SEPTEMBER 1998

FLORIDA KEYS
CARRYING CAPACITY STUDY

SCOPE OF WORK

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SCOPE OF WORK

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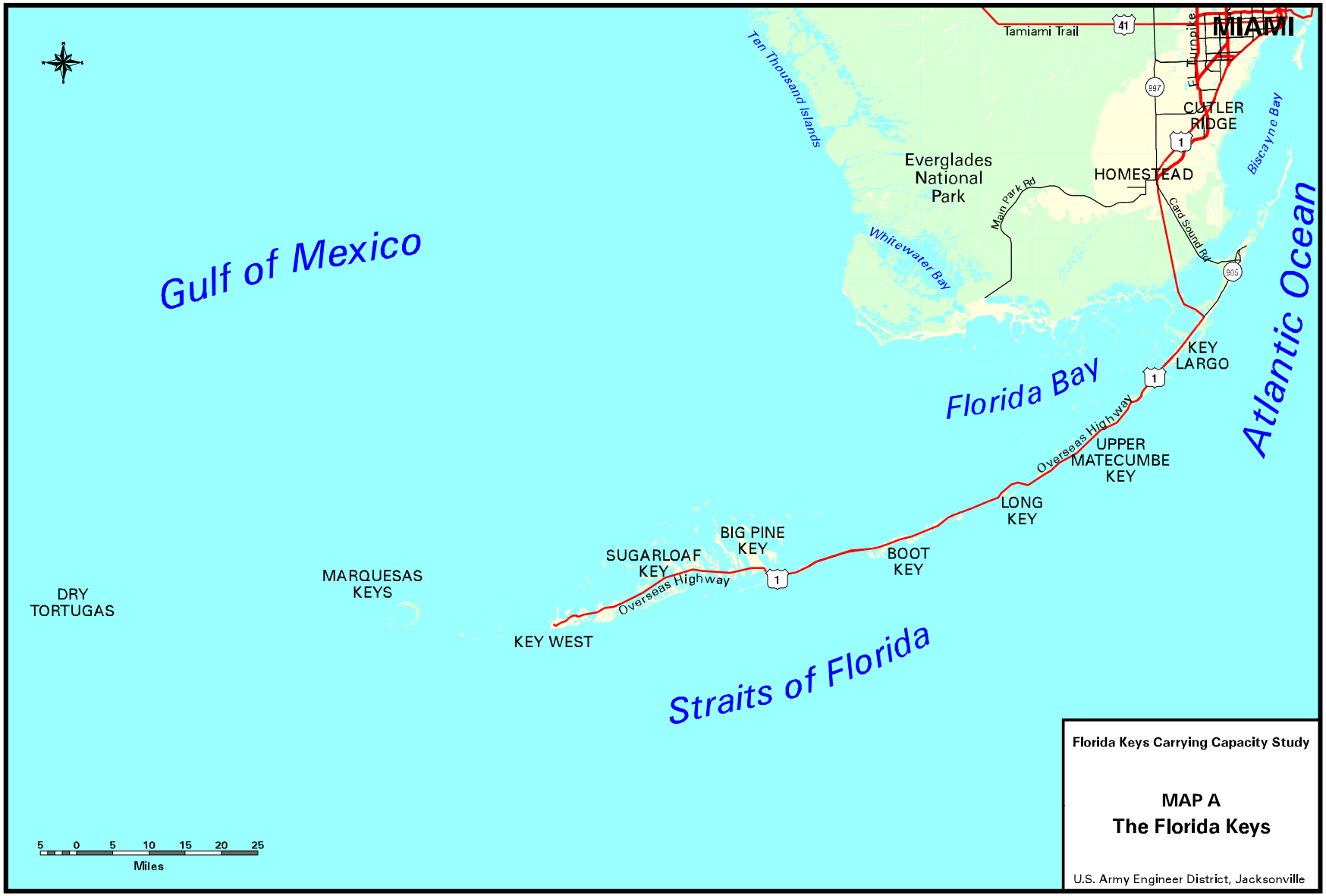
Executive Summary

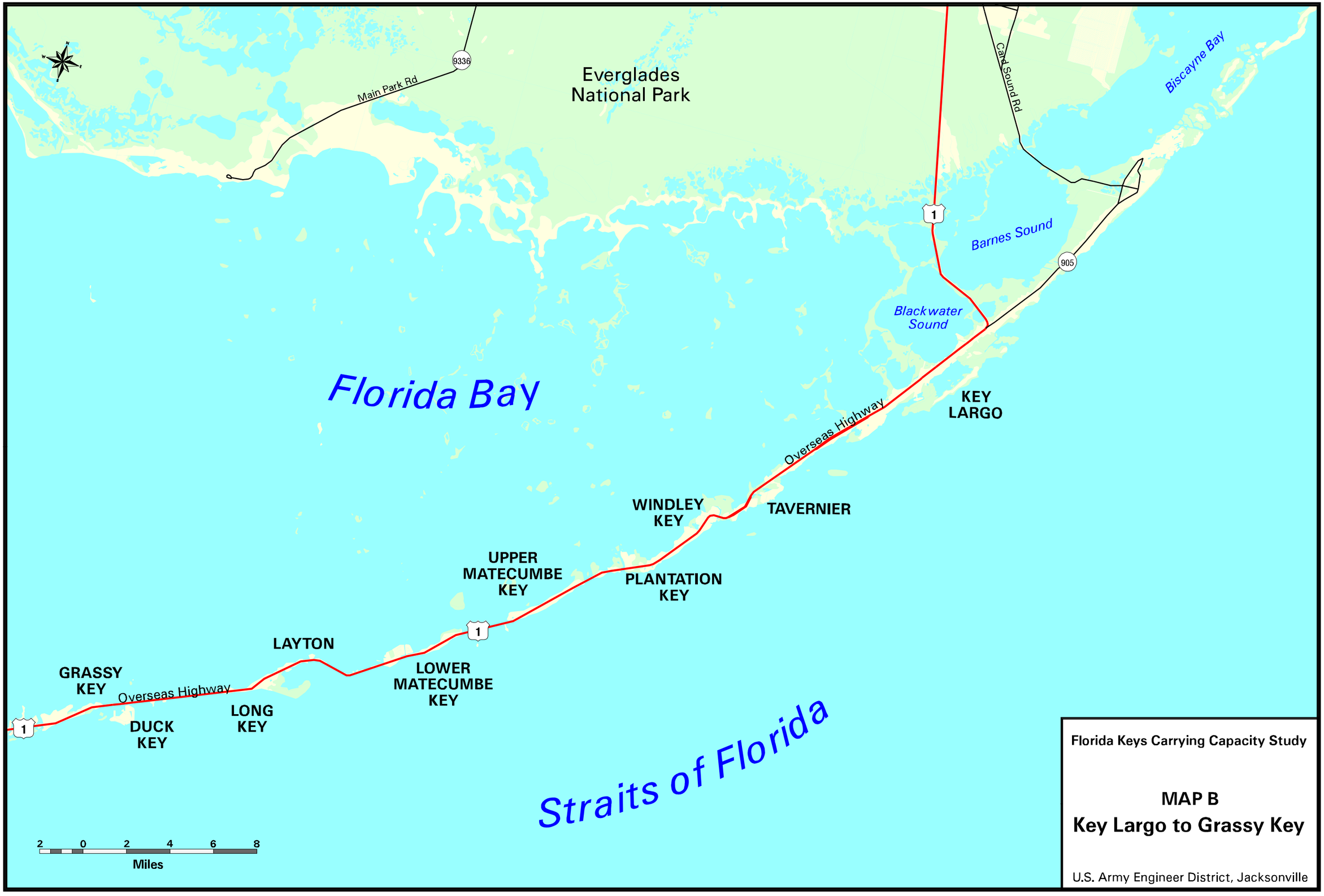
The Florida Keys have long been recognized at local, state and national levels as ecologically rich, culturally significant and environmentally sensitive. The Florida Keys attract a growing number of visitors and new residents. To assure the sustainability of the Keys unique resources, comprehensive planning is required to address the complexity of the situation. Conducting a Florida Keys Carrying Capacity Study is the best way to complement and assist the planning effort. This study will provide an information database and an analysis of consequences (i.e. a planning tool) that may be used to determine the level of land development activities that will avoid further irreversible and/or adverse impacts to the Florida Keys ecosystem.

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. 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 system. (*Florida Administrative Weekly*, April 12, 1996)

This study explores past (where possible), present and future impacts on that ecosystem. Several scenarios are included in the study to represent potential future conditions. Each scenario, with its set of assumptions, projects any impacts it may have on identifiable Florida Keys components, such as natural resources, human infrastructure and the social environment. An interactive, spatially explicit Carrying Capacity Analysis Model (CCAM) will be developed that will simulate the conditions of land development activities and population growth, through time, described by the various input assumptions. Utilizing relationships that describe land development and population growth impacts on the environment, CCAM will determine and inventory the impacts on the natural resources and human infrastructure in the Florida Keys. Next, CCAM will compare the impacts on the natural resource elements with their associated requirements, responses, limiting factors and tolerance limits, where identified and quantified, and on the existing infrastructure. CCAM will then spatially identify the natural resource element(s) and human infrastructure whose carrying capacities may have been exceeded. In the case of the human infrastructure, the cost estimate for retrofitting and/or new construction to meet the additional population requirements will be provided.

This scope of work was prepared by the U.S. Army Corps of Engineers in response to a request from the Florida Department of Community Affairs (DCA) under the Intergovernmental Cooperation Act (31 USC 6505) and (10 U.S.C. 3036 Ld). The impetus for the contractual agreement between the two agencies was DCA's requirement to comply with Florida Administration Commission Rule 28-20.100.


Gulf of Mexico
Atlantic Ocean
Florida Bay
Straits of Florida
Ten Thousand Islands
Everglades National Park
Whitewater Bay
Main Park Rd
Tamiami Trail
41
MIAMI
Fl Turnpike
997
CUTLER RIDGE
Biscayne Bay
1
HOMESTEAD
Card Sound Rd
905
KEY LARGO
Overseas Highway
UPPER MATECUMBE KEY
LONG KEY
BOOT KEY
BIG PINE KEY
SUGARLOAF KEY
MARQUESAS KEYS
DRY TORTUGAS
KEY WEST
5 0 5 10 15 20 25
Miles
Florida Keys Carrying Capacity Study
MAP A
The Florida Keys
U.S. Army Engineer District, Jacksonville

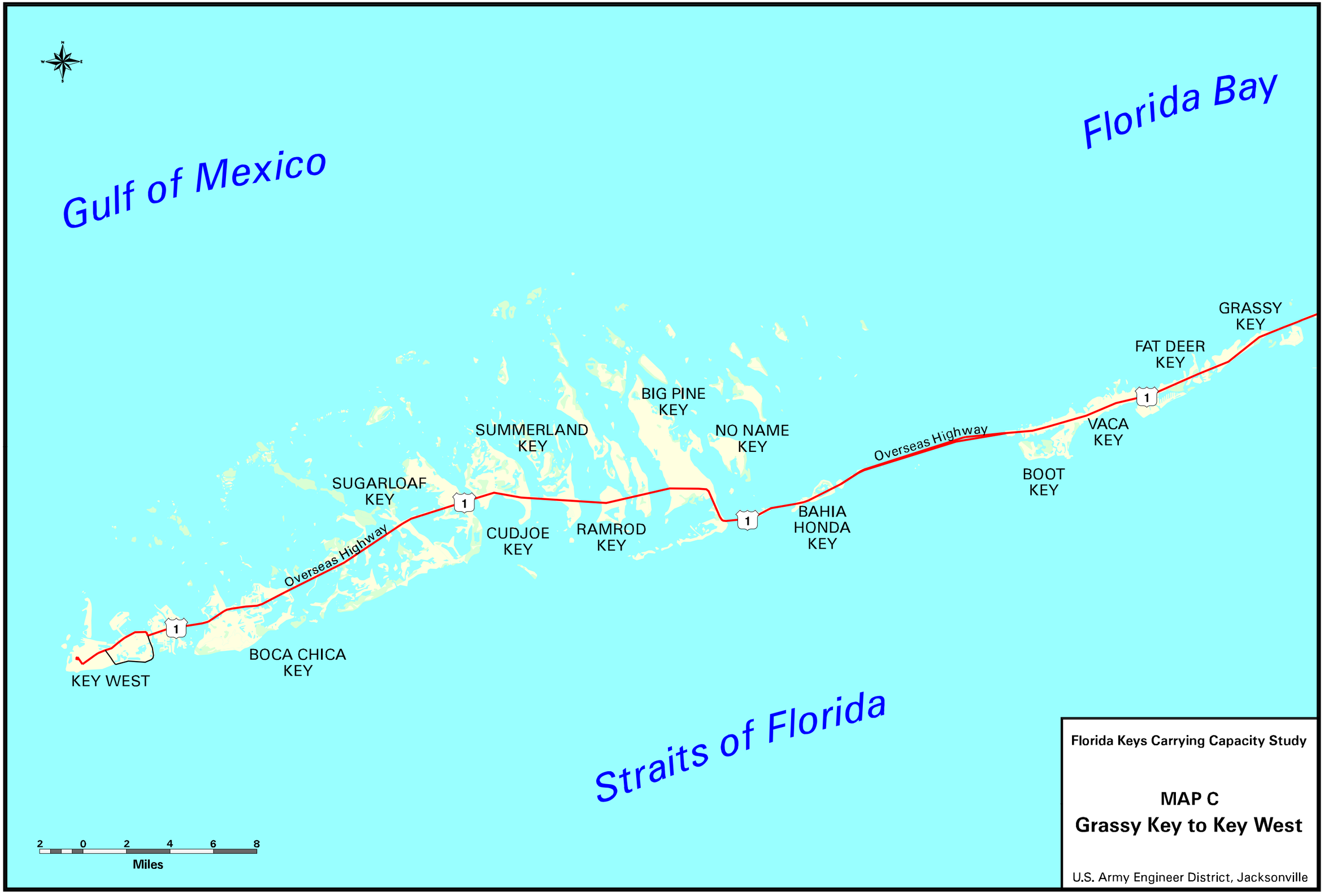


Florida Keys Carrying Capacity Study

MAP B

Key Largo to Grassy Key

U.S. Army Engineer District, Jacksonville


Gulf of Mexico
Florida Bay
GRASSY KEY
FAT DEER KEY
1
VACA KEY
BOOT KEY
Overseas Highway
BIG PINE KEY
NO NAME KEY
SUMMERLAND KEY
SUGARLOAF KEY
CUDJOE KEY
RAMROD KEY
BAHIA HONDA KEY
BOCA CHICA KEY
KEY WEST
Straits of Florida
2 0 2 4 6 8
Miles
Florida Keys Carrying Capacity Study
MAP C
Grassy Key to Key West
U.S. Army Engineer District, Jacksonville

Glossary of Terms

Adverse Impact – Impact that will cause a natural resource or species to be no longer sustainable.

Carrying Capacity - Maximum population impacts an area can sustain over time with a given level of technology and societal preferences.

Carrying Capacity Analysis Model - A computer model that links input assumptions; a GIS database; study element databases; natural resource and endangered species threshold ranges or tolerance limits; and linkages to population as a measure of development, and produces evaluation and graphically displayed output (e.g. maps) characterizing the effects of different scenarios.

Concept - The underlying focus supporting the approach.

Effective Population - The number of all users (permanent; seasonal; tourists) residing in the study area at any given point in time.

Element - An identifiable component of the Florida Keys. There are three categories of identified study elements for the Florida Keys Carrying Capacity Study: natural resources (water quality, ecosystem and endangered species); human infrastructure (population forecast, stormwater, wastewater, transportation, marinas/channels/ports, hurricane evacuation and other infrastructure services) and social environment (existing, historic and future).

Expected Value - An expression of measurement for each element threshold within the pressures and constraints of a given scenario.

Indicators - Measurable variables that signal a threshold limit for a given resource is about to be or has been surpassed.

Indicator Species – A species used as a gauge for the condition of a particular habitat, community, or ecosystem. A characteristic, or surrogate species for a community or ecosystem.

Keys Partitions or Service Areas - Zones or regions within the Keys that are based upon a logical delineation (to be defined in the study).

Keystone Species – Species that have a disproportionately large effect on other species in a community.

Project Management Team – A team of representatives from the Florida Department of Community Affairs, Monroe County and the U.S. Army Corps of Engineers that will manage and coordinate the Florida Keys Carrying Capacity Study.

Scenarios - A set of characteristics defining different conditions.

Service Areas or Keys Partitions - Zones or regions within the Keys that are based upon a logical delineation (to be defined in the study).

Study Element Relationships - The relationship of each element as a function of population. The purpose of the relationship is to enable prediction of changes in the study element as the population changes.

Sustainability – A state where all species populations and their activities neither deplete nor degrade natural resources and the underlying environmental support system over the long term.

Threshold – A scientifically derived tolerance range of values, beyond which a natural resource or species is not sustainable. A societal threshold is a scientifically derived tolerance range of values, beyond which changes are unacceptable.

Tolerance limits - The range of environmental conditions that a species requires to survive; example: Corals require a very narrow range of temperature, water clarity and nutrient concentration conditions.

ACRONYMS

ADCIRC	ADvanced CIRCulation Model for Shelves, Coasts, and Estuaries
ADID	Advanced Identification of Wetlands Program
ASTM	American Society for Testing and Materials
CCAM	Carrying Capacity Analysis Model
DCA	Department of Community Affairs
EPA	Environmental Protection Agency
ERNS	Emergency Response Notification System
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FGFWFC	Florida Game and Fresh Water Fish Commission
FGDC	Federal Geographic Data Committee
FGIB	Florida Geographic Information Board
FKCCS	Florida Keys Carrying Capacity Study
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FKERTF	Florida Keys Environmental Restoration Trust Fund
FKNMS	Florida Keys National Marine Sanctuary
FMRI	Florida Marine Research Institute
FMRIS	Florida Marine Resource Information System
FNAI	Florida Natural Areas Inventory

GPD	Gallons Per Day
HTRW	Hazardous, Toxic and Radioactive Waste
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NSDI	National Spatial Data Infrastructure
OSDS	On-Site Disposal System
PCA	Project Cooperation Agreement
PMT	Project Management Team
RCRA	Resource Conservation and Recovery Act
RFP	Request For Proposal
SFWMD	South Florida Water Management District
SHOALS	Scanning Hydrographic Operational Airborne Lidar Survey
SLOSH	Sea, Lake and Overland Surge from Hurricanes
SOW	Scope of Work
TAC	Technical Advisory Committee
TSD	Transportation, Storage and Disposal
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
WC	Water Circulation
WQ	Water Quality
WQPP	Water Quality Protection Program

SECTION 1
INTRODUCTION

A conceptual scope of work (SOW) for the Florida Keys Carrying Capacity Study is described herein. The detailed SOW for use in the contracting process will be prepared prior to initiation of the advertisement and selection process. The Florida Keys Carrying Capacity Study does not assume that the current amount of development or any future amount of development is appropriate or is not appropriate. The carrying capacity analysis will provide the information to be used by local, regional and state planners to determine whether the current amount of development should be reduced, is appropriate or additional development could occur in non-environmentally sensitive areas.

Carrying Capacity Concept

The Keys Carrying Capacity Study concept is about sustainable development. 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. The 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 impact 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 system. (*Florida Administrative Weekly*, April 12, 1996)

This study will provide an information database and an analysis of consequences that may be used to determine the level of land development activities that will avoid further irreversible and/or adverse impacts to the Florida Keys ecosystem. Equally fundamental to this study is the identification of restoration opportunities for the Florida Keys ecosystem. Among the basic premises of the carrying capacity concept is the ability to scientifically determine many thresholds for both societal and natural resources tolerance ranges that are measurable in trends or quantifiers. Other thresholds that are not measurable in trends or quantifiers will be determined by alternative methods to be defined during the course of the study. Sustainable development requires avoidance of natural resource waste and degradation. This concept acknowledges the potential of future technological contributions, scientific discoveries and/or a community's ability to redefine its character over time. However, this acknowledgment is shadowed by the basic premise that biological limits exist, and will ultimately determine the carrying capacity.

Study Area

The Florida Keys Carrying Capacity Study is focused on the portion of Monroe County that spans from Key Largo to the Dry Tortugas. The Florida mainland will be excluded except for the hurricane evacuation route to the Turnpike. The "Florida Keys" formally consists of 113 miles of low-lying islands with a combined area of approximately 100 square miles. They include over 200 additional offshore islands. The study area boundary found below the mean high water mark follows that of the Florida Keys National Marine Sanctuary. U.S. Highway 1 provides a mainland connection that joins a chain of 38 islands arcing southwesterly toward Cuba and the Gulf of Mexico. Mile markers begin with 0 in Key West and end with 113 south of Florida City. Florida Bay and the Gulf of Mexico lie to the north and northwest of the Keys respectively. The Atlantic Ocean lies to the east.

Miami oolite and Key Largo limestone dominate the geology of these islands typified by tropical hardwood hammocks, pine rocklands, transition zones and tidal wetlands. Existing fresh water wetlands and catchments, receiving 35 to 45 inches of annual rainfall, are intrinsically linked to sea fluctuations. The fragile marine environment contains seagrass meadows, mangrove islands and living coral reefs.

Four National Wildlife Refuges overlap land and water in the Keys, along with three State Parks. In addition, four state botanical, geological and historical sites, as well as four State Preserves are found within the study area of Monroe County. The Florida Keys also have a designated National Marine Sanctuary. Over 100 species of flora and fauna within the boundaries of the Florida Keys are identified on Federal and/or State lists as: endangered, threatened, species of special concern, commercially exploited, candidate, or proposed for listing. This ecosystem also includes human habitation.

The Keys have an extensive history of human occupation dating back to the Calusa and Tequesta Indians. A number of prehistoric and historic sites included in the National Register of Historic Places are located in the Keys. Today more than 80,000 permanent residents live on the Florida Keys. Approximately 2.5 million tourists travel annually to the Florida Keys to visit and/or live seasonally.

Study Authority

This study will fulfill the Department of Community Affairs' need to comply with Administration Commission Rule 28-20.100 which requires that the carrying capacity analysis 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. Executive Order 96-108, Section III.1. coordinates state agency activities necessary to implement the Administration Commission Rule. Section III.1. of Executive Order 96-108 states "DEP [Florida Department of Environmental Protection], DCA [Department of Community Affairs], HRS [Florida Department of Health and Rehabilitative Services], and the Department of Transportation (DOT) shall, and the South Florida Water Management District (SFWMD) is requested to, assist Monroe County in the implementation of the Permit Allocation System contained in the 2010 Plan, and in conducting a carrying capacity analysis. Said agencies shall specifically adhere to

and implement the findings of a carrying capacity analysis as it relates to and affects the rate of growth and permit allocation in Monroe County."

The U.S. Army Corps of Engineers (USACE) participation in the development of this SOW is authorized under the Support For Others program in accordance with the Intergovernmental Cooperation Act (31 USC 6505) and (10 U.S.C. 3036 Ld.). A Memorandum of Agreement (1996) between the Florida Department of Community Affairs (DCA) and the Jacksonville District, USACE provides the Federal/non-Federal legal agreement for development of this SOW.

Continued Federal participation in the development and completion of the Florida Keys Carrying Capacity Study (FKCCS) will require a Project Cooperation Agreement (PCA) between the DCA and the USACE. The PCA will provide the Federal/non-Federal legal agreement for the development and completion of the FKCCS.

Monroe County Planning Background

The Florida Keys have long been recognized at local, state, and national levels as ecologically rich, culturally significant and environmentally sensitive. Originally the upper Keys were considered for inclusion in the 1947 Federal legislation which created the Everglades National Park, but were later dropped from the proposed legislation.

The Florida Keys were designated in 1974 by the State of Florida as its first "Area of Critical State Concern" due to a renewed emphasis to protect them as a state, national, and international resource. A subsequent legal challenge ensued over that designation. In 1979 the Keys were re-designated as an "Area of Critical State Concern" by the Florida Legislature. It was at this same time that the "Principles for Guiding Development" were established to set local land use planning and land development regulation standards. The "Principles for Guiding Development" gave the rights of review and approval for all local Monroe County planning actions to the State land planning agency. In support, Monroe County was given technical and financial assistance to modify its existing land use planning program to comply with the newer, more rigorous standards. Efforts to reconcile development expectations and property rights with the natural environment were less than adequate despite an improved comprehensive plan and land development regulations which were approved in 1986. Further efforts by Monroe County and the City of Key West resulted in establishing a Rate of Growth Ordinance to limit annual building permits.

Study Background

In 1991, the Monroe County Board of County Commissioners adopted the *Monroe County Year 2010 Comprehensive Plan.* The DCA did not find the plan in compliance with Florida Statute, Section 163.3184(1)(b). Subsequent administrative proceedings, documented by the Hearing Officer, highlight specific aspects of the ecosystem as having already exceeded carrying capacity thresholds such as: nearshore

waters, seagrasses, and the endangered Key Deer. In addition, hurricane evacuation was noted as having reached its upper capacity limit.

In 1996, both the Florida Administration Commission and the Governor, through Executive Order 96-108, called for the preparation of a "carrying capacity analysis" for the Florida Keys. The State of Florida DCA's pursuit of a Florida Keys Carrying Capacity Study is a logical extension of the ongoing efforts within Monroe County to support a healthy sustainable environment and economy.

Scope of Work Approach

The Corps conducted a "carrying capacity study" literature search and found no previously used analysis to be directly applicable to the unique situation of the Florida Keys. A study approach for the carrying capacity analysis was developed using information obtained from the literature search. A broad approach was chosen where elements of human society would be included as explicit variables in the modeling yet the value of protecting non-human species and the ecological system would establish the fundamental basis for the study.

Several meetings were held and input sought from Monroe County residents, and a multi-discipline, multi-agency, cross-section of interested citizens. Subsequently, the following committees, teams and working groups were created which provided significant contributions to the development of the study outline and SOW: Technical Advisory Committee (TAC) (see Appendix A), Study Team (see Appendix B), and an Interagency Working Group (see Appendix C). Included within the study is a component for further public involvement and peer review. Critical to the study is an inclusion of both local and national perspectives. Subsequent to finalizing the SOW, an additional peer review was performed in March 1998. The peer review group participants are included in Appendix D. The SOW has also been revised based upon comments from the DCA and the Governor's office.

Study Goal

The goal of the Florida Keys Carrying Capacity Study is to determine the ability of the Florida Keys ecosystem, and the various segments thereof, to withstand all impacts of additional land development activities. The 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 impact 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 system. (*Florida Administrative Weekly,* April 12, 1996)

The FKCCS will provide an information database and an analysis of consequences (i.e. a tool) that may be used to determine the level of land development activities that can be supported by a healthy, balanced, functioning ecosystem in the Florida Keys. This will be accomplished through the identification of component thresholds which define ecosystem sustainability. The study will also provide local, state and federal planners with the information needed for making sound decisions that are critical to a sustainable Florida Keys ecosystem.

Study Objectives

1. Effectively inform and obtain information from Keys citizens through a public involvement and peer review study component.

2. Develop a knowledge base for each element in the study which can be utilized independently and reflect all related studies by various agencies.

3. Define requirements, responses and limiting factors for each key natural resource indicator or species of concern of the Florida Keys ecosystem, identifying and quantifying tolerance limits, wherever possible.

4. Develop relationship(s) that describe the impact that land development activities, humans and associated infrastructure have on the environment in the Florida Keys, e.g. amount and pathways of nutrient and contaminant inputs to nearshore waters.

5. Develop an analysis tool for objective assessment and projection of the outcomes of different scenarios. e.g. affecting aquatic nutrient loads; sustainable tourism; diversity of high quality habitats; aesthetics; and community character issues.

6. Identify areas and the natural resource category requiring restoration efforts to restore ecosystem integrity.

7. Deliver a tool for planning the future of Monroe County.

8. Document the interconnected nature of the Florida Keys ecosystem.

9. Answer questions such as what and sometimes how elements affect reaching the goal of sustainability, while acknowledging that decisions and policies are established in the regulatory, political and public arenas.

Study Approach

A simplified description of the study approach to be utilized is:

1. Identify indicator species, keystone species and species of concern and natural resource indicators of sustainability for each ecosystem—marine, uplands and wetlands.

2. Collect and synthesize existing data, other applicable study results and Geographic Information System (GIS) coverages,

3. Identify critical data and essential study gaps and obtain the data or perform the study,

4. Populate databases and GIS coverages,

5. Determine scientifically derived requirements, responses and limiting factors for natural resources and species of concern, identifying and quantifying tolerance limits, wherever possible,

6. Develop relationship(s) that describe the impact that humans and associated infrastructure have on the environment in the Florida Keys, e.g. amount and pathways of nutrient and contaminant inputs to nearshore waters, and

7. Develop interactive computer driven model(s) that interfaces databases; GIS coverages; natural resource or species of concern requirements, responses, limiting factors, and tolerance limits; and relationships that describe human/infrastructure impacts on the environment.

SECTION 2
STUDY ADMINISTRATION/PUBLIC INFORMATION

Administration and management of the Keys Carrying Capacity Study will utilize a team approach, e.g. Project Management Team (PMT) and study team. The PMT and study team will develop the contracts required to execute the carrying capacity study; perform study tasks, as necessary; secure and manage funding; track milestones; report on the study status; provide coordination between contractors; conduct public and technical coordination workshops; ensure that the final carrying capacity analysis model meets the study requirements; and write the final report. Technical workshop participants will be selected by the PMT, in accordance with the technical issue to be resolved. If the PMT determines that an advisory committee or peer review group is necessary during the study, appropriate representatives will be selected at that time. The purpose of the advisory committee or peer review group, if required, would be to provide technical expertise and guidance on the development of the carrying capacity analysis model, direction for additional research, and direction for resolving outstanding issues.

Appendix E includes the estimated cost and schedule for performing the work required to complete the FKCCS, and identifies anticipated work in kind (WIK) credit tasks to be completed by the DCA. Technical workshops identified in this SOW may reveal the need for additional research, data collection and/or data analyses. It is understood between the USACE and the DCA that the SOW and/or WIK credit tasks may be adjusted during the study period by written agreement between the Executive Committee members. The modification of the SOW and/or WIK credit tasks will not change the statutory requirement of cost sharing responsibilities or the maximum limit on allowable WIK credit, pursuant to Section 105 of the Water Resources Development Act of 1986.

Public information will be a significant and integral part of the FKCCS. While the FKCCS will be strictly scientifically driven, due to the widespread public, political, agency and media interest, a diligent effort will be expended to provide a rigorous public information program. The primary objectives of the Public Information effort are:

1. Inform Keys citizens and all stakeholders throughout the course of the study;

2. Provide opportunities for interaction between the public and those persons involved in the formulation of the FKCCS,

3. Obtain information and input from the public,

4. Provide effective transfer to the public of the carrying capacity analysis procedures and study results, and

5. Provide the public with insight and direction on study decisions.

Study Administration

Task 1. Contracts. Due to its complex nature, this study will be executed in phases. To facilitate this approach, the study will be divided into contracts based around the necessary expertise and experience in the following areas: public information, modeling and scenario development, data collection for the natural resource categories, and data collection for the human infrastructure and social categories. The Public Information contract will be ready for advertisement after the signing of the PCA and transfer of funds by the DCA.

Task 1.a. Coordinate Contracting Procedure. Based upon this conceptual SOW, detailed scopes of work will be developed for the Request For Proposal (RFP) process. Coordination of the study requirements for each contract delivery order will be provided throughout the entire contracting procedure, i.e. until the contract is awarded.

Task 1.b. Administer Contract Delivery Orders. This task requires the administration of the contract(s) through coordination with the contractor(s) to ensure that the contractor(s) understand(s) the requirement(s) of the delivery order(s).

Task 2. Conduct Coordination Workshops. Coordination between all parties involved in the development of every phase of the study is critical to its timely and successful completion. A series of PMT/contractor coordination workshops are planned at key milestones in the study (see Appendix E). At these workshops the PMT will review the specific deliverables each contractor is responsible for, refine the contractors focus as necessary, and discuss the overall direction of the study and the schedule.

Task 3. Coordinate Public and Agency Input. Public and agency input will be solicited through public and technical workshops. This input will be coordinated with the PMT, study team, contractors, and the public.

Task 4. Coordinate Peer Review Process. Peer reviews, if necessary, will be performed by members of the science and technology community that are not otherwise associated with the study effort. This task may require coordination of peer reviews of study parameters such as data collection; scientific determination of requirements, responses, limiting factors, and tolerance limits, if identifiable and quantifiable, of natural resource indicators and species of concern; and modeling.

Task 5. Final Report. A FKCCS report will be prepared documenting the data collection; public and technical workshops; peer review efforts, if applicable; modeling; methodology and study process.

Public Information

Task 1. Prepare Public Information Plan. The Contractor shall develop a Public Information Plan that guides the conduct of the Public Information effort. In preparing the plan, the Contractor will carry out the following sub-tasks:

Task 1.a. Develop Coordination Plan for On-Going Related Studies. In developing the plan the Contractor will identify and coordinate with all public information efforts of related, on-going studies in the Keys. This effort will provide synergy and avoid unnecessary duplication of information, meetings, etc. Such on-going Keys study efforts include, but are not limited to, the Monroe County Sanitary Wastewater Master Plan, the Monroe County Stormwater Master Plan, the Florida Keys National Marine Sanctuary (FKNMS) studies, the FKNMS Water Quality Protection Program studies and Florida Bay studies.

Task 1.b. Develop Stakeholder List. The Contractor shall prepare a list of all stakeholders to be informed on the progress of the study. Stakeholders consist of individuals, political leaders, formal and informal groups, and governmental and non-governmental organizations that are expected to be interested or concerned about the future of the Keys. The list of stakeholders is expected to be extensive, and include both on-Keys and off-Keys groups. This list will be updated on a quarterly basis by the Contractor over the course of the study. The Contractor will not only utilize standard Public Information methods (analysis of past participation in similar issue areas, self identification, third party identification, etc.) to identify all the stakeholders, but also an effort will be made to seek innovative methods. The search for and use of the innovative methods for stakeholder identification will be documented in the Public Information Plan.

Task 1.c. Identify the Information Exchange to be Accomplished During the FKCCS. The Public Information plan shall identify:

(1) Public Information objectives for each study phase.

(2) Information to be provided to all the stakeholders, and information to be obtained from all the stakeholders for each study phase.

(3) Groups or interests with whom information must be exchanged.

(4) Special circumstances that affect the selection of Public Information techniques.

(5) Public Information methods to be utilized to accomplish the required information exchange for each study phase.

Key phases and issues of the study to be addressed by the plan shall include, but are not limited to:

-Study initiation

-What the study is and isn't
-Scoping
-Identification of carrying capacity indicators and factors
-Identification of issues
-Future scenario development
-Study progress reviews
-Study findings
-Study completion/transfer of carrying capacity analysis model and study outputs to the DCA.

In accomplishing task 1.c. the Contractor shall specify the Public Information methods to accomplish the information exchange at each phase of the FKCCS. Methods to be utilized to inform the stakeholders may include, but not be limited to: briefings, exhibits/displays, feature stories, technical reports, news conferences, newsletters, information brochures, public service announcements, speakers bureau, presentations to civic and technical groups, hot line, press kits, and a web site. Methods to interact with the stakeholders may include, but not be limited to: small group workshops, interviews, focus groups, surveys, hotline, poster sessions, on-site meetings/walking tours, and public information exchanges.

Task 2. Public Information Plan Review and Update. The Contractor shall prepare the draft Public Information plan for submittal to the PMT for review and comment within six weeks of Notice to Proceed. The Contractor shall respond to the official comments of the team, and prepare a final Public Information plan within two weeks of receipt of official comments. The final plan shall be submitted to the PMT for review and acceptance. When accepted, the final plan will constitute the basis for conducting Public Information activities in support of the FKCCS. The Contractor shall meet with the PMT over the course of the FKCCS to provide updates on Public Information activities and findings, and to obtain guidance for updating and adjusting the Public Information Plan.

Task 3. Prepare Computerized Mailing List. The Contractor shall develop and maintain a computerized mailing list of all the stakeholders. The mailing list shall be capable of being sub-divided and sorted on the basis of relevant categories (i.e. residential location, type of public, etc.).

Task 4. Prepare Public Information Materials. The Contractor shall prepare appropriate materials for informing the various stakeholders identified in the Public Information Plan. The type and character of such information materials will be dependent on the stakeholders identified, specific needs in relation to the phase of the study, and issues of concern. It is anticipated that such public information materials will consist of briefings, exhibits/displays, feature stories, technical reports, news conferences, news releases, newsletters, information brochures, public service announcements, speakers bureau, presentations to civic and technical groups, hot line, press kits, internet website, brochures, fact sheets, and media kits.

Task 5. Public Information Plan Execution. The Contractor shall be responsible for executing the activities specified in the approved Public Information Plan and for providing all logistics and supplies necessary to accomplish such activities.

SECTION 3
PRODUCTS OF THE STUDY

General

The primary FKCCS product will be a carrying capacity analysis for the Florida Keys. It will be performed by applying future scenarios to a spatially explicit carrying capacity analysis model (CCAM) that utilizes land development impacts as a common denominator. The scenarios reflect different visions of the Florida Keys, and will be applied to the CCAM to allow for comparable output. The output provided will consist of an evaluation, by element, of the projected impact of each scenario and Geographic Information System (GIS) maps that graphically display the impact. Beyond revealing presently exceeded natural resource and species of concern tolerance limits, this approach is intended to define the impact(s) of a scenario prior to any crisis stage or degradation.

Other products of this study will include a set of "tools" to support future studies and analyze other future scenarios. The set of tools will include: element databases and relationships; the CCAM; and a GIS database. These tools may also be used to evaluate the sensitivities of input assumptions and tolerance limits and will continue to serve as a basis for future planning efforts in response to new information and/or changes in element relationships.

Central to this analysis is the identification and development of each study element (described in more detail in Section 4). This will be accomplished through the development of scientifically derived carrying capacity tolerance limits and identification of the explicit linkage of the element to population as a measure of land development activities. The complexity of carrying capacity tolerance limits, linkages and interrelationships will be addressed through incorporating risk and uncertainty analyses in the CCAM (IWR 1996).

Scenario Development

Five separate scenarios shall be developed and evaluated according to the descriptions herein. Four of the scenarios represent different future conditions and one scenario represents the pre-1930's (pre-overland highway) condition of the Keys. Where applicable, the evaluation of the impacts of widening U.S. Highway 1 will also be simulated for a scenario. Each scenario shall include tolerance limit input for all study elements. Expression of the tolerance limit information (measurement units) may vary from element to element. For example, species tolerance limits are typically described as the upper limit of a given range of tolerance prior to the occurrence of negative impacts to the species population. Similarly, the tolerance limit equivalent for an infrastructure element is often described as the upper limit of service that can be provided prior to incurring additional costs of retrofitting or new construction. Each tolerance limit will be linked to population, as a measure of land development activities, and its distribution

through time and space. This will be the cornerstone assumption upon which the impact of the scenarios will be determined.

The complete development of each scenario is a critical step in the carrying capacity analysis. Regarding the carrying capacity methodology, the following will be determined for each scenario:

Task 1. Spatial partitioning (i.e. how the elements for the scenario will be partitioned across space). What is the smallest area (minimum mapping unit) that will be looked at? Will it be a parcel, block, acre, key or group of keys? Some elements are likely to be very detailed while others may be coarse;

Task 2. Temporal partitioning (i.e. scenario time period and time step). How long of a period will be considered and how many time steps will be in that period? Are results going to tabulated every 1 year or every 5 years for 20 years? Unlike spatial partitioning, the time period and time step should be the same for all elements in a given scenario;

Task 3. Population distribution (spatial and temporal). How is the effective human population distributed in space and time? Effective population is defined as the number of all users (permanent, seasonal, tourist) residing in the study area at any given point in time. Effective population in this case must consider the various resource consumption patterns of tourists versus seasonal residents versus permanent residents. Therefore, population distribution will include differentiation of population breakdown (i.e. permanent, seasonal and tourist) and determination of appropriate factor(s) for application to the projected population forecast to account for the various resource consumption patterns; and

Task 4. Input assumptions:

Scenario 1. Historical Condition. Using available data, this scenario shall define natural resource conditions in the Florida Keys prior to construction of the overland highway. Information on the natural resources of the Keys prior to extensive land development activities will be developed. This information will be used for comparison purposes, wherever possible, with present day conditions of natural resources. Since it is likely that sufficient and suitable data may not be available, this scenario may not be input into CCAM, however, all historical data will be mapped and archived.

Scenario 2 Current Amount of Developed Land with Preservation Aspect. This scenario shall define a snapshot of the existing condition in the Keys. Future conditions will require natural resource preservation, with no net increase in the amount of developed land. Redevelopment and restoration opportunities will be identified and implemented. Preservation of vacant land will be required unless a restoration trade-off can be performed (e.g. development of vacant land in a non-critical habitat area (less environmentally sensitive) in exchange for restoration of critical habitat (more environmentally sensitive) including removal of structure(s) in that area). Cost estimates

for restoration opportunities will be provided. The restoration opportunities and cost estimates will be indexed to allow for increasing tourism demand and inflation.

Scenario 3 Optimal Sustainable Future. This scenario will begin with the existing condition in the Keys and future conditions will represent sustainable development in the Keys. Critical upland/wetland sites will be selected for natural resource conservation and restoration. Site selection will consider maintenance of ecosystem processes through adequate habitat representation with minimal disturbance. Corridors between selected sites and existing protected areas will be maintained. Sustainable development methodology, such as clustered developments, will be utilized on sites deemed non-critical upland or wetland sites. As with all of the other scenarios, a full representation of elements will be displayed, however, this scenario will maintain an optimum sustainable level (i.e. most beneficial) for each element. This scenario will compare elements, identifying conflicts and those elements that, if allowed to dominate, may have the potential to inhibit sustainability in the Florida Keys.

Scenario 4 Current Rate of Growth to Build Out. This scenario shall reflect total build out in the Florida Keys. All vacant lands consistent with land development regulations, building codes and schedules shall be projected as developed in accordance with Monroe County's Comprehensive Plan. The build out projections for land development activities are available from Monroe County Growth Management Office.

Scenario 5. Catastrophic Event. This scenario will separately simulate a category 5 hurricane impact on each of the three individual zones defined in Monroe County's Hurricane Evacuation Plan. Damages to public and private infrastructure and natural resources will be simulated. This scenario shall address, within the context of each element, (1) the cost of reconstruction, in the case of infrastructure or the cost of restoration, in the case of natural habitat and (2) the cost to purchase the impacted land in lieu of reconstruction or restoration. This catastrophic event shall be applied to scenarios 2, 3 and 4, at the point in time when its fiscal investment has been maximized.

Study Elements

Study elements identified as integral to the sustainability of the Florida Keys are grouped into three categories: Natural Resources; Human Infrastructure; and Social Environment. A quick reference list of these elements is located in the Table of Contents. An individual discussion for each study element is found in Section 4. Databases for each element shall be developed adhering to the following requirements:

1. Databases include, but are not limited to, a documented literature search; data collection from existing sources and studies; and new data collection identified as needed and appropriate.

2. Data collection and database development will be coordinated with and include the requirements of the analysis model.

3. Each database shall define scientifically derived requirements, responses, and limiting factors for each key natural resource indicator or species of concern, identifying and quantifying tolerance limits, where possible, in accordance to the analysis model requirements. This data shall be extrapolated from existing information and/or result from a consensus of a team of experts in each element's appropriate field.

4. Each element database shall identify, where appropriate, areas requiring restoration efforts to ensure ecosystem integrity and/or additional infrastructure investment necessary to support sustainability.

5. Complete citations shall be required to substantiate sound scientific fact. All maps used in the study shall meet National Map Accuracy Standards. All GIS data shall meet the Florida Geographic Information Board (FGIB), Florida Marine Research Institute (FMRI), and the Federal Geographic Data Committee (FGDC) standards.

General deliverables applicable to all elements are listed in the following paragraphs. Specific deliverables, applicable to a specific element, are described in a task list found within each element discussion in Section 4. Although all the elements mentioned in this scope of work shall be included in the study, the study is not strictly limited to this listing. It is possible, through either the public involvement process or element development, an unlisted element may be identified for inclusion in this study.

Task 1. Gather pertinent information on study elements and their requirements, responses, limiting factors and tolerance limits.

Task 2. Define scientifically-derived requirements, responses, and limiting factors for each element, identifying and quantifying tolerance limits, where possible. The requirements, responses, limiting factors and tolerance limits of the natural resources are the criteria upon which the determination of the carrying capacity of the Florida Keys ecosystem will be based. This data will be developed through a series of facilitated workshops immediately following study initiation. Workshop participants will include members of the peer review group that reviewed the SOW in March 1998; other identified natural resource experts; and local, state and federal agency representatives, as appropriate. It is anticipated that two to three workshops will be required:

Workshop Number 1. The first workshop will be held approximately one month following study initiation. The workshop will further define these issues, provide direction for additional research, and identify components of these issues that cannot be resolved within the study period. In the case of the latter, alternatives for proceeding without the requirements, responses, limiting factors, and tolerance limit for the natural resource will be developed.

Workshop Number 2. The second workshop will be held approximately one month following workshop number 1. The purpose of this workshop will be to

present and discuss the proposed requirements, responses, limiting factors and tolerance limit each natural resource, based upon results of the additional research directed by workshop 1. In addition, this workshop will provide further refinement of alternatives to address those issue components that may have been identified at workshop 1 as not resolvable during the study period. The goal of workshop 2 will be to obtain consensus on natural resource requirements, responses, limiting factors and tolerance limits; however, a third workshop will be held if additional research or coordination is required.

Task 3. Develop database. Data collection and database development will be coordinated with and include the requirements of the analysis model.

Task 4. Add any additional study elements and databases as appropriate.

Task 5. Develop a relationship between each study element, land development activities and population changes. The purpose of the relationship is to predict changes in the study element as land development activities occur and the population changes, providing the link between land development activities, effective human population and the natural environment in the Florida Keys. These relationships will be developed through a series of facilitated workshops that will be held immediately following study initiation. It is anticipated that two to three workshops will be required:

Workshop Number 1. This workshop will be held approximately one month after study initiation. Workshop participants will include members of the peer review group that reviewed the SOW in March 1998; other identified demographers and natural resource experts; those with knowledge of past changes in the keys; and local, state and federal agency representatives, as appropriate. The first workshop will further define this issue, provide a brainstorming platform for developing methodologies (i.e. designing studies and scopes of work) for use in defining these relationships and provide direction for additional research. It is possible that this workshop may identify components of the human cause/natural resource effect relationship that cannot be developed within the study period. In this case, alternatives for proceeding without a certain human cause/natural resource effect relationship will be developed.

Workshop Number 2. The second workshop will be held approximately one month following workshop number 1. The purpose of this workshop will be to present and discuss possible methodologies for use in defining the human cause/natural resource effect relationship in the Florida Keys, based upon further research and results of workshop number 1. In addition, this workshop will provide further refinement of alternatives to address proceeding without a certain human cause/natural resource effect relationship. The goal of workshop 2 will be to obtain consensus on the cause/effect relationship methodologies, however, if necessary, a third workshop will be held.

Geographic Information System

Much of the data for this study will fall into two broad categories, graphical data and tabular data. GIS has the capability to manage and query a variety of graphical and tabular information data sets. One notable feature of GIS is that all data are geo-referenced. There are significant amounts of existing data on the Florida Keys available in GIS format with the U.S. Army Corps of Engineers, National Park Service, FMRI, South Florida Water Management District, Florida Keys National Marine Sanctuary, and Monroe County.

The large quantity of data and information that will be collected and compiled as part of this study will require a system for its storage, retrieval, and analysis. All GIS coverages will be turned over to the FMRI for stewardship upon completion of the FKCCS. Therefore, the database design must be closely coordinated with FMRI to ensure compatibility with their standards and practices. Coordination is also required with the FGIB and the FGDC to ensure compatibility with state and federal standards and practices, respectively.

Task 1. Database Design. A design phase is critical to ensure standards are established for the data collection and so that data are organized in a manner to facilitate a variety of future uses. It is anticipated that much of the design work and data definition can be modified from existing documents and databases from several of the above mentioned government agencies. All database design work must be coordinated with FMRI, FGIB and FGDC to ensure compatibility with their GIS standards and practices. In addition, database development will be coordinated with and include the requirements of the analysis model.

Task 1.a. Establish global parameters such as map projection coordinate system and horizontal and vertical datums.

Task 1.b. Compile a list of existing data, data that will be collected as part of the study and the complete set of attributes in the relational database.

Task 1.c. Define minimum accuracy standards for all data types and develop a plan on how to integrate and handle coarse resolution or historic data that cannot meet these requirements but still add value to the study.

Task 1.d. Develop a plan to integrate data sets that are not comprehensive or complete over the whole study area but have a significant use for part of the study area.

Task 1.e. Determine if data size requirements require a tiling of large data sets. If data sets are to be tiled, the GIS must provide a way to access this information as a single data set, or single data sets such as image catalogs or map libraries.

Task 1.f. Provide input and coordination during the concurrent scenario development phase.

Task 1.g. Document completed database design including name and type of data, location of data in the directory structure of each data set, and attribute definitions. The database design must be closely coordinated with FMRI to ensure compatibility with their standards and practices. Coordination is also required with the FGIB and the FGDC to ensure compatibility with state and federal standards and practices, respectively.

Task 2. Purchase Hardware and Software. ARC/INFO and ARCVIEW are the GIS software to be utilized for the KCCS. ARC/INFO is used by the U.S. Army Corps of Engineers, the Florida Marine Research Institute (FMRI) and Monroe County. The FMRI will serve as the repository for all GIS data and coverages developed for this study. Database integration software compatible with ARC/INFO and ARCVIEW (e.g. Oracle) may also be utilized. Hardware requirements will include a multi-tasking workstation capable of handling large images and data sets (exceeding 500 megabytes per file). Due to constantly improving technology, specific hardware recommendations will be developed at the time of acquisition.

Task 3. Database Setup, Initial Data Conversion and Integration. The initial setup of the system and population of the databases from existing data are expected to take several months. Transferring data from other agencies and reformatting it to the specifications developed in the database design phase will be a labor intensive period. It is assumed here that much of the data will arrive in digital format, however, there is likely to be a considerable amount of non-digital data such as paper maps and reports, which must be digitized or will require data input. As information is placed in the GIS, appropriate metadata and accompanying documentation will be created.

Task 4. GIS Database Administration and Use. Information collected, whether new or historical, will require timely placement in the database. Most new data collected according to specifications from the database design should fit in the database with little trouble. Some historical data, however, will require a more labor intensive effort to be entered into the database. Administrative tasks, such as routine backups; data exchange with other agencies, work groups, or contractors; documentation upkeep; and occasional map production or demonstrations, require a database administrator over the life of the study.

Task 5. Documentation. The complete database will be fully documented with a users guide, data dictionaries and metadata submissions. Development of all metadata will be coordinated with FMRI, FGIB and FGDC to ensure state and federal standards are met. Metadata will reside on the FGIB spatial digital library system and on the USACE node of the National Spatial Data Infrastructure (NSDI). All documentation will be available in soft copy form, through the standardized help interface system, as part of the database. Complete documentation will also be provided in hard copy format.

Carrying Capacity Analysis Model

An interactive, spatially explicit, computer-driven carrying capacity analysis model (CCAM) will be developed that interfaces the GIS coverages; input scenarios; element databases that include requirements, responses, limiting factors, and identification and quantification of tolerance limits, where possible; and relationships that describe human and land development impacts on the environment. The CCAM will be a future-oriented, planning and decision-making tool. Risk and uncertainty analyses will be incorporated into the model to improve the planning process and the quality of decisions made to balance the management of environmental resources, human infrastructure and land development activities in the Florida Keys ecosystem. Development of the CCAM will be coordinated with data collection and database design to ensure that all requirements of the analysis model are included.

The analysis model will characterize the differences between the various input scenario assumptions. Then, depending on the scenario, it will simulate the conditions of land development activities and population growth, through time, described by those assumptions. Utilizing the relationships that will describe land development and population growth impacts on the environment, CCAM will determine and inventory the impacts on the natural resources and human infrastructure in the Florida Keys. Next, CCAM will compare the impacts on the natural resource elements with their associated requirements, responses, limiting factors and tolerance limits, where identified and quantified, and on the existing infrastructure. CCAM will then spatially identify the natural resource element(s) and human infrastructure whose carrying capacities may have been exceeded. In the case of the human infrastructure, the cost estimate for retrofitting and/or new construction to meet the additional population requirements will be provided.

The output provided by the analysis model will enable the user to view the consequences of a future scenario and provide assistance in understanding an element's response to the changes and pressures that different scenarios place on them. Summaries comparing natural resource values to their associated requirements, responses, limiting factors and tolerance limits, where identified and quantified, will be emphasized. GIS maps will be produced that will identify areas in need of restoration. The output will allow the user to view and print information from the CCAM and GIS database in maps, charts, and tables.

Task 1. Build model framework. Scenario inputs; requirements, responses, limiting factors, and tolerance limits, where identified and quantified; and land development activities and population growth cause/effect on natural resources and human infrastructure information will be assembled and made ready for construction of the CCAM. It is understood that the development of this type of carrying capacity analysis model within the Florida Keys has not been completed to date. There are uncertainties among some peer review group participants whether development of this CCAM is

possible. For that reason, a workshop will be held, if necessary, for further definition of the model's framework.

Model Framework Workshop. This workshop will be held approximately one month after study initiation. Participants will include members of the peer review group that reviewed the SOW in March 1998; other identified modeling and natural resource experts; and local, state and federal agency representatives, as appropriate. The purpose of the workshop will be to define the CCAM framework and output (see Task 2). It is anticipated that only one workshop will be required.

Task 2. Develop and format output. Output will be developed that characterizes the Florida Keys ecosystem and human infrastructure after each scenario has been simulated in the CCAM.

Task 3. Construct Model. Based on the model framework and output requirements, the CCAM will be constructed. Adaptive management will be included in the SOW for the model development and construction to ensure that only critical elements remain within the CCAM. For example, if preliminary data collection and integration determine that stormwater is not a critical factor affecting nearshore water quality or human infrastructure requirements in the Florida Keys, then it may be dropped out of the CCAM so that resources can be focused on a more crucial natural resource or human infrastructure limiting element.

Task 4. Testing. Upon completion of design and construction, the CCAM will be tested to ensure ease of use and error free operation.

Task 5. Documentation. The analysis model and the output will be fully documented (twelve 12 printed copies and one diskette in the latest version of Microsoft WORD) in user manuals, help pages, tutorials, technical specification documents, and program coding. All documentation will also be available in soft copy form, through the standardized help interface system, as part of the CCAM.

Task 6. Transitional Training. The transfer of the CCAM to Monroe County, DCA and other appropriate agencies will include hands-on training.

References:

U.S. Army Corps of Engineers, Water Resources Support Center, Institute for Water Resources. *An Introduction to Risk and Uncertainty in the Evaluation of Environmental Investments*. IWR Report 96-R-8. Alexandria, Virginia. March 1996.

SECTION 4
STUDY PLAN

This section provides the conceptual study work plan for completion of the FKCCS. Data compiled for all elements shall be the result of a comprehensive, documented literature search. Consultation with others regarding any current research activity will be conducted to avoid duplication of effort in data collection. Appropriate references will be provided for all data and information. Data collection and database development will be coordinated with and include the requirements of the CCAM.

Natural Resources Category

The Natural Resources category addresses water quality, ecosystems and species of concern found within the Florida Keys. The work performed for this category will include identification of indicator species, keystone species and species of concern; natural resource indicators of sustainability; determination of scientifically derived requirements, responses, limiting factors and tolerance limits, where identifiable and quantifiable, for natural resources and species of concern; and development of the relationship(s) that describe the impact that land development activities and population growth have on the environment and human infrastructure in the Florida Keys.

Water Quality Element

Anthropogenic types and levels of water quality impacts vary throughout the Keys. The waters in and around the Florida Keys are predominantly designated as Outstanding Florida Waters. This designation prohibits any degradation of water quality, however there are no set water quality standards. Water quality parameters that will sustain a healthy marine environment can be defined by certain requirements, responses, limiting factors and tolerance limits. Also, some water quality parameters, such as those affected by effluent, may be altered by technology (e.g. stormwater and sewage treatment). Two master plans are currently under development by Monroe County to address water quality issues: the Monroe County Sanitary Wastewater Master Plan and the Monroe County Stormwater Master Plan. All applicable information from these master plans and the Florida Keys National Marine Sanctuary Water Quality Protection Program (WQPP) will be incorporated into the water quality analysis to avoid duplication of effort.

Task 1. Literature Review. All available literature, information, data and research, and published science literature regarding ground and surface water quality, nearshore flushing, and hydrogeology will be reviewed, compiled, and evaluated. Additional archival research and interviews will be conducted if required. All applicable information from the Florida Keys National Marine Sanctuary WQPP will be incorporated into this literature review. Information to be acquired shall include, but is not limited to, the following:

Task 1. a. Property History and Usage. Readily available data only will be accessed to incorporate property history and usage into the knowledge database for this study. Usage of property by the Federal Government, industrial and commercial businesses will be highlighted. Information on property history and usage will include (1) uses of current and former owners, (2) type and quantity of structural demolition debris and/or residue, and (3) information that may indicate the presence of hazardous or toxic substances. This shall involve inventory of potentially hazardous substances used on the property (e.g. fuels, solvents, chemicals), storage practices (e.g. underground storage tanks, tanks and drums) and disposal practices (e.g. landfills, dumps, and septic systems). The potential presence of underground storage tanks on the property will be determined and the following information for each probable tank will be provided: location, size, probable contents and quantity, age, depth, present use and condition.

Task 1.b. Hazardous, Toxic and Radioactive Waste (HTRW) Coordination Documentation. The location of HTRW contamination sites within the Florida Keys will be incorporated into the knowledge database for this study and will also be a factor for consideration during water quality assessments. GIS mapping of HTRW sites will be included.

Readily available data and databases of federal, state, regional and local agencies will be accessed to determine the location of any HTRW contamination sites in the study area. Available federal databases to include are the National Priorities List, Comprehensive Environmental Response, Compensation, and Liability Information System list, Resource Conservation and Recovery Act (RCRA) Transportation, Storage and Disposal (TSD) facilities List, RCRA generators list, Toxic Release Inventory and the Emergency Response Notification System (ERNS) list (hazardous spills). State databases to include are FDEP's HTRW site list, landfill and/or solid waste disposal site list, and leaking Underground Storage Tank (UST) list. The federal RCRA and ERNS lists and the state landfill and/or solid waste disposal site list and the leaking UST list provide the location of potential HTRW sites. Information on potential HTRW sites could be useful in the water quality assessments and, in the future, if water quality begins to decline in the vicinity of one of these sites.

The following information for each HTRW contamination site will be provided, if available:

(1) Identification of the nature and extent of contamination including chemical constituents,

(2) Qualitative analysis of the impacts of the contamination in the absence of corrective action, including (a) identification of potential source origins, (b) contaminant release mechanisms, (c) exposure routes and (d) potential exposure risk and adverse health effects to human and wildlife populations,

(3) Surface and sub-surface conditions,

(4) Vegetation (i.e. any studies conducted for the purpose of revealing distressed vegetation or illegal disposal sites within hydrologically-influenced zones),

(5) Soils (i.e. soil surveys consisting of textured olfactory analysis and using official geological designations),

(6) Above ground and underground storage tanks,

(7) Confined waters (e.g. canal systems), and

(8) Wells of any type (water or monitoring, etc.).

Task 1.c. Monroe County Sanitary Wastewater Master Plan (SWMP). All available and applicable information from the Wastewater Master Plan will be incorporated into this water quality analysis including, at a minimum:

(1) Pollutant loading estimates from existing on-site disposal systems (OSDS), cesspits, package treatment plants, and modeling results of other point and non-point sources on the Florida Keys.

(2) Pollutant loading estimates from new or improved wastewater treatment systems meeting updated operational standards,

(3) Inventories of wastewater treatment plants and OSDS areas which identify (a) agency responsible for operations, (b) plant capacities, (c) number and type of hook-ups, (d) costs associated with improving facilities to meet minimum level of service standards, (e) funding sources and construction schedules for system improvements, and (f) average and peak flow design capacity for sanitary sewer facilities.

Task 1.d. Monroe County Stormwater Master Plan (SMP). All available and applicable information from the SMP will be incorporated into this water quality analysis including, at a minimum:

(1) Level of retention and/or detention in the overall system,

(2) Projection of new development and redevelopment projects for input into scenario assumptions,

(3) An inventory of stormwater conveyance, treatment and discharge systems, both natural and constructed,

(4) The capacity, treatment efficiency, and estimated pollutant loading of each stormwater conveyance, treatment and discharge system, and

(5) The effects on water quality of pollutant loading, including the effects on any freshwater storage areas.

Task 2. Selection of Case Study Areas. These case study areas will be chosen for completion of a nutrient/contaminant loading analysis to nearshore waters. The case study areas will coincide with those utilized in the SWMP and the SMP, considering wastewater and stormwater "hot spots" to be identified in tasks 3 and 4 of this element and the impacts of development typical for sections of the Florida Keys, given the varying hydrologic and geologic conditions along the upper, middle and lower Keys. For example, a more developed area such as Key West would represent a highly developed service area, whereas some undeveloped middle Key would represent the least developed area of the island chain.

Task 3. Wastewater Evaluation. Wastewater effluent from on-site disposal systems (OSDS), including septic tanks and cesspits, may be degrading water quality in the Florida Keys, especially in confined water bodies (e.g. canals). There is also concern on the effects of wastewater effluent in the nearshore waters (EPA 1992). Also, discharges from sewage treatment/package plants add nutrients into injection wells and nearshore receiving waters. This evaluation addresses quality and quantity of wastewater flows and wastewater impacts on water quality. These tasks are to be accomplished in coordination with the development of the Monroe County SWMP, which is currently underway. Within this study, wastewater is also treated as a separable element under the Human Infrastructure Category, since the required infrastructure, and associated cost, for wastewater treatment in the Florida Keys for the future scenarios will be determined by the anticipated patterns of land development activities.

Task 3.a. Identify "Hot Spots". Water quality "hot spots" for confined, groundwater and nearshore waters will be identified using water quality data and wastewater loading estimates from Monroe County, FKNMS and other sources. At a minimum, the following will be considered in the "hot spot" identification:

(1) Known potable water flows; the proportion of cesspools, septic tanks (permitted On-site Wastewater Treatment Systems), Alternative Treatment Units, and package Wastewater Treatment Plants; and the number of lots smaller than 0.25 acre;

(2) Documented evidence of water quality problems;

(3) Developed canals with poor circulation or water exchange characteristics;

(4) Development and wastewater loading density; and

(5) The percent of build-out presently attained (i.e. the potential for future development and increased adverse water quality impacts).

The "hot spot" identification list will include "hot spots" already identified in the Phase I and II reports of the FKNMS Water Quality Protection Program as well as any modifications proposed by the South Florida Water Management District and/or other appropriate agencies. The "hot spot" list will include areas where live-aboards and recreational vessels discharge significant quantities of pollutants. The analysis will account for all known pollution discharge types from vessels (i.e. sanitary wastes, hydrocarbons, bilge, etc.). Areas where Total Nitrogen and Total Phosphorus from vessel discharge make up a significant portion (> 3% TN, > 5% TP) of every wastewater discharge shall be specially noted as areas of appreciable vessel nutrient loading. The resultant "hot spot" list will be utilized in the water quality modeling described later in this element.

Task 3.b. Develop Relationship Between Wastewater Effect on Water Quality and Land Development Activities/Effective Population Change. This relationship will predict changes in water quality due to wastewater and effective population change, providing a link between land development activities/effective human population and water quality in the Florida Keys. This relationship will be used by the CCAM to simulate future scenarios. This relationship will be developed through a series of facilitated workshops held immediately after study initiation. See Section 3, Study Elements, Task 5.

Task 4. Stormwater Evaluation. Stormwater runoff may be a key factor in the degradation of water quality in confined and nearshore waters. Stormwater inputs are typically known to cause increased nutrient levels, reduced water transparency, sedimentation, contamination from spilled oil and petroleum products, pesticides, herbicides, trace elements, and heavy metals. These impacts may be affecting the marine communities in the Florida Keys. This evaluation will address stormwater quality and identify areas of significant impact. Within this study, stormwater is also treated as a separable element under the Human Infrastructure Category, since the required infrastructure, and associated cost, for stormwater treatment in the Florida Keys for the future scenarios will be determined by the anticipated patterns of land development activities.

Task 4.a. Determine Stormwater Impacts. The Water Quality Protection Program (WQPP) Phase II Report and the WQPP Document for the Florida Keys National Marine Sanctuary, July 1996 will be consulted for evaluation of currently established "hot spots." Currently, no "hot spots" specifically attributable to stormwater runoff have been identified.

Task 4.b. Identify Chemical Constituents of Stormwater Run-Off. Scientifically derived estimates will be made of the amounts of suspended solids, hydrocarbons, pesticides, herbicides, heavy metals and other toxic substances that enter nearshore waters via stormwater runoff.

Task 4.c. Develop Relationship Between Stormwater Runoff Effect on Water Quality and Land Development Activities/Effective Population Change. This

relationship will predict changes in water quality due to stormwater and effective population change, providing a link between land development activities/effective human population and water quality in the Florida Keys. This relationship will be used by the CCAM to simulate future scenarios. This relationship will be developed through a series of facilitated workshops held immediately after study initiation. See Section 3, Study Elements, Task 5.

Task 5. Water Quality Modeling. Information regarding the effects on water quality from stormwater runoff and pollutant loading will require water quality modeling. This analysis is intended to generate scientifically derived data to be incorporated into the CCAM for assessing the impacts of human infrastructure on water quality in the Florida Keys and to define the water quality carrying capacity of each case study area by projecting the anticipated level of nutrient/pollutant loading that is possible without degrading water quality in the Florida Keys. The model will describe the site specific interactions between local geology, surface water, nearshore water, existing site specific land uses, nutrient loading sources and quantities, pollutant loading sources and quantities, surface runoff, shoreline erosion, and live-aboard vessels. The work described under this task will be conducted for each case study area.

Task 5.a. Mapping of Contributing Areas. Surface runoff and groundwater input into nearshore coastal waters for each case study area will be identified based upon available topographic maps. When pre-existing hydrogeological data is not available, a site investigation will be necessary to determine groundwater flow conditions for each case study area. Groundwater flow characteristics are to be determined from information derived from the installation of three to six monitoring wells in each case study area.

Task 5.b. Water Quality Sampling and Analysis. The existing water quality databases from academia, U.S. Geological Survey (USGS), Florida International University, University of Miami, National Oceanic and Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), South Florida Water Management District (SFWMD) and Monroe County will be supplemented, where necessary. This may include the collection of both ground and surface water samples. Sampling will be conducted in accordance with Florida Department of Environmental Protection (FDEP) requirements.

Task 5.c. Nearshore Transport Analysis. Water circulation is a critical component in moving nutrients and sediment from points of origin to their ultimate destination. Important time frames are days (storm and hurricane impacts), months (seasonal impacts) and years (cumulative impacts). An analysis of flushing characteristics and circulation patterns of the nearshore waters of each case study area will be conducted (i.e. pattern of release and nearshore transport of nutrients/pollutants from established groundwater routes and/or point and non-point sources). The Florida Bay hydrodynamic modeling (USACE, Waterways Experiment Station) and existing nautical charts and topographic maps will provide some of the available data regarding flow and bathymetry.

Model Oversight Committee and Workshop. There are a couple of options available for the modeling of nearshore water circulation in the Florida Keys, which are discussed in the following paragraphs. A model oversight committee will be established to direct this study element. The Committee will consist of experts within the field of hydrodynamic and physical processes numerical modeling. A workshop with the committee will be held within the first few months after the study initiation. The workshop will determine the necessity, feasibility and scope of the numerical modeling effort, and the selection of model(s) to be used.

The Florida Bay Water Quality Study includes numerical modeling of water circulation (WC) and water quality (WQ). The Florida Keys are treated in the model as the boundary conditions. The numerical model grid terminates at about Big Pine Key, therefore, the lower Keys are not included. The grid could be extended and calibrated to include the lower Keys.

The other water circulation numerical modeling option is the ADvanced CIRCulation model for shelves, coasts, and estuaries (ADCIRC). ADCIRC simulates long wave hydrodynamic processes in a study area. ADCIRC employs a two-dimensional, depth-integrated finite element solution of the generalized wave-continuity equation. Recently, STWAVE has been coupled to run simultaneously with ADCIRC. STWAVE is a computationally efficient finite element numerical model for near-coast time independent spectral wave energy propagation simulations, which allows wave contributions to total water level and water circulation to be determined.

Considerable WC and WQ data is being collected as part of the comprehensive water quality monitoring program for the FKNMS. This data will be coupled with the selected water circulation model, and will serve as a probabilistic diagnostic tool for estimating the destination of land (i.e. wastewater, stormwater) and marine (i.e. boats) nutrient/pollutant loads.

Task 5.d. Land Use/Nutrient Loading Analysis. Land use and sewage treatment system mapping will be utilized to estimate the level of nutrient loading generated from existing and future development in each case study area. The resulting nutrient concentration in the groundwater will be estimated. After obtaining the estimated level of nutrient loading to groundwater and the flushing characteristics of the nearshore waters, an initial approximation of nutrient loading to nearshore receiving waters will be estimated for each case study area based on engineering judgment and hydrological expertise.

Task 5.e. Live-Aboards and Recreational Vessel Discharges. Analysis must account for all known pollution discharge types from vessels (e.g. sanitary wastes, hydrocarbons, bilge). These loading quantities shall be included in the overall nutrient loading estimate.

Task 5.f. Model Calibration. The developed model will be calibrated using existing water quality conditions measured in the nearshore waters. The calibration shall be

conducted by adjusting the loading parameters to obtain a best fit between the loading predicted by the model and actual conditions.

Task 5.g. Model Runs/Future Alternatives. The calibrated model will be applied to the future scenarios. Within the CCAM, the predicted concentrations will be compared with critical concentrations of nutrients expected to lead to degradation of water quality (i.e. water quality parameter requirements, responses, limited factors, and tolerance limits, if identified and quantified).

Task 5.h. Report. A Water Quality Analysis Report with will be prepared that documents the model preparation, assumptions, calibration and results. In addition, the nutrient loading numerical model would be submitted as part of the CCAM.

References: These references are not meant to be all inclusive. The literature search required in task 1 of this element must include all available literature, information, data, research, and published scientific literature regarding ground and surface water quality, nearshore flushing and hydrogeology, not just the references and sources listed here.

Big Pine Key National Deer Refuge. Unpublished sampling water quality data for the north end of Big Pine Key.

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Pitts, P. A. 1994. An Investigation of Near-Bottom Flow Patterns Along and Across Hawk Channel, Florida Keys. Bulletin of Marine Science, 54(3): 610-620.

Pitts, P. A. and N. P. Smith. 1996. Final Report Long-term Transport Patterns in Florida Bay, Agreement MR020. Harbor Branch Oceanographic Institution.

Pitts, P. A. and N. P. Smith. 1996. Long-term Net Transport Through Three Tidal Channels in the Interior of Florida Bay, Final Report. Harbor Branch Oceanographic Institution. The Third Report in Connection with Cooperative Agreement CA 5280-4-9022.

Smith, N. P. 1994. Long-term Gulf-to-Atlantic Transport Through Tidal Channels in the Florida Keys. Bulletin of Marine Science, 54(3): 602-609.

Wang, J. D. and C. Monjo. 1995. A Study to Define Model and Data Needs for Florida Bay. Applied Marine Physics, Rosenstiel School of Marine and Atmospheric Science, University of Miami.

Wang, J.D.; J. van de Kreeke; N.Krishnan and D. Smith. 1994. Bulletin of Marine Science, 54(3): 579-601.

Ecosystems Element

There are three significant habitat types in the Florida Keys: marine, uplands and wetlands. Each of these ecosystems are discussed in more detail in the following paragraphs. For each ecosystem in the Florida Keys, the studies and work within this element will include mapping; identification of indicator species, keystone species, and species of concern; identification of indicators of sustainability; development of scientifically derived requirements, responses, limiting factors and tolerance limits, where possible; and historical change analysis. This data will be integrated into the CCAM for determining the existing condition of the ecosystems and for simulating the effect of land development activities and effective human population on the ecosystems in each of the future scenarios. Using this data, CCAM will provide maps depicting future trends and areas requiring restoration.

Marine Environment

Critical components of the Key's marine ecosystem are the coral reef, seagrasses, and fauna targeted by commercial and recreational fisheries. Coral reefs are well known for their beauty and complex diversity of life. Reef communities are in some ways similar to forest communities on land, in that the dominant organisms provide other members of the community with food and shelter. Shelter, however, is the primary contribution of coral reefs. The massive and intricate frameworks constructed by reef building organisms provide an almost infinite array of habitats for plants and animals, leading to greater biologic activity and diversity than in most other marine environments (Myers et al. 1992). Seagrasses, on the other hand, serve as a nursery for marine life, providing food and protection from predators.

Land development activities and infrastructure can adversely impact the marine environment through nutrification, pollution, and sedimentation, primarily through wastewater and stormwater inputs into the nearshore waters. Nutrient rich and sediment laden water from external sources, such as the Gulf of Mexico or Florida Bay, may also impact the nearshore marine environment of the Florida Keys.

Direct human contact with marine flora and fauna from divers, anchoring, boat groundings, propeller dredging of seagrasses and harvest of specific species, have risen with increased permanent and seasonal human population. Unfortunately, voluntary use of mooring buoys and poorly understood channel marking systems are the only systems in place to prevent boating impacts.

Upland Habitats

Land development activities and infrastructure can fragment significant upland habitats, some of which are needed by endangered species for survival, the Key Deer for example. There is an established link between habitat protection and endangered species protection. Land development activities in the Florida Keys will continue to eliminate or fragment tropical hardwood hammocks and pine rockland habitats.

Wetlands

Wetlands include mangroves, freshwater wetlands, saltmarshes, and buttonwood wetlands. Wetlands in the Florida Keys have been mapped by EPA and Monroe County's Advanced Identification of wetlands program (ADID). Saltwater wetlands are important marine life nurseries in the Florida Keys. Wetlands are critical foraging habitat for numerous migratory and wading birds. In addition, wetlands provide an important buffer zone between developed uplands and the marine ecosystem by providing shoreline stabilization, flood control and water purification. Unique problems associated with the freshwater wetlands in the Lower Keys include contamination, draw down, saltwater intrusion of the watering holes for the endangered Key deer and the subsequent mortality of upland plants, such as slash pines.

Task 1. Literature Review. All available literature, information, data, GIS maps, research and published scientific literature regarding ecosystems within the Florida Keys will be reviewed, compiled, evaluated and documented. GIS coverages for the Florida Keys are available through FMRI and FGIB. The website for available FMRI GIS coverages is 'www.fmri.usf.edu/sori'. The website for the Florida data directory (FGIB) is 'sun6.dms.state.fl.us/als/public_html'. Additional research, data collection and GIS mapping will be conducted if required. There are numerous data available through the FKNMS, Florida Natural Areas Inventory (FNAI), FMRI, USGS and other researchers included in the resources section of this element.

Task 2. Delineate and Map Marine, Upland, Wetland Ecosystems and Transition Zones. The marine, upland and wetland ecosystems and transition areas will be mapped based upon existing delineations previously performed by FNAI, FMRI and Monroe County. Available GIS mapping and data from FKNMS, FNAI, FMRI, USGS, Monroe County and any other resources will be utilized to map the ecosystems and transition zones of the Florida Keys. Any identified gaps in the ecosystems delineation and mapping will be identified and GIS maps will be prepared.

Task 3. Identify Ecosystem Indicators of Sustainability for Each Ecosystem. A series of facilitated workshops will be held which will include members of the peer review group that reviewed the scope of work in March 1998; other natural resource experts; and local, state and federal agency representatives, as appropriate. It is anticipated that one to two workshops will be required:

Workshop Number 1. The first workshop will be held approximately one month following identification of indicator species, keystone species and species of

concern (see Species of Concern Element, Task 4). The goal of this workshop will be to identify natural resource indicators for each ecosystem within the Florida Keys ecosystems. The needs of identified indicator species, keystone species and species of concern will be included in the indicators. If the goal cannot be achieved at this workshop, direction for additional research will be obtained in preparation for workshop 2.

Workshop Number 2. The second workshop will be held approximately one month following workshop number 1. The purpose of this workshop will be to present and discuss the proposed natural resource indicators, based upon results of the additional research directed by workshop 1.

Task 4. Develop Scientifically Derived Requirements, Responses, and Limiting Factors for all Ecosystem Indicators, Identifying and Quantifying Tolerance Limits, Where Possible. This study task will also require facilitated workshops, which are described in Section 3, Study Elements, Task 2. The requirements, responses, limiting factors and tolerance limits for all ecosystem indicators will be integrated into the CCAM for determining the existing condition of the Florida Keys and for simulating the effect of land development activities and human infrastructure on the ecosystems in each of the future scenarios.

Task 5. Habitat Change Analysis. A habitat change analysis will provide insight into habitat changes over time and their correlation to land development activities and effective population changes over time. In addition, it will assist in the prediction of habitat changes in the future scenarios. This analysis will use aerial photography for detecting change.

For habitat change analysis in the marine ecosystem, the FKNMS has identified five zones within the sanctuary for assessing natural resource and habitat changes: wildlife management areas, ecological reserves, sanctuary preservation areas, existing management areas, and special use areas. These zones, which encompass approximately 300 square miles, will be the focus of detecting changes. The changes within these zones must consider the management principles mandated by the FKNMS and the effect that these principles may have on the change analyses. Similar analyses by the FKNMS will be incorporated when available. Any marine areas in the Florida Keys that are not included in one of the five FKNMS zones will extrapolate the habitat change analysis from one of the five zones that is most similar and suitable.

For habitat change analyses in the upland and wetland ecosystems, GIS mapping and databases of the Florida Game and Fresh Water Fish Commission (FGFWFC) FKNMS, FNAI, USGS, Monroe County and other sources will be examined for existing habitat change analyses. Any areas not included in an existing habitat change analysis will extrapolate the analysis from an area that is similar and suitable.

Task 5.a. Identify Baseline Conditions. The oldest, suitable existing aerial photography will be utilized for identification of baseline conditions. One source is the color aerial photography of the Florida Keys flown by NOAA from December 1991 through April 1992. It is recognized that this photography does not provide a very long historical record for comparison, however, it may be the only suitable aerial photography for this analysis. Another potential source of historical aerial photography to be investigated is Pan American Surveys in Miami, Florida.

Task 5.b. Current Conditions. Multi-spectral digital aerial images of current conditions will be acquired and the habitats will be identified and delineated. For those areas located in the marine environment, SHOALS (Scanning Hydrographic Operational Airborne Lidar Survey) hydrographic survey data may be coupled with the multi-spectral images to produce accurate digital bathymetry. The SHOALS data will be acquired only if cost effective.

Task 5.c. Habitat Change Analysis. An analysis and comparison of the historical to current aerial photography will be made. Habitat changes, by type, will be documented, summarized in tables and mapped in GIS.

Task 5.d. Future Trends. Using this habitat change analysis and the change in land development activities and effective population that occurred during the habitat change analysis period, the relationship of habitat changes to land development activities and effective population changes in the Florida Keys will be developed. The regulatory changes that have occurred during the analysis period will be included in an effort to identify habitat changes driven by the regulatory changes. This information will be utilized to assist in determination of the relationship between each study element and land development activities and effective population changes for use in the CCAM for simulating the future scenarios.

References: These references are not meant to be all inclusive. The literature search required in task 1 of this element must include all available literature, information, data, research, published scientific literature and GIS mapping of the ecosystems in the Florida Keys, not just the references and sources listed here.

Cambridge Abstracts.

Chiappone, M. 1996. Site Characterization for the Florida Keys National Marine Sanctuary and Environs. Volumes 1 - 10. Publication of the Nature Conservancy. Vol. 1 Geology and Paleontology. Vol. 2 Oceanography and Shallow-water. Vol. 3 Historical Overview of Development and Natural History. Vol. 4 Marine Benthic Communities. Vol. 5 Invertebrate Infauna and Epifauna. Vol. 6 Fishes and Fisheries. Vol. 7 Nekton, Plankton, and Oceanic Influences. Vol. 8 Functional Ecology and Ecosystem Trophodynamics. Vol. 9 Controversies and Conservation Issues. Vol. 10 Bibliography of the Florida Keys and Environs.

Conservation and Recreation Lands Annual Reports.

Environmental Protection Agency, Monroe County Field Office.

FDEP. 1995-96. GIS Annual Report, lists GIS activities in the DEP. It documents and updates studies in which GIS technology has been integrated for ecosystem protection and management.

FDEP. 1995. A Plan for Forest Conservation in the Florida Keys.

FGFWFC GIS

Florida. December 1991. Aerial infrared photography with land coverage was flown for the state of Florida, including the Florida Keys. Topographic habitat polygon data are classified to a minimum of one half acre polygon size.

Florida GIS data directory (FGIB)=sun6.dms.state.fl.us/als/public_html.

Florida Key Deer Population Viability Assessment, 1990.

Florida Keys Environmental Restoration Trust Fund (FKERTF), as a source of past and potential restoration and enhancement projects in Keys, C. Kruer, Manager.

FKERTF. 1995. Invasive Exotics Mapping Project mapped all invasive exotics on Big Pine Key and No Name Key and other lands of National Key Deer Refuge in Lower Keys in aerial photo map atlas at a scale of 1" = 200'. Maps available from Kruer.

FKERTF is completing a similar exotics mapping project on all of North Key Largo in conjunction with Crocodile Lakes NWR.

Florida Keys Invasive Exotics Task Force has mapped all invasive exotics in the Keys at a scale of 1" = 1100', field data is presently being digitized to create a map atlas with accompanying assessment (see Kruer).

FKNMS Final Management Plan/Environmental Impact Statement.

FKNMS. First Biennial Report to Congress of the FKNMS Water Quality Protection Program.

FKNMS. December 1991 through April 1992. Natural color aerial photography of south Florida including Florida Bay, Biscayne Bay and the Florida Keys was flown by NOAA. The photography was flown at a scale of 1:48,000. The purpose of the work was to develop benthic habitat maps of the Florida Keys National Marine Sanctuary.

FMRI. FKNMS Benthic Communities Mapping (by Kruer and Zieman for FMRI and NOAA), GIS map atlas to be published by FMRI.

FMRI GIS available coverages=www.fmri.usf.edu/sori.

FMRI and Kruer. 1995. Land Use/Land Cover GIS Habitat Maps.

FNAI Habitat Maps.

Kruer, C. 1994. Mapping Assessment of Vessel Damage to Shallow Seagrasses in the Florida Keys. Final Report to DEP and University South Florida Institute of Oceanography. Contract No. 4710-123L3.

Kruer for EPA. Advanced Identification of Wetlands GIS mapping project for Monroe County.

Kruer for FNAI. 1993. An Assessment of Florida's Remaining Coastal Upland Natural Communities: Florida Keys, Monroe County.

Monroe County Comprehensive Plan 2010.

Myers, R.L., J. Ewel and M.H. Carr. 1992. *Ecosystems of Florida*. University Presses of Florida: Gainesville, Florida.

National Audubon Society. Strong and Bancroft. Upper Keys Habitat Fragmentation and its Effects on Wildlife Species Reports.

National Audubon Research Center. Ross et al. Pineland Die Off on Upper Sugarloaf.

National Audubon Research Center. Strong and Bancroft. Publications of Historical Changes in Upper Keys.

Nature Conservancy. Pro-Site Research Database is a recent comprehensive literature search on the Florida Keys.

Nature Conservancy. Science Brief Publication, Florida Key's Initiative.

REDI-MAPP aerials for Monroe County.

South Florida Regional Planning Council, Hollywood, Florida. September 1995. Florida Marine Resource Information System, Final Report. The report is a publication of the Florida Department of Community Affairs, Coastal Management Program, funded by a grant from NOAA.

University of Miami, Marsalek. Benthic habitat mapping, benthic communities were classified into 10-15 categories.

USFWS. Biological Opinion on Federal Emergency Management Administration of the Nation Flood Insurance Program in Monroe County, Florida.

USFWS GIS.

USFWS. 1992. Management Agreement for Submerged Lands Within Boundaries of the Key West and Great White Heron National Wildlife Refuges.

USFWS. 1997. Multi-Species Recovery Plan.

Species of Concern Element

The classification of species as state and federally endangered species often result from diminished habitat or a species specific impact. The Florida Keys has a variety of endangered species endemic to a restricted range, such as the Key deer, American crocodile, silver rice rat, Key Largo cotton mouse, Key Largo wood rat, Lower Keys marsh rabbit, Key mud turtle, Stock Island tree snail, Shaus' swallow tail butterfly, piping plover, white-crowned pigeon, colonial nesting birds, shorebirds and several sea turtle species. Habitat protection that encompass numerous other animal and plant species offers a reasonable approach to species protection. Habitat conservation gaps and conservation easements need to be included in acquisition and protection strategies. Habitat encroachment, cumulative effects, and secondary effects such as increased introduction of exotic species near developments should be included in this portion of the study.

The studies and work within this element will use available data to identify and map threatened and endangered species and species of special concern; and identify indicator species, keystone species and other species of concern, including scientifically derived development of their requirements, responses, and limiting factors, identifying and quantifying tolerance limits, where possible. This data will be integrated into the CCAM for determining the existing condition of the indicator species, keystone species, and other species of concern; and for simulating the effect of land development activities, human infrastructure and effective population on those species in each of the future scenarios. Using this data, the CCAM will provide maps depicting future trends such as the impact of land development activities and effective human population change on the indicator species, keystone species, and other species of concern, as well as areas requiring restoration.

In addition, the optimum physical and chemical factors making up species' environment will be defined in general terms. This optimum environment is to be composed of, among other factors, the quantity, quality, composition, and juxtaposition of required habitats. A biological community description (dominant vegetation types) for the indicator species, keystone species and other species of concern, as well as threatened and endangered species and species of critical concern will be included. It is acknowledged that many of the indicator species, keystone species and other species of concern are the endangered and threatened species and species of critical concern since they are good indicators of general environmental trends. The structure of community types will be described including limiting factors affecting growth and abundance or distribution of species populations.

The FGFWFC, FNAI and U.S. Fish and Wildlife Service (USFWS) have extensive information available on endangered species. For example, the USFWS Multi-species Recovery Plan contains all the latest natural history information on the 68 endangered or threatened species in South Florida and the FGFWFC has published "Closing the Gaps in Florida's Wildlife Habitat Conservation System". Several habitat-based GIS applications

are available through the FDEP. The carrying capacity model for endangered species will include some refinement of existing GIS databases and computerization of FDEP's conservation easement database.

Task 1. Literature Review. All available literature, information, data, GIS maps, research, and published scientific literature regarding threatened and endangered species and species of critical concern within the Florida Keys will be reviewed, compiled, evaluated and documented. Additional research, data collection and GIS mapping will be conducted where required.

Task 2. Identification of Species. Using existing lists from Monroe County; FNAI; FGFWFC; Florida Department of Agriculture and Consumer Service, Division of Plant Industry; and USFWS, threatened and endangered species and species of critical concern will be identified including populations of amphibians, arthropods, birds, fish, mammals, mollusks, plants and reptiles present in the Florida Keys.

Task 3. GIS Mapping of Occurrence of and Habitat Locations of Threatened and Endangered Species and Species of Critical Concern within the Florida Keys. The biological community and habitat attributes of threatened and endangered species and species of critical concern within the Florida Keys will be mapped in GIS.

Task 4. Identification of Indicator Species, Keystone Species and Other Species of Concern. Due to the multitude of species living in the Florida Keys ecosystem, indicator species, keystone species, and other species of concern must be identified so that the CCAM is not overwhelmed. Using the data from tasks 1, 2 and 3, the indicator species, keystone species and other species of concern will be identified. The identified species will be subject to the approval of the PMT.

Task 5. Develop Scientifically Derived Requirements, Responses, and Limiting Factors, Identifying and Quantifying Tolerance Limits, Where Possible, for the Indicator Species, Keystone Species and Other Species of Concern. See Section 3, Study Elements, Task 2. The requirements, responses, limiting factors and tolerance limits for the indicator species, keystone species and other species of concern will be integrated into the CCAM for determining their existing condition within the Florida Keys and for simulating the effect of land development activities and human infrastructure on them in each of the future scenarios.

References: These references are not meant to be all inclusive. The literature search required in task 1 of this element must include all available literature, information, data, GIS maps, research, and published scientific literature regarding threatened and endangered species and species of critical concern within the Florida Keys, not just the references and sources listed here.

Chiappone, M. 1996. Site Characterization for the FKNMS and Environs. Volumes 1 - 10. Publication of the Nature Conservancy.

FDEP GIS Book. *1995-96 Annual Report*. It lists GIS activities in the DEP and documents and updates studies in which GIS technology has been integrated for ecosystem protection and management.

FGFWFC. 1994. Closing the Gaps in Florida's Wildlife Habitat Conservation System.

FGFWFC Databases.

Florida Keys Invasive Exotics Task Force GIS.

FKNMS Final Management Plan Environmental Impact Statement.

FNAI Databases.

Folk, Klimstra, and Kruer. 1991. Habitat Evaluation: National Key Deer Range. Prepared for FGFWFC Non-game Program.

Nature Conservancy Florida Keys Initiative. Science Brief.

South Florida Region Planning Council, Hollywood, Florida. September 1995. Florida's Marine Resource Information System, Final Report. The report is a publication of the Florida Department of Community Affairs, Coastal Management Program, funded by a grant from NOAA.

USFWS Biological Opinion for FEMA.

USFWS GIS.

USFWS Multi-Species Recovery Plan.

Human Infrastructure Category

Fundamental to any development initiative is the need for a certain level of supporting services and facilities. Florida state law requires local governments to ensure established levels of services and facilities which support their approved comprehensive plan. Current land use policies in turn dictate future demands. Human Infrastructure as a category shall emphasize those elements integral to the environmental evaluation of the CCAM and hurricane evacuation since it is a paramount consideration in the Florida Keys due to limited evacuation routes. The integral elements will be population forecast; stormwater; wastewater; transportation; marinas, heavily traveled channels, ports; and hurricane evacuation. Other elements needed to determine adequate supporting services and facilities will be rolled into "Other Infrastructure Services". Other infrastructure services will include police and law enforcement; schools; hospitals/health delivery; fire/emergency services; and recreation. The primary focus of other infrastructure services

investigations will be to identify the cost for additional infrastructure construction or retrofit in the CCAM simulation of the future scenarios. All applicable information from the Monroe County Comprehensive Plan will be incorporated into the development of this element to avoid any duplication of effort.

Population Forecast Element

Task 1. Permanent and Seasonal Population Analysis.

Task 1.a. Calculate current effective population of the Florida Keys. If various sources (i.e., agencies, studies, etc.) provide population data that is in disagreement, an effort will be made to reconcile conflicting data. This can be accomplished by (1) contacting responsible sources and requesting data updates and/or acceptable error ranges and (2) utilizing census information, researching property appraiser's listings, etc. Key subparts of the effective population shall be analyzed and forecast, including, but not be limited to, visitors (tourists), the elderly, and children.

Task 1.b. Forecast of Future Effective Level of Population. Estimates shall extend from past trends, and, at the same time, incorporate such factors as anticipated commercial/industrial growth, economic class shifts, developable land available, local birth and death rates, and government activities. The local census bureau, planning office, chamber(s) of commerce, office(s) of tourism, local utility company(ies), and movers are some sources of information that will be consulted in making projections.

Short-term (2010 projection) and long-term estimates (50-yr) will be provided. Effective level of population, economic land use, and other associated planning studies will be referenced. Population forecasts should be capable of showing anticipated patterns of growth and development in the Keys (i.e. where population growth is expected to occur), and show estimates according to permanent and seasonal residents, and tourist populations. Resultant population projections will be used to estimate demands on human infrastructure elements identified in this scope of work.

Resource:

University of Florida, Bureau of Economic and Business Research.

Wastewater Element

This element will utilize information from the Monroe County Sanitary Wastewater Master Plan. Therefore, coordination with Monroe County is required. The future wastewater requirements, based on future land development activities and effective population assumptions, will be utilized in the CCAM simulation of the future scenarios. Within this study, wastewater is also addressed under the Water Quality Element of the Natural Resources Category, since acceptable water quality is a paramount environmental consideration for the Florida Keys ecosystem.

Task 1. Estimate Current and Projected Wastewater Flows. Current capacity in gallons per day (gpd) for wastewater treatment facilities will be estimated. Future wastewater flows in gpd will be projected based upon effective population forecasts from the Population Forecast Element. The future estimates will consider the needs of the CCAM for simulating the future scenarios.

Task 2. Identify Future Wastewater Treatment Requirements. A comparison of current and projected wastewater treatment capacities in gpd will be made. Shortfalls will be identified.

Task 3. Evaluate Alternatives to Meet Projected Wastewater Treatment Requirements.

Task 3.a. Compare Centralized Wastewater Collection and Treatment Alternatives with OSDS.

Task 3.b. Evaluate Existing Wastewater Collection Systems. Existing waterwater collection systems will be evaluated to determine the degree to which they could be utilized in centralized wastewater collection and treatment alternatives. This effort will provide an estimate of the number or percentage of OSDS that could be replaced by the implementation of centralized wastewater collection and treatment facilities.

Task 3.c. Evaluate Potential Wastewater Collection and Treatment Alternatives. A minimum of three of the most favorable alternatives (or combinations of alternatives) will address the following:

(1) The maximum reasonable utilization of existing wastewater collection facilities;

(2) The use of centralized, clustered, and decentralized approaches; and

(3) The inclusion of "hot spots" identified in the Water Quality Element.

The cost for each of the favorable alternatives or combination of alternatives will be provided for integration into the CCAM for simulating the future scenarios.

Stormwater Element

This element will utilize information from the Monroe County Stormwater Master Plan. Therefore, coordination with Monroe County is required. Future stormwater treatment requirements, based on future effective population assumptions, will be utilized in the CCAM simulation of the future scenarios. Within this study, stormwater is also

addressed within the Water Quality Element of the Natural Resources Category, since acceptable water quality is a paramount environmental consideration for the Florida Keys ecosystem.

Task 1. Quantify Significant Stormwater Flows into "Hot Spot" Areas. Stormwater runoff flows into "hot spot" areas will be calculated by the use of a method that relates rainfall to runoff. One, or a combination, of the following methods may be used:

(1) Rational Method. Use of this method shall require proper selection of runoff and retardance coefficients. This method is best suited for the urban areas of the Florida Keys where a high percentage of imperviousness is common. (References: "Design and Construction of Sanitary and Storm Sewers," Manual of Engineering Practice No. 37 {New York: American Society of Civil Engineers, 1960}; C.F. Izzard, "Hydraulics of Runoff from Developed Surfaces, Proc. Highway Res. Bd. 26 (1946): 129-150).

(2) Simulation Models. Such simulation models as the EPA's Stormwater Management Model may be used as a basis for the development of site-specific model(s) designed to estimate significant stormwater runoff into "hot spot" areas.

Task 2. Estimate Current and Projected Stormwater Flows. Current stormwater flows will be estimated. Future stormwater flows will be projected based upon land development activities and effective population forecasts from the Population Forecast Element. The future estimates will consider the needs of the CCAM for simulating the future scenarios.

Task 3. Identify Future Stormwater Treatment Requirements. A comparison of current and projected stormwater treatment capacities will be made. Shortfalls will be identified.

Task 4. Evaluate Alternatives to Meet Projected Stormwater Treatment Requirements. The following programs, some of which are listed in the WQPP, will be analyzed and evaluated for potential to significantly contribute to the reduction of pollution from stormwater runoff.

(1) Street Sweeping,

(2) Ordinances for controlling fertilizer application on public and private landscaping,

(3) Collection locations and a public education program for the proper use and disposal of household fertilizers, pesticides, motor oil, and other hazardous household chemicals,

(4) Retention/detention treatment ponds (including cost for integration into the CCAM for simulating the future scenarios), and

(5) Litter control programs and public education programs.

Evaluations are to include, but not be limited to, defensibly calculated estimates of mass removals of key pollutants (e.g. Total Phosphorus, Total Nitrogen, Total Suspended Matter, Metals, Hydrocarbons, etc.) that will occur as a result of each program.

Transportation Element

U.S. Highway 1 is the main road linking the individual islands and communities to each other and to the mainland. The primary purpose of this element will be to ensure that the road network is adequate to provide hurricane evacuation for the effective population in each of the future scenarios. Traffic volumes under the future scenarios and population forecast will be estimated, and compared to the transportation network capacities. Shortfalls in capacity will be identified. Accepted methodology utilized by Florida Department of Transportation (FDOT) will be applied.

Task 1. Estimate Current Traffic Volumes on Key's Primary and Secondary Roads.

Task 2. Develop Relationships Between Traffic Volumes and Population and Demographic Variables (number of trips, origin-destination, permanent, seasonal residents, tourists, etc.).

Task 3. Determine Capacity and Level of Service of Current Transportation Network.

Task 4. Project Future Traffic Volumes Based on Population Forecast and Scenario Assumptions.

Task 5. Identify Shortfalls in Capacity and Level of Service of Transportation Network.

Relevant Data: (This list of data items should be related to the traffic projection and analysis tasks so that only the most useful data is collected.)

-Traffic counts by the FDOT
-Traffic delay studies by Monroe County
-Traffic circulation patterns
-Traffic speed data
-Accidents involving wildlife
-Accident data by the Florida Highway Patrol, Monroe County Sheriff and FDOT

-Potential build out of each island (Development and population projections from all scenarios will be needed to predict the alternative future traffic volumes.)
-Potential build out and land uses in South Dade County as they pertain to the Hurricane evacuation route exiting the Florida Keys
-Historic number of permits for residential units by island (as defined in the Monroe County Rate of Growth Ordinance)
-Census data for household size, number of automobiles per household
-Hotel occupancy rates as may be maintained by the Monroe County Tourist Development Council and/or local Chambers of Commerce
-Monroe County Comprehensive Plan, Technical Background Data including the origin-destination data

Factors:

-Trip generation rates of different land uses.
-Locations of different land uses.
-Automobiles per household.
-Alternative means of travel such as but not limited to transit, taxi, bicycle, and walking.

Relationships:

Reductions in the level of service standards will impact other elements such as response times by Emergency Services. The capacity and condition of roads will also affect the ability to evacuate the Keys in the event of an approaching hurricane. However, such an evacuation shall also be dependent on the road network and shelters out of the Keys.

Consider alternative systems that look beyond present practices and are environmentally friendly, such as: local and express buses; inter-county buses; multi-use trails for bicycles and walkers, etc.

Marinas, Heavily Traveled Channels, Ports Element

The residents and tourists of the Florida Keys use a variety of facilities in support of water navigation and recreational boating. Three major supporting facilities are marinas, channels, and ports. Vessels and their operation, maintenance and associated infrastructure have impacts on water quality and the coastal and marine environment. The information provided in this element will be utilized within the FKCCS and the CCAM to provide data for the impacts of marinas, channels, ports and boats on the water quality and marine environment of the Florida Keys, both existing impacts and future impacts due to increased effective population and demand.

Task 1. Identify all Marinas, Heavily Traveled Channels and Ports. All marinas, heavily traveled channels and ports (public and private) in the study area will be identified

and will include wet slips, dry racks, boat ramps, parking lot capacity, docks, boat repair facilities, and pump out facilities.

Task 2. Estimate the Current Annual Demand for Marinas, Heavily Traveled Channels and Ports. Effective population and standard participation rates will be used to estimate the total number of visits to marina and port facilities annually. Live-aboards will be included.

Task 3. Estimate the Current Annual Supply Capacity. Using standard outdoor recreation and/or navigation capacity tables where possible, the annual supply capacity will be estimated.

Task 4. Estimate the Projected Future Demand. The project future demand for marina, heavily traveled channels and port facilities will be estimated based on projected effective population increases in the future scenarios.

Relevant Data:

FDEP GIS Book. *1995-96 Annual Report.*

University of Miami, Rosentiel School of Marine and Atmospheric Science, Division of Marine Affairs and Policy. 1995. *Urban Growth and Sustainable Habitats, Case Studies of Policy Conflicts in South Florida's Coastal Environment*. "To Jet Ski or Not to Jet Ski: Personal Watercraft Conflicts in the Lower Keys." Pages 133-154.

Simmons, Alyson. Community Outreach Coordinator, FKNMS. *Boater Education in the FKNMS.*

USACE, Jacksonville District, Federal projects in Monroe County:

Key West Harbor, Key West Bight, Garriod Bight
Intracoastal Waterway, Miami to Key West
Largo Sound Channel
Smathers Beach, Key West, Florida Shore Protection Project.

Hurricane Evacuation Element

Current hurricane evacuation problems and needs in the Florida Keys, Monroe County, Florida will be evaluated. The overall objective of this is to provide emergency management officials with comprehensive and updated information on the major items affecting hurricane evacuation planning and decision-making.

Task 1. Existing Data Collection. Existing data will be collected to identify baseline conditions and, where appropriate, converted to GIS. A detailed description of each geographic data layer (coverage) is summarized in Appendix A of the report:

"Florida's Marine Resource Information System Final Report," South Florida Regional Planning Council, September 1995. Database coverages contained in the FMRIS that are relevant to the Hurricane Evacuation Element of this study include: Hospitals, Keys Treatment Plants, Major Roads, Schools and other shelter facilities, etc.

Task 1.a. Topographic Data. The most current existing topographic data will be included in the study database. The FDOT has recently flown aerial photography suitable for updating base mapping for new inundation maps, more accurate shelter evaluations and approaching roadways.

Task 1.b. Flood Data. Flood information and data from the most recent maps and atlases developed from the results of the Sea, Lake and Overland Surge from Hurricanes (SLOSH) Modeling provided by the National Hurricane Center (NHC) and the most recent FIRM's from FEMA Flood Insurance Studies (FIS) will be included in the study database. A new SLOSH Model for the Florida Bay Basin is scheduled to start in Oct/Nov 1998 with expected completion before June 1999.

Task 1.c. Hazardous Sites. Hazardous sites such as propane storage facilities, natural gas pipeline terminals, fuel storage facilities, tank farms, etc., shall be inventoried with a brief discussion of the facility. These facilities will be located by their state plane coordinates or longitude and latitude so they can be displayed on a map showing their proximity to shelters and critical facilities. The County shall play a major role in developing this data.

Task 1.d. GIS Mapping. Each major land feature, evacuation routes, roadway profiles, infrastructure, shorelines, spot-elevations and contours will be placed in separate coverages.

Indicators:

Indicators such as resident and tourist populations, structures, buildings, road infrastructure, waves, storm surge, tides, topographic and bathymetric elevations are relevant to the hurricane evacuation study element. Factors such as number of permits issued for new construction and reconstruction are directly related to total population of the Florida Keys and affect the ability of people to evacuate the Florida Keys as a storm approaches.

Limits & Scope:

Some information, such as wave, surge and wind data, may be needed from areas outside the study boundary limits. The hurricane evacuation potential for Monroe County is related to the hurricane evacuation capabilities in the adjacent counties to the north. Hurricane evacuation information on Dade County, and other counties, shall be included as necessary and factors that affect the evacuation of the Florida Keys shall be defined.

Relevant Data:

Base maps depicting other factors and elements of importance to this hurricane evacuation element will be developed as a part of the FKCCS. Critical parameters are the location of transportation routes, populations, buildings, topography and storm characteristics. The latest approved Monroe County Land Use Plan shall be consulted for proposed land development activities and population densities at build out. The location of all mobile homes, trailers, and substandard housing will be delineated on maps.

Resources:

FDEP GIS Book. *1995-96 Annual Report.*

FEMA. March 3, 1997. *Flood Insurance Study, Monroe County, Florida and Incorporated Areas.*

South Florida Regional Planning Council. September 1995. *Florida's Marine Resource Information System Final Report.*

Task 2. Hurricane Evacuation Analyses. Hurricane evacuation analyses will have the capacity to evaluate the problems and opportunities associated with a growing demand for hurricane evacuation capability from the Florida Keys as described in the following:

Task 2.a. Hazards Analysis. The basis for the hazards analyses will be the most recent maps and atlases developed from the results of the SLOSH Modeling provided by the NHC and the most recent FIRM's from FEMA's FIS's for the County and local communities (See Task 1.b. Flood Data). Hazards from inland wind effects shall be evaluated, since these are considered critical where sub-standard housing and mobile homes are located. The hazardous sites mapping from task 1.c. will be utilized here.

Task 2.b. Potential Hazards. The hazards analysis shall identify the potential tropical storm hazards to the County and shall include investigations of potential storm surge/tide, waves, high winds, roadway flooding by rainfall runoff and storm tide occurring prior to the arrival of and during tropical storms, and a history of tropical storms activity in the region. If necessary, the NHC, FEMA, DCA and Monroe County will serve on an oversight committee to review any modeling activity relating to tropical storms hazards.

Task 2.c. Tropical Storm Surge. A new SLOSH Model by the NHC is scheduled to begin in Oct/Nov 1998 and should be completed by June 1999.

Task 2.d. Evaluate Sea Level Datum. Compilation of existing gage data or other method will be used to determine the current Mean Sea Level as compared to the standard National Geodetic Vertical Datum established in 1929. Some data would indicate that sea level may have increased about 0.7 foot since 1929. Continuous NOAA, National Ocean Service tide gage records exist for Key West from 1913 to the present. These existing records will be used and a new tide gage is not required.

Task 2.e. Freshwater Flooding. FIRMs and past freshwater flooding experiences (e.g. repetitive flood areas) will be used to determine the approximate number of vulnerable dwelling units subject to evacuation outside the surge inundation area. The number of dwelling units is to be based on Monroe County GIS parcel maps, and building locations identified from aerial photography. All roadways subject to freshwater flooding

will be identified and placed in a GIS coverage. Mapping of fresh water flooded areas are shown on the FIRM for the County, which are available in digital format.

Task 2.f. Tropical Storm Inundation Atlases. Inundation mapping will be performed showing areas that will be flooded by storm surge. The storm inundation maps will be shown with wave heights added to the storm surge.

Task 2.g. Vulnerability Analysis. The vulnerability analysis will include a comprehensive evaluation and identification of the levels of vulnerability, primary evacuation zones, the population-at-risk, and tropical storm surge effects on institutional/medical facilities as well as dry storage facilities. All vulnerable properties will be put into the study database. Additional information will be provided showing those segments of U.S. 1 and Card Sound Road that will be overtopped initially under the various hurricane scenarios and storm tracks. This inundation information for each scenario will be shown on a plan overlay to the U.S. 1 and Card Sound Road area. This will be very useful for the deployment of emergency vehicles during the pre-landfall period.

Task 2.h. Population Data. Provide/update information, by evacuation zones, on special needs populations, the estimated number of people living in various dwelling unit types by seasonal occupancy rates, the estimated tourist population, the number of people to be evacuated, and the number of vehicles to be used in an evacuation effort. Population estimates should be based on the year 2000 estimates and should include 5-year population projections to 2050.

Task 2.i. Life Safety/Critical Facilities Surge Analysis. Work to be performed for this analysis will include inventories and determinations of storm surge susceptibility of medical facilities, nursing homes, detention centers, schools and other institutions that may require special consideration during evacuation. Also, a determination of storm surge vulnerability will be made for other critical facilities such as water supply lines, wastewater treatment plants and electrical generating/transfer facilities. Critical facilities will be located by state plane coordinates and longitude and latitude.

Task 2.j. Demographic/Socio-Economic Profile. A summary of the demographic and socio-economic profile of the County will be provided.

Task 2.k. Mobile Home/RV Parks. The name and location of all mobile home and recreational vehicle parks will be provided in tabular and GIS format. These units are particularly vulnerable to high winds and are always evacuated during any hurricane threat.

Task 2.l. Special Considerations. Identify any areas and population (see Social Environment Element) that require special consideration relative to preparedness, warning and evacuation such as handicapped, elderly and families with small children.

Task 2.m. Strategies. A discussion of evacuation and sheltering strategies for the County (e.g. phased evacuation, close routes at certain hours before landfall, refuge use notification timing) based on relevant transportation analysis will be provided.

Task 2.n. Behavioral Analysis. A behavioral analysis will be provided based on discussions with County Emergency Management Directors or upon an appropriate recent survey of area residents to investigate the likely evacuation responses under a variety of hurricane threat situations.

Task 2.o. Shelter Analysis. Shelter analysis data will be updated and stored in a standard database format to promote ease of updating and compatibility. The traditional analyses would address critical parameters of existing shelter evaluations, existing private shelter, projected shelter needs, and other potential shelter options such as refuge of last resort and/or vertical evacuation alternatives.

Task 2.p. Transportation Analysis. The transportation analysis will be a regional study including estimates of vehicle movements into and out of the region. The study will incorporate and build on previous studies and utilize professionally accepted transportation models or other appropriate computer analysis systems. General study methods and modeling procedures will be documented. The analysis will investigate various evacuation methodologies, timing strategies, shelter/refuge strategies, and traffic control measures in order to minimize clearance times. Sensitivity analyses will be conducted to evaluate the impacts of variations in population; mobilization response curves simulating a quick, medium, and slow response; increase and reduction in highway capacity; drawbridge operations; percent of vehicles pulling trailers; and seasonal and tourist population.

Resources:

FDEP GIS. *1995-96 Annual Report*.

Post, Buckley, Schuh & Jernigan, Inc. for USACE and FEMA. January 1993. *Hurricane Andrew Assessment - Florida, Review of Hurricane Evacuation Studies Utilization and Information Dissemination*.

South Florida Regional Planning Council. June 1987. *South Florida Hurricane Contingency Planning Study*.

USACE and Monroe County Civil Defense. February 1991. *Monroe County Hurricane Emergency Plan.* This report was based on vulnerability and shelter analysis that were completed in 1989 and utilized 1984 shelter data. The transportation analysis was completed in 1991 and utilized 1980 census data that was updated to 1988 values. Hurricane data available through 1987 was utilized. The SLOSH modeling utilized was completed in January 1990.

USACE, FEMA, NOAA, NHC, DCA. February 1991. *Lower Southeast Florida Hurricane Evacuation Study, Technical Assessment, Monroe County*.

USACE, FEMA, NOAA, NHC, Florida Division of Emergency Management. October 1989. *Lower Southeast Florida Hurricane Evacuation Study, Monroe County Appendix*. The following reports were included in the Appendix: "Behavioral Analysis, Lower Southeast Florida Hurricane Evacuation Study," University of South Florida; "Hazard Analysis Monroe County, A Storm Surge Atlas for the Florida Bay Area," Storm Surge Group, NHC, NOAA; "Transportation Analysis, Monroe County, Lower Southeast Florida Hurricane Evacuation Study, Technical Data Report," Post, Buckley, Schuh, & Jernigan, Inc.; "Vulnerability Analysis, Monroe County."

Other Infrastructure Services Element

This element will provide the cost of all other infrastructure services required for effective population changes in the CCAM simulation of future scenarios. Other infrastructure services will include water supply, police and law enforcement, schools, hospitals/health delivery, fire/emergency services, and recreation. Information from the Monroe County Comprehensive Plan and other readily available sources will be utilized to the maximum extent.

Task 1. Estimate Current Levels of Service. Current levels of service for each of the other infrastructure services will be estimated.

Task 2. Estimate Future Required Levels of Service. Projected future levels of service will be estimated based upon the effective population forecasts in the CCAM simulation of future scenarios.

Task 3. Identify Shortfalls in Levels of Service. Shortfalls in levels of service will be identified by comparing projected and current levels of service.

Task 4. Estimate Cost for Providing Required Future Levels of Service. Costs for all infrastructure services that indicate a shortfall in any of the future scenario simulations will be estimated. This information will be integrated into the CCAM.

Social Environment Category

As stated earlier, the objective of the FKCCS is to conduct a carrying capacity study in the Florida Keys such that land development activities and effective population changes are linked with environmental impact, infrastructure improvements and impacts on the social environment, including economic, sustainable tourism, quality of life and community character. This category is concerned with developing an understanding of those socioeconomic forces driving and being impacted by change in the Keys as well as how these forces effect community life. There is concern that standard sociological, anthropological and social impact assessment methods have not worked in the past and

innovative methods must be promoted and utilized, wherever possible, in this analysis. Therefore, not only will the standard methods be utilized, an effort will be made to seek, promote and utilize new, innovative methods for the socioeconomic analyses and assessments in this category.

Tasks are not exclusively sequential. Some can be done concurrently, and some iterations are expected, especially as input is derived from the public involvement program (see Public Involvement, Section 2).

Task 1. Literature Review. U.S. Bureau of the Census and local planning studies and reports will be used to the extent practicable. The literature search will include information, if available, about social attitudes towards other carrying capacity studies throughout the world. For example, where has the social environmental been ascertained and factored into carrying capacity studies. This information will be useful for developing techniques and approaches, as well as for previous lessons learned. Some new data collection may be required, especially concerning public preferences and attitudes associated with the public involvement program.

Task 2. Existing and Historical Socioeconomic Description. The existing and historical socioeconomic environment in the Keys will be described, including identification and description of the significant socioeconomic forces that have produced or are producing; or may be impacted by, environmental and social change in the Keys.

Task 2.a. Develop Profile of Socioeconomic Structures and Processes. A descriptive profile of socioeconomic structures and processes of the Florida Keys communities will be developed using standard and new, innovative sociological, anthropological, social impact, and regional development assessment methods (see Finsterbush et al. *Social Impact Assessment Methods*, 1983. Sage). The social profile should describe existing conditions and significant historical trends and, at a minimum, include the following factors, plus any additional elements that are identified through public involvement efforts (See Public Involvement, Section 2):

(1) Population composition (number, age, sex, migration patterns, distribution, ethnicity, race, education, live-aboards, income distribution, identification and distribution of traditional disadvantaged population groups); visitor demographic characteristics (numbers, distribution, seasonal patterns of visitation);

(2) Regional economy must be described and analyzed in detail, including income, employment patterns, occupation distribution (i.e. how do residents make a living—factory workers, restaurant workers, fishermen, etc.), identification of key economic sectors and type of economy (e.g. tourism, fishing, retirement living), commuting patterns, unemployment, underemployment and local fiscal conditions;

(3) Community character/quality of life pertains to valued amenities and qualities that combine to make the Keys a special place to live. The amenities and

qualities that constitute community character/quality of life elements can only be discerned through public input; however, it is likely that the following elements will be part of such a list: lifestyles, perceptions of safety, perceptions of neighborliness, pride in being part of the Keys community, awareness/acceptance of community norms, pace of life, relation to/valuation of natural environment, aesthetics i.e. visual character along U.S. Highway 1, recreation, employment and noise levels;

(4) Recreation and entertainment;

(5) Tourism; and

(6) Zoning, planning and land use.

Task 2.b. Develop Socioeconomic Relationships. The significant relationships among elements in the socioeconomic profile, human infrastructure and natural resources categories will be identified in an effort to describe potential socioeconomic changes that may occur and the impacts of such change. The socioeconomic elements that are contributing to change in the Florida Keys and that could potentially impact carrying capacity levels will be identified. Similarly, the socioeconomic elements that may be impacted by human infrastructure or natural resources, or from constraints imposed by carrying capacity levels will be identified. For example, effective population impacts human infrastructure and natural resources carrying capacities. Tourism is likely to be impacted by natural resources, such as water quality. Understanding of these key relationships will be utilized for assessing the socioeconomic environment in the future scenarios.

Task 3. Develop, Describe and Analyze the Socioeconomic Environment Under Future Scenarios. For each study scenario, projections of socioeconomic indicators will be included in the assumptions in an effort to represent the Keys socioeconomic environment under that scenario. Socioeconomic changes and their impact on the socioeconomic environment of the Florida Keys will be identified. The analysis will describe changes from existing conditions and significant changes in past trends. Similarities and differences between alternative scenarios will also be highlighted.

Task 4. Identify Socioeconomic Impacts that are Potentially Unacceptable to Segments of the Keys Community or to Other Appropriate Populations. The significant impacts associated with socioeconomic change are likely to conflict with views, preferences, or attitudes of the Keys community, with major segments of that community, or with other appropriate populations, such as tourists or non-resident permitted landowners. Traditionally disadvantaged groups will be identified and their socioeconomic preferences will be incorporated in this impact assessment. This will ensure that not only the views and preferences of the most vocal advocates for or against the FKCCS are included, but also those groups that may not have the opportunity, knowledge or ability to be vocal about their views and preferences.

Standard and new, innovative sociological, anthropological, social impact assessment methods, as well as appropriate input from the public involvement program, will be evaluated to identify and describe potentially unacceptable impacts. The description will include the group or segment of the community or other population likely to find the impact unacceptable and the underlying reason for their sentiment.

Resources:

FDEP GIS Book. *1995-96 Annual Report.*

Florida Keys/Key West Report. 1996. *Economic Contribution of Recreating Visitors to the Florida Keys/Key West*.

Florida Keys/Key West Report. 1996. *Importance and Satisfaction Ratings By Recreating Visitors to the Florida Keys/Key West*.

Florida Keys/Key West Report. 1996. *Visitor Profiles Florida Keys/Key West*.

Note: The three preceding reports are available on the World Wide Web at:
http://www-orca.nos.noaa.gov/projects/econkeys/econkeys.html

Social Science Subgroup of the South Florida Ecosystem Restoration Task Force Working Group. February 1998. *South Florida Social Science Symposium, Building a Social Science Action Plan for South Florida, Draft Summary of Symposium Results.*

SECTION 5
TECHNOLOGY TRANSFER

The FKCCS is mandated by the Florida Administration Commission Rule 28-20.100 to be completed no later than December 31, 2000. A large quantity of information, databases, GIS, the CCAM and the FKCCS report will be generated by that date. The final product of the FKCCS is to provide a database and interactive model (i.e. CCAM) that will enable planners and decision makers to evaluate the effects of their decisions on the Florida Keys ecosystem, hurricane evacuation and infrastructure such as stormwater and sanitary wastewater treatment facilities.

While the information, databases, GIS and CCAM will be final products of this study, it may be beneficial for the future success of planning efforts in Monroe County that an "adaptive" management paradigm be adopted. (Holling 1978, Waters 1986, Gunderson et al. 1995). Adaptive management views regional development policy and management decisions as "experiments" rather than as "solutions", acknowledging that such complicated issues and questions as those addressed in the FKCCS will not be solved all at once. To maximize its utility, it may be that the Keys carrying capacity analysis is not one that can be completed in short or due time; but should be ongoing so that problems and opportunities could be continuously identified and addressed, various issues could be brought more clearly into focus over time, emphasis could be placed on monitoring and feedback to check and improve the CCAM, and staff and other participants could gain increasing understanding and technical expertise.

One possible solution for facilitation of planning and decision making in an ecosystem and human environment as complicated as the Florida Keys may be the establishment of a permanent operating center where relevant knowledge is continuously amassed, improved, reanalyzed, and utilized. This would require institutional infrastructure, i.e. an operations center including an office, computers and personnel. A long-term knowledge center or resource center may be the optimal ultimate destination for the FKCCS information, databases and the CCAM. This center could be utilized by local, state and federal planners and resource managers for obtaining information and data needed at one place for making their decisions.

A FKCCS knowledge center would also facilitate adaptive management of the information, databases and the CCAM. The emphasis could be placed on the ability to refine the model when new information and data is acquired, such as the addition of new elements or new interactions between elements. Although the study and model are scheduled to be complete by 2000, the modeling refinement process may need to continue past this date to reap the full benefits of this effort. The substantial funding obtained to complete the FKCCS and the development of the CCAM warrants an effort be made to ensure that the model not become obsolete soon after completion. Continuing refinement of the databases, GIS mapping, information and the CCAM after year 2000 will most likely improve and prolong their usefulness (Walters1986). Recommendations

concerning continuation of use of the FKCCS and its information, databases, GIS and the CCAM will be developed during the course of this study.

References:

Gunderson, L., C. S. Holling, and S. Light (eds). 1995. *Barriers and Bridges to the Renewal of Ecosystems and institutions*. Columbia University Press: New York, New York.

Holling, C. S. (ed). 1978. *Adaptive Environmental Assessment and Management*. Wiley: London, England.

Walters, C. J. 1986. *Adaptive Management of Renewable Resources*. McGraw Hill: New York, New York.

FLORIDA KEYS
CARRYING CAPACITY STUDY

APPENDIX A

STEERING AND TECHNICAL ADVISORY COMMITTEES

APPENDIX A

STEERING AND TECHNICAL ADVISORY COMMITTEES

AGENCY	STEERING COMMITTEE MEMBER	TECHNICAL ADVISORY COMMITTEE MEMBER
Environmental Protection Agency	John Hankinson (404) 347-4728	Bill Kruczynski (305) 743-0537
Florida Department of Environmental Protection	Edwin J. Conklin, Jr. (904) 488-6058	G.P. Schmahl (305) 292-0311
National Oceanic and Atmospheric Administration	Jeff Benoit (301) 713-3155	Paul Moen (305) 242-7120
Everglades National Park	Dick Ring (305) 242-7000	Brien Culhane (305) 242-7210
U.S. Army Corps of Engineers	Colonel Terry Rice (904) 232-2241	Susan McKeon (Study Manager) (904) 232-3332
U.S. Fish and Wildlife Service	Geoffrey Haskett (404) 679-7152	Barry Stiegliz (305) 872-2239
South Florida Water Management District	William E. Graham (305) 821-1130	David Thatcher (561) 687-6330
Florida Department of Community Affairs	Charles Pattison (904) 922-1751	Ty Symroski (305) 289-2402
Florida Department of Health and Rehabilitative Services	John Heber (904) 488-4070	Jack Teague (305) 292-6894
Florida Keys Aqueduct Authority	Jim Reynolds (305) 296-2454, ext. 242	Susan Loder (305) 296-2454, ext 249
Florida Game and Freshwater Fish Commission	Dr. Allen Egbert (904) 487-3796	Phil Frank (305) 289-2365
Florida Department of Transportation	Frank Carlile (904) 922-5820	Barbara Culhane (305) 470-5220
State Senate, District 40	Daryl Jones (305) 442-6901	Cpt Ed Davidson (305) 743-6054
Board of County Commissioners of Monroe County	Keith Douglass (305) 289-6000 Jack London (305) 292-4512	Bill Wagner (Emer Mgt Dir) (305) 289-6018 Jim Hendrix (Co. Attorney) (305) 292-3470 Michael Lannon (Super of Schools) (305) 296-6523 Bob Herman (Planning Director) (305) 289-2536 George Garrett (Dir. Marine Resources) (305) 289-2507
City of Key Coloney Beach	William H. Botten (305) 289-1212	Cindy Stong (305) 743-7333

AGENCY	STEERING COMMITTEE MEMBER	TECHNICAL ADVISORY COMMITTEE MEMBER
City of Key West	Dennis Wardlow (305) 292-8102	(None)
Florida Keys Environmental Fund	Charles W. Causey (305) 664-9779	Ed Davidson (305) 743-6054
Florida Keys National Marine Sanctuary	Mike Collins (305) 852-5837	Jim Harvey (561) 832-7291
Monroe County Commerical Fishermen	Karl Lessard (305) 743-5996	Karl Lessard (305) 743-5996
1000 Friends of Florida	Patricia S. McKay (904) 222-6722	Richard Grosso (954) 262-6140
Florida Wildlife Federation	Manly Fuller (904) 656-7113	Manly Fuller (904) 656-7113
Upper Keys Citzens Association, Inc.	Dagney Johnson (305) 852-5268	Dagney Johnson (305) 852-5268
Florida Keys Citizens Coalition, Inc	Dr. Snell Putney (305) 872-8888	Eugene Shinkevich (305) 872-4346
National Wildlife Federation	Mark Van Putten (703) 790-4455	(None)
The Nature Conservancy, Florida Keys Initiative		Mark Robertson (305) 296-3880
South Florida Regional Planning Council	Carolyn Dekle (954) 985-4416	Carolyn Dekle (954) 985-4416
Friends of the Everglades	Joette Lorion (305) 279-1166	Juanite Green (305) 852-2187
Key West Chamber of Commerce	Kim Works (305) 294-2587	Virginia Panico (305) 294-2587
Islamorada Chamber of Commerce	Bill Fox (800) 322-5397	Hendry Rosenthal (305) 664-4503
Big Pine Key Chamber of Commerce	Jay Marzella (800) 872-3722	Connie McSorley (305) 872-2411
Key Largo Chamber of Commerce	Ginna Drake (305)	Dick Drake (305) 451-1911
Marathon Chamber of Commerce	Ray Kichener (800) 842-9580	Harold E. Dillon (305) 743-6038
Key West - Last Stand	Elliott Baron (305) 296-0062	Elliott Baron (305) 296-0062
Lower Keys - Big Pine Key Civic Association	Robert Schneider (305) 872-3509	Robert Schneider (305) 872-3509
Marathon - Community of Concerned Citizens	Authory Culver (305) 743-7926	Authory Culver (305) 743-7926
Islamorada - Port Largo Property Association	Tom Garrettson (305) 453-0826	Ann Nickerson (305) 451-0082
Key Deer Protection Alliance, Inc.		Jerry Dykhuisen (305) 872-1922
Key Largo - Issak Walton League	Dick Drake (305) 451-1911	Amy Knoles (305) 664-9279
Individuals	Lloyd Good, Jr. (305) 745-3211 James S. Mattson (305) 852-3388	John DeGrove (954) 355-5253 Nora Williams (305) 852-4060

AGENCY	STEERING COMMITTEE MEMBER	TECHNICAL ADVISORY COMMITTEE MEMBER
	Debra Harrison (305) 289-1010	Alicia Roemmele-Putney (305) 872-8888

FLORIDA KEYS
CARRYING CAPACITY STUDY

APPENDIX B

IN-HOUSE STUDY TEAM
IN-HOUSE ADVISORS

APPENDIX B

IN-HOUSE STUDY TEAM

NAME	BRANCH	SECTION
Captain Edward Pruett	Project Management	n/a
Vern Gwin	Plan Formulation	Flood Control and Flood Plain Management
Mark White	Environmental	Environmental Quality
Susan McKeon	Environmental	Environmental Studies
David McCullough	Environmental	Environmental Studies
William Hunt	Socio-Economics	n/a
Flora Herring	Socio-Economics	n/a

IN-HOUSE ADVISORS

NAME	BRANCH	SECTION
Richard Punnett	Hydrology & Hydraulics	Hydrology Investigation
John Hashtak	Plan Formulaiton	Flood Control and Flood Plain Management, Chief
Elmar Kurzbach	Environmental	Environmental Studies Section, Chief
James McAdams	Environmental	Environemntal Quality Section, Chief
Eric Raasch	Socio-Economics, Chief	n/a
Hanley Smith	Environmental, Chief,	n/a
George Strain	Plan Formulation, Chief,	n/a

FLORIDA KEYS
CARRYING CAPACITY STUDY

APPENDIX C

INTERAGENCY WORKING GROUP

APPENDIX C

INTERAGENCY WORKING GROUP

NAME	DISCIPLINE	AGENCY	TITLE
Mark Dunning	Sociology	USACE, Institute for Water Resources	Sociologist
George Garrett	Biology/Chemistry/ Zoology	Monroe County	Director of Marine Resources
Bill Hansen	Economics	USACE, Institute for Water Resources	Economist
Paul Holt	Geographical Information Systems	USACE, Jacksonville District (Contractor)	Senior Geographer
Eric Hughes	Wetlands/Water Quality	Environmental Protection Agency	Jacksonville based, EPA-COE Liaison for Restudy
Tom Matthews	Marine Biology/ Fisheries Science	Florida Department of Environmental Protection	Marine Biologist
Susan McKeon	Environmental Studies	USACE, Jacksonville District	Study Manager/Biologist
Ken Orth	Community Planning	USACE, Institute for Water Resources	Workshop Facilitator/ Community Planner
David Schmidt	Ocean Coastal Engineering/Remote Sensing	USACE, Jacksonville District	Coastal Section, Chief
Larry Stanislawski	GIS/Forest Resources/ Surveying and Mapping	USACE, Jacksonville District (Contractor)	GIS Specialist
Ty Symroski	Community Planning	Florida Department of Community Affairs	Planning Manager, Florida Keys Field Office
Mark White	Environmental Engineering	USACE, Jacksonville District	Water Quality Specialist

FLORIDA KEYS
CARRYING CAPACITY STUDY

APPENDIX D

PEER REVIEW GROUP PARTICIPANTS

APPENDIX D

PEER REVIEW GROUP PARTICIPANTS

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Thomas Bancroft (202) 429-2689	The Wilderness Society
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John Clark (305) 872-4114	Mote Marine Laboratory (Field Site)
Alice Clarke (305) 348-1693	Florida International University Department of Environmental Studies
Robert Costanza (410) 326-7263	University of Maryland Institute for Ecological Economics
Donald DeAngelis (305) 284-3974	U.S. Geological Survey Biological Resources Division
Roland Ferry	U.S. Environmental Protection Agency, Region 4 Coastal Program Section
David Godschalk (919) 962-3983	University of North Carolina at Chapel Hill Department of City and Regional Planning
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Marilyn Hof	U.S. Department of the Interior National Park Service Denver Service Center

APPENDIX D

PEER REVIEW GROUP PARTICIPANTS

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John Ogden (813) 553-1100	University of South Florida Florida Institute of Oceanography
Hillary Swain (941) 465-2571	Archbold Biological Station
Joel Trexler (305) 348-1966	Florida International University Department of Biological Sciences

FLORIDA KEYS
CARRYING CAPACITY STUDY

APPENDIX E

SCHEDULE AND COST ESTIMATE

Keys Carrying Capacity Study
Government Time and Cost Estimate

Section refers to location of task within September 1998 scope of work.

Task	Cost	Total	DCA WIK Credit
Section 2			
Study Administration			
DCA	$385,669		$385,669
PD-P	$275,000		
DP-I	$168,000		
Subtotal		$828,669	
Contract Procedure (EN-DC)		$25,000	
Public Involvement (PD-PN)		$276,000	
Section 2 Total Cost		**$1,129,669**	
Section 3			
Scenario Development			
EN-HH	$5,000		
PD-PN	$20,000		
RE-A (Real Estate Costs for Land Buying/Land Conservation Options)	$24,500		
Subtotal		$49,500	
Geographic Information System			
IM-I			
Database Design	$30,000		
Hardware/Software/Maintenance	$90,000		
Database Setup/Initial Data Conversion & Integration/Metadata	$60,000		
GIS Data Management and Administration	$80,000		
Documentation	$10,000		
GIS Mapping of Element Databases (Included in each element cost estimate)			
Subtotal		$270,000	
Carrying Capacity Analysis Model			
Model Framework Workshop	$40,547		$13,447
IM-I (Build/Test Model)	$359,000		
EN-HI (Coordination/Data Review/Model Support)	$2,500		
Model Transition & Training Cost Estimate Located in Section 5			

Subtotal		$402,047	
Section 3 Total Cost		**$721,547**	
Section 4			
Natural Resources Category			
Water Quality Element (PD-EE except where noted differently)			
Literature Review	$49,850		
GIS Mapping of HTRW sites (IM-I)	$7,150		
Monroe County Sanitary Wastewater Master Plan	$927,984		$927,984
Monroe County Stormwater Master Plan	$299,750		
Selection of Case Study Areas--case study areas from SWMP will be utilized.			
Wastewater Evaluation			
Identify "Hot Spots"			
Data, analyses and cost included in Monroe County SWMP for DCA WIK credit			
GIS Mapping of Wastewater Hot Spots	$6,600		
Wastewater-WQ-Land Development Activities Relationship	$20,800		
Workshop: Wastewater-WQ-Land Dev. Activities Relationship	$78,594		$26,894
Stormwater Evaluation	$50,000		$50,000
Workshop: Stormwater Runoff-WQ-Land Dev. Activities Relationship	$78,594		$26,894
Water Quality Modeling			
Mapping of Contributing Areas			
PD-EE	$91,670		
IM-I	$8,250		
Travel for Installation of Groundwater Wells as needed	$4,800		
Water Quality Sampling & Analysis	$62,970		
Travel	$7,200		
Nearshore Transport Analysis/Nutrient Loading Model Calibration/Runs (WES)	$145,000		
Model Workshop	$45,547		$13,447
EN-HI--Coordination, Date Review, Model Support	$2,500		
Land Use/Nutrient Loading Analysis	$29,220		
Live Aboards & Recreational Vessel Discharges	$7,220		
Report	$34,720		
Travel (Public Meetings)	$3,200		
Subtotal		$1,961,619	
Ecosystems Element (PD-ES unless otherwise noted)			
Literature Review	$15,000		
Delineate and Map Marine, Upland and Wetland Ecosystems/Transition Zones			
PD-ES	$10,000		
IM-I	$6,600		
Identify Ecosystem Indicators of Sustainability			

Workshops	$74,980		$23,280
PD-ES	$7,000		
Develop Requirements/Responses/Limting Factors/Tolerance Limits			
Workshops	$74,980		$23,280
PD-ES	$7,000		
Habitat Change Analysis			
Identify Baseline Conditions	$4,500		
Current Conditions			
Digital Aerial Orthophotos	$400,000		
Analysis			
PD-ES	$16,350		
GIS Mapping	$14,900		
Future Trends/Relationship Between Each Study Element&Land Development Activities	$37,500		
Subtotal		$668,810	
Species of Concern Element			
Literature Review	$15,000		
Identification of Species	$15,000		
GIS Mapping	$13,800		
Identification of Indicator Species, Keystone Species and Other Species of Concern	$12,500		
Develop Requirements/Responses/Limting Factors/Tolerance Limits			
Workshops	$74,980		$23,280
PD-ES	$7,000		
Subtotal		$138,280	
Total Natural Resources Category		**$2,768,709**	
Human Infrastructure Category			
Population Forecast Element (PD-D)		$69,800	
Wastewater Element (PD-EE)			
Data, analyses and cost included in Monroe County Sanitary Wastewater Master Plan			
Stormwater Element (PD-EE)			
Quantify Significant Stormwater Flows	$4,575		
Estimate Current and Projected Stormwater	$38,500		$38,500
Identify Future Stormwater Treatment Requirements	$11,500		$11,500
Evaluate Alternatives to Meet Projected Stormwater Treatment	$12,825		
Subtotal Stormwater Element		$67,400	
Transportation Element			
PD-D	$141,000		
PD-N	$2,500		
Subtotal Transportation Element		$143,500	

Marinas, Heavily Traveled Channels, Ports Element			
PD-D	$83,600		
IM-I	$11,000		
Subtotal Marinas, Heavily Traveled Channels, Ports Element		$94,600	
Hurricane Evacuation Element			
PD-PF	$350,000		
IM-I	$44,000		
Subtotal Hurricane Evacuation Element		$394,000	
Other Infrastructure Services Element			
Estimate Current/Future/Shortfalls in Levels of Service (PD-D)	$348,200		
EN-C (Human Infrastructure Cost Estimates)	$16,000		
Subtotal Other Infrastructure Services Element		$364,200	
Total Human Infrastructure Category		**$1,133,500**	
Social Environment Category (PD-D)		**$97,400**	
Section 4 Total Cost		**$3,999,609**	
Section 5: Technology Transer/Transition Plan (PD-PN) Total Cost		**$89,250**	
Review Support (Required by Engineering Circular 1105-2-208)		**$50,000**	
Subtotal Study Cost		**$5,990,075**	
Study Contingency		**$9,925**	
Total		**$6,000,000**	$1,564,175
			$64,175
			$1,500,000

Notes:
SWMP = Sanitary Wastewater Master Plan
WIK shown exceeds 25% of total study cost

STUDY SCHEDULE AVAILABLE ON KEYS CARRYING CAPACITY STUDY HOMEPAGE