available information was insufficient or inappropriate to establish predictive relationships between additional land use activities and environmental parameters. Therefore, much available information, while valuable, was not used to build model relationships.
- Similarly, stakeholders have pointed out the apparent omission of the effects of tourism in the model. The model incorporates “tourists” as part of the population present in the Keys on any given day (see Section 5), and directly measures their impact on water consumption, demand for non-residential land uses, and government expenditures. Data for other tourism-related parameters, such as boating or diving, are insufficient or inappropriate to establish predictive relationships between land use activities and those parameters.

Stakeholders, particularly the public, expressed additional expectations. These included an evaluation of external issues such as the effect of further development in the tri-county area of southeast Florida, the potential effects of a government change in Cuba, the effects of sea level rise, or the potential effects of Everglades restoration activities. The study addresses issues such as tourists and potable water, which are generated outside the Florida Keys. The Monroe County Tourist Development Council established the Inter-Governmental Cuba Committee to address issues regarding the opening of Cuba (Inter-Governmental Cuba Committee 2000). The potential effects of the Everglades restoration activities will be addressed in the Florida Bay/Florida Keys Feasibility Study. In adherence to its mandate, the FKCCS focused on the effects of land development activities in the Florida Keys.

### **1.6.3 Other Similar Models**

Other models address the impact of land use. The CCIAM is unique in that it has attempted to create the structure necessary to evaluate, *simultaneously*, the effects of land development activities on ecological, water quality, and human issues for a specific area. These four examples illustrate similar applications of land use and ecological models:

- **Quest** – (The Sustainable Development Research Institute at the University of British Columbia) evaluates the social, economic, and environmental consequences of scenario choices. Similar to the CCIAM, Quest is modular,

with individual modules that work together to provide a comprehensive assessment of scenario consequence. Also, Quest allows the user to build scenarios based on choices and visions, instead of most probable future. Different from CCIAM, Quest provides for a set of conceptual constructs not built upon real data or specifically designed for an area.

- **What if?** – (Community Analysis & Planning Systems, Inc.) The model determines what would happen if a set of policies is implemented. It considers policy choices such as alternative land use controls, agricultural and open space requirements, or the expansion of public infrastructure. Like the CCIAM, it incorporates GIS and non-GIS data. Different from CCIAM, and similar to a land use planning model, What if? focuses on conducting land suitability analyses, land use demand, and allocation of future land use patterns. In CCIAM, the user makes many of those decisions.
- **UrbanSim** – (University of Washington) A popular model, UrbanSim evaluates the interactions between transportation and land use. It was originally developed for Honolulu, Hawaii, and has now been implemented in Oregon. Different from CCIAM, it focuses on estimating the demand for real estate at different locations.
- **Chesapeake Bay Models** – Models to evaluate the relationship between land use and the health of the bay have been in development for over 20 years. The effort has grown to involve multiple interconnected models, with technical advisory boards, numerous researchers, and continuous calibration. Detailed models, created by different teams over many years, are interconnected and continuously updated. After 20 years, the models are still being refined.

None of these models provide comprehensive environmental and socioeconomic planning capabilities, and are limited in the scope of their application.

Many of the reviewers comments reflect the misunderstanding that this report represents the conclusions of the study, that the “smart growth scenario” used to test the model (described in Section 11) represents a recommended scenario, or that the model “allows” for increased levels of impacts. This report discusses only the testing and refinement of the model; the smart growth scenario was used only for testing, and the model is “blind” to the users’ decisions in defining a scenario. The final report of the FKCCS will apply the model, as well as use all gathered information, to assess and discuss carrying capacity issues in the Florida Keys.