FINAL

WATER QUALITY PROTECTION PROGRAM FOR THE FLORIDA KEYS NATIONAL MARINE SANCTUARY

PHASE II REPORT

U. S. Environmental Protection Agency
Oceans and Coastal Protection Division

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GENERAL INTRODUCTION

1.0 LEGISLATIVE MANDATE AND PURPOSE

The Florida Keys National Marine Sanctuary (FKNMS) was created with the signing of HR5909 [Public Law 101-605, Florida Keys National Marine Sanctuary and Protection Act (FKNMSP Act)] on 16 November 1990. Included in the FKNMS are 2800 square nautical miles of nearshore waters extending from just south of Miami to the Dry Tortugas. The Environmental Protection Agency (EPA) and the State of Florida have been directed to develop a Water Quality Protection Program for the FKNMS. This program will be considered by the National Oceanic and Atmospheric Administration (NOAA) for inclusion in the comprehensive management plan that will be prepared to guide the use of the FKNMS.

The purpose of the Water Quality Protection Program is to "recommend priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution to restore and maintain the chemical, physical, and biological integrity of the Sanctuary, including restoration and maintenance of a balanced, indigenous population of corals, shellfish, fish and wildlife, and recreational activities in and on the water" (FKNMSP Act). In addition to corrective actions, the Act also requires development of a comprehensive water quality monitoring program, a research plan, and provision of opportunities for public participation in all aspects of developing and implementing the program.

The FKNMS is the first marine sanctuary to have a Water Quality Protection Program. The establishment of such a program recognizes the critical role of water quality in maintaining Sanctuary resources. The ecological integrity of Sanctuary ecosystems is dependent on the maintenance of outstanding water quality, including high water clarity, low or undetectable nutrient levels (especially in the case of coral reefs), low concentrations of xenobiotics, and variations in other water quality parameters within the tolerance limits of Sanctuary biota.

Although the Water Quality Protection Program focuses on water quality and environmental problems, the economic impacts of deteriorating water quality must also be considered when evaluating the cost of options for reducing pollution. The habitats of the Sanctuary and adjacent areas, including Florida Bay and the Everglades, support an abundance of fish and wildlife, sustain enormously valuable commercial and recreational fisheries, and attract anglers, divers, naturalists, and other tourists from all over the world. Thus, the economy of the Florida Keys is tied directly to resources that depend on the maintenance of Sanctuary habitats and water quality. The variety and magnitude of recent ecological problems in the Sanctuary and adjacent areas (e.g., Florida Bay) as reviewed in the Phase I report (EPA 1992) indicate that *something is wrong* and that existing management actions are not adequate to prevent continuing environmental degradation. That is, there is a significant "cost of doing nothing." Socioeconomic aspects of all recommended corrective actions that are eventually included in NOAA's management plan for the Sanctuary will be analyzed as part of the Environmental Impact Statement for the management plan and are not discussed further here.

2.0 BACKGROUND

The Water Quality Protection Program has been developed in two phases. During Phase I, information on the status of the Sanctuary's natural environment was compiled and synthesized (EPA 1992). Priority problems were identified through this literature review and by developing consensus among technical experts and other participants in technical workshops. Building on this information base, Phase II focused on three goals:

- Developing options for corrective action
- Developing a water quality monitoring program and associated research program
- Developing a public education and outreach program

Phase II included seven main tasks, as outlined below, to address these three goals. Other tasks involved development of a Work/Quality Assurance Project Plan for Phase II and preparation, review, and revision of this Phase II report.

DEVELOPING OPTIONS FOR CORRECTIVE ACTION

- **Task 2 — Institutional and Agency Management Inventory**
  Identify institutions and agencies with jurisdiction affecting water quality in the FKNMS.

- **Task 3 — Management/Institutional and Agency Options**
  Based on the institutional and agency management inventory (Task 2) and suggestions from agency personnel, develop a comprehensive range of management and institutional options to reduce water pollution and improve the existing regulatory/management system.

- **Task 4 — Engineering Options**
  Develop a comprehensive range of engineering options to reduce water pollution.

- **Task 5 — Funding Sources**
  Identify and evaluate potential funding sources for implementing corrective actions identified in Tasks 3 and 4.

DEVELOPING MONITORING AND RESEARCH PROGRAMS

- **Task 6 — Monitoring Program**
  Develop a comprehensive water quality monitoring program to monitor the status of water quality and biotic resources, determine the effectiveness of pollution controls, and redirect the Water Quality Protection Program if necessary.

- **Task 7 — Research Program**
  Develop a research program to complement the Monitoring Program (Task 6) by identifying cause/effect relationships involving pollutants, transport pathways, and biological communities.

DEVELOPING PUBLIC EDUCATION AND OUTREACH PROGRAM

- **Task 8 — Public Education and Outreach Program**
  Develop a public education and outreach program to promote public awareness of water quality issues.

Separate draft reports were prepared for each Phase II task listed above, with the exception of Tasks 3 and 4 which were combined into one report. During the preparation of draft task reports, two EPA/State of Florida workshops were held to discuss preliminary findings and receive input from technical experts and the public: a Monitoring/Research Workshop (July 1992) and an Engineering/Management Options Workshop (August 1992). Following the workshops, draft task reports were prepared and reviewed by EPA, NOAA, and the State of Florida. The draft reports were then revised and combined into this draft Phase II report, which will be circulated for public comment and revised as necessary. Findings from Phases I and II will be incorporated into the Water Quality Protection Program Document, which is the final report for this project.

Options for corrective action, monitoring and research programs, and a public education and outreach program developed during Phase II will be considered by NOAA for inclusion in the comprehensive management plan for the FKNMS, which will address many other management concerns in addition to water quality. The comprehensive range of options included in the Tasks 3 and 4 report will be evaluated according to a set of specific factors and objective criteria. This evaluation process will result in the development of the recommended priority corrective actions that will be included in the Water Quality Protection Program Document. Therefore, the options presented in the Phase II report should not be regarded as recommended or approved courses of action. Some may seem obviously beneficial and innocuous, whereas others may be so expensive or controversial that they would never be implemented. Environmental and socioeconomic impacts of all options that are eventually incorporated into NOAA's management alternatives will be evaluated in an Environmental Impact Statement.

3.0 REPORT FORMAT

The Phase II report is divided into separate reports corresponding to the tasks listed above (except Tasks 3 and 4, which were combined). Appendices are provided following each task report rather than at the end of the document. Because of the phased nature of this project, the Phase II report contains relatively few literature citations. An extensive literature review was conducted for Phase I. Readers should consult EPA (1992), herein cited as the "Phase I report" for further information.

4.0 REFERENCE

EPA. 1992. Water Quality Protection Program for the Florida Keys National Marine Sanctuary: Phase I Report. Final report submitted to the Environmental Protection Agency under Work Assignment 3-225, Contract No. 68-C8-0105. Continental Shelf Associates, Inc., Jupiter, FL and Battelle Ocean Sciences, Duxbury, MA.

TASK 2 — INSTITUTIONAL AND AGENCY MANAGEMENT INVENTORY

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ACRONYMS

ACCC	Areas of Critical County Concern
ACSC	Areas of Critical State Concern
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
CFR	Code of Federal Regulations
CWA	Clean Water Act (Federal Water Pollution Control Act of 1972)
CZARA	Coastal Zone Act Reauthorization Amendments of 1990
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
DRI	Developments of Regional Impact
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FAC	Florida Administrative Code
FDCA	Florida Department of Community Affairs
FDER	Florida Department of Environmental Regulation
FDHRS	Florida Department of Health and Rehabilitative Services
FDNR	Florida Department of Natural Resources
FKAA	Florida Keys Aqueduct Authority
FKNMS	Florida Keys National Marine Sanctuary
FMP	Florida Marine Patrol
FMRI	Florida Marine Research Institute
FS	Florida Statutes
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
GIS	Geographic Information System
GMS	Groundwater Monitoring System
KML	Keys Marine Lab
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPRSA	Marine Protection, Research, and Sanctuaries Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
OFW	Outstanding Florida Waters
OPM	Office of Policy and Management
ORC	Objections, Recommendations, and Comments
OSDS	on-site sewage disposal system
RAMS	Regulatory Analysis Management System
RCRA	Resource Conservation and Recovery Act of 1976
RPC	Regional Planning Council
SARA	Superfund Amendments and Reauthorization Act of 1986
SFRL	South Florida Regional Laboratory
SFWMD	South Florida Water Management District
TMDL	Total Maximum Daily Load
UIC	Underground Injection Control
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
UST	Underground Storage Tank
WQBEL	Water Quality Based Effluent Limitation
WQPP	Water Quality Protection Plan
WWTP	wastewater treatment plant

TASK 2 — INSTITUTIONAL AND AGENCY MANAGEMENT INVENTORY

1.0 INTRODUCTION

Task 2 involved two objectives. The first objective was to identify and list the federal, state, regional, and local institutions and agencies with jurisdiction over activities that affect water quality in the FKNMS. The second objective was to provide an inventory of institution and agency programs, authorities, and resources that currently exist relative to water quality. This information will serve as background information that will be used in Task 3 of Phase II. This background information was used subsequently in Task 3 to develop a comprehensive range of management and institutional options to address water quality problems.

Information pertinent to Task 2 was collected through various means. Relevant literature, legislative laws, agency administrative rules, and Memorandums of Agreement and Understanding (MOAs and MOUs) between various agencies were reviewed. Key regulatory agencies at federal, state, regional, and local levels of government were identified, and specific contacts within those agencies were established. Survey questionnaires concerning program functions were developed and mailed to key individuals associated with specific water quality regulatory programs. Individuals within identified programs were interviewed either in person or via telephone (see Appendix A following Task 2 text).

Section 2.0 of this report provides a list of institutions and agencies with jurisdiction for water quality in the FKNMS. The list includes institutions and agencies at federal, state, regional, and local levels. Relevant regulations and programs are also listed under each institution and agency. The programs that have been inventoried are those that were related to one of the pollution sources identified in Phase I. Those pollution sources are as follows.

- Dredge and fill activities
- Hazardous materials/waste
- Industrial discharges
- Landfills
- Live-aboard vessels
- Marinas
- Oil spills
- Pesticides
- South Florida Water Management District (SFWMD) canals
- Stormwater runoff
- Wastewater treatment

Section 3.0 of this report describes all specific regulations and programs by institutions and agencies with jurisdiction and resources relative to water quality in the FKNMS. For each institution and agency, the following aspects are discussed:

- Program Responsibilities;
- Authority (implementing authority that enables the agency to assume regulatory responsibility);
- Objectives (objectives of the regulation or program);
- Jurisdiction (jurisdictional coverage);
- Operation (how the program operates);
- Funding;
- Staffing; and
- Tracking (the means used by agencies to track progress or compliance).

2.0 LIST OF INSTITUTIONS AND AGENCIES WITH JURISDICTION FOR WATER QUALITY IN THE FLORIDA KEYS NATIONAL MARINE SANCTUARY

Many government agencies have responsibilities over activities that potentially produce direct or indirect water quality impacts in the FKNMS. The following is a list of federal, state, regional, and local agencies and existing management tools (regulations or programs) that relate to water quality in the FKNMS.

I. FEDERAL
- (A) U.S. Environmental Protection Agency
  - (1) Florida Keys National Marine Sanctuary Program
  - (2) Gulf of Mexico
  - (3) Section 404, Dredge and Fill
  - (4) National Pollutant Discharge Elimination System (NPDES) — Domestic and Industrial Wastewater
  - (5) NPDES — Stormwater Discharges
  - (6) Federal Facilities — NPDES and Resource Conservation and Recovery Act (RCRA)
  - (7) Ocean Discharge
  - (8) Nonpoint Source Management Programs
  - (9) Ocean Dump ng
  - (10) Undergrou njection Control
  - (11) Marine San on Devices
  - (12) Resource C servation and Recovery Act (RCRA)
  - (13) Comprehen e Environmental Response, Compensation and Liability Act (CERCLA; Superfund)
  - (14) Undergroun Storage Tanks
- (B) U.S. Coast Guard
  - (1) Oil and Ha dous Substance Spills
  - (2) Marine San ion Devices
- (C) National Oceanic d Atmospheric Administration
  - (1) Florida Ke National Marine Sanctuary Program
  - (2) Coastal Zo Management Act
- (D) U.S. Army Corps f Engineers
  - (1) Section 40 Dredge and Fill
- (E) U.S. Fish and Wi life Service
  - (1) Fish and W llife Coordination Act
  - (2) Endangere pecies Act of 1973

II. STATE
- (A) Department of A culture
  - (1) Mosquito trol
- (B) Department of C munity Affairs
  - (1) Areas of Cr cal State Concern
  - (2) Developme of Regional Impact
  - (3) Local Comp ehensive Planning
  - (4) Coastal Zone Management
- (C) Department of Environmental Regulation
  - (1) Florida Keys National Marine Sanctuary Program
  - (2) Domestic Wastewater
  - (3) Industrial Wastewater
  - (4) Point Source Evaluation
  - (5) Wastewater Facilities Regulation and Permitting
  - (6) Underground Injection Control
  - (7) Water Quality Standards

(8) Ambient Monitoring
(9) Stormwater Management
(10) Wetland Resource Utilization Permitting (Dredge and Fill)
(11) Solid Waste Management
(12) Storage Tank Regulation
(13) Emergency Response Program
(14) Local Government Comprehensive Plan Review

(D) Department of Health and Rehabilitative Services
(1) On-site Sewage Disposal

(E) Department of Natural Resources
(1) Administration of National Marine Sanctuaries
(2) Environmental Crimes Program
(3) Submerged Lands and Preserves
(4) Florida Marine Research Institute

III. REGIONAL

(A) Florida Keys Aqueduct Authority
(1) Wastewater

(B) South Florida Water Management District
(1) Wetland Regulation
(2) Stormwater Management

IV. LOCAL

(A) Monroe County
(1) Comprehensive Plan
(2) Land Development Regulations

(B) City of Key West
(1) Comprehensive Plan
(2) Land Development Regulations
(3) Wastewater Treatment

(C) City of Key Colony Beach
(1) Comprehensive Plan
(2) Land Development Regulations
(3) Wastewater Treatment

(D) City of Layton
(1) Comprehensive Plan
(2) Land Development Regulations

3.0 INVENTORY OF INSTITUTIONS AND AGENCIES WITH JURISDICTION AND RESOURCES RELATIVE TO WATER QUALITY

This section of the report provides an inventory of institutions and agencies along with their specific regulations and programs relative to water quality in the FKNMS. For each institution and agency, the following aspects are discussed.

- Program Responsibilities;
- Authority (implementing authority that enables the agency to assume regulatory responsibility);
- Objectives (objectives of the regulation or program);
- Jurisdiction (jurisdictional coverage);
- Operation (how the program operates);
- Funding;

- Staffing; and
- Tracking (the means used by agencies to track progress or compliance).

3.1 FEDERAL

3.1.1 U.S. Environmental Protection Agency

3.1.1.1 FLORIDA KEYS NATIONAL MARINE SANCTUARY PROGRAM

PROGRAM RESPONSIBILITIES: EPA and the State of Florida have joint responsibility for preparing a Water Quality Protection Plan (WQPP) for the FKNMS. EPA's primary role is to coordinate the overall work program, review and comment on all work products, serve as liaison with all federal agencies and the Florida Department of Environmental Regulation (FDER), and implement effective intergovernmental coordination and public participation.

AUTHORITY: Legislative authority for general authorization of National Marine Sanctuaries is set out in Title III of the Marine Protection, Research, and Sanctuaries Act (as amended). More specifically, the Florida Keys National Marine Sanctuary Program has been authorized by Public Law 101-605, Florida Keys National Marine Sanctuary and Protection Act.

OBJECTIVE(S): Three objectives are set out in the Florida Keys National Marine Sanctuary and Protection Act as follows:

- To protect the resources of the Florida Keys;
- To educate and interpret for the public regarding the Florida Keys marine environment; and
- To manage human use in the FKNMS consistent with the Act.

Further, Title III of the National Marine Sanctuaries Act (as amended) contains additional objectives that are as follows:

- To provide authority for comprehensive and coordinated conservation and management of those marine areas that will complement the existing regulatory authorities; and
- To support, promote, and coordinate scientific research of those marine waters.

More specifically, the purposes of the WQPP will be to

1. recommend priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution;
2. assign responsibilities for the implementation of the program;
3. address legal, institutional, and management issues and recommend changes;
4. establish a comprehensive water quality program;
5. provide adequate opportunity for public participation; and
6. identify funding mechanisms to implement the WQPP.

JURISDICTION: The FKNMS Program has jurisdiction seaward of the mean high tide line to the outer limits of the FKNMS as defined in the Florida Keys National Marine Sanctuary and Protection Act.

OPERATION: The EPA Region IV Project Manager and the FDER Florida Keys Coordinator are responsible for seeing that the WQPP for the FKNMS is produced in a timely fashion. The work effort includes administering and monitoring the consulting team contracted to prepare a draft WQPP. Project management also includes expediting technical information exchange and coordinating meetings between the consultant and technical staff of EPA. The EPA Project Manager will be involved in scheduling all public and technical work sessions.

FUNDING: In 1991, $100,000 was appropriated for the Florida Keys under the Near Coastal Waters Program. In addition, $200,000 was provided through EPA Headquarters from the Clean Water Act, Section 104(b)(3).

unding for 1992 is being provided via Congressional add-on in the amount of $625,000. Additionally, $50,000 was transferred from EPA Headquarters Gulf of Mexico Program to fund a demonstration project at Bahia Honda State Park, and $37,500 of Near Coastal Waters Program funding was awarded for an alternative sewage treatment system near Marathon. All EPA administrative costs related to the FKNMS are funded out of the Region IV EPA operating budget.

STAFFING: There is one EPA staff member located in the Region IV Coastal Planning Unit who works full time as the Florida Keys Project Manager.

TRACKING: Tracking of program performance is based on milestones and work products set out in the work program. Frequent communication between the EPA Project Manager, FDER Florida Keys Coordinator, and other involved resource agencies and consultants occurs to ensure that the WQPP being prepared results in an acceptable product. The WQPP will identify how compliance will be monitored.

3.1.1.2 GULF OF MEXICO

PROGRAM RESPONSIBILITIES: The EPA has primary responsibility for the Gulf of Mexico Program. The program focuses on assessing and characterizing environmental characteristics of the Gulf of Mexico, developing Action Agendas that identify needed corrective actions, and the ways and means to accomplish the recommended actions. Further, an important element of the program is the development and implementation of measures that can improve coordination and cooperation among the various states bordering the Gulf. Another major component of the program is public awareness. Through this program, the staff sponsors and organizes programs and symposiums that raise the level of awareness of issues impacting the Gulf of Mexico.

AUTHORITY: This program was established in 1988 through an EPA Region IV initiative. It has continued as an initiative program; however, there are several legislative bills pending that, if passed, would formally establish the Gulf of Mexico Program. They include the Gulf of Mexico Commission Act of 1992 sponsored by Senator Bentsen of Texas; the Gulf of Mexico Preservation Act sponsored by Senator Gramm of Texas, as well as House of Representative Bill #5249 sponsored by Representatives Ireland and Goss, both of Florida, and House of Representative Bill #5441 sponsored by the Sunbelt Caucus.

OBJECTIVE(S):

- To provide a mechanism for addressing complex problems in the Gulf of Mexico that cross state, federal, international, and jurisdictional lines;
- To provide better coordination and collaboration among federal, state, and local programs affecting the Gulf;
- To provide a forum for affected user groups, public and private educational institutions, and the general public to participate in the "solution" process;
- To establish interagency protocols, standards, and/or MOUs that will improve cooperation and minimize duplication among various levels of government;
- To ensure that uses and economic growth of the Gulf are managed in an environmentally sound manner;
- To identify and address environmental issues before irreversible damage or high cost prevents their repair;
- To improve communication and cooperation through participation in decisionmaking, and work toward consensus on technical solutions; and
- To collect all other previously evaluated data and information on the Gulf of Mexico to improve the decision-making process.

JURISDICTION: The geographical boundaries of the program include all waters of the United States within the Gulf of Mexico, which includes the coastal waters of Florida, Alabama, Mississippi, Louisiana, and Texas. In terms of the FKNMS, it includes the coastal counties of Dade and Monroe.

OPERATION: EPA Headquarters in Washington, D.C. has lead administrative responsibility. Both Regions IV and VI have regional program offices headed by the regional coordinators. The Program Office is located in Stennis Space Center in Mississippi. The organization consists of a Policy Review Board, a Technical Steering Committee, and a Citizen Advisory Committee. In addition, there are a series of specialized work groups (e.g., habitat degradation, nutrient enrichment, toxic substances and pesticides, and data and information transfer).

Since the program was established in 1988, a variety of activities has been undertaken. They have included such things as environmental characterization studies and management action plans. The program has also held a Gulf Symposium, established citizen networks, and developed a database system known as the Gulf of Mexico Program Electronic Bulletin Board.

The program is currently focused on developing Action Agendas for the Gulf in the following areas related to water quality issues:

- Nutrient Enrichment
- Marine Debris
- Public Health
- Toxics/Pesticides
- Living Aquatic Resources
- Freshwater Inflow

FUNDING: Being an initiative program, funding comes from the EPA operating budget; thus, the amount is dependent upon annual Congressional appropriations for EPA, and ultimately is contingent upon the level of priority EPA places on the program. Historically, there has been a steady increase in funding. In 1988, the program received $500,000. By 1992, funding had increased to $1,400,000.

STAFFING: Staff for this program is located at four EPA locations: Headquarters - Washington, D.C., Region IV - Atlanta, Georgia; Region VI - Dallas, Texas; and the Stennis Space Center - Mississippi. Staff at Headquarters and Regions IV and VI have one specific person assigned to the program. Additional assistance is provided by other EPA-based programs that exist at those locations. The field operation located at the Stennis Space Center has eight professionals with support staff. In terms of staff, the field office includes a director, a technical director, a senior scientist, an administrative assistant and three project officers.

TRACKING: EPA is presently reviewing the success of the program's initial five-year strategy. Success may be difficult to judge, because no quantifiable objectives were originally set. The strategy for the next five years will be more quantifiable in terms of achievements. Examples may include number of acres of habitat restored or how well actions have lead to compliance with objectives of the program.

3.1.1.3 SECTION 404, DREDGE AND FILL

PROGRAM RESPONSIBILITIES: The EPA Region IV Wetlands Regulatory Section staff has the responsibility to review and comment on all dredge and fill permit applications, and take enforcement actions on unpermitted discharges. In addition, the Region has the authority to fund Advance Identification of Wetland studies.

AUTHORITY: Legislative authority for regulating dredge and fill activities is derived from the Federal Water Pollution Control Act of 1972 and subsequent amendments, commonly known as the Clean Water Act (CWA). Section 404 of the CWA created a permit program to regulate the discharge of dredge and fill material into navigable waters of the United States and adjacent wetlands. Primary responsibility for the program has been delegated to the U.S. Army Corps of Engineers (USACE). However, EPA has been assigned certain authority under Section 404 that enables the agency to review and comment on the impact of proposed dredge and fill activities on municipal water supplies, shellfish beds and fishery areas, wildlife, and recreational areas. Further, the law provides EPA with enforcement powers and veto of unacceptable reviews under Section 404(c). These enforcement powers are set out in Section 309 of the CWA.

In addition to the CWA, dredge and fill permit applicants must also adhere to the federal administrative rules in the Code of Federal Regulations (CFR). Those rules that pertain to Section 404 permits are as follows:

- 33 CFR Parts 320-330;
- 40 CFR Part 122 — Administered Permit Programs: The National Pollutant Discharge Elimination System;
- 40 CFR Part 124 — Procedures for Decisionmaking;
- 40 CFR Part 230 — Guidelines for Disposal Sites for Dredge and Fill Materials; and
- 40 CFR Part 231 — Procedures for Section 404(c) "veto" of USACE permit.

Further clarification of USACE's and EPA's dredge and fill responsibilities have been defined in three MOAs. They address enforcement, mitigation, and jurisdiction.

OBJECTIVE(S): To restore and maintain the chemical, physical, and biological integrity of waters of the United States through the control of discharges of dredge and fill material.

JURISDICTION: Section 404 jurisdiction extends throughout the Florida Keys and FKNMS. Whether a Section 404 dredge and fill permit is required depends on if the activity will take place in "navigable waters" (waters of the United States, including adjacent wetlands). "Waters of the United States" is defined in 40 CFR 122.2, Definitions. The USACE and EPA have a MOA regarding jurisdictional determination. In practice, the USACE generally makes the determination.

OPERATION: While the USACE has primary permitting and enforcement responsibility for Section 404 permits, EPA has statutory enforcement authority to deal with discharges of dredge and fill material where no permit has been obtained. The USACE has similar authority for situations in which Section 404 permits have been issued and their conditions violated. Both the USACE and EPA have authority to seek civil or administrative remedies for unauthorized discharges into wetlands. In addition, EPA can pursue criminal action in its enforcement areas.

Under Section 404(c), the EPA can "veto" permits that have already been USACE-approved if the activity will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas, wildlife, or recreational areas. In reality, EPA has exercised this veto action only 11 times, nationwide, since the CWA was enacted in 1972.

The MOAs between EPA and USACE are to facilitate coordination. Generally, they address procedural matters regarding permitting and enforcement. Significant MOAs between the USACE and EPA address the issue of mitigation and define enforcement referrals between the Jacksonville office and EPA Region IV.

Due to the presence of extensive wetland vegetation and low-lying topography throughout the Florida Keys, the USACE has extensive Section 404 jurisdiction. Therefore, a large percentage of Section 404 permit applications reviewed in south Florida are in the Florida Keys (D. Powell, EPA Region IV, personal communication, 1992). In *Federal Wetlands Regulation in Florida Keys: Net Losses in a Special Place*, the author, Ross Burnaman, reviewed 96 permits in 1989 and 158 in 1990. On average, statewide, there are between 1,000 and 1,500 dredge and fill permit applications filed annually.

EPA Region IV operates under the premise that intertidal wetlands can stabilize shorelines and sequester nutrients and sediments found in upland runoff (Odum *et al.* 1982, Odum and McIvor 1990, and Adamus *et al.* 1991). Wetlands also retain heavy metals and organic pesticides, and can detoxify the latter (Adamus *et al.* 1991). These ecosystem functions, particularly shoreline stabilization, nutrient removal, and sediment trapping, are performed by wetlands in the Keys. These processes result in reduction of turbidity and nutrient loading in FKNMS waters, providing direct benefits to water quality.

In recognition of these benefits, EPA Region IV is funding an Advance Identification of Wetlands project in the Florida Keys, in cooperation with the USACE, FWS, National Aeronautics and Space Administration, FDNR, Florida Game and Fresh Water Fish Commission, and Monroe County. This project will improve implementation of the provisions of Section 404 by providing a basis for testing dredge and fill impacts against the 404(b)(1) disposal site guidelines.

FUNDING: Staff costs for this program are funded from the general Region IV EPA operating budget.

STAFFING: The Wetlands Regulatory Section in EPA has the responsibility for reviewing and commenting on all Section 404 permit applications and enforcement. One person is responsible for the Florida Keys, as well as nine other south Florida counties. The present staffing level makes it nearly impossible to provide the level of attention to each permit application that will ensure the objectives of the program are achieved.

TRACKING: Generally, no extensive tracking occurs. Only when EPA recommends denial or when a permit application is appealed through the Section 404(c) appeal process does any sort of tracking occur. The USACE is required to formally submit a response to EPA indicating how they have addressed the EPA comments.

3.1.1.4 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM — DOMESTIC AND INDUSTRIAL WASTEWATER

PROGRAM RESPONSIBILITIES: The Water Permits and Enforcement Branch of EPA has responsibility for permitting domestic and industrial facilities that discharge wastewater into the oceans, territorial seas, or marine waters of the United States, and enforcing all of these permits.

AUTHORITY: Legislative authority for regulating point source discharges is derived from the CWA.

In addition to the CWA, point source dischargers must also adhere to the following CFRs:

- 40 CFR Part 121 — State Certification of Activities Requiring a Federal License or Permit;
- 40 CFR Part 122 — Administered Permit Programs: The National Pollutant Discharge Elimination System;
- 40 CFR Part 124 — Procedures for Decisionmaking;
- 40 CFR Part 125 — Criteria and Standards for the National Pollutant Discharge Elimination System;
- 40 CFR Part 129 — Toxic Pollutant Effluent Standards;
- 40 CFR Part 131 — Water Quality Standards; and
- 40 CFR Part 136 — Guidelines Establishing Test Procedures for the Analysis of Pollutants.

OBJECTIVE(S): To restore and maintain the chemical, physical, and biological integrity of the nation's waters.

JURISDICTION: The scope of this program encompasses all areas within the Florida Keys and the FKNMS.

OPERATION: Domestic and industrial NPDES permits are required of all surface water dischargers. Because Florida has not been delegated program responsibilities by EPA, the EPA Region IV Water Permits and Enforcement Branch handles all permitting and enforcement activities in Florida, including the Florida Keys. (When an EPA program is delegated to a state, it means that EPA no longer has primacy for regulating or permitting; however, EPA retains oversight responsibility for the delegated program.) Florida is in the process of petitioning to become a delegated state. Even though Florida is not a delegated state, Region IV coordinates its NPDES permitting and enforcement efforts with the Bureau of Wastewater Facilities Regulation of the FDER.

When the EPA NPDES Permits Section prepares a draft NPDES permit, a copy of the permit is sent to the Bureau of Wastewater Facilities Regulation for comment. This is in accordance with the 401 Certification process that is detailed in 40 CFR Part 121. This activity is undertaken to ensure that the proposed NPDES permit will be consistent with State of Florida water quality standards and other concerns of the state. The state has 60 days in which to comment. An MOU between the State of Florida and EPA delineates the responsibilities of both agencies regarding permitting. The importance of coordination is underscored by the fact that, at this point in time, the State of Florida also requires NPDES permitted wastewater facilities to receive a permit from the state as well. If Florida becomes a delegated state, this duplication in permitting will be eliminated.

Over the past several years, there has been a decline in the number of NPDES facilities permitted in the Florida Keys. Over the past three years, 20 permits have been processed for wastewater facilities in the Florida Keys. Because it is the goal of the state to eliminate surface water discharges, an increase in the number of first-time permit applications most likely will not occur in the future. Until all surface water discharges are eliminated in the Florida Keys, there will continue to be some level of NPDES permitting activity because NPDES permits must be renewed every five years.

Coordination of enforcement activities also takes place between EPA and FDER. Annually, EPA and FDER develop what commonly is known as the "Inspection Commitments List" for NPDES permitted surface water dischargers. This list identifies which NPDES permitted wastewater treatment facilities will be inspected and the date of the inspections. This is done to avoid EPA inspecting a facility one week and FDER inspecting the same wastewater facility the succeeding week. Sometimes inspections are conducted at the same time. When joint inspections do not occur, EPA and FDER try to maintain a six-month interval between their individual site inspection visits to make the inspection process less burdensome on the permit holder.

All major dischargers (e.g., power plants, City of Key West wastewater treatment plant [WWTP]) are inspected annually. Minor facilities are visited every five years. Although EPA and FDER coordinate inspections, the facility operators do not know when an inspection will occur.

FUNDING: The NPDES permitting and enforcement staffs are funded from the Region IV EPA operating budget.

STAFFING: The Water Permits and Enforcement Branch is separated into two sections. One processes permits and the other enforces the approved permits. Staffing in the Permit Section varies depending upon the number of permit applications received. The Enforcement Section has four individuals assigned to cover Broward, Dade, and Monroe Counties.

TRACKING: Once permits are issued, permittees must file monthly or quarterly Discharge Monitoring Reports. Data from the Discharge Monitoring Reports are entered into EPA's computerized tracking program known as Permit Compliance Systems. This database contains all types of information on each permittee such as previous enforcement actions, water quality effluent parameters, and permit conditions. Field inspections are also conducted to determine permit compliance. The information generated is used to support enforcement actions, and as input in the permit renewal process.

3.1.1.5 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM — STORMWATER DISCHARGES

PROGRAM RESPONSIBILITIES: The Water Permits and Enforcement Branch of EPA has responsibility for permitting and enforcing stormwater discharges from a variety of industrial operations as defined in 40 CFR Part 123, as well as stormwater discharges from large and medium municipal separate storm sewer systems.

AUTHORITY: Legislative authority for regulating stormwater discharges is derived from Section 402(p) of the CWA. In addition to the CWA, point source dischargers must also adhere to the federal administrative rules (i.e., CFR). Those that pertain include the following:

- 40 CFR Part 121 — State Certification of Activities Requiring a Federal License or Permit;
- 40 CFR Part 122 — Administered Permit Programs: The National Pollutant Discharge Elimination System;
- 40 CFR Part 124 — Procedures for Decisionmaking;
- 40 CFR Part 125 — Criteria and Standards for the National Pollutant Discharge Elimination System;
- 40 CFR Part 129 — Toxic Pollutant Effluent Standards;

- 40 CFR Part 131 — Water Quality Standards; and
- 40 CFR Part 136 — Guidelines Establishing Test Procedures for the Analysis of Pollutants.

OBJECTIVE(S): To restore and maintain the chemical, physical, and biological integrity of the nation's waters.

JURISDICTION: The scope of this program encompasses all areas within the Florida Keys and the FKNMS.

OPERATION: This is a relatively new program. Final regulations for the program were published November 16, 1990. Only separate stormwater facilities are regulated under this program. Combined sanitary and stormwater systems that discharge into surface waters of the United States are already required to operate under an NPDES permit. No permits have been issued by the Region IV office at this time. Since the enactment of the administrative rules pertaining to separate stormwater facilities, all industrial and municipal dischargers subject to these rules have been preparing their applications for "Permit to Discharge Storm Water Discharges Associated with Industrial Activity." These applications must be submitted by the fall of 1992 to EPA.

To date, no municipal stormwater NPDES application has been submitted or is expected to be submitted to EPA from any jurisdiction in the Florida Keys. According to the Final Rule dated November 16, 1990, only those incorporated places having a population of 100,000 or more are required to prepare a stormwater application. There have been no modifications made to the Final Rule adopted in 1990. However, Section 402(p)(2)(E) of the CWA allows the EPA Administrator or a state to require a stormwater discharger to obtain an NPDES stormwater permit regardless of population size if the discharge contributes to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

NPDES stormwater permits are required for activities associated with industrial uses. Those activities that are defined as industrial uses are described in 40 CFR 122.26. Permits may be applied for in one of three ways: through an individual permit, through a group permit, and through a notice of intent to be covered by a general permit. Relative to the Florida Keys, this aspect of the program has particular relevance to marinas. Only those marinas that are involved in vehicle (boat) maintenance activities (including vehicle rehabilitation, mechanical repairs, painting, fueling and lubrication) or equipment cleaning operations are considered industrial activities. As such, they are required to apply for a NPDES stormwater permit. Those marinas that are engaged primarily in retail sale of fuel and lubricating oils or that primarily provide sports or recreation services or products are not required to apply for a NPDES stormwater permit.

FUNDING: Staff positions are funded out of the general Region IV EPA operating budget.

STAFFING: There are six people in the Storm Water and Municipal Unit dedicated to permitting. Enforcement of the permits will be handled by the NPDES Enforcement Section. There are four individuals who conduct compliance inspections in Broward, Dade, and Monroe counties. No increase in staffing is anticipated at this time. As the program matures, staffing needs will focus more on enforcement than permitting, because the stormwater permits will be general permits covering large numbers of facilities in one permit. However, regardless of whether a permit has 1 or 50 facilities, enforcement is done on a facility-by-facility basis.

TRACKING: Monitoring results will be submitted in Discharge Monitoring Reports similar to those used for monitoring NPDES domestic and industrial wastewater discharge facilities. Compliance with the permits will be the responsibility of the NPDES Enforcement Section. It is anticipated that this program will also input monitoring information into EPA's Permit Compliance Systems computerized database. Site inspections will also be conducted to determine compliance with permit conditions.

3.1.1.6 FEDERAL FACILITIES — NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM AND RESOURCE CONSERVATION RECOVERY ACT

PROGRAM RESPONSIBILITIES: The Federal Activities Branch has permitting and enforcement responsibilities for all federal wastewater facilities that discharge to surface waters. In addition, the branch is responsible for permitting RCRA activities at federal facilities; however, enforcement of RCRA permits is the responsibility of the RCRA Permitting and Compliance Branch located in the Waste Management Division of EPA.

AUTHORITY: Legislative authority for the tasks performed by this branch is derived from the following public laws:

- CWA; and
- RCRA.

Further, Executive Order 12088 describes the federal facilities compliance strategy that must be adhered to by federal agencies.

OBJECTIVE(S):

CWA objectives:

- To restore and maintain the chemical, physical, and biological integrity of the nation's waters;
- To provide for the protection and propagation of fish, shellfish, and wildlife, and to provide for recreation in and on the water; and
- To ensure federal compliance with applicable pollution control standards.

RCRA objectives:

- To protect human health and environment;
- To conserve valuable material and energy resources; and
- To encourage recycling, reuse, and treatment of hazardous wastes.

JURISDICTION: Program jurisdiction extends throughout the Florida Keys and the FKNMS.

OPERATION: Staff members are not located in the Water Management Division or the Waste Management Division, but in the Federal Activities Branch of the Office of Policy and Management (OPM). The OPM is a separate division within EPA.

Permits for wastewater and RCRA projects are prepared by permit writers in the Federal Activities Branch. Prior to finalization, the permits are circulated to either the NPDES Permits Section or the RCRA Permits Section, as appropriate, for review and comment. Upon receipt of these comments and those from the federal installations seeking the permits, the permits are finalized. Once the permit is issued, only wastewater permits are enforced by the Federal Activities Branch. The individual with RCRA responsibilities within the branch monitors for violations only. All enforcement actions are taken by the RCRA Compliance Section located in the Waste Management Division.

FUNDING: The Federal Activities Branch staff is funded out of the Region IV EPA operating budget.

STAFFING: There are five technical staff members assigned to the Region IV Federal Activities Branch. There is no one person assigned to either the Florida Keys or the State of Florida. The staff is responsible for writing all wastewater and RCRA permits as well as enforcing wastewater permits or monitoring RCRA violations in eight states. One individual has responsibility for wastewater and another for RCRA-related activities. The other staff members are assigned responsibility for coordinating activities that involve the Tennessee Valley Authority, National Aeronautic and Space Administration, and Department of Energy.

TRACKING: All federal wastewater facilities submit monthly Discharge Monitoring Reports to the NPDES coordinator within the Branch. The RCRA coordinator in the Federal Activities Branch submits monthly federal facility compliance reports to the RCRA Permitting and Compliance Branch. In addition, the Federal Activities Branch staff makes on-site inspections annually.

3.1.1.7 OCEAN DISCHARGE

PROGRAM RESPONSIBILITIES: The Ocean Discharge Program is housed within the Wetlands, Oceans and Watersheds Branch of EPA. The program involves establishing bioassessment criteria for the discharge of point source pollutants into the marine environment, meaning the oceans, territorial sea, or contiguous zone. This program is implemented through the NPDES permitting program which requires applicants to develop monitoring programs to measure degradation of the marine environment.

AUTHORITY: Legislative authority for point source ocean discharge regulation is contained in Section 403(c) of the CWA. In addition to the CWA, ocean dischargers must also adhere to the federal administrative rules in the CFR as follows:

- 40 CFR Part 125 — Criteria and Standards for the National Pollutant Discharge Elimination System, Subpart M — Ocean Discharge Criteria.

OBJECTIVE(S): To ensure that ocean outfalls cause no "unreasonable degradation" of the marine environment. Unreasonable degradation is defined as significant adverse changes in ecosystem diversity, productivity, and stability of the biological community within the area of discharge and surrounding biological community (40 CFR Part 125, Subpart M).

JURISDICTION: The only surface water dischargers that are under the jurisdiction of this program are those whose discharge point occurs seaward of the "baseline" (mean low tide mark). "Baseline" has been delineated by the federal State Department. The only surface water discharger in the FKNMS that falls under the jurisdiction of this program is the City of Key West WWTP.

OPERATION: The ocean discharge program is an integral part of the NPDES permitting process for ocean discharges. While the program does contain a provision that no discharge permit be issued until it is established that the discharge will not harm the receiving waters, in reality, the program operates somewhat differently. Certainly, new dischargers must meet that provision. However, there are a number of existing situations where sewage treatment plants are operating under an existing NPDES permit, like the City of Key West WWTP, that was approved prior to 1980, the date when Section 403(c) was added to the CWA legislation. However, there is a "reopener clause" in the CWA that provides EPA with an opportunity to address a situation where a sewage treatment plant is creating severe environmental damage. Thus when an NPDES permit is being reviewed, EPA can add new provisions to the applicant's NPDES permit based on new information derived as a result of the 403(c) monitoring study.

Staff in the Coastal Planning Section supports the NPDES Permits Section by reviewing required NPDES monitoring programs that are prepared for the purpose of assessing the impacts on the surrounding biological communities. Region IV has oversight responsibility in delegated states. Because Florida is not a delegated state, EPA administers the 403(c) ocean discharge program in Florida.

The Region IV office coordinates with the FDER NPDES coordinator as well as with the applicant. Once a draft monitoring plan is initially drafted, both the state and applicant have an opportunity to review and comment. Based on the responses, the initial monitoring plan is modified. The approved plan then becomes a part of the approved NPDES permit. Coordination is essential with the Water Permits and Enforcement Branch, because they have responsibility for writing the NPDES permit as well as enforcing it. While there is no ocean discharge monitoring program in place in the Florida Keys, Region IV staff has been working with the City of Key West. The city submitted a proposed monitoring program two years ago as part of its NPDES permit application package. EPA staff recently prepared a revised program and met with city officials to discuss the proposed program suggested by EPA.

FUNDING: Funding for ocean discharge coordination and research activities in Region IV has been relatively stable over the past three years: 1990 — $200 thousand; 1991 — $200 thousand; 1992 — $190 thousand. However, in 1993 a significant reduction in appropriated funds for the program is anticipated. The expected funding level will probably be in the range of $80-100 thousand. No specific funds are allocated to the Florida Keys. The source of funds come from EPA headquarters, Section 104(B)(3) of the CWA. EPA Region IV staff costs are funded out of the general Region IV EPA operating budget.

STAFFING: One technical staff person in Region IV has responsibility for coordinating the ocean discharge program in the six coastal states within the region. Approximately 30% of the individual's time involves work in the Florida Keys. Although not prerequisite, individuals in this program should have a background in marine biology/ecology and/or oceanography.

TRACKING: Ocean discharge monitoring plans are based on a case-by-case situation. Generally, the monitoring plan describes the various sampling methodologies to be used to gather information. Once completed, the data are evaluated using various statistical techniques to determine if the discharges affect marine communities and natural coastal habitats. Also, there is an internal EPA administrative MOU that directs the Enforcement Section of the Water Permits and Enforcement Branch to notify the ocean outfall coordinator of all enforcement actions. This enables the ocean discharge coordinator an opportunity to recommend modifications to the permit.

3.1.1.8 NONPOINT SOURCE MANAGEMENT PROGRAMS

PROGRAM RESPONSIBILITIES: This is a nonregulatory program that directs states to develop nonpoint source management programs. The Nonpoint Source (NPS) Program staff provides administrative oversight on state management plans to ensure that the requirements of Section 319 of the CWA are met; administers the agency's nonpoint source grant program; and provides technical assistance to the states upon request.

AUTHORITY: There is no legislative authority for regulating nonpoint source discharges; it is a nonregulatory program contained in Section 319 of the CWA. There are no federal administrative rules for the nonpoint source program codified in the CFR.

However, Section 6217 of the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 requires all states with federally-approved Coastal Zone Management Programs (CZMP) to develop a Coastal Nonpoint Pollution Control Program. A set of "economically" achievable management measures that, to the greatest degree possible, lead to a contaminant reduction in nonpoint sources of pollution is to be a part of each program.

OBJECTIVE(S): To control and abate nonpoint source pollution, through voluntary measures.

JURISDICTION: The scope of this program encompasses all areas within the Florida Keys and the FKNMS.

OPERATION: The Nonpoint Source Program is assigned to the Watershed Unit in the Wetlands, Oceans and Watersheds Branch of EPA Region IV. The EPA nonpoint source staff has three primary duties: overseeing all state NPS programs in Region IV; administering the Section 319(h) grants program that is used to implement individual state nonpoint programs; and assisting states in the development and implementation of nonpoint source management programs.

In Florida, the EPA staff coordinates its efforts with the FDER, Bureau of Surface Water Management, Nonpoint Source Management Section. Generally, EPA staff has no direct contact with local governments in the Florida Keys.

A new program which may impact state nonpoint source programs is Section 6217 of the 1990 CZARA. Section 6217 requires states with an approved coastal zone management program to develop and submit a Coastal Nonpoint Pollution Control Program to EPA and NOAA for approval. Guidance to implement Section 6217(g) of the 1990 CZARA is under promulgation. This program identifies quantitative estimates of pollution reduction for each measure, and any necessary monitoring techniques that assess the success of the measures in reducing pollution loads and improving water quality. Local governments will also be required to identify, develop, and implement pollution control measures. Failure of the State to comply with the federal mandate may jeopardize up to 30% of their funding under Section 306 of the Coastal Zone Management Act (CZMA) and Section 319 of the CWA. The State's and EPA's bioassessment efforts should serve as the basis of setting standards that can provide quantitative and/or narrative standards for not only, water quality, but for marine habitats also.

FUNDING: Funds for the Section 319 Nonpoint Source Management Programs are appropriated annually by the United States Congress.

EPA Region IV receives an annual grant allocation for Section 319(h). Of this annual grant allocation, 50% of the funds are set aside to provide each state with a base amount to implement its programs. The other 50% is competitive money. The amount of competitive funds a state receives depends upon whether its proposed work plan for the ensuing year includes projects that attempt to control particularly difficult or serious nonpoint source pollution problems or projects that provide innovative methods or practices for controlling nonpoint source pollution. Region IV awards Section 319(h) grants to states with EPA-approved NPS management programs based on approvable workplans and competitive projects.

Over the past three years, Florida has received increased allocations. In 1990, the state received 1,294,000; in 1991, $1,479,000; and in 1992, $1,520,000. Continued increases will depend upon how well Florida can compete for the discretionary portion of the grant program.

STAFFING: There is only one person assigned full time to the Nonpoint Source Management Program in Region IV, which covers eight states. The U.S. Soil Conservation Service and the U.S. Forest Service have one individual each assigned to the Region IV Watershed Unit responsible for NPS pollution. It is recognized that from a nonpoint source perspective, especially in the South, any effective water quality improvement must be linked to land uses such as agricultural and forestry practices.

TRACKING: The work products resulting from the Section 319(h) grant program provide one method of tracking program compliance. The other method occurs by evaluating the progress the state makes toward implementing its nonpoint source management plan.

3.1.1.9 OCEAN DUMPING

PROGRAM RESPONSIBILITIES: The Coastal Regulatory Unit within the Wetlands, Oceans and Watersheds Branch administers the Ocean Dumping Program. There are two aspects to the program: the site designation process and the issuance of ocean dumping permits. The staff coordinates and interacts with all other EPA technical personnel involved in the site designation process. The staff also reviews and comments on proposed USACE ocean dumping permits.

AUTHORITY: Legislative authority establishing the Ocean Dumping Program is derived from Title I — Marine Protection, Research, and Sanctuaries Act ([MPRSA] as amended).

In addition, the program parameters are described in further detail in the provisions of 40 CFR 220 Subpart H — Ocean Dumping.

OBJECTIVE(S):

- To regulate the dumping of all types of materials into ocean water;
- To prevent or strictly limit dumping into ocean waters of any material that would adversely affect human health, welfare, or amenities, or the marine environment, ecological systems or economic potentialities.

JURISDICTION: All ocean waters of the United States are subject to the requirements imposed by the Ocean Dumping Program.

OPERATION: For a site to be designated for ocean dumping, it will require extensive study and evaluation. An Environmental Impact Statement (EIS) must be prepared. Because the designation process is the responsibility of EPA, EPA prepares the EIS internally. The process is complex and lengthy. Few sites are left to be designated. There was a site designated within close proximity to Key West; however, the designation was removed because it was never used. The designated site nearest to the Florida Keys is located in waters offshore of Miami.

Generally, ocean dumping permits are sought by a federal government agency such as the U.S. Navy or port authorities looking for a site to dump dredge material generated from harbor maintenance or harbor deepening projects. The USACE is the responsible agency in the permitting process only for dredged material, otherwise EPA has the lead. EPA reviews and comments on proposed permits for ocean dumping. In seeking an ocean dumping permit, the material the applicant seeks to discharge at one of the designated dump sites must undergo stringent testing for toxicity in sediments. Testing for mercury, radionuclides, and other potential toxic contaminants is required. There is a Testing Manual that identifies acceptable detection limits. Dredge material that cause a 20% mortality rate as compared to the reference sediment will not be allowed to be disposed of at the disposal site. Before any permit is issued from the USACE, the USACE issues a public notice for comments. It is at this time that EPA receives an opportunity to review and comment. EPA comments are based on the criteria set out in 40 CFR 220 — Subsection H. Permits generally have a life of three to five years before the permit needs to be renewed, though this is not fixed.

FUNDING: Staff positions are funded out of the EPA Region IV operating budget.

STAFFING: The program is administered by two individuals at EPA Region IV. They are responsible for six coastal states in the region.

TRACKING: Tracking occurs during the enforcement phase of the ocean dumping by the USACE.

3.1.1.10 UNDERGROUND INJECTION CONTROL

PROGRAM RESPONSIBILITIES: The EPA Underground Injection Control (UIC) staff has the responsibility of regulating and/or assisting states in managing the injection of fluids into wells so as to prevent endangering drinking water sources. Federal staff has regulatory functions as well as oversight duties in states that have been delegated UIC responsibilities.

AUTHORITY: Legislative authority for UIC is enabled under the Safe Drinking Water Act, Part C.

The rules under which the section functions are incorporated within the CFR as follows:

- 40 CFR Part 124 — Procedures for Decisionmaking;
- 40 CFR Part 144 — UIC Program;
- 40 CFR Part 145 — State UIC Program Requirements; and
- 40 CFR Part 146 — UIC: Criteria & Standards.

OBJECTIVE(S): To protect the underground sources of drinking water from contamination.

JURISDICTION: The scope of this program encompasses all areas within the FKNMS. This area, like all others in the United States, is subject to the provisions and regulations promulgated as a result of the Safe Drinking Water Act.

OPERATION: Florida has been delegated UIC program responsibility by EPA. The responsibilities are set out in an MOU. The Region IV UIC Section has oversight responsibility. Florida has authority to regulate Class I (hazardous waste injected below lowermost formation which is within 0.25 mile of a well used for potable water needs), Class III (minerals), Class IV (hazardous or radioactive waste injected above a formation which is within 0.25 mile of a well used for potable water needs), and Class V (40 CFR Part 146.5 defines Class V injection wells as those not included in Class I, II, III, or IV). There are 16 types of Class V injection wells. EPA retains regulatory responsibility for Class II wells (oil and natural gas).

Region IV personnel make periodic visits to FDER headquarters in Tallahassee to monitor program performance. If requested by the state, EPA UIC staff will provide technical advice during the permitting process. EPA is a member of the FDER Technical Advisory Committee that reviews design and construction programs, primarily for Class I wells. A complete compliance and tracking component is required as part of Florida's EPA-approved UIC program.

FUNDING: The Region IV UIC program administration costs are funded from the Region IV EPA operating budget that is funded annually through Congressional appropriations.

The Florida UIC program has received approximate: $200,000 annually from EPA to supplement the funds the state appropriates to operate its UIC program. The f ral funds amount to approximately 10% of the total Florida budget.

STAFFING: The Region IV UIC Section has 20 st members. Approximately two to three man-years of time are devoted annually to the Florida program. The b of that time is spent dealing with injection wells in southern Florida.

TRACKING: The UIC program is tracked in t ways. One method involves meeting with FDER staff responsible for the UIC program. Generally, these s occur at the FDER headquarters in Tallahassee; however, from time to time, EPA staff does visit FDER distr offices. Also, those permitted to operate an injection well must submit quarterly compliance reports to FDER d ict offices that subsequently are submitted to EPA. If these reports indicate that the district is not making progr toward achieving the goals of the annual grant work plan, EPA staff works closely with FDER staff to correct y deficiency.

3.1.1.11 MARINE SANITATION DEVICES

PROGRAM RESPONSIBILITIES: This program allows states to prohibit discharge of any sewage from all vessels; however, prior to enacting such a regulation or program, the state must first submit an application to EPA for approval. EPA has no enforcement powers requiring vessels to have such sanitation devices. Enforcement is in the domain of the U.S. Coast Guard (USCG).

AUTHORITY: Legislative authority giving EPA the responsibility for approving a state's prohibition on discharging waste from all vessels is enabled under Section 312 of the CWA.

Administrative rule 40 CFR Part 140 describes the standards for marine sanitation devices.

OBJECTIVE(S): To prevent the discharge of untreated or inadequately treated sewage into or upon navigable waters from new and existing vessels.

JURISDICTION: The scope of this program extends throughout the FKNMS.

OPERATION: If a state desires to prohibit sewage discharge from all vessels within its state waters, it must petition EPA for approval. Petitions may be initiated by private interest groups as well as by government entities but are forwarded to EPA via the Governor's office. Approval is contingent upon the application justifying the prohibition of discharge. The availability of pumpout facilities is the most important criteria in deciding whether or not to approve the petition. There has been only one application submitted and approved in Region IV, Destin Harbor in northern Florida. In addition to reviewing petitions, of which there have been only a few, the most time is spent on answering questions and providing the public with information about the program.

FUNDING: No funding is specifically earmarked for this program. The time that staff spends administering the program is absorbed in the general operating budget of EPA. Funding is appropriated annually by Congress.

STAFFING: Presently, the individual handling the Ocean Discharge Program serves as an information coordinator for marine sanitation devices.

TRACKING: No tracking of program performance occurs.

3.1.1.12 RESOURCE CONSERVATION AND RECOVERY ACT

PROGRAM RESPONSIBILITIES: Key program responsibilities involve the management and tracking of hazardous wastes from generator to transporter to treatment, storage, and disposal. In addition, other responsibilities include developing solid waste management plans; preparing guidelines for solid waste management; prohibiting open dumping; and encouraging recycling, reuse, and resource conservation and recovery systems. The RCRA staff also manages the cleanup of contaminated sites; however, unlike the Superfund program, the RCRA program deals with only <u>active</u> sites rather than inactive or uncontrolled sites that fall under CERCLA jurisdiction.

AUTHORITY: Legislative authority for the tasks performed by this section are enabled under the following laws:

- RCRA; and
- Hazardous and Solid Waste Amendments of 1984.

The rules under which the section functions are delineated in 40 CFR Parts 261 and 262.

OBJECTIVE(S):

- To protect human health and environment;
- To conserve valuable material and energy resources; and
- To encourage recycling, reuse, and treatment of hazardous wastes.

JURISDICTION: The scope of the program encompasses all areas within the Florida Keys and the FKNMS.

OPERATION: All defined RCRA activities must be permitted by EPA or a delegated state, whichever applies. Also, federal facilities are not exempt from the provisions of RCRA. If the state is a designated RCRA state, it can enforce RCRA on Federal Reservations with the exception of RCRA corrective actions. Corrective actions are handled by EPA.

All federal facilities with RCRA activities related to corrective action are permitted by EPA in an unauthorized state. The Federal Facilities Branch located in EPA's Waste Management Division is responsible for monitoring corrective action permits for violations. Enforcement of violations is handled by the RCRA Federal Facilities Branch. Within the Florida Keys, the Boca Chica Naval Air Station is seeking an open-burning and detonation permit from the EPA. EPA sends draft corrective action permits to states for comment.

Florida is a delegated state for the RCRA base program; therefore, it has a significant role in permitting and managing RCRA base program activities of federal and non-federal facilities. The RCRA function in Florida is housed in the Division of Waste Management of the FDER. While Florida has permitting and enforcement capability, EPA has oversight responsibility.

FUNDING: Region IV RCRA program staff positions are funded out of the general EPA Region IV operating budget.

The State of Florida receives approximately $2 million annually to implement the hazardous waste RCRA work plan. Grant funds have remained relatively stable over the past few years.

STAFFING: In EPA Region IV one person is assigned to Florida from the RCRA Permits Section, as well as an individual in the Federal Facilities Branch who is responsible for the Boca Chica Naval Air Station.

TRACKING: Two types of tracking occur in the RCRA program. One occurs as a result of EPA's state oversight responsibilities. An individual within the RCRA Permitting and Compliance Branch is assigned the responsibility of coordinating and monitoring the Florida program. Secondly, FDER must submit quarterly reports to Region IV that describe the status of all ongoing RCRA projects in the state. Also, EPA staff receives copies of all correspondence that occurs between the Florida solid/hazardous waste management staff and the various active projects.

3.1.1.13 COMPREHENSIVE ENVIRONMENTAL RESPONSE COMPENSATION AND LIABILITY ACT

PROGRAM RESPONSIBILITIES: Program responsibilities include identifying sites where hazardous substances have been or might have been released into the environment; ensuring that the sites are cleaned up by responsible parties or the government; evaluating damages to natural resources; and developing claim procedures for parties who have cleaned up sites or spent money to restore natural resources. This program focuses on remediation of inactive sites.

AUTHORITY: Legislative authority for the program is enabled under the following public laws:

- CERCLA; and
- Superfund Amendments and Reauthorization Act (SARA).

OBJECTIVE(S):

- To identify sites where hazardous substances have been, or might have been, released into the environment;
- To ensure that the sites are cleaned up by responsible parties or the government;
- To evaluate damages to natural resources; and
- To create a claims procedure for parties who have cleaned up sites or spent money to restore natural resources.

JURISDICTION: The scope of this program encompasses all areas within the Florida Keys and the FKNMS. This area, like all others in the United States, is subject to the provisions and regulations promulgated as a result of CERCLA and SARA.

OPERATION: The Region IV Superfund staff coordinates its efforts with FDER. While there are 30 Superfund sites in south Florida, there are none in the Florida Keys; therefore, this particular EPA program is not relevant to the FKNMS program. Federal installations that handle and dispose of hazardous materials like those used at Boca Chica Naval Air Station are managed under the RCRA program. The Naval Air Station is still an active facility; therefore, its activities are managed by the RCRA Section.

FUNDING: The Superfund staff costs are funded out of the Region IV operating budget.

STAFFING: There are 10 staff members assigned responsibility for administering the Superfund program south of Orlando.

TRACKING: Remediated sites are monitored every five years to evaluate continued effectiveness of the remedial action.

3.1.1.14 UNDERGROUND STORAGE TANKS

PROGRAM RESPONSIBILITIES: This program is responsible for regulating underground storage tanks (UST) to ensure that current and potential future drinking water sources are not contaminated by leaking tanks.

AUTHORITY: Legislative authority for the task performed by this section is enabled under the following public law:

- RCRA Subtitle I, Regulation of Underground Storage Tanks.

The administrative rules under which the unit functions are incorporated within 40 CFR Parts 280 and 281, Underground Storage Tank Regulations.

In addition, EPA has authorized the FDER through an MOA to implement the Underground Storage Tank Program in accordance with 40 CFR Part 280.

OBJECTIVE(S): To prevent USTs from leaking, to locate existing USTs that are leaking, and to clean up those that have been identified as having a leaking problem.

JURISDICTION: All USTs that exist within the FKNMS are subject to the rules and regulations of RCRA, Subtitle I.

OPERATION: RCRA Subtitle I grants EPA primary authority for developing and enforcing the UST Program. This program exempts all USTs larger than 110 gallons, tanks storing very low concentrations of regulated substances, and emergency backup tanks holding regulated substances for only a short period of time and expeditiously emptied after use.

Within Florida, USTs are regulated by the FDER through an MOA with EPA. Nothing in the MOA restricts in any way EPA's authority to fulfill its oversight and enforcement responsibilities under Subtitle I of RCRA. The state is responsible for implementing the technical standards, corrective action requirements, and financial responsibility requirements, as described in Part 280, Subparts A-H. This MOA is reviewed annually. Modifications to the MOA may be made to ensure consistency with the state program modifications, and federal regulatory changes, or upon request of either EPA or FDER.

FUNDING: Region IV UST program staff positions are funded in part with monies from the National Leaking Underground Storage Tank Trust Fund and from the general EPA Region IV operating budget.

Annually, Florida receives grant funds from EPA Region IV to assist the state in meeting its responsibilities under the MOA. The grant has averaged $160,000 annually.

STAFFING: The Region IV staff has three key functions: providing overall program oversight, enforcing compliance with the program requirements, and administering grant fund programs. Because Florida has an extensive program in place, Region IV staff focuses its attention on states with less sophisticated UST programs. No staffing needs were identified.

TRACKING: The FDER submits quarterly reports to Region IV that document the number of sites that had leaking tanks that have been cleaned up, and the number of new sites where leaking tanks have been found. In addition, Region IV staff meets approximately two to three times per year with FDER in its oversight capacity.

3.1.2 U.S. Coast Guard

3.1.2.1 OIL AND HAZARDOUS SUBSTANCE SPILLS

PROGRAM RESPONSIBILITIES: The 7th USCG District Marine Safety Office staff is responsible for spill contamination within navigable waters of the Florida Keys. As responsible agency, it is the first point of contact for all spills taking place in coastal waters.

AUTHORITY: The USCG receives its legislative authority regarding oil spill response from the Section 311 of the CWA.

OBJECTIVE(S): To ensure that the recovery and cleanup of oil and hazardous substances from the waters of the United States is done as quickly and efficiently as possible to eliminate any long-term impact to the marine environment.

JURISDICTION: The USCG has lead responsibility for oil spill response within or threatening the coastal zone (tidal waters); EPA directs cleanup in nontidal waters. Therefore, the USCG is the responsible agency in the FKNMS.

OPERATION: When a spill occurs, it becomes the primary duty of the responsible party to see that adequate actions are taken to clean up the spill. If a spill is handled by the responsible party or its contractor, the USCG assumes an oversight role. In that role, the USCG constantly monitors the effectiveness of the spill clean-up effort. As long as the spill is being adequately cleaned up, the USCG will not become directly involved. However, should the USCG determine that the effort is not being adequately handled, the USCG would assume responsibility and activate proper clean-up procedures. The USCG would contract with one of the clean-up firms that is on the USCG "Base Ordering Agreement" list. This list includes firms that have a successful spill clean-up history, proper equipment, experience with preferred USCG record keeping procedures, and clean-up crews with adequate levels of training.

If the spill occurs in open ocean waters or the scale of the spill is significant, the USCG activates the Gulf Coast Strike Team out of Mobile, Alabama. This occurs because independent contractors do not have the type of equipment necessary for large spills in open ocean waters. The Strike Team has skimmers and retrieval vessels available for immediate response.

The USCG interacts closely with NOAA during spill clean-up operations. There is a NOAA Scientific Support Coordinator located in Miami. This individual provides the USCG with information about the presence of sensitive environmental resources in the vicinity of the spill or in the area of the projected trajectory. Modeling oil spill trajectories is another support service NOAA provides to the USCG.

FUNDING: Administrative costs incurred in oil and hazardous substance spill operations are funded out of the USCG operating budget. Federal funds are available to underwrite the cost of cleanup. They come from the Oil Spill Liability Trust Fund. These costs are recoverable from the responsible party according to the CWA 311(b)(10) as amended by the Oil Pollution Act of 1990.

STAFFING: The Marine Safety Office has 10 individuals involved in marine pollution activities; however, dependent upon the seriousness of the event, additional USCG staff may be assigned to the task.

TRACKING: The USCG monitors spill clean-up operations of the responsible party or contractor as they are ongoing.

3.1.2.2 MARINE SANITATION DEVICES

PROGRAM RESPONSIBILITIES: The USCG has the responsibility of governing the design, construction, and installation of marine sanitation devices that either retain, dispose of, or discharge sewage. In addition, the USCG is responsible for ensuring that vessels contain USCG-certified marine sanitation devices.

AUTHORITY: Legislative authority for this program set out in Section 312 of the CWA.

The following administrative rules regulate activities related to marine sanitation devices:

- 33 CFR Part 159 — Marine Sanitation Devices Certification Process; and
- 40 CFR Part 140 — Marine Sanitation Device Standard.

OBJECTIVE(S): To prevent the discharge of untreated or inadequately treated sewage into or upon navigable waters from new and existing vessels equipped with installed toilets.

JURISDICTION: The scope of this program extends throughout the FKNMS.

OPERATION: Any individual or corporation that designs and builds a marine sanitation device must first submit the device to the USCG for certification. Marine sanitation devices are designed and operated to either retain, dispose of, or discharge sewage. The USCG has the authority to ensure that the device is working satisfactorily. Generally, the USCG only enforces the marine sanitation device provisions of 40 CFR Part 140 if it has boarded a vessel for some other reason, such as drug interdiction.

Section 312(f)(1) of the CWA gives the states the authority to regulate the design, manufacture, installation, or use of any marine sanitation device on a "houseboat" if state standards enacted under this section of the CWA are more stringent than those set out in Section 312 of the CWA. However, Florida has never sought to regulate marine sanitation devices. Houseboat is defined as "a vessel, which for a period of time determined by the state in which the vessel is located for a period time, *is used* primarily as a residence and *is not used* primarily as a means of transportation."

Further, under Section 312, states may establish "no discharge zones." These are areas in which a state has determined that the protection and enhancement of water quality requires greater environmental control such as prohibiting any discharge of sewage, whether treated or not from all vessels. However, such a prohibition cannot be enacted until EPA determines that adequate facilities for safe and sanitary removal and treatment of sewage from all vessels is reasonably available. If the EPA Administrator determines such a prohibition is warranted, he will by regulation prohibit such discharges.

FUNDING: No funding is specifically earmarked for this program. Staff costs are absorbed in the general operating budget of the USCG. Operating funds are derived from annual Congressional appropriations.

STAFFING: The USCG does not have anyone specifically assigned to this program. Generally, enforcement costs are absorbed in other USCG-funded programs.

TRACKING: No tracking of program performance occurs.

3.1.3 National Oceanic and Atmospheric Administration

3.1.3.1 FLORIDA KEYS NATIONAL MARINE SANCTUARY PROGRAM

PROGRAM RESPONSIBILITIES: NOAA has lead responsibility for preparing a comprehensive management plan for the FKNMS. The program is to be prepared in accordance with the procedures specified in Sections 303 and 304 of the MPRSA.

While all national marine sanctuaries are required to prepare comprehensive management plans, the FKNMS legislation recognized the overriding importance of water quality in the Florida Keys. Included in the legislation is the requirement to prepare a WQPP for the FKNMS. While NOAA does not have the lead role in the development of the WQPP, it will make a determination of whether or not the WQPP is consistent with the FKNMS Comprehensive Management Plan. EPA and the Governor of the State of Florida have lead responsibility in developing the WQPP for the FKNMS.

AUTHORITY: The FKNMS Program has been established based on the following public laws:

- Title III — National Marine Sanctuaries Act (as amended); and
- Public Law 101-605 — Florida Keys National Marine Sanctuary and Protection Act.

More specifically, the purposes of the WQPP will be to

1. recommend priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution;
2. assign responsibilities for the implementation of the program;
3. address legal, institutional, and management issues and recommend changes;
4. establish a comprehensive water quality program;
5. provide adequate opportunity for public participation; and
6. identify funding mechanisms to implement the WQPP.

OBJECTIVE(S): Three objectives are set out in the Florida Keys National Marine Sanctuary and Protection Act as follows:

- To protect the resources of the Florida Keys;
- To educate and interpret for the public regarding the Florida Keys marine environment; and
- To manage human use in the sanctuary consistent with the Act.

Further, Title III — National Marine Sanctuaries Act (as amended) contains the following objectives:

- To provide authority for comprehensive and coordinated conservation and management of those marine areas that will complement the existing regulatory authorities; and
- To support, promote, and coordinate scientific research of those marine waters.

JURISDICTION: The FKNMS area of jurisdiction extends seaward of the mean low tide line to the outer boundary as defined in the Florida Keys National Marine Sanctuary and Protection Act.

OPERATION: NOAA has primary responsibility to prepare the comprehensive management plan for the FKNMS. The WQPP prepared by EPA and the State of Florida is to be incorporated into the comprehensive management plan. NOAA is participating in the development of the WQPP in a consultation role, and providing technical information needed for developing the WQPP.

FUNDING: In 1991, $100,000 was appropriated for the Florida Keys WQPP under the Near Coastal Waters Program. In addition, $200,000 was provided through EPA Headquarters from the CWA, Section 104(b)(3). Funding for 1992 is being provided via Congressional add-on in the amount of $625,000.

STAFFING: NOAA has several staff members who participate in the development of the WQPP and provide technical information needed for the plan. One EPA staff member located in the Region IV Coastal Planning Unit works full time as the Florida Keys Project Manager and interacts frequently with the NOAA staff.

TRACKING: Tracking of program performance is based on milestones and work products set out in the annual work program. Frequent communication between the EPA Project Manager and other involved resource agencies and consultants occurs to ensure that the WQPP now being prepared results in an acceptable product. The WQPP will identify how compliance will be monitored.

3.1.3.2 COASTAL ZONE MANAGEMENT ACT

PROGRAM RESPONSIBILITIES: The Department of Commerce through NOAA has been charged with the responsibility of administering the provisions the CZMA. NOAA reviews and approves all state Coastal Zone Management Programs (CZMPs). Once approved, all federal activities within a state's defined coastal zone boundary must be consistent with the state's adopted CZMP, except when the "national interest" is at stake. Annually, NOAA provides grant funds to states to support the implementation of the CZMPs.

AUTHORITY: The legislative authorization establishing the federal role in managing the coastal ecosystem is set out in the CZMA.

OBJECTIVE(S):

- To protect, maintain, and develop the natural, commercial, recreational, ecological, industrial, and aesthetic resources in the coastal zone;
- To achieve coordination among state, regional, and local officials and agencies; and
- To involve citizens of the state in coastal zone issues.

JURISDICTION: All areas of the FKNMS are subject to the provisions of the CZMA.

OPERATION: NOAA approved Florida's CZMP in September 1981. Annually, NOAA processes the state CZMP grant application. These funds are used to augment those of the state for the purpose of implementing the state's CZMP.

FUNDING: NOAA staff positions are funded through the general operating budget of the agency. The amount of state CZMP grants is dependent upon annual Congressional appropriations. CZMP monies made available to states comes from Section 306 of the CZMA.

STAFFING: NOAA coordinates with the State of Florida regarding CZMP matters through the Gulf and Caribbean Branch of Coastal Programs, Division of Coastal Resource Management.

TRACKING: A thorough examination of the implementation and effectiveness of the state CZMP is undertaken every three years, and a limited review at the time the state CZMP grant is negotiated. The state also submits quarterly progress reports. NOAA staff makes periodic visits to Tallahassee to interact with the state administrators of the CZMP.

3.1.4 U.S. Army Corps of Engineers

3.1.4.1 DREDGE AND FILL REGULATION

PROGRAM RESPONSIBILITIES: The USACE Regulatory Division has responsibility for issuing and enforcing permits involving dredge and fill activities or permits for placement of structures in waters of the United States.

AUTHORITY: Legislative authority for the program is enabled under the following public laws:

- Section 10 of the Rivers and Harbors Act of 1899;
- Section 404 of the CWA; and
- Section 103 of the MPRSA.

OBJECTIVE(S): To determine whether the proposed activity is or is not contrary to the public interest. Criteria used to make such a determination address issues related to water quality degradation, endangerment to wildlife and plant communities, archeological impact, and public safety.

JURISDICTION: USACE jurisdiction extends throughout the Florida Keys and FKNMS. In the instance of Section 404 dredge and fill permits where both the USACE and EPA have specific and separate roles, the USACE and EPA have entered into a MOA regarding jurisdictional determination. In practice, the USACE generally makes the determination.

OPERATION: The focus of this operation description is on Section 404 permits. The USACE has primary responsibility for issuing Section 404 permits for the discharge of dredge and fill material into "navigable waters." In the Florida Keys, much of the land area falls under the USACE jurisdiction. Compared to the other southern Florida counties of Palm Beach, Broward, and Dade, the number of Section 404 applications submitted in Monroe County is considerably higher. In the past year, over 150 applications were submitted from Monroe County. Statewide, an estimated 1,000-1,500 applications were processed by the USACE. The permit applications ranged from requests to place fill on lots for house pads and driveways, to fill needed to plant trees in yards.

Initial screening of permits is conducted out of the Miami USACE office. The more complex and controversial permits are processed in the Jacksonville District USACE office. The USACE has one full-time staff person stationed in Marathon whose sole job involves processing various aspects of Section 404 permit applications in the Florida Keys. Most of his time is spent making jurisdictional determinations and conducting permit compliance inspections. Jurisdictional determinations are undertaken when requested by citizens wanting to know if a permit is required. EPA has authority to determine jurisdiction as well; however, the Agency generally defers to the USACE.

During the permitting process, the USACE sometimes discusses projects with relevant federal resource agencies, i.e., Department of Agriculture, Department of Agriculture's Stabilization and Conservation Service, the Department of Interior's U.S. Fish and Wildlife Service (FWS), the Department of Commerce's National Marine Fisheries Service (NMFS), and EPA. In the Florida Keys, the USACE consults primarily with EPA, NMFS, and FWS.

Both the USACE and EPA have enforcement responsibilities under Section 404. EPA has statutory enforcement authority for cases in which <u>no</u> permit has been obtained prior to the dredging or filling of material into "navigable waters" of the United States. The USACE only provides enforcement for cases in which there has been a violation in a Section 404 permit they have issued. Both the USACE and EPA have authority to seek civil or administrative remedies for discharges into wetlands. In addition, EPA can pursue criminal action in its enforcement areas.

Under Section 404(c), the EPA can "veto" permits that have already been USACE-approved if use of the site will have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas, wildlife, or recreational areas. In reality, EPA had exercised this veto action only 11 times nationwide since the CWA was enacted.

There are three MOAs between the USACE and EPA. They address procedures and coordination matters. One involves an "elevation" of a permit decision if EPA has serious objections to the proposed permit written by the USACE. The "elevation" delays the project and subjects the proposed permit to higher peer review. Another MOA between the USACE and EPA addresses the issue of mitigation, and the third MOA addresses jurisdiction.

Compliance reviews are conducted by staff members as well as by a private contractor. The contractor is used for initial compliance review of selected permits. This is a sort of "screening process" that allows the USACE to focus attention on the more serious violations. Based on the results of the initial review, if additional compliance inspections are warrante , they are conducted by USACE staff.

FUNDING: The USACE Section 404 activities are funded through annual Congressional appropriations. Although no specific funding figures were available, it was indicated that funding has gone up significantly over the past several years. Increased funding has resulted in the Jacksonville District hiring 11 people during the past year.

STAFFING: There is one full-time field person located in Marathon. The only other staff person working full time on USACE Florida Keys projects is located in the Jacksonville District Office. Although there is a Miami office, it is involved only minimally. It becomes involved when there is an unusually high number of permit applications in the Florida Keys.

TRACKING: Information generated via the permitting and compliance process is being entered into the USACE database known as the Regulatory Analysis Management System (RAMS). It contains the Section 404 permits and special conditions, as well as data on compliance inspection. The existing RAMS database can be queried by the USACE Project Manager; however, this feature has not been used that much to date. As the database evolves and the level of computer sophistication increases, it is anticipated that querying of the database will increase. The USACE does not share its permit database information with other federal, state, regional, or local agencies.

3.1.5 U.S. Fish and Wildlife Service

3.1.5.1 FISH AND WILDLIFE COORDINAT ON ACT

PROGRAM RESPONSIBILITIES: To protect e wildlife resources and associated habitats, the FWS is directed to provide technical assistance to Federal, State, a l public and private agencies and organizations, to make surveys and investigations of wildlife of the public dom , including lands and waters acquired or controlled by federal agencies, and to accept donations of land and cor ibutions of funds to further the protection of the wildlife and its habitat.

AUTHORITIES: The FWS receives its legislati authority through Public Law 85-624, 72 Stat. 563; 16 U.S.C. 661 et seq.

OBJECTIVE(S): To provide that wildlife cons rvation receives equal consideration and is coordinated with other features of water-resource development progr ns through effective and harmonious planning, development, maintenance, and coordination with wildlife conservation and rehabilitation efforts.

JURISDICTION: The scope of the program encompasses all areas within the Florida Keys and the FKNMS.

OPERATION: Coordination of wildlife resources and habitat concerns in the Florida Keys is administered out of the FWS Vero Beach Office of Ecological Services. The office serves an area extending from Tampa/Vero Beach, south.

Coordination activities involve both, regulatory and planning matters. In the Keys, most coordination issues involve dredge and fill permit applications; however, the FWS has also assisted in the Smathers Beach beach renourishment program, and has been involved in discussions regarding the siting of a school on Big Pine Key. The Service has been active in the development of the FKNMS planning effort.

Whenever a federal agency seeks to undertake a project or any public or private agency seeking a federal permit or license (e.g., dredge and fill), the applicant must consult with the FWS. When a request is received, the FWS investigates and prepares a report containing an analysis of the impacts of the proposed action on the wildlife resources and associated habitat, and recommendation(s) to mitigate the loss of or damage of the wildlife resources and habitat.

FUNDING: Annually, the FWS funds a portion of the program out of its operating budget. This provides the program with a "base level of funding". Additional revenues are generated via federal interagency transfers. Whenever a federal agency requests that the FWS conduct an investigation and prepare a report regarding a specific federal permit or project, the agency must cover the cost to conduct the FWS evaluation. In the case of state or local agencies, or private organizations, the FWS baseline funding covers the expenses incurred.

STAFFING: The Vero Beach office has several biologists that handle regulatory responsibilities; however, only one of those individuals is assigned to the Keys. This person also is responsible for activities occurring in Dade County. There are three other biologists that serve specialized roles. One deals solely with endangered species issues, another is involved in environmental contaminants and marine ecology, and the third deals with beach erosion and renourishment issues as they relate to wildlife resources and habitat. There is a shortage of staff; therefore, project monitoring suffers.

TRACKING: The project reports and recommendations prepared by the FWS staff is followed up to some degree. The quality of the monitoring effort depends upon staff limitations. The FWS tracks projects through status or monitoring reports, and field inspections (number of inspections depends upon manpower available). The FWS has no methodology for evaluating program effectiveness.

3.1.5.2 ENDANGERED SPECIES ACT OF 1973

PROGRAM RESPONSIBILITIES: Federal agencies are required to consult with the FWS to ensure that their proposed federal permit action or project will not jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined by the Secretary of the Interior, after consultation as appropriate with the affected state, to be critical, unless exempted from such protection in accordance with the exemption process set out in the Act.

AUTHORITIES: Legislative authority for this program is set out in the Endangered Species Act of 1973. The administrative rule specifying the responsibilities of the FWS is 50 CFR.

OBJECTIVE(S):

- To provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved; and
- To provide a program for the conservation of such endangered species and threatened species that are in danger of or threatened with extinction.

JURISDICTION: The scope of the program encompasses all areas within the Florida Keys and the FKNMS.

OPERATION: Relative to the Florida Keys, this program's regulatory responsibility rests with the FWS Office of Ecological Services located in Vero Beach. Each federal agency is required to ensure that any action it authorizes or carries out is not likely to jeopardize the continued existence of endangered or threatened species, or result in destruction or adverse modification of their critical habitat. Once consultations and investigations are completed a written statement setting forth the Department's opinion is prepared. If jeopardy or adverse modification is determined, the Department will suggest reasonable and prudent alternatives that can be taken to implement the federal agency action.

The program contains penalty and enforcement provisions that are to ensure compliance with the provisions of the Act.

The FWS is involved in the envir onmental planning and management of "Trust Resources" (i.e., migratory birds, raptar birds, andranomous fishes, habitats of above, wetlands). This can include preparation of recovery plans. Also, the FWS becomes involved in oil spill contingency planning.

FUNDING: The Endangered Species program is funded out of the FWS general operating budget.

STAFFING: Staff located in the Florida Keys are involved in refuge management. The Vero Beach office has several biologists that handle regulatory responsibilities; however, only one person is assigned to the Keys. This individual also has programmatic responsibility for Dade County. Within the Vero Beach office there is only one biologist with expertise regarding wildlife and habitat having a federal designation as Threatened and Endangered Species. This one individual must cover all areas south of Tampa/Vero Beach. This program also includes two enforcement officers located in Miami responsible for enforcing the provisions of the Act.

TRACKING: The program is tracked through status and monitoring reports and/or field inspections. Violations are pursued in accordance with the program's enforcement provisions.

3.2 STATE

3.2.1 Florida partment of Agriculture

3.2.1.1 MOSQUITO CONTROL

PROGRAM RESPONSIBILITIES: The state M squito Control Program is administered by the Bureau of Entomology and Pest Control. Responsibilities o he state office involve oversight responsibility for all local mosquito control programs; review and approval ll county or mosquito control district work plans and work budgets; and administration of state funding progr s.

While the State's function is more administrative nature, local mosquito control districts implement arthropod control. In Monroe County, the Mosquito Contro District is an independent special taxing district comprised of a locally elected board. The Mosquito Control trict headquarters is located on Stock Island. Its primary responsibilities involve eradication of adult mosquit and larval control.

AUTHORITY: Legislative authority for the Mosq Control Program is contained in Chapter 388 Florida Statute (FS).

OBJECTIVE(S):

- To achieve and maintain such levels of arthropod control as will protect human health and safety and foster the quality of life of the people;
- To promote the economic development of the state, and facilitate the enjoyment of its natural attractions by reducing the number of pestiferous and disease-carrying arthropods; and
- To conduct arthropod control in a manner consistent with protection of the environmental and ecological integrity of all lands and waters throughout the state.

JURISDICTION: This program is administered by the Florida Department of Agriculture throughout Florida. The Mosquito Control District has jurisdiction throughout Monroe County, including both incorporated and unincorporated areas.

OPERATION: The Bureau of Entomology and Pest Control permits the types of application procedures that local mosquito control districts must use. The Bureau also conducts training courses and licenses operators.

The Mosquito Control District applies pesticides via aerial spraying or truck spraying to control the adult mosquito population. Which method is used depends on the level of infestation, which is determined by the information (e.g., mosquito counts) District inspectors collect daily throughout the Florida Keys. Aerial spraying is conducted out of the Marathon Airport. In addition to Marathon, there are three other staging areas in the Florida Keys. They are Key Largo (at Mile Marker 100), Islamorada, and Stock Island.

FUNDING: The primary source of funds for the Monroe County Mosquito Control District are generated from ad valorem taxes. Historically, the District received substantial funds from the State, approximately $135,000 annually; however, recent cutbacks in state revenues have severely curtailed the amount of state funds to the District. It is anticipated that the District will receive approximately $15,000 for fiscal year 1992-1993.

STAFFING: There are 8 full-time professional staff members assigned to the Mosquito Control Program in the Department of Agriculture. The District has 36 full-time staff members. Sixteen are field inspectors. Others include office administrators, supervisors, a pilot, and mechanics.

TRACKING: The Mosquito Control District maintains detailed logs containing the locations where all applications of pesticides are made, when they are made, how they are made (i.e., aerial spraying or surface spraying), and specifically what types of pesticides are used. These logs are transferred to the Bureau and maintained for future reference.

District field inspectors also maintain detailed records of mosquito counts they make daily. The District Director is hoping to computerize the information once funds become available.

3.2.2 Florida Department of Community Affairs

3.2.2.1 AREAS OF CRITICAL STATE CONCERN

PROGRAM RESPONSIBILITIES: The Areas of Critical State Concern (ACSC) staff is located in the Bureau of State Planning. It is responsible for review of all development plans and permits including site visits; administration of all resource planning and management committees and review of all comprehensive plans, plan amendments, and development regulations within designated ACSC

AUTHORITY: Legislative authority for administering this program is contained in Section 380.05 FS.

OBJECTIVE(S): The objective of this program is to provide another level of legislative review for development plans within areas where unique and fragile natural resources exist and local protection is lacking. ACSC are declared where there is a perceived need to protect public resources from risk by unregulated or inadequately regulated development. Specific ACSC objectives that address water quality issues in the FKNMS are as follows:

- To coordinate with local governments and planning authorities responsible for the Florida Keys area to ensure that their adopted comprehensive plans or amendments to the adopted plans are consistent with the legislative principles adopted for guiding development in ACSC;
- To strengthen local government capabilities for managing land development and growth in a manner consistent with ACSC principles so that the ACSC designation may be removed from the Florida Keys;
- To protect marine resources and shorelines including wetlands, mangroves, seagrasses, coral reefs, and their respective faunas;
- To protect upland resources including tropical biological communities, freshwater wetlands, native vegetation, dune ridges, beaches, and wildlife; and
- To limit the adverse effects of development on water quality throughout the Florida Keys.

JURISDICTION: Technically, this program has very little jurisdiction with the FKNMS area because the ACSC program jurisdiction ends approximately 250 ft seaward of the mean high water line. However, this program is important to the FKNMS because of the limits placed on upland development.

OPERATION: Local governments within an ACSC must give notice to the Florida Department of Community Affairs (FDCA) of any development permit application, amendment to the adopted comprehensive plan, or revision or addition to the local government's land development regulation for review and comment. The FDCA may appeal any development order issued by a local government to the Governor and Cabinet. No work authorized by the developer can take place once an appeal has been filed. Following a hearing, the Governor and Cabinet issue a decision either granting or denying permission to develop, based on standards and rules in Chapter 380 FS known as the Principles for Guiding Development. The Governor and Cabinet may attach specific conditions and restrictions to their decision. The FDCA must approve any amendments to the comprehensive plan or land development regulation or they do not become effective. While a number of areas have been studied for designation, only five areas have actually been designated since the legislation was originally enacted in 1979.

In addition to reviews of development permits, comprehensive plan amendments, and revisions or additions to local government land development regulations, the FDCA, in accordance with the statutory law defining this program, established the Florida Keys Resource Planning and Management Committee. The purpose of the committee is as follows:

- To serve as liaison ber ... en state and local governments;
- To make recommend... s to the FDCA as to the sufficiency of the comprehensive plans and land development regulati... n the Florida Keys;
- To make recommen... s to the FDCA concerning changes in regional and state comprehensive plans and regulatory prog... affecting the Florida Keys;
- To assist local gover... nts in carrying out planning functions; and
- To review all govern... t agency reports relative to the Florida Keys.

The committee functions through fo... subcommittees: the ACSC Subcommittee (responsible for reviewing progress of local governments in relation to ... als of the ACSC program), Intergovernmental Coordination Subcommittee, Water Quality Subcommittee, and ... mprehensive Planning Subcommittee. These committees meet from time to time to coordinate policy matters t... arise in the Florida Keys. The Water Quality Subcommittee has been quite active. Recently, the Subcommitte... nalized a series of water-quality recommendations that addressed issue areas such as wastewater, stormwater, m... nas, and mosquito spraying.

Further, Section 380.051 FS des... es steps to be taken to institute a coordinated agency review process. Coordinated agency review means ... view of the proposed location, densities, intensity of use, character, major design features, and environmental ... pacts of a proposed development. It directs the FDCA to develop by rule coordinated agency review proced... with various state agencies, which must also adopt rules specifying review procedures. At a minimum, it is ... nclude the FDER, Florida Department of Natural Resources (FDNR), and Florida Department of Health and ... abilitative Services (FDHRS). In addition, it mandates that state and regional agencies enter into local intergove... ntal agreements with local governments in the Florida Keys to achieve a more streamlined set of permitting proc... s. This would include standardizing review procedures, data requirements, and data collection methodologies. ... hile this portion of the statute has never been fully implemented, it still remains in the statute.

FUNDING: This program was funde... itially by a $6-million appropriation specifically for the Florida Keys from the state legislature in 1986. A l... ge portion of this money has been spent on land acquisition and on comprehensive planning. Current funding comes from the ACSC statewide trust fund.

STAFFING: Bureau of State Planning personnel assigned to the ACSC program include five administrative personnel in Tallahassee and five agency field office personnel located in Key West.

TRACKING: This program is administratively tracked by the development orders, comprehensive plan amendments, and changes to land development regulations. Success or failure of the program depends on meeting goals established in the Principles for Guidance Development; however, there is no comprehensive monitoring program in place to assess the biological health of the natural resources.

3.2.2.2 DEVELOPMENTS OF REGIONAL IMPACT

PROGRAM RESPONSIBILITIES: The Developments of Regional Impact (DRI) Program is administered by the DRI staff located within the Bureau of S· Planning. A DRI is defined as a development that, because of its size, character, and location, would substantia ;y affect the health, safety, or welfare of the citizens of more than one county. There are 14 types of development subject to the DRI rules, including large residential projects, offices, industrial sites, retail uses, hospitals, marinas, airports, post-secondary schools, mining operations, petroleum storage facilities, and hotels. This program involves a comprehensive assessment of the regional impacts by the appropriate Regional Planning Council (RPC) prior to the proposed development being approved by local government.

AUTHORITY: Legislative authority that authorizes the DRI process is contained in Section 380.06 FS — Environmental Land and Water Management. The rules through which this process functions are set forth in Chapter (9J-2 of the Florida Administrative Code (FAC).

OBJECTIVE(S):

- To protect the natural resources and environment of the state;
- To ensure a water management system that will reverse the deterioration of water quality and provide optimum utilization of limited water resources;
- To facilitate orderly and well-planned development; and
- To protect the health, welfare, safety, and quality of life of the residents of the state.

JURISDICTION: The DRI process applies to all areas of Monroe County just as it does in any other county in the State of Florida.

OPERATION: The Bureau of State Planning DRI staff is responsible for determining if a project requires a DRI review. If the project is determined to be a DRI, the developer must then file an application document with the local government of jurisdiction, the appropriate RPC, and the Bureau of State Planning. The DRI process is coordinated by the local RPC and includes participation of all interested agencies. In the case of developments adjacent to the FKNMS, this will be the South Florida RPC. Undoubtedly, many environmental groups associated with the FKNMS would participate. The local RPC receives technical support from the Bureau of State Planning staff in Tallahassee. The RPC submits an assessment report that summarizes the anticipated impacts and recommends to local government whether the project should be approved, modified, or denied. Local government is required to make the final decision on the approval or denial of the DRI at a public hearing. The developer, RPC, and FDCA have the right to appeal this decision to the Governor and Cabinet sitting in their capacity as the Land and Water Adjudicatory Commission.

Recently, the Marathon Airport terminal expansion underwent a DRI review. The RPC indicated that the Key West Airport expansion program may also trigger DRI review. In terms of water quality, airport expansions are of concern, because existing facilities are close to coastal waters and hazardous materials are heavily used. Further, new marinas 150 wet slips or greater or 200 dry slips or greater, are a DRI and among other issues, create a water quality concern.

FUNDING: Positions in the Bureau of State Planning are funded out of the state operating budget. The South Florida RPC defrays such costs by imposing special DRI fees.

STAFFING: There are 18 positions within the DRI Section of the Bureau of State Planning. Of those, one person is assigned to monitor and track DRIs in Broward, Dade, and Monroe counties. In terms of the RPC, there is a DRI Coordinator; however, there are seven other planners who provide technical support in various aspects of DRI reviews such as traffic, environment, drainage, and wastewater.

TRACKING: The progr is tracked through letters of interpretation, DRI applications and documents, and annual DRI monitoring reports submitted by the RPC. In addition, the FDCA and RPCs coordinate with one another extensively.

3.2.2.3 LOCAL COMPREHENSIVE PLANNING

PROGRAM RESPONSIBILITIES: The overall statewide responsibilities of the local comprehensive planning process are as follows:

- Plan for sound infrastructure;
- Properly manage natural resources;
- Provide for adequate education;
- Maintain an attractive quality of life;
- Provide a regulatory atmosphere that encourages enterprise; and
- Develop fiscal stability characterized by reasonable tax rates.

AUTHORITY: Legislative authority for the comprehensive planning process is mandated under the following statutes:

- Chapter 163 Part II FS — The Local Government Comprehensive Planning and Land Development Regulation Act — Confers on local officials the statutory authority and responsibility to plan and regulate the use of land by adopting local comprehensive plans and land development regulations;
- Section 186.507 FS — Outlines the requirements of comprehensive regional policy plans;
- Chapter 187 FS — The State Comprehensive Plan — A compilation of goals and objectives that Florida is to achieve through the planning process; and
- Chapter 380 — Land and Water Management.

The rules that implement Section 163.3161 FS are as follows:

- Chapter 9J-5 FAC — Minimum Criteria for Review of Local Government Comprehensive Plans and Determination of Compliance;
- Chapter 9J-11 FAC — Submittal Requirements for Proposed Local Government Comprehensive Plans; and
- Chapter 9J-24 FAC — Procedures and Criteria for the Review of Land Development Regulations.

OBJECTIVE(S): Local governments have the responsibility for regulating and planning the use of lands and land development within their jurisdictions. The Bureau of Local Planning is responsible for reviewing local government growth management plans and ensuring that the plan is in compliance with the requirements of Rule 9J-5 FAC, and is integrated on state, regional, and local levels. Vertical integration occurs among the State Comprehensive Plan, comprehensive regional policy plans, and local government comprehensive plans. Land development regulations must be adopted that are consistent with and implement the local comprehensive plan. Levels of service standards that are adequate and realistic must be adopted for public services and facilities located within each government's jurisdiction.

JURISDICTION: The comprehensive planning process as coordinated under the Bureau of Local Planning affects all upland areas adjacent to the FKNMS (i.e., Monroe County). There are four local government entities in this area, including Monroe County, the City of Key West, the City of Layton, and the City of Key Colony Beach. In addition, the regional comprehensive plan developed by the South Florida RPC affects water quality within the FKNMS in the same manner as local government plans.

The local government comprehensive plan process has the potential to significantly affect water quality within the FKNMS based on:

- Maintaining or reducing hurricane evacuation time, which would create restrictions on upland development limiting future growth in the Florida Keys;
- Control of upland land development procedures;

- Stormwater runoff retention requirements; and
- Sanitary sewer and wastewater treatment facilities level of service requirements.

OPERAT N: The comprehensive planning process for the Florida Keys has been an interactive process between the FDCA and the government entities in Monroe County. This process is facilitated by a FDCA field office located in Key West. Field office staff members review the plan for consistency with the Principles for Guiding Development, and make recommendations to the main office in Tallahassee. Final decisions on the acceptability of the proposed comprehensive plans and their amendments are made in Tallahassee.

The current status of the local government comprehensive planning process in the Florida Keys is as follows.

- Monroe County has adopted and submitted its plan. The plan has been found to be noncompliant. Negotiations were conducted and a settlement agreement was signed (see below). A remedial plan has been submitted to the FDCA. This plan is being revised by the County and is due to be adopted in early 1993. Another compliance determination will be made by the FDCA at that time.
- The City of Key West has adopted and submitted an initial plan which was found to be noncompliant. The City has been working with FDCA staff and some differences have been resolved, but the FDCA and the City have yet to officially enter into a settlement agreement.
- The City of Layton has adopted and submitted a plan which was found to be noncompliant. No settlement agreement has been reached between the City of Layton and the FDCA.
- The City of Key Colony Beach has adopted a plan and submitted it to the FDCA. This plan was originally rejected by rule, but subsequently amended by the City and approved by the FDCA.

Exhibit C (Monroe County Remedial Actions) of the FDCA's Settlement Agreement with Monroe County contains the following amendments to existing policy statements affecting water quality within the FKNMS.

- Storm Water Plan — The County should complete a Storm Water Master Plan within one year of funding becoming available for the necessary engineering studies. A long-term funding source such as a "stormwater authority" is to be established specifically for the implementation of the stormwater management plan. The master plan will incorporate drainage level of service standards for all developed and/or redeveloped areas, and best management practices for single family residences, which address water quality and quantity.
- Wastewater Plan — The County should develop, through the Florida Keys Aqueduct Authority (FKAA) or other appropriate entity, a comprehensive wastewater management plan that will address central sewer system possibilities, package plants, and alternative on-site disposal systems. This master plan shall contain a fully integrated approach to water management from the well head in Florida City through final use and disposal.
- On-site Sewage Disposal System (OSDS) — The County shall establish a remedial plan defining nutrient limiting standards for OSDSs that will apply to all development in the Florida Keys, including subdivision lots that were platted before 1971. The County shall require systems that are efficient at removing phosphate and total nitrogen from effluent. The County will work with the FDHRS to establish uniform standards for nonconventional septic tanks and treatment systems in the Florida Keys. Included in the remedial plan will be standards for the type of systems required, allowable density, minimum elevation the bottom of the septic tank must be above the water table, setbacks, and other limiting factors to ensure protection of surface and groundwater.

FUNDING: $247,000 was allocated for the comprehensive planning process in Monroe County in 1991. As yet, no funds have been allocated to Monroe County for 1992.

STAFFING: The Bureau of Local Planning has a total staff of 56 personnel to review comprehensive plans for 459 government entities within the State of Florida. Responsibilities also include technical assistance to the local governments, review of the amended plans for consistency, and negotiating settlement agreements. Six staff members in Tallahassee are currently working with comprehensive plans from the Florida Keys area. Field staff members located in the Key West office are also assigned comprehensive plan review responsibilities. As mandated by Section 163.3184(4) FS, the FDCA staff must seek comments from other state agencies such as the FDER and FDNR.

TRACKING: Local governments must prepare periodic progress reports that evaluate the success local governments are making in achieving their adopted plan objectives. These documents are known as Evaluation Appraisal Reports. When deficiencies have been noted, local governments must recommend corrective actions. These reports must be submitted to the FDCA no later than five years from the date of adoption of the local government's comprehensive plan.

3.2.2.4 COASTAL ZONE MANAGEMENT

PROGRAM RESPONSIBILITIES: The overall responsibilities of the CZMP are as follows:

- To protect, maintain, and develop the natural, commercial, recreational, ecological, industrial, and aesthetic resources in the coastal zone through coordinated management;
- To involve the citizens of the state in addressing issues in the coastal zone; and
- To amend existing statutes or provide additional regulatory authority to any government body if it meets the federal consistency provisions of Section 380.23 FS.

AUTHORITY: Legislative authority establishing the CZMP in Florida is set out in Section 380.2 FS.

OBJECTIVE(S): To develop and implement a CZMP for the State of Florida and to achieve coordination among state, regional, and local officials and agencies.

JURISDICTION: "Section 380.21 requires the State of Florida to prepare and submit to the U.S. Department of Commerce a coastal zone management plan which includes the boundaries of the coastal zone. This plan defines the boundary of the coastal zone as the entire state of Florida."

OPERATION: During the 1992 legislative session, the CZMP was transferred from the FDER to the FDCA. In recent years, the program was primarily a grant program channeling funds to special projects that affect or further the protection, maintenance, or development of Florida's coastal resources. Besides the grant aspects of the CZMP, an important feature of the CZMP is the federal consistency provision. The CZMA requires all proposed federally approved activities (e.g., offshore oil drilling, proposed federally financed wastewater treatment facilities, etc.) planned within the jurisdictional boundaries of the State of Florida to be consistent with the state's adopted CZMP, except when the "national interest" is at stake.

Because the program has been transferred from FDER to FDCA, FDCA staff has indicated that program emphasis will shift from one of a granting program to one that will see staff and coastal management committees more involved in addressing substantive management issues and problems that ultimately become reflected in state policy. Staff members will prepare issue position papers, and the Interagency Management Committee will review and make policy recommendations.

FUNDING: Staff positions are funded out of FDCA's operating budget.

STAFFING: The CZMP is located in the Office of the Secretary, FDCA. There are a total of 15 positions.

TRACKING: In the past, grant program performance was tracked based on staff's evaluation of the work products and interaction with grant recipients.

3.2.3 Florida Department of Environmental Regulation

3.2.3.1 FLORIDA KEYS NATIONAL MARINE SANCTUARY PROGRAM

PROGRAM RESPONSIBILITIES: The State of Florida and EPA have joint responsibility in developing a WQPP for the FKNMS. The Governor has assigned primary responsibility for program implementation to the FDER. Within the FDER there is an individual whose activities include coordinating the WQPP work program with all state and regional agencies as well as interacting with EPA staff, reviewing and commenting on all work products produced by consultants, and ensuring effective intergovernmental coordination and public participation.

AUTHORITY: Legislative authority for National Marine Sanctuaries is set out in Title III of the Marine Protection, Research, and Sanctuaries Act (as amended). More specifically, the Florida Keys National Marine Sanctuary Program has been authorized by Public Law 101-605, Florida Keys National Marine Sanctuary and Protection Act.

OBJECTIVE(S): Three objectives are set out in the Florida Keys National Marine Sanctuary and Protection Act as follows:

- To protect the resources of the Florida Keys;
- To educate and interpret for the public regarding the Florida Keys marine environment; and
- To manage human use in the FKNMS consistent with the Act.

Further, Title III of the National Marine Sanctuaries Act (as amended) contains additional objectives that are as follows:

- To provide authority for comprehensive and coordinated conservation and management of these marine areas that will complement the existing regulatory authorities; and
- To support, promote, and coordinate scientific research of these marine waters.

More specifically, the purposes of the WQPP will be to

1. recommend priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution;
2. assign responsibilities for the implementation of the program;
3. address legal, institutional, and management issues and recommend changes;
4. establish a comprehensive water quality program;
5. provide adequate opportunity for public participation; and
6. identify funding mechanisms to implement the WQPP.

JURISDICTION: The FKNMS program has jurisdiction seaward of the mean high tide line to the outer limits of the FKNMS as defined in the Florida Keys National Marine Sanctuary Act; however, Florida's jurisdiction extends only to the outer boundaries of state waters.

OPERATION: FDER and EPA Region IV staffs are responsible for seeing that the WQPP for the FKNMS is produced in a timely fashion. The work effort includes administering and monitoring the consulting team contracted to prepare a draft WQPP. Project management also includes expediting technical information exchange and coordinating meetings between the consultant and technical staff of FDER and other state agencies. The FDER Project Manager is involved in scheduling all public and technical work sessions.

FUNDING: In 1991, $100,000 was appropriated for the Florida Keys under the Near Coastal Waters Program. In addition, $200,000 was provided through EPA headquarters from the CWA, Section 104(b)(3). Funding for 1992 is being provided via Congressional add-on in the amount of $625,000. The FDER Project Managers's staff position is funded from CZMP monies the state receives from NOAA.

STAFFING: There is one FDER staff member located in the FDER headquarters in Tallahassee who works full time on Florida Keys issues related to the FKNMS program.

TRACKING: Tracking of program performance is based on milestones and work products set out in the work program. Frequent communication between the FDER Florida Keys Coordinator, the EPA Project Manager, and other involved resource agencies and consultants occurs to ensure that the WQPP now being prepared results in an acceptable product. The WQPP will identify how compliance will be monitored.

3.2.3.2 DOMESTIC WASTEWATER

PROGRAM RESPONSIBILITIES: The Domestic Wastewater Program at the district level within the FDER is responsible for the review, approval, and permitting of local domestic wastewater treatment facilities. The Tallahassee Domestic Wastewater Section provides technical oversight and guidance to the permitting procedure. The section is also responsible for formulating FDER rules related to wastewater treatment, reuse, and disposal of wastewater and residuals (sludge). This section also acts as the liaison between the FDER and FDHRS on on-site sewage disposal issues.

The Ft. Myers District Office, which is responsible for Monroe County, is involved in permitting domestic wastewater treatment facilities that generate more than 2,000 gallons of flow per day and all on-site wastewater treatment and disposal in excess of 5,000 gallons per day. Systems falling below these standards are regulated by the Monroe County Public Health Unit.

AUTHORITY: Legislative authority for the Domestic Wastewater Program is contained in the following statutes:

- Section 373.016 FS — Declaration of policy of the Florida Water Resources Act of 1972;
- Section 373.026 FS — General powers and responsibilities of the FDER regarding Florida's water resources;
- Section 403.021(2) FS — Legislative policy regarding wastewater;
- Section 403.061 FS — Powers and responsibilities of the FDER concerning the control of air and water pollution;
- Section 403.085 FS — Secondary wastewater treatment; and
- Section 403.086 FS — Secondary and additional wastewater facilities.

The rules under which the Domestic Wastewater Section operates are as follows:

- Chapter 17-3 FAC — Water Quality Standards
- Chapter 17-4 FAC — Requirements for Permits
- Chapter 17-28 FAC — Underground Injection Control
- Chapter 17-28.700 FAC — Ground Water Monitoring Requirements
- Chapter 17-302 FAC — Surface Water Quality Standards
- Chapter 17-600 FAC — Domestic Wastewater Facilities
- Chapter 17-601 FAC — Domestic Wastewater Treatment Plant Monitoring
- Chapter 17-603 FAC — Operator Certification
- Chapter 17-604 FAC — Collection Systems and Transmission Facilities
- Chapter 17-610 FAC — Reuse of Reclaimed Water and Land Application
- Chapter 17-640 FAC — Domestic Wastewater Residuals
- Chapter 17-650 FAC — Water Quality Based Effluent Limits

Other legislative authority supporting the activities of the domestic wastewater program is the CWA — Public Law 92-500.

OBJECTIVE(S): To ensure that no wastewater is discharged into the environment without the degree of treatment necessary to meet state water quality standards.

JURISDICTION: This program applies to all upland lands adjacent to the FKNMS.

OPERATION: This program operates on essential y three levels. Permitting activities are carried out at the district office level and supplemented at the district branch level. Rule formulation and program oversight are conducted out of the Tallahassee Office. Coordination is accomplished by the issuance of program guidance memorandums from the Tallahassee Office to the district offices. These memorandums are designed to ensure uniform and consistent application of the domestic wastewater rules during the permitting process. Every district and district branch person receives formal training on any new rules or regulatory procedures. Enforcement and compliance activities are conducted primarily by the Marathon District Branch Office with support from the Ft. Myers District Office.

FUNDING: Funding for this particular program comes from General Revenue and from fees charged to permit holders.

STAFFING: The district has four individuals assigned to processing domestic wastewater permit applications. Each person spends approximately 5 to 10 hours per week processing permits in the Florida Keys. There are two individuals based at the Marathon District Branch Office who are assigned to this program. The Marathon Field Office of the FDER operates in conjunction with program staff assigned to the Ft. Myers District Office, but the staff at Marathon is limited and has a variety of other duties.

TRACKING: Tracking permit issuance, enforcement, and compliance actions are handled through the Ft. Myers District Office. Inspection data are submitted to the Ft. Myers District Office by the Marathon District Branch Office on a continuous basis. Data are ultimately entered into the FDER Groundwater Monitoring System (GMS) computerized database; however, in light of available staff, permitting and enforcement activities have higher priority. Data entry into the GMS is slow. Once programs are established in the form of rules or regulations, there are no formalized follow-up studies to evaluate their individual effectiveness. All district water facilities administrators meet in Tallahassee every six weeks.

3.2.3.3 INDUSTRIAL WASTEWATER

PROGRAM RESPONSIBILITIES: The Industrial Wastewater Program at the district level within the FDER is responsible for the review, approval, and permitting of local industrial wastewater treatment facilities (primarily seafood processing plants and laundries in the Florida Keys). The Tallahassee Industrial Wastewater Section provides technical oversight and guidance to the local FDER district and field staffs concerning permitting procedures.

AUTHORITY: Legislative authority for the Industrial Wastewater Program is contained in the following statutes:

- Section 403.021(2) FS — States the policies on control of air and water pollutants; and
- Section 403.061 FS — States the powers and responsibilities of the FDER concerning control of air and water pollution.

The rules under which the Industrial Wastewater Program operates are as follows:

- Chapter 17-4 FAC — Requirements for Permits;
- Chapter 17-302 FAC — Surface Water Quality Standards; and
- Chapter 17-660 Series FAC — Rules Pertaining to Industrial Waste Limits in Wastewater Facilities.

Another legislative authority supporting the activities of the industrial wastewater program is the CWA — Public Law 92-500.

OBJECTIVE(S): To ensure that no wastewaters are discharged into the environment without the degree of treatment necessary to meet state water quality standards.

JURISDICTION: This program applies to all industries discharging wastewater into the FKNMS.

OPERATION: This program operates in a tiered fashion. The Marathon District Branch Office is responsible for compliance and enforcement (i.e., inspections); the Ft. Myers District Office is responsible for permitting; and the Tallahassee Office is responsible for overall program oversight, policy guidance, and rule development.

All water quality standards are re-evaluated every three years. This process is known as the "Triennial Review" and is mandated under the CWA design and operation. Standards and criteria for industrial wastewater facilities may be adopted in statute, administrative rule, or departmental policy form. They are set by the central office in Tallahassee.

FUNDING: Funding for this program comes from General Revenue. No funds have been specifically designated for the Florida Keys area.

STAFFING: There are four professional staff members assigned to this program in Tallahassee. These people provide technical assistance and review functions for the Marathon District Branch Office and Ft. Myers District Office staffs and interact with EPA on NPDES requirements based on provisions in the CWA.

The district has two individuals assigned to processing industrial wastewater permit applications. Each person spends, on average, 5 to 10 hours per week processing permits in the Florida Keys. The same two individuals at the Marathon District Branch Office who are involved in domestic wastewater treatment compliance and enforcement activities are also responsible for industrial wastewater compliance and enforcement.

TRACKING: Once permits have been approved, tracking is achieved through compliance monitoring and inspections. District offices are responsible for ensuring that compliance monitoring data are provided by the permittee. Inspection data are provided from the Marathon FDER staff whenever inspections are made. These data are centralized at the district office and entered into the state's computerized databases; however, entry of data in a timely fashion is slowed down due to understaffing.

3.2.3.4 POINT SOURCE EVALUATION

PROGRAM RESPONSIBILITIES: The specific responsibilities of the Point Source Evaluation Program involve developing water quality based effluent limitations (WQBELs) for point source surface water discharges and developing total maximum daily loads (TMDLs) for water bodies.

AUTHORITY: Legislative authority for the Point Source Evaluation Program is contained in the following statutes:

- Section 373.016 FS — Declaration of policy of the Florida Water Resources Act of 1972;
- Section 373.026 FS — States the general powers and responsibilities of the FDER regarding Florida's water resources;
- Section 403.021(2) FS — States the policies on control of air and water pollutants; and
- Section 403.061 FS — States the powers and responsibilities of the FDER concerning the control of air and water pollution.

The rules under which the Point Source Evaluation Program operates are as follows:

- Chapter 17-4 FAC — Requirements for Permits;
- Chapter 17-302 FAC — Surface Water Quality Standards;
- Chapter 17-550 FAC — Permitting Public Water Systems;
- Chapter 17-600 Series FAC — Rules Pertaining to Domestic Wastewater Facilities; and
- Chapter 17-650 FAC — Water Quality Based Effluent Limitations.

Additional linkages between this program's activities and those of other state and federal agencies are found under the following:

- Section 403.60 FS, which establishes the Interstate Environmental Control Compact; and
- CWA — Public Law 92-500.

OBJECTIVE(S): To protect the beneficial uses of waters of the state by developing effluent limitations for wastewater facilities.

JURISDICTION: This program applies to all surface water discharges into the FKNMS.

OPERATION: The Point Source Evaluation Section develops WQBELs, supervises the development of WQBELs, and provides guidance for the development of WQBELs. WQBELs establish effluent limitations for point source discharges to surface waters that will protect water quality and maintain the designated use of the water body. Level I WQBELs are intended to be developed in the FDER district offices using existing information. Some additional data collection by the Department or the applicant may be required. The level of analysis is relatively simple and typically does not require computer modeling. Level II WQBELs are directed by the Point Source Evaluation Section in Tallahassee. These WQBELs are more involved than Level I WQBELs and usually include some level of computer modeling. For most situations, the permit applicant is responsible, under the direction of the Point Source Evaluation Section, for the data collection, computer modeling, and impact analysis. The WQBEL is then developed by the Department based on the information provided by the applicant. However, the Department has the option of doing this work rather than requiring it of the applicant.

The Point Source Evaluation Section is also responsible for the development of TMDLs for designated water bodies. The TMDLs are basinwide assessments that incorporate the development of effluent limitations for point and nonpoint sources as well as management plans for the basin.

The Outstanding Florida Waters (OFW) designation for most of the waters in the Florida Keys assures even greater protection than the water quality criteria that apply to designated water classes. Actual permits are issued at the district level with Tallahassee staff acting in an advisory and oversight capacity. Coordination with other local, state, and federal regulatory agencies is accomplished through the MOA and MOU processes.

During the past three years, the Point Source Evaluation Section assisted in permitting three wastewater facilities in the Florida Keys. Two cases involved reverse osmosis plants, and the other included evaluating discharges at the Key West Power Plant.

FUNDING: Funding for this particular program comes from General Revenue. No funds have been specifically designated for the Florida Keys area.

STAFFING: There are 12 professional staff members assigned to the Point Source Evaluation Program in Tallahassee. These people provide technical assistance to FDER staff located throughout the state as well as direct the development of, and sometimes develop, level II WQBELs.

There are no specific individuals based in the Florida Keys or the Ft. Myers District Office who are assigned to this program. Interaction between Marathon, Ft. Myers, and Tallahassee is limited. Field staff focus most of their efforts on compliance and enforcement.

TRACKING: Compliance monitoring occurs once permits have been approved. District offices are responsible for ensuring that compliance monitoring data are provided by the permittee. These monitoring data are centralized at the district office and entered into the state's GMS.

3.2.3.5 WASTEWATER FACILITIES REGULATION AND PERMITTING

PROGRAM RESPONSIBILITIES: The Bureau of Water Facilities Planning and Regulation has oversight responsibility for all district wastewater facility permitting, enforcement, and compliance activities. Their duties are as follows:

- Training of district personnel;
- Coordination of data needs for individual districts, and technical assistance with data management;
- Identification of bioassay requirements for toxicity testing;
- NPDES coordination with EPA;
- Provide technical assistance to district personnel; and
- Develop rules and provide interpretations to district personnel.

AUTHORITY: Legislative authority for the Wastewater Facilities Regulation and Permitting Program is contained in the following statutes:

- Section 373.016 FS — Declaration of policy of the Florida Water Resources Act of 1972;
- Section 373.026 FS — States the general powers and responsibilities of the FDER regarding Florida's water resources;
- Section 403.021(2) FS — States the policies on control of air and water pollutants;
- Section 403.061 FS — States the powers and responsibilities of the FDER concerning the control of air and water pollution; and
- Section 403.0885 FS — Establishes the federally approved state NPDES program.
- Other sections of Chapter 403 FS

The rules under which the Bureau operates are as follows:

- Chapter 17-4 FAC — Requirements for Permits;
- Chapter 17-17 FAC — Electrical Power Plant Siting;
- Chapter 17-23 FAC — Industrial Siting;
- Chapter 17-28 FAC — Groundwater Monitoring Requirements;
- Chapter 17-103 FAC — Rules of Administrative Procedure—Final Agency Action (Non-Rule Making);
- Chapter 17-301 FAC — State Waters of the State;
- Chapter 17-302 FAC — Surface Water Quality Standards;
- Chapter 17-550 FAC — Permitting Public Water Systems; and
- Chapter 17-600 Series FAC — Rules Pertaining to Domestic and Industrial Wastewater Facilities.

Additional linkages between this program's activities and those of other federal agencies are found in CWA — Public Law 92-500 (i.e., Sections 401 and 402).

OBJECTIVE(S): To regulate wastewater and stormwater discharges to a level at which there are no adverse water quality impacts.

JURISDICTION: This program applies to all wastewater facilities in the Florida Keys.

OPERATION: The Bureau oversees all wastewater treatment permitting and enforcement statewide. Permitting and enforcement are actually handled at the district and/or district branch levels, with the section in Tallahassee serving as a technical resource. Data from enforcement/compliance monitoring is initially maintained at district offices but is eventually passed on to the Tallahassee Office. The Tallahassee Office serves as a technical advisor to the districts in terms of data management needs.

At the present time, Florida is not a delegated state in terms of NPDES permitting. EPA coordinates with the Wastewater Facilities Regulation Section when it is processing NPDES permits. The purpose of coordinating is to allow the state input regarding NPDES permits being written by EPA, and to ensure that the permit is consistent with all state water quality standards. The FDER has 60 days in which to comment. Because Florida is not a delegated state, surface water dischargers are required to have an FDER permit as well. However, Florida is in the process of becoming a delegated state; if this occurs, needless duplication in the permitting process will be removed.

All actual state permitting or review of NPDES proposed permits is done at the district office level. All follow-up inspection and compliance monitoring is done at the district and branch levels.

FUNDING: Funding for the program comes from General Revenue, fees charged to dischargers, and federal grants. No funds have been specifically designated for the Florida Keys area.

Currently 106 Grant funds from the CWA are being utilized for the following purposes:

- To fund the state's existing ambient water quality monitoring program (only two routine sampling stations for this program are located in the Florida Keys);
- To defer cost of compliance inspections; and
- To help fund the state's data retrieval network.

STAFFING: There are nine professional staff members in the Wastewater Facilities Regulation Section located in Tallahassee. They have statewide responsibility. These people provide technical assistance and serve in an overview capacity for all district and district branch offices in Florida. The staff also coordinates the EPA NPDES permit commenting process.

TRACKING: Compliance inspection, enforcement records, and monitoring data are centralized at the district office and entered into the state's computerized GMS. From time to time, section staff members make field visits.

3.2.3.6 UNDERGROUND INJECTION CONTROL

PROGRAM RESPONSIBILITIES: Within FDER, the UIC Section regulates injection wells to ensure that current and potential future drinking water sources are not contaminated by underground injection of waste.

AUTHORITY: Legislative authority mandating this program is contained in the following statutes:

- Chapter 37 Part III — Regulation of Wells; and
- Chapter 403 FS — Environmental Control.

The UIC Program operates according to the provisions described in Chapter 17-28 FAC — UIC, Criteria and Standards.

Florida is designated as a "Primacy State" under the EPA's rules for enforcing the Safe Drinking Water Act — Public Law 93-523. This means that Florida has the primary responsibility for issuing all underground injection well permits. The EPA oversees this process and reviews issued permits.

OBJECTIVE(S): To ensure that no current or potential future source of drinking water is contaminated by underground injection of waste.

JURISDICTION: The UIC Program has jurisdiction throughout the Florida Keys.

OPERATION: At the present time, all injection wells in the Florida Keys are Class V shallow injection wells for domestic sewage or stormwater runoff. Permitting is done through the Ft. Myers District Office, with the Tallahassee Office serving as an oversight body and providing technical support and policy evaluation when necessary.

Class V injection well permits for wastewater facilities require monthly operating reports and follow-up inspections. Stormwater wells are exempt from monitoring requirements. There is an ongoing monitoring study being conducted on Class V injection wells on Saddlebunch Key.

FUNDING: The Florida UIC Program has received approximately $200,000 annually from EPA to supplement the funds the state appropriates for operating the state program. This constitutes approximately 10% of the total Florida budget. The major source of funding comes from state General Revenue.

STAFFING: There are five full-time professional staff members assigned to this program at the Tallahassee Office. Permitting and enforcement are handled at the district office level. Follow-up inspections, if required, are handled from the Marathon District Branch Office.

TRACKING: Injection wells are tracked by permit application and by entry into the state's GMS database at the Ft. Myers District Office. If monitoring is required for the permit, the permittee is required to submit reports to both the Tallahassee Office and the Ft. Myers District Office simultaneously.

3.2.3.7 WATER QUALITY STANDARDS

PROGRAM RESPONSIBILITIES: The Water Quality Standards Section is responsible for updating state water quality standards for surface waters. Changes in these standards include classifications of surface waters, periodic review and update of water quality standards, and designations of use in OFW.

AUTHORITY: Legislative authority mandating this program is contained in the following statutes:

- Chapter 403 FS — General regulations to prevent, control, and prohibit the pollution of air and water; and
- Section 403.061 FS — Grants the FDER the power to establish rules that provide for a special category of waterbodies called OFW, worthy of special protection because of their natural attributes.

The regulation under which the program primarily operates is Chapter 17-302 FAC — Surface Water Quality Standards. This rule contains surface water use classifications, associated beneficial uses, standards applied to surface waters, state antidegradation policy, and OFW.

OBJECTIVE(S):

- To adopt, modify, and repeal rules and regulations to carry out the intent and purposes of Section 403.061 FS;
- To adopt a comprehensive program for the prevention, control, and abatement of pollution of waters of the state;
- To establish classes in accordance with the present and future most beneficial uses, and allow their modification with public input;
- To establish ambient water quality standards for the state as a whole or for any part thereof, and allow mixing zones;
- To allow for field studies and periodic sampling in a logical geographic manner to determine levels of water quality and source(s) of pollution;
- To encourage and conduct studies, investigations, and research relating to pollution and its causes, effects, prevention, abatement, and control; and
- To collect and disseminate information and conduct educational and training programs relating to pollution.

JURISDICTION: This program applies throughout the state waters within the FKNMS.

OPERATION: Most coastal waters in the Keys have a Class III designation. Waters within the Everglades National Park are designated as Class II. In addition, the Florida Keys were designated as OFW in 1985. The OFW program is implemented through the FDER's permitting system. Only those activities that require a FDER permit are affected. The Key West sewage outfall, Stock Island power plant mixing zone, and various artificial water bodies are exempt from the OFW designation under Chapter 17-302.700(9)(i) FAC.

All pollution sources in existence prior to implementation of OFW in 1985 are "grandfathered in", and do not have to meet the OFW water quality standards for the Florida Keys. The vast majority of Keys development occurred prior to the 1985 OFW designation. Presently, the FDER is in the midst of conducting a triennial review of its water quality standards as required by the CWA. One of the issues that is being studied is "grandfathering" of water quality standards.

FUNDING: This program is funded entirely from General Revenue. No additional funds have been allocated for the FKNMS.

STAFFING: There are five staff positions in this Section, one of the smallest in the Department. These include one secretary, three Environmental Specialist IIIs, and an Environmental Administrator. Staff responsibilities include classification, reclassification, OFW designations, proposed standards changes, triennial review of surface water standards, and related issues as they arise.

TRACKING: Classifications, standards review and changes, and OFWs are handled and tracked within the FDER Headquarters, with some support from other sections and districts for specific projects.

3.2.3.8 AMBIENT MONITORING

PROGRAM RESPONSIBILITIES: The Ambient Monitoring Subsection is responsible for administration of the Department's surface water ambient monitoring program and for coordination with other surface water monitoring programs at the federal, state, regional, local government, and citizen group levels. Specific responsibilities include preparation of the biennial Water Quality Assessment 305(b) Report, management of the state's STORET databases and associated training program, management of the state's mercury databases, oversight and contract management for a wide variety of ambient monitoring programs statewide (water management districts, other state agencies, universities, and other entities), extensive Geographic Information System (GIS) support services, technical assistance in the planning, design implementation and data analysis for surface water monitoring programs, and scheduling district sample collection for analysis at the Department's Central Lab facility.

AUTHORITY: Legislative authority mandating this program is contained in the following statutes:

- Chapter 373.026 FS - General Powers and Duties of the FDER; and
- Section 403.061 FS - Powers of FDER to Control and Prohibit Pollution of air and water.

OBJECTIVE(S):

- To provide for maximum coordination and compatibility among all entities in Florida conducting surface water ambient monitoring programs;
- To monitor the quality of Florida's water resources in order to characterize baseline conditions and assess impacts;
- To produce assessments of the conditions of Florida's water resources;
- To provide for centralized surface water resource data management and associated training; and
- To provide for the development and implementation of new surface water resources monitoring techniques.

JURISDICTION: This program applies throughout the state waters within the FKNMS.

OPERATION: At present, monitoring efforts in the Florida Keys are associated with compliance monitoring and enforcement conducted through the Marathon District Branch Office. Long-range planning, however, includes investigating new methods to assess the quality of water resources in estuarine and marine environments and providing for a monitoring network that will extend into waters of the FKNMS.

FUNDING: This program is funded entirely from General Revenue. No additional funds have been allocated for the FKNMS.

STAFFING: There are six administrative staff in the ambient monitoring program (five staff members in Tallahassee and one in Orlando) and approximately 20 field staff in the district offices. The field personnel are active participants in the planning and policy-making process of the overall program.

TRACKING: Monitoring is extremely limited in the FKNMS area and is almost uniformly associated with specific permit requests. This type of monitoring is handled primarily by the Marathon District Branch Office and the Ft. Myers District Office. Monitoring data flow back to Tallahassee slowly through the GMS, and occasionally by special request.

3.2.3.9 STORMWATER MANAGEMENT

PROGRAM RESPONSIBILITIES: The Stormwater/Nonpoint Source Management Section is responsible for administering the state's stormwater and nonpoint source management programs. They help develop program policy, which is implemented through State Water Policy, and work with the water management districts to develop stormwater system design criteria that achieve the desired treatment level. They also are responsible for providing technical assistance, coordinating with EPA on NPDES stormwater permitting, and for coordinating and overseeing implementation of the stormwater program by the Water Management Districts and local governments.

AUTHORITY: Legislative authority for the Stormwater Management Program is contained in the following statutes:

- Chapter 163 FS — Intergovernmental Programs;
- Chapter 187 FS — State Comprehensive Plan;
- Section 373.026 FS — General Powers and Responsibilities of the FDER Regarding Florida's Water Resources;
- Section 373.026 FS — Legislative Intent Regarding Pollution of Surface and Groundwaters;
- Chapter 373 Part IV FS — Management and Storage of Surface Waters;
- Section 403.021(2) FS — Policies on Control of Air and Water Pollutants;
- Section 403.061 FS — Powers and Responsibilities of the FDER Concerning the Control of Air and Water Pollution; and
- Section 403.0891 FS — State, Regional, and Local Stormwater Management Plans and Programs.

The rules under which the Stormwater Management Program operates are as follows:

- Chapter 17-4 FAC — Requirements for Permits;
- Chapter 17-25 FAC — Regulation of Stormwater Discharge;
- Chapter 17-40 FAC — Water Policy; and
- Chapter 17-302 FAC — Surface Water Quality Standards.

Other legislative authority supporting the activities of the stormwater management program is found in the CWA — Public Law 92-500.

The permitting of stormwater discharges was delegated to the South Florida Water Management District (SFWMD) in 1982. This was done to streamline regulatory procedures. The SFWMD rules pertaining to stormwater discharge are found in Chapter 40E-4 and Chapter 40E-40 of the FAC.

OBJECTIVE(S): To control stormwater discharges to a level at which there are no adverse impacts in the bodies of water receiving them. The stated goal of this program is to reduce pollutant loads carried into Florida surface waters by 80% in Class I, II, or III state waters or by 95% in OFW. Additional responsibilities include flood protection and maintenance of water reserve levels in surface water retention areas.

JURISDICTION: The FDER has jurisdiction over all stormwater management activities in the Florida Keys; however, the FDER has delegated stormwater regulatory and permitting responsibilities to the SFWMD. While all individuals must comply with all stormwater regulations, the SFWMD administrative rule Chapter 40E-4 FAC exempts developments under 10 acres in size or projects with less than 2 acres of impervious surface from having to submit stormwater management applications.

OPERATION: At the present time, the FDER Stormwater Management Program provides technical assistance and advice to the various water management districts upon request, reviews comprehensive plans, monitors technical advancements in stormwater management and control, investigates new technologies for stormwater control, and reviews water quality research relative to stormwater. Recommendations are made to the Standards and Monitoring Program, and other agency programs, as necessary. Staff of the Stormwater Management Section provides technical assistance to district and district branch personnel. They do not play any present role in stormwater discharge permitting in the FKNMS because of the 10-acre exemption provision now in force at the district.

FUNDING: Funding for this particular program comes from General Revenue with limited additions from EPA through the 319 Grant Program. These funds are used to implement the state's EPA-approved Nonpoint Source Management Program. No funds are specifically designated for the FKNMS.

STAFFING: There are six professional staff members assigned to the Stormwater Management Program in Tallahassee. One part-time person is assigned specifically to this program at the Ft. Myers District Office or Marathon District Branch Office.

TRACKING: As far as the stated goals of this program are concerned, there is no tracking. Permit approvals and permitting policies are decided upon at the district level. Any monitoring, if required, is handled at the district branch. There is relatively little flow of data to the Tallahassee Office. Even if there were more and faster exchange of existing data, evaluation of stormwater management policies and procedures would require considerably more in-depth monitoring than is currently possible.

3.2.3.10 WETLAND RESOURCE UTILIZATION PERMITTING (DREDGE AND FILL)

PROGRAM RESPONSIBILITIES: Staff of the Bureau of Wetlands Resource Management is responsible for administering Florida's dredge and fill program. This includes making jurisdictional declaratory statements, evaluating and approving wetland mitigation proposals, and reviewing and processing dredge and fill permit applications.

AUTHORITY: Legislative authority for this program is contained in the following statutes:

- Chapter 403 Part VIII FS — Permitting of Activities in Wetlands; and
- Chapter 253 FS — General Authority for the FDER to Accomplish its Mission.

The rules under which the program operates are as follows:

- Chapter 17-4 FAC — Requirements for Permits
- Chapter 17-25 FAC — Regulation of Stormwater Discharge;
- Chapter 17-301 FAC — Extent and Boundaries of the Surface Waters of the State;
- Chapter 17-302 FAC — Surface Water Quality Standards;
- Chapter 17-312 FAC — Dredge and Fill Activities; and
- Chapter 17-321 FAC — Mangrove Protection.

OBJECTIVE(S):

- To conserve the waters of the state;. and
- To protect, maintain, and improve the quality of the state waters for public water supplies; for the propagation of wildlife, fish, and other aquatic life; and for domestic, agricultural, industrial, recreational, and other beneficial uses.

JURISDICTION: This program has jurisdiction that extends from the mean high tide line offshore to the limits of state waters.

OPERATION: Applications for wetlands resource permits (dredge and fill permits) that involve more than 10 acres are processed in the Tallahassee Office. Applications for smaller projects are processed by the Ft. Myers District Office and the Marathon District Branch Office. Permit processing is governed by Sections 403.91-403.929 FS — Permitting of Activities in Wetlands. In determining whether or not a permit should be issued or denied, the applicant must provide reasonable assurances that the project will not violate water quality standards or be contrary to the public interest. Projects within OFW such as the Florida Keys must meet more stringent requirements including not lowering ambient water quality in any way and proving the project is clearly in the public interest. Part IV of Chapter 17-312 FAC is titled "Additional Criteria for Dredging and Filling Within Outstanding Florida Waters in Monroe County." This part provides specific regulations concerning protection for algae, coral, sponge, and seagrass communities; siting and design criteria for piers and boat moorings; and permitting requirements for marinas and shoreline stabilization.

FUNDING: Funding for this program comes from General Revenue, supplemented occasionally by grants from the Pollution Recovery Fund (Permit Fee Trust Fund).

STAFFING: The Tallahassee Office has one full-time staff person assigned to this program for Monroe County. There are two professional-level positions assigned for Monroe County in the Ft. Myers District Office, and one position in the Marathon District Branch Office.

TRACKING: The program is tracked through permit applications, inspection reports, and issued decisions. Tallahassee maintains files on the cases it handles, and the Ft. Myers District Office maintains files on those permits it issues.

3.2.3.11 SOLID WASTE MANAGEMENT

PROGRAM RESPONSIBILITIES: *Permitting and monitoring of landfills and solid waste disposal sites.*

AUTHORITY: Legislative authority for this program is contained in Chapter 403 FS — Florida Air and Water Pollution Control Act, which is the primary statute upon which most FDER rules have been developed.

Rules specific to the function of solid waste management are as follows:

- Chapter 17-4 FAC — Requirements for Permits; and
- Chapters 17-701 through 17-729 FAC — Rules Governing the Solid Waste Program.

OBJECTIVE(S): To ensure that solid waste disposal be conducted in a manner and under conditions that reduce the waste of recoverable resources and eliminate the dangerous and deleterious effects of improper disposal upon air quality, water quality, and human health, safety, and welfare.

JURISDICTION: The program is applicable throughout the Florida Keys.

OPERATION: At present, there are four major (Class 1) landfills in the Florida Keys. All are in the process of being closed. All landfill permitting is handled through the Ft. Myers District Office, which also has oversight of district branch solid waste activities. Monitoring and enforcement are handled through the Marathon District Branch Office.

FUNDING: Funding for this program comes from General Revenue. No funds have been specifically allocated to the Florida Keys area.

STAFFING: There is one FDER staff person in the Marathon District Branch Office whose responsibilities involve solid waste, primarily in the areas of compliance and enforcement. Aside from landfill monitoring, she also is responsible for all activities dealing with hazardous materials/wastes and USTs.

TRACKING: Landfills are monitored by sampling water from shallow wells drilled near the landfill and analyses of this water for leachates. Data from the sampling program are compiled in the Ft. Myers District Office and entered into the GMS database system.

3.2.3.12 STORAGE TANK REGULATION

PROGRAM RESPONSIBILITIES: FDER and FDHRS staffs work cooperatively in administering storage tank regulation. Activities include cleanup of sites contaminated by aboveground and underground storage tank system discharge, enforcement of new standards for storage tank installation and removal to prevent discharge from contaminating groundwater.

AUTHORITY: Legislative authority is contained in Chapter 376 FS — Pollutant Discharge, Prevention, and Removal.

Florida is a delegated state in terms of EPA's storage tank regulatory procedures authorized under RCRA, Subtitle I. Responsibility is delegated to the state program through an MOU between EPA and the FDER. In addition, FDER has contracted with the Monroe County Public Health Unit to conduct storage tank inspections.

Applicable rules under which this program functions are as follows:

- Chapter 17-761 FAC — Underground Storage Tank Systems;
- Chapter 17-762 FAC — Aboveground Storage Tank Systems;
- Chapter 17-769 FAC — The Florida Petroleum Liability Insurance and Restoration Program;
- Chapter 17-770 FAC — Clean-Up Criteria; and
- Chapter 17-773 FAC — Reimbursement for Petroleum Contamination Site Cleanup.

OBJECTIVE(S):

- To clean up previously contaminated sites;
- To ensure proper precautions, in the form of new tanks with secondary containment and proper installation; and
- To prevent contamination in the future.

JURISDICTION: This program covers the Florida Keys.

OPERATION: This program regulates all USTs larger than 110 gallons and all aboveground storage tanks larger than 550 gallons. Storage tank content can include ammonia, chlorine, pesticides and derivatives, and petroleum or petroleum products. Under the 1976 RCRA legislation, the FDER is directed, to the greatest extent possible, to contract with local governments to perform the compliance and enforcement activities associated with the state tank rules. The tank program staff in Tallahassee has contracted with Monroe County FDHRS to perform annual compliance inspections, installation inspections, and enforcement activities for storage tank facilities in the county. Ultimately, the Ft. Myers District Office is responsible for enforcement actions. The Monroe County FDHRS is responsible for all preliminary compliance and enforcement activities and for public assistance and complaint response.

FUNDING: Funding for contracted services and Tallahassee staff positions is provided through the Inland Protection Trust Fund (Section 376.3071 FS).

STAFFING: Two FDER staff members are assigned to this program. One Program Supervisor is in the Ft. Myers District Office. One Environmental Specialist II works part-time in the Marathon District Branch Office. Three Monroe County FDHRS personnel in the Public Health Unit are assigned to this program in the Florida Keys.

TRACKING: FDER maintains computerized lists available of registered facilities, facilities inspected to date, and clean-up actions in progress, pending, or under enforcement action.

3.2.3.13 EMERGENCY RESPONSE PROGRAM

PROGRAM RESPONSIBILITIES: The FDER Bureau of Waste Cleanup has primary responsibility for interdepartmental coordination for emergency response. This program involves the abatement and proper management of environmental emergencies caused by oil and hazardous materials spills. FDER-mandated functions include administration of Emergency Services Contracts, Disposal Services Contracts, and Emergency Drinking Water Funds. The section also has a variety of specific responsibilities acquired through interagency agreements and MOUs.

AUTHORITY: Legislative authority for this program is contained in the following statutes:

- Section 376.30 through 376.319 FS — Legislative Intent Regarding Pollution of Surface and Groundwater;
- Section 403.061 FS — Powers and Responsibilities of the FDER in Regard to Air and Water Pollution;
- Section 403.161 FS — Prohibitions, Violations, and Penalties; and
- Section 403.1655 FS — Environmental Short-Term Emergency Response Program.

There are also a number of critical MOUs, with the FDNR, Florida Game and Fresh Water Fish Commission, and USCG, on the use of dispersants and other chemicals to treat oil spills, enabling the Emergency Response Section to perform its function. Additional authorization is specified in the Hazardous Materials Annex XXV, State of Florida Peace Time Emergency Plan.

OBJECTIVE(S):

- To provide a mechanism for the state to respond to short-term emergencies;
- To have available financial resources to respond to emergencies that pose an immediate environmental or public health threat; and
- To coordinate the FDER response with other federal, state, and local entities.

JURISDICTION: The Emergency Response Program has a jurisdictional responsibility throughout the Florida Keys and FKNMS.

OPERATION: Within the State of Florida, there is a multi-agency Hazardous Materials Task Force specified under the Hazardous Materials Annex XXV, State of Florida Peace Time Emergency Plan. Within this structure, the responsibilities of all state agencies are outlined. The FDNR normally has responsibility for spills that occur in coastal waters, and the FDER for spills that occur on land. The FDCA maintains communication links between agencies and can serve as backup for the responsible agency handling a spill. In the event of an oil or hazardous material spill, that threatens the coastal zone or occurs far offshore, the USCG would be the responsible agency. Both the FDNR and FDER have representatives on the Regional Response Team. There is an interagency agreement, between the FDNR and FDER, that gives the Emergency Response Section of the FDER responsibility for deciding when and if dispersants may be used.

FUNDING: Administrative staff positions are funded from the FDER operating budget. Based on the nature of the incident, spill clean-up activities are funded by either the Water Quality Assurance Trust Fund or the Inland Protection Trust Fund.

STAFFING: One full-time professional staff person .s in Tallahassee. There are no full- or part-time FDER professionals specifically assigned to emergency response in the FKNMS. Should a spill occur within the marine environment, the Florida Marine Patrol (FMP) would assign staff members as needed.

TRACKING: This program is tracked based on emergency responses to given situations involving spills of oil or hazardous materials. Such spills occur frequently on a statewide basis. A computerized database of response activities is available.

3.2.3.14 LOCAL GOVERNMENT COMPREHENSIVE PLAN REVIEW

PROGRAM RESPONSIBILITIES: The FDER Office of Intergovernmental Programs is responsible for general environmental management issue review of all local government comprehensive plans submitted to the FDCA.

AUTHORITY: Legislative authority for the tasks performed by the FDER Office of Intergovernmental Programs is provided under the following statutes:

- Section 163.3177 FS — Elements of Comprehensive Plan — Required and optional elements to include in the prescription of principles, guidelines, and standards for the orderly and balanced future development of an area;
- Section 163.3178 FS — Coastal Management — Protection of human life and limitations of public expenditures in areas subject to destruction by natural disasters. Restrictions to development activities may be imposed where such activities would damage or destroy coastal resources;
- Section 163.3184(4) FS — Intergovernmental Programs - Identification of the FDER as a review agency for local comprehensive plans and plan amendments;
- Chapter 186 FS — State and Regional Planning — Integrated planning system to ensure coordinated administration of government policy;
- Section 187.201 FS — State Comprehensive Plan — Policy guidance for the orderly growth of Florida;
- Chapter 373 FS — State Water Resources Plan — Responsibilities of the FDER for water resource protection;
- Chapter 380 FS — Land and Water Management — Protection of the natural resources and environment of the state; and
- Chapter 403 FS — Environmental Control — Regulation to control and prohibit the pollution of air and water.

The rules under which the Office of Intergovernmental Programs functions are promulgated under the following elements of the FAC:

- Chapter 9J-5 FAC — Minimum criteria for the review of local government comprehensive plans; and
- Department 17 Series — Regulations to conserve, protect, and restore air, water, and natural resources in the State of Florida.

OBJECTIVE(S): To ensure that local government plans conform to and are consistent with the FDER's legislatively mandated responsibilities to protect the natural resources and environment of the State of Florida.

JURISDICTION: The FDER Office of Intergovernmental Programs reviews all local government comprehensive plans statewide. Within the area adjacent to the FKNMS, this has meant review of the local government comprehensive plans of Monroe County, City of Key West, City of Layton, and City of Key Colony Beach.

OPERATION: The FDCA provides the FDER Office of Intergovernmental Programs with copies of the comprehensive growth management plan proposed by a local government entity. The Office of Intergovernmental Programs is responsible for coordinating the FDER's review and draws upon the technical expertise of agency personnel in various divisions within the FDER. Copies of appropriate sections of the proposed comprehensive growth management plan are circulated to the appropriate group and its comments requested. In addition to review by technical staff in Tallahassee, the district that contains the local government entity submitting the plan under review is also requested to submit review comments. The Office of Intergovernmental Programs has 45 days from the date of receipt to return comments to the FDCA.

The FDER staff, through the local government comprehensive plan review process, is able to affect water quality issues in the following ways:

- Influencing conservation/preservation of natural resources;
- Influencing upland development and growth;
- Ensuring that the FDER requirements for sanitary waste, drinking water, and waste management planning are addressed; and
- Ensuring that the FDER stormwater standards are included in the local plans.

FUNDING: The positions of the FDER staff conducting the local government comprehensive reviews are funded through state General Revenue.

STAFFING: There are four professional staff members assigned to this program for the entire state.

TRACKING: The local government comprehensive plan review process within the Office of Intergovernmental Programs has a specific task to perform within a specific time frame. Copies of comments from the various FDER bureaus and sections are synthesized into an FDER response. This response is forwarded to the FDCA. The Office of Intergovernmental Programs maintains the responses and supporting documentation; therefore, it is possible to track whether FDER comments have been incorporated into approved comprehensive growth management plans. To date, the Office of Intergovernmental Programs has completed initial review and submitted comments on proposed local government comprehensive plans from all local government entities in the Florida Keys. The Office of Intergovernmental Programs has been involved in negotiations between the FDCA and county/municipalities regarding compliance or approval of any of the submitted plans. This remains an ongoing process.

3.2.4 Florida Department of Health and Rehabilitative Services

3.2.4.1 ON-SITE SEWAGE DISPOSAL

PROGRAM RESPONSIBILITIES: County public health units are charged with the responsibility of ensuring proper construction, installation, and operation of individual OSDSs.

AUTHORITY: Legislative authority for this program is contained in the following statutes and rule:

- Section 381.0064 FS — Requires the FDHRS to provide continuing education courses for septic tank contractors, pumpout operators, environmental health specialists, and master plumbers who install septic tanks or service septic tanks;
- Section 381.0065 FS — Provides the installation conditions for OSDSs;
- Section 381.0066 FS — Provides the authority to implement a fee schedule designed to recapture the cost of carrying out the on-site disposal program; and
- Chapter 10D-6 FAC — Contains the regulations promulgated by the FDHRS to oversee the installation and operation of individual on-site disposal systems.

OBJECTIVE(S): To ensure that OSDSs are designed, installed, and maintained in such a way as to prevent ground- and surface-water contamination and to prevent human health problems.

JURISDICTION: The OSDS permitting program has jurisdiction throughout Monroe County.

OPERATION: The OSDS program is administered at the state level and at the local level. The Tallahassee Office is primarily responsible for policy, research, evaluation, and technical support services. It advises the district level staff members and coordinates with them directly on most issues.

Permitting and enforcement are done by the Monroe County Public Health Unit. In Monroe County, there are three offices for environmental health services, including the Stock Island Office (main office), Marathon Office, and Tavernier Office.

Individual OSDSs regulated by the FDHRS/Monroe County Public Health Unit fall into the following categories:

- Domestic sewage less than or equal to 5,000 gallons per day;
- Food service establishments with total wastewater flows that are less than or equal to 3,000 gallons per day; and
- OSDS in areas zoned for industry or manufacturing, or an equivalent use, for which the system can be demonstrated to be exclusively for domestic waste.

OSDSs with design flows in excess of the ones stated above may also be permitted through an appeal process involving a hearing before the OSDS State Variance Review Group, provided the FDER has determined it to be impractical to consolidate flow through sewering in low-density areas.

Individuals may also apply to the OSDS State Variance Review Group for special permits for innovative or nonstandard OSDSs, or for special exemptions from given OSDS requirements. Usually, these types of applications are from individual home owners who need an OSDS to build on their property. In the past, the OSDS State Variance Review Group has approved approximately 1/3 of the applications as requested, another 1/3 have received a favorable decision but approval is subject to stipulated conditions, and finally, 1/3 are denied approval. Over the past three years, roughly 3,500 OSDS permits were processed in the Florida Keys.

FUNDING: Funding for this program comes from General Revenue and from fees charged for permits. Funding for this program was $220,422 in fiscal year 1991-1992.

STAFFING: There are six full-time professionals in the Tallahassee Office [a]nd eight professional staff members in the Florida Keys. Staffing in the Florida Keys has shown a downward tren[d] over the last three years. There were 12 professional level staff people assigned to this program in 1990, and 10 [i]n 1991.

TRACKING: At the local level, this program is tracked by permit applic[ati]ons, inspection reports, and eventual permit actions (issuance of denial). There is a county ordinance that requ[ir]es OSDS facilities to be inspected at three-year intervals to determine if they are functioning properly. However, [th]e ordinance never defined who would be responsible for implementing the ordinance. Further, as of February [19]93, the County has not provided any funding to initiate the inspection program.

3.2.5 Department of Natural Reso[urc]es

3.2.5.1 ADMINISTRATION OF NATIONAL MARINE SANCTUARIES

PROGRAM RESPONSIBILITIES: The Bureau of Sanctuaries and Research Reserves is responsible for administration and management of National Marine Sanctuaries and National Estuarine Research Reserves. There are two National Marine Sanctuaries in Florida. They are both located in the Florida Keys at Looe Key and Key Largo.

AUTHORITY: Legislative authority for this program is contained in Section 370.021(5)(a) and (b) FS, which provides state authority to Sanctuary Officers for enforcement positions under the FDNR enforcement authorization, Chapter 253 FS.

Federal statutes enforced under this authority are as follows:

- MPRSA (as amended);
- Magnuson Fisheries Conservation and Management Act;
- Endangered Species Act;

- Marine Mammal Protection Act;
- Fish and Wildlife Improvement Act; and
- Lacy Act Amendments; and
- Atlantic Tunas Convention Act.

OBJECTIVE(S):
- To enhance resource protection through the implementation of comprehensive, long-term management tailored to the resources;
- To promote and coordinate research to expand scientific knowledge on significant marine resources and improve management decision making;
- To enhance public awareness, understanding, and wise use of the marine environment through public education, interpretive, and recreational programs; and
- To provide for the maximum compatible public and private use of special marine areas.

JURISDICTION: The legislative authority of this program is limited to the Looe Key National Marine Sanctuary and Key Largo National Marine Sanctuary.

OPERATION: The National Marine Sanctuary Program is administered at the federal level by NOAA of the U.S. Department of Commerce.

FUNDING: The 1991-1992 funding for the both Looe Key and Key Largo National Marine Sanctuaries consists of a direct federal budget appropriation of $220,000 and a federal appropriation through the FDNR in the form of an Operations Grant of $765,000.

STAFFING: Bureau of Sanctuaries and Research Reserves staffing consists of the following:
- Looe Key National Marine Sanctuary
  — 1 Administrator
  — 2 Environmental Specialists
  — 3 Law Enforcement Officers
  — 1 Secretary
  — 2 Maintenance Mechanics
  — 1 Administrative Assistant

- Key Largo National Marine Sanctuary
  — 3 Environmental Specialists
  — 4 Law Enforcement Officers
  — 1 Maintenance Mechanic

TRACKING: This is an administrative program tracked through standard state administrative procedures. Records documenting violations and fines are maintained by each sanctuary office. Because it receives federal funding, the program is also tracked by NOAA.

3.2.5.2 ENVIRONMENTAL CRIMES PROGRAM

PROGRAM RESPONSIBILITIES: The Environmental Crimes Program is essentially an effort by the Marathon District Office of the FMP to centralize environmental crime detection and enforcement within a specialized unit. This centralization of authority is an outgrowth of an interagency Environmental Crimes Task Force established by the Monroe County Sheriff's Department. The creation of this specialized unit increases the efficiency of all the district's officers. Patrol officers now have a fellow officer whose primary responsibility is enforcing environmental crimes (e.g., illegal dredge and fill activities, mangrove destruction) that they can report suspicious situations to for followup, without sacrificing their patrol time and other law enforcement duties. The concept of a designated officer or officers for environmental crimes is spreading with the various districts of the FMP. Specific courses in environmental crime are now being offered at the FMP.

AUTHORITY: Legislative authority for the FMP to investigate environmental crime is contained in the following statutes:

- Chapter 161 FS — Authorizes the FMP to monitor all dredge and fill activities and associated coastal construction;
- Chapter 370 FS — Empowers the FMP to enforce all Florida fish and game regulations concerning seasons, quotas, and gear types;
- Section 372.072(4) FS — Authorizes the FMP to enforce the Threatened and Endangered Species Act; and
- Chapter 376 FS — Authorizes the FMP to deal with spills and pollutant sources.

OBJECTIVE(S):

- To discourage environmental degradation by enforcing civil and criminal penalties; and
- To educate the general populace about the importance of protecting and maintaining the natural marine resources in the Florida Keys.

JURISDICTION: FMP Officers enforce the laws of the State of Florida throughout state waters.

OPERATION: The Environmental Crimes Program operates within the regular administrative framework of the Marathon District Office of the FMP. Due to the nature of the work, close coordination and cooperation are required between the FMP, the local office of the FDER, other FDNR divisions, and on occasion the Monroe County Public Health Unit.

During regular FMP operations, an officer who is either informed of or encounters a potential environmental crime makes a preliminary assessment, then turns the case over to the officer responsible for environmental crimes. The patrolling officer is then able to continue his regular duties while a specialist follows up on what may be an involved and time-consuming case.

There has been discussion among various law enforcement organizations in the Florida Keys to adopt a concept known as "cross deputization." If this concept is implemented, FMP officers would have the authority to enforce all applicable federal environmental laws (see Section 3.2.5.1), in addition, to the state environmental statutes as described above. Similarly, the federal National Marine Sanctuary officers at Looe Key and Key Largo would have the authority to enforce state environmental laws.

FUNDING: There is no special funding earmarked for the Environmental Crimes Program. Program expenses are paid out of the regular operating budget of the FMP Marathon District Office.

STAFFING: One officer is currently assigned full time to this program.

TRACKING: Tracking environmental crimes consist of reports, investigations, and in some cases charges and eventual court decisions. All data concerning environmental crimes, other than court records and oil spill reports, remain in the FMP Marathon District Office.

3.2.5.3 SUBMERGED LANDS AND PRESERVES

PROGRAM RESPONSIBILITIES: The Bureau of Submerged Lands and Preserves has responsibility for permitting any activity that occurs on state submerged lands. Examples of activities requiring permits are as follows:

- Dredge and fill (the majority of permits requested);
- Live rock collection; and
- Live-aboard mooring fields.

AUTHORITY: Legislative authority for this program is contained in the following statute and rules:

- Chapter 18-14 FAC — Specifies the administrative fines for damaging state lands;
- Chapter 18-18 FAC — Specifies management of submerged lands within the Biscayne Bay/Card Sound Aquatic Preserve;
- Chapter 18-21 FAC — Specifies management of sovereign submerged lands; specifies management of submerged land within Aquatic Preserves;
- Chapter 18-21.041 FAC — Specifies special rules adopted in 1985 to augment the existing rules governing the management of sovereign submerged lands in the Florida Keys;
- Chapter 253 FS — Provides the Board of Trustees with the authority to manage lands held in trust for the people of Florida; and
- Chapter 258 FS — Management of Aquatic Preserves.

OBJECTIVE(S): To regulate use of state-owned submerged lands in such a way as to protect, enhance, and ensure the balanced use of these lands for the benefit of present and future generations.

JURISDICTION: All submerged lands within state waters of the FKNMS are subject to the laws and regulations of the State of Florida.

OPERATION: The primary regulatory responsibility of the Division of State Lands relative to water quality within the FKNMS concerns construction on or over lands within its jurisdiction including marinas, water-related industries, and docking facilities of all types. The role of the Bureau of Submerged Lands and Preserves is proprietary rather than regulatory. In terms of dredge and fill projects or marina siting projects, actual permits are issued by the FDER. Once those permits have been issued, the Bureau of Submerged Lands and Preserves issues "leases" for the submerged lands involved. They have the authority to place special stipulations, such as water quality monitoring or mitigation requirements, into these land leases. They also charge for all leases issued to commercial entities such as marinas. Submerged land leases must be renewed periodically to enable the Bureau to determine if a given commercial enterprise is meeting the requirements of its lease. Submerged land leases can be canceled if violations of the leasing agreement are detected or continued.

FUNDING: The 1991-1992 budget for bureau activities in the Florida Keys is $85,086 per year.

STAFFING: Three full-time staff members and one temporary staff member are located in the Florida Keys and operate out of Marathon.

TRACKING: Re-evaluations of whether the stipulated conditions of submerged land leases are being adhered to and whether they are effectively protecting the lands of the state are made periodically at the time leaseholders seek to have their leases renewed.

3.2.5.4 FLORIDA MARINE RESEARCH INSTITUTE

PROGRAM RESPONSIBILITIES: The Florida Marine Research Institute (FMRI) is housed within the Division of Marine Resources. It operates two research facilities in the Florida Keys. One is located in Marathon (South Florida Regional Laboratory [SFRL]) and the other on Long Key (Keys Marine Lab [KML]). The Institute's major research laboratory is in St. Petersburg, Florida. All are conducting research programs aimed at the wise management of marine resources in the FKNMS.

AUTHORITY: Legislative authority for this program is contained in the following statutes:

- Chapter 370 FS — Salt Water Fisheries — Authorizes the Division of Marine Resources;
- Section 370.02(2) FS — Summarizes the duties of the Division of Marine Resources; and
- Section 370.02(2)(b)1-6 FS — Establishes the FMRI and designates its purpose to be "to conduct high-quality marine research on which management decisions can be based."

OBJECTIVE(S): To conduct high-quality marine research to form the basis for management decisions. Research projects currently in progress at the laboratories within the FKNMS are oriented primarily toward the management of commercial fisheries species such as conch, lobster, and finfish. A coral reef ecosystem program is based out of the St. Petersburg facility. Research efforts at St. Petersburg concentrate on studies in the FKNMS.

JURISDICTION: The FMRI conducts research statewide, thus this includes all areas within state boundaries.

OPERATION: Both the SFRL and the KML operate in close coordination with the FMRI's main laboratory in St. Petersburg. The KML program is operated jointly with the Florida Institute of Oceanography. To date, the focus of the SFRL has been toward research concerning fisheries management issues, while the KML has sought to provide a base of operations for the entire spectrum of marine researchers and educators. Of particular interest to water quality issues are studies being conducted at the KML concerning nutrient dynamics, seagrass ecosystems, and water current patterns.

FUNDING: Funding for all Florida K ys and FKNMS-related research programs conducted by the FMRI is $1,925,123.

STAFFING: There are eight professio staff members assigned to the programs conducted through SFRL, and one person at the KML. There are 23 pr ssional staff members at the St. Petersburg facility working on programs that relate to the habitats or resources w in the FKNMS.

TRACKING: Individual research proj s have stated goals and objectives. Research projects are tracked by interim reports, budget expenditures, an normal management procedures. Results are presented in the form of in-house reports, presentations, and scient publications.

3.3 REGIONAL

3.3. Florida Keys Aqueduct Authority

3.3.1.1 WASTEWATER

PROGRAM RESPONSIBILITIES: Th FKAA presently provides potable water to the Florida Keys. Within its enabling legislation, the FKAA has the legislative mandate to provide wastewater service to all areas within its defined service area. At this time, the FKAA does not provide such service, although it is exploring the possibility of assuming the operational responsibilities of the City of Key West wastewater treatment facility.

AUTHORITY: Legislative authority enabling the creation of the FKAA is set out in Florida Law 76441.

OBJECTIVE(S): To create a body with the power to "Own, acquire, construct, reconstruct, operate, maintain, extend, and improve water systems, and to regulate the use and supply of water within the Authority boundaries."

JURISDICTION: The FKAA has authority over all water supply matters throughout the Florida Keys.

OPERATION: At this time, the FKAA supplies only potable water to the Florida Keys.

FUNDING: In terms of wastewater, no funds are expended for such a program at this time.

STAFFING: No staff is assigned because no wastewater program exists, although the Executive Director and the Deputy Executive Director have had discussions with the City of Key West about assuming the city's wastewater operations.

TRACKING: Not applicable until the FKAA ultimately becomes the purveyor of wastewater service.

3.3.2 South Florida Water Management District

3.3.2.1 WETLAND REGULATION

PROGRAM RESPONSIBILITIES: To regulate development that potentially affects freshwater or estuarine wetlands in order to protect and preserve water quality within those areas.

AUTHORITY: The FDER has delegated certain wetland resource permitting responsibilities to the SFWMD. The delegation of such responsibilities is in conformance with Chapter 403, Sections 120.54 and 380.23 FS, and Chapters 17-4, 17-301, 17-302, 17-312, and 17-321 FAC.

OBJECTIVE(S):

- To preserve ambient water quality; and
- To prevent the loss of wetlands.

JURISDICTION: Within the Florida Keys, the SFWMD regulates activities within freshwater resources, only. Activities within Florida Bay and the Atlantic Ocean are regulated by other agencies. While all individuals must comply with all SFWMD stormwater regulations, the SFWMD administrative rule (Chapter 40E-4 FAC) exempts developments under 10 acres in size or projects with less than 2 acres of impervious surface from having to submit stormwater management applications.

OPERATION: On July 9, 1992, the SFWMD's Governing Board approved an MOU with the FDER which delegates certain dredge and fill permitting responsibilities from the FDER to the SFWMD. This agreement will go into effect on November 1, 1992. The dredge and fill activities for which the SFWMD will have responsibility will occur only when a surface water permit is required from the SFWMD for a proposed project. If the project is submitted after implementation of the agreement, the SFWMD will permit the proposed dredge and fill activity using FDER's rules and criteria.

Although no dredge and fill permits have been issued to date, the procedures to be followed will be the same as those applicants now follow to secure surface water management permits (see discussion in Section 3.3.2.2).

FUNDING: The SFWMD does not budget funds according to geographic area, such as the Florida Keys. Funds are allocated district-wide according to program needs, (i.e., surface water management, water use, natural resources management, field engineering, etc.). Funding sources are derived from ad valorem taxes and permit application fees.

STAFFING: While the SFWMD has an Intergovernmental Representative based in Big Pine Key, permitting and compliance activities are handled through the main office in West Palm Beach. Two additional enforcement/compliance staff members will be added in FY 1992/93 to handle dredge and fill responsibilities on a district-wide basis.

TRACKING: The SFWMD will utilize a post-permit compliance program as it currently does for surface water management permits. The program consists of both office and field activities. Each permit is tracked by a computer program with regard to data-dependent special conditions of the permit requiring the submittal of specific information by the permittee. Information has not been received from the SFWMD at this time.

The SFWMD is completing a multi-phase automation program for permit issuance and compliance. It consists of processes for the automated production of permit staff reports, database storage of important data from those staff reports, correctly timed and scheduled retrieval of permit data for site inspection monitoring reports, automated comparison of actual field or monitoring report data against permit values, and tracking and scheduling of required compliance and enforcement actions.

3.3.2.2 STORMWATER MANAGEMENT PERMITTING

PROGRAM RESPONSIBILITIES: Permitting and regulation of stormwater discharge.

AUTHORITY: Legislative authority which establishes the SFWMD's responsibility for stormwater management is provided in Chapter 373 FS, Parts II, III and IV and Section 120.54 FS. Chapters 40E-1 through 40E-4 FAC contain the rules of the SFWMD as they relate to implementation of Parts II, III, and IV of Chapter 373 FS. Water quality responsibilities were delegated from the FDER under Chapter 17-25 FAC in 1982.

OBJECTIVE(S):

- To provide assurance of adequate flood protection;
- To be consistent with State water quality standards; and
- To preserve wetland habitat values.

JURISDICTION: Within the Florida Keys, the SFWMD regulates activities within freshwater resources only. Activities within Florida Bay and the Atlantic Ocean are regulated by other agencies. While all individuals must comply with all SFWMD stormwater regulations, the SFWMD administrative rule Chapter 40E-4 FAC exempts developments under 10 acres in size or projects with less than 2 acres of impervious surface from having to submit stormwater management applications.

OPERATION: The three types of individual and general stormwater management permits include letters of conceptual approval, construction permits, and operation permits. During the past three years, a total of 121 surface water management permits were issued in the Florida Keys, the majority of which were General Permits (60) or Permit Exemptions (56). The remainder of the surface water management permits issued were Individual Permits (5) (J. Smith, SFWMD, personal communication, 1992).

Within the SFWMD, the Regulation Department has responsibility for processing and issuing stormwater permits. Internally, the Department's permitting activities are coordinated through surface water management review meetings that are held weekly. These meetings are also attended by staff from the local FDER office and SFWMD staff from other departments and divisions depending on the specific resource issues associated with a given project.

When the SFWMD staff members review development permits, they evaluate them based in part on water quality/ stormwater management impacts. Key factors include potential on-site impacts; quality, drainage, and discharge of water offsite; impacts of stormwater to existing surface or underground groundwater; and downstream wetlands impacts.

These issues are also coordinated with agencies external to the SFWMD. Coordination is handled in several ways. A copy of each new permit application submitted is transmitted to the FDER. The FDER and other agencies, such as the Florida Game and Fresh Water Fish Commission, FDNR, USACE, and other local government agencies, are copied on sufficiency letters and staff reports prior to the issuance of permits. Staff at these agencies are also contacted on an as needed basis to deal with specific problems that arise in the review of specific projects.

In addition to applications issued by the SFWMD, the county requires an applicant to obtain a Letter of Coordination to verify that the site has received a preliminary review by the SFWMD prior to the issuance of local development approvals. These letters are issued by the SFWMD's Surface Water Management Division to Monroe County based on information submitted by the applicant, and they generally indicate permit requirements and any major resource concerns.

FUNDING: The SFWMD does not budget funds according to geographic area such as the Florida Keys. Funds are allocated district-wide according to program needs, (i.e., surface water management, water use, natural resources management, field engineering, etc.). Funding sources are derived from ad valorem taxes and permit application fees.

STAFFING: While the SFWMD has an Intergovernmental Representative based in Big Pine Key, permitting and compliance activities are handled through the main office in West Palm Beach. Because of the limited number/scope of applications submitted, no one person is assigned to the Florida Keys. The existing permitting staff is adequate to process permits in the Florida Keys.

During Fiscal Year 1992, the SFWMD developed major enhancements in its overall compliance program which will benefit all areas of the SFWMD. Six new positions were approved for compliance work and four other existing positions were redirected into compliance work. While none of these positions are assigned exclusively to the Florida Keys, they do increase the overall availability of SFWMD staff for compliance work.

TRACKING: The surface water management permit compliance program consists of both office and field activities. Each permit is tracked by a computer program with regard to data-dependent special conditions of the permit requiring the submittal of specific information by the permittee.

The SFWMD is completing a multi-phase automation program for permit issuance and compliance. It consists of processes for the automated production of permit staff reports, database storage of important data from those staff reports, correctly timed and scheduled retrieval of permit data for site inspections monitoring reports, automated comparison of actual field or monitoring report data against permit values, and tracking and scheduling of required compliance and enforcement actions.

3.4 LOCAL

3.4.1 Monroe County

3.4.1.1 COMPREHENSIVE PLAN

PROGRAM RESPONSIBILITIES: Monroe County, like all counties and cities in the State of Florida, has been mandated by law to prepare a long-range comprehensive plan that will serve as a blueprint for anticipated growth, as well as to address problems that exist. All local comprehensive plans must address eight broad areas, each constituting an element of the plan. They include future land use, transportation, conservation, recreation and open space, infrastructure (potable water, drainage, solid waste, wastewater, and aquifer recharge), housing, intergovernmental coordination, and capital improvements. In addition, local governments within coastal areas must prepare a coastal management element that addresses special issues such as beach erosion, hurricane evacuation, and estuarine pollution problems.

AUTHORITY: The Monroe County Comprehensive Plan has been prepared in accordance with various provisions of the following statutes:

- Section 163.3161 FS — The Local Government Comprehensive Planning and Land Development Regulation Act — Confers on local officials the statutory authority and responsibility to plan and regulate the use of land by adopting local comprehensive plans and land development regulations;

- Chapter 187 FS — The State Comprehensive Plan — A compilation of goals and objectives that Florida is to achieve through the planning process;
- Section 186.507 FS — Outlines the requirements of regional comprehensive policy plans; and
- Section 380.0552 FS — The Florida Keys Area Protection Act — Contains the principles for guiding development that must be addressed in local government comprehensive plans in the Florida Keys.

The administrative rules that local governments are required to satisfy are as follows:
- Chapter 9J-5 FAC — Minimum criteria for review of local government comprehensive plans and determination of compliance;
- Chapter 9J-11 FAC — Submittal requirements for proposed local government comprehensive plans; and
- Chapter 9J-24 FAC — Procedures and criteria for the review of land development regulations.

OBJECTIVE(S): To utilize and strengthen the existing role, processes, and powers of local governments in the establishment and implementation of comprehensive planning programs to guide and control future development.

The local government comprehensive plan process has the potential to significantly affect water quality within the FKNMS based on:
- Maintaining or reducing hurricane evacuation times, which would create restrictions on upland development limiting future growth in the Florida Keys;
- Control of upland land development procedures;
- Stormwater runoff retention level of service requirements; and
- Sanitary sewer and wastewater treatment facilities level of service requirements.

JURISDICTION: The provisions of the Monroe County Comprehensive Plan 1990-2010 apply to all areas of the unincorporated county.

OPERATION: In the State of Florida, not only were local governments required to undertake the preparation of long-range growth policy plans, but so was the state through the auspices of the state planning agency, FDCA, and all eight RPCs. The grand design for planning in the State was based on what has been termed a "top-down" planning process. Regional policy plans and local government comprehensive plans had to be consistent with the state plan. FDCA, as the state planning agency, was charged with the responsibility of determining whether regional comprehensive policy plans and local government comprehensive plans were consistent with the state plan, and in compliance with statutory laws and administrative rules governing comprehensive plans. Because the Florida Keys are designated ACSC, the comprehensive plan must meet not only the requirements of the Local Government Comprehensive Planning Act, but also the Principles for Guiding Development in the Florida Keys as set forth in Section 380.0552 FS.

The State Comprehensive Plan was prepared first and adopted by the Florida Legislature. Next came the regional policy plans and finally local government comprehensive plans. Monroe County has been involved in plan preparation for a number of years.

The policies set out in the following plan elements can affect water quality in the FKNMS:
- Future Land Use;
- Conservation;
- Coastal Management;
- Solid Waste;
- Wastewater; and
- Drainage.

Monroe County has adopted and submitted its plan. The plan has been found to be noncompliant. Negotiations have been conducted and the required settlement agreement has been reached. This agreement must now be adopted by the county.

FUNDING: The County Comprehensive Plan was funded in large part by the FDCA; however, County funds from generating operating revenues was a source of funding as well.

STAFFING: Comprehensive planning is conducted out of the County's Planning Department. This department is housed within the Division of Growth Management. The department is involved with all issues affecting the Monroe County Comprehensive Plan, as well as other areas of planning concern such as the FKNMS. The Planning Department has 5 planners and 20 support personnel (e.g., planning technicians, graphic designer, secretaries). Persons in the planning positions have educational backgrounds and experience not only in such areas as transportation and land use but also in environmental matters. The county recently established the Department of Marine Resources. It deals specifically with issues related to the FKNMS. Two staff members are assigned to the department.

TRACKING: The Monroe County Planning Department is planning to establish a Geographic Information System (GIS) mapping program. The GIS database will be constructed from information generated from the County Comprehensive Plan effort. However, a number of government agencies will serve as valuable resources. It includes the multiple databases maintained by the FDER, as well as information from the FMRI and the SFWMD.

All proposed changes to the adopted comprehensive plan are reviewed and processed by the FDCA Bureau of Local Planning for consistency and compliance with adopted state and regional comprehensive policy plans. In addition, because the Florida Keys are designated ACSC, the FDCA field staff also provides comments regarding proposed plan amendments. Once the FDCA Florida Keys staff completes its review, comments are submitted to the Tallahassee Office for inclusion into the Department's official Objections, Recommendations, and Comments (ORC) response.

The county is required to review its comprehensive plan and make adjustments as necessarily annually, as directed by Chapter 163 FS. In addition, the county is required by Section 163.3191 FS to review its comprehensive plan at least every five years after the plan was adopted. The report that documents the review is known as the Evaluation and Appraisal Report.

3.4.1.2 LAND DEVELOPMENT REGULATIONS

PROGRAM RESPONSIBILITIES: Local governments are required to adopt or amend land development regulations which are consistent with and implement their adopted comprehensive plans. Land development regulations must be incorporated into a single land development code, and it must contain, at a minimum, regulations that

- Govern the subdivision of land;
- Implement the land use categories (should contain provisions for ensuring appropriate densities and intensities, compatible adjacent land uses, and open spaces);
- Control land uses around identified cones of influence for potable water wells;
- Regulate development in areas subject to seasonal and periodic flooding;
- Ensure adequate drainage facilities to control individual and cumulative impacts of flooding and non-point source pollution;
- Regulate signage;
- Ensure that proposed development meet or exceed adopted level of service standards, commonly known as concurrency management; and
- Regulate parking.

Further, local governments may include other specific and detailed provisions necessary or desirable to implement the adopted comprehensive plan.

AUTHORITY: Legislative authority directing local governments to prepare land development regulations is set forth in Section 163.3202 FS. Administrative Rule 9J-24 FAC specifies the regulations that must be contained within the single land development code, as well as criteria for determining consistency of the land development regulations in relation to the local government comprehensive plans. In addition, the rule describes the role and rules involving the FDCA, and how substantially affected persons, local governments and the FDCA may initiate an administrative review of the land development regulations.

OBJECTIVE(S): To utilize and strengthen the existing role, processes, and powers of local governments in regulating the development of the area within their jurisdiction, and ensure that affected persons have a means to assure that land development regulations implement and are consistent with the local comprehensive plan.

JURISDICTION: The provisions of the Monroe County Land Development Regulations apply to all areas of the unincorporated county.

OPERATION: Chapter 9.5 of the Monroe County Code contains the county's land development regulations. The existing regulations control signage, parking, density and intensity of land use, subdivision of land, adequate facilities (concurrency management), floodplain management, and environmental resource protection. Section 9.5-345, Environmental Design Criteria, contains provisions regarding the placement of fill in environmentally sensitive habitats, (i.e., salt marsh and buttonwood associations, mangroves and submerged lands, beach-berm complex). Also, the land development regulations include special rules for places in the unincorporated county designated as Areas of Critical County Concern (ACCC). The purpose of this regulation is to provide procedures and standards for areas with special environmental sensitivity, important historical or archaeological resources, substantial capital improvement deficiencies or significant redevelopment opportunities. North Key Largo, Ohio Key, Holiday Isles, and Big Pine Key have been designated ACCCs. These environmental standards relate more to habitat protection than to water quality protection.

The county has no wellfield protection regulation. The only specific regulation directly affecting groundwater is the prohibition of well excavation in "high quality pineland" areas. The county is the sole supplier of potable water to Monroe County. The wellfields are not within the Florida Keys, but are located west of Florida City in southeast Dade County. While contamination of the freshwater lens on Big Pine Key may not be an immediate threat to public health, it could affect the environment which contributes to the economy of the Florida Keys, and thus indirectly affect its residents. Saltwater intrusion is of primary concern since shrinkage of a given lens system could result.

In addition, there is no stormwater management regulation that sets official standards; however, the county does address stormwater concerns in its development review process. The county is in the process of adopting a stormwater management regulation. The county also has no regulation controlling how hazardous materials and waste are managed. While there are no officially adopted standards, the county addresses such concerns on a case-by-case basis, whenever it is appropriate (T. Symroski, Monroe County, personal communication, 1992).

Another ordinance was enacted in June 1992 that will have a major impact on future development within the Florida Keys. It is known as the Dwelling Unit Allocation Ordinance. This ordinance is one of the new land development regulations (commonly called a rate of growth ordinance) recently added to the county's existing land development regulations. The ordinance regulates the rate at which the county will issue building permits for residential dwelling units commensurate with the county's ability to maintain a reasonable and safe hurricane evacuation clearance time. Between 1989-1990, housing units in the unincorporated county increased at a rate of approximately 900 units per year. The Dwelling Unit Allocation Ordinance allows only 255 dwelling unit permits be issued annually; this amounts to a three-fold decrease in residential development. What this means in terms of water quality is that the prioritization water quality protection strategies should focus first on correcting existing problems, then on controlling the impacts of new development.

Administrative responsibility rests with the Planning Department that is situated within the Division of Growth Management. The existing County Land Development Regulations establish a Development Review Committee comprised of the planning director, the development review coordinator, representatives from the public works department, health department, county engineer, county biologist, and any other staff person the county administrator or planning director feels is necessary to include. Also, the regulations provide for a FDCA representative on the committee as long as the area is designated ACSC. Also, the regulations state that those local, regional, state and federal agencies that have entered into a intergovernmental agreement with the county should have an opportunity to participate.

Because it is within the ACSC, the county must transmit all development permits it approves to the FDCA field office in Key West for review. The state has 45 days from the date the permit is transmitted to the state planning agency, the FDCA, to appeal the local action. Permits can range from a roof repair to variance petition to a new hotel site plan.

FUNDING: The county's land development regulations are being modified in part through financial assistance received from the State of Florida under the Local Government Comprehensive Planning Assistance Program, Chapter 163 FS. In addition, the county has utilized local general revenues to underwrite the costs of updating the land development regulations.

STAFFING: The Planning Department has 5 planners and 20 support personnel (e.g., planning technicians, graphic designer, secretaries). One of the planners serves as the Department Review Coordinator whose primary duties are facilitating and coordinating the permitting process, coordinating with the regional, state and federal agencies, and preparing the materials necessary for review by the Development Review Committee, Planning Commission, and Board of County Commissioners.

Persons in the planning positions have educational backgrounds and experience not only in areas such as transportation and land use, but also in environmental matters. The county recently established the Department of Marine Resources. Staff within that department deal specifically with issues related to the FKNMS. Two staff members are assigned to the department.

TRACKING: All building permits in the county are tracked by a computerized data management system. When site plans and subdivision applications are submitted, they are assigned to one of several assistant building officials. These individuals are responsible for controlling the flow of the application through the review process; therefore, they know exactly where each application is in the review process. Finally, the county will be setting up a tracking system for the new Dwelling Unit Allocation Ordinance.

3.4.2 City of Key West

3.4.2.1 COMPREHENSIVE PLAN

PROGRAM RESPONSIBILITIES: The City of Key West, like all counties and cities in the State of Florida, has been mandated by law to prepare a long-range comprehensive plan that will serve as a blueprint for anticipated growth, as well as address problems that exist. All local comprehensive plans have to address eight broad areas, each constituting an element of the plan. They include future land use, transportation, conservation, recreation and open space, infrastructure (potable water, drainage, solid waste, wastewater, and aquifer recharge), housing, intergovernmental coordination, and capital improvement. In addition, local governments within coastal areas must prepare a coastal management element that addresses special issues such as beach erosion, hurricane evacuation, and estuarine pollution problems.

AUTHORITY: The City of Key West Comprehensive Plan has been prepared in accordance with various provisions of the following statutes:

- Section 163.3161 FS — The Local Government Comprehensive Planning and Land Development Regulation Act — Confers on local officials the statutory authority and responsibility to plan and regulate the use of land by adopting local comprehensive plans and land development regulations;
- Section 186.507 FS — Outlines the requirements of regional comprehensive policy plans;

- Chapter 187 FS — The State Comprehensive Plan — Compilation of goals and objectives that Florida is to achieve through the planning process; and
- Section 380.0552 FS — The Florida Keys Area Protection Act — Contains the principles for guiding development that must be addressed in local government comprehensive plans in the Florida Keys.

The administrative rules that local governments are required to satisfy are as follows:
- Chapter 9J-5 FAC — Minimum criteria for review of local government comprehensive plans and determination of compliance;
- Chapter 9J-11 FAC — Submittal requirements for proposed local government comprehensive plans; and
- Chapter 9J-24 FAC — Procedures and criteria for the review of land development regulations.

OBJECTIVE(S): To utilize and strengthen the existing role, processes, and powers of local governments in the establishment and implementation of comprehensive planning programs to guide and control future development.

The local government comprehensive plan process has the potential to significantly affect water quality within the FKNMS based on:
- Hurricane evacuation time, restrictions on upland development limiting future growth in the Florida Keys;
- Control of upland land development procedures;
- Stormwater runoff retention level of service requirements; and
- Sanitary sewer and wastewater treatment facilities level of service requirements.

JURISDICTION: The provisions of the City of Key West Comprehensive Plan apply to all areas within the legally defined boundaries of the city.

OPERATION: In the State of Florida, not only were local governments required to undertake the preparation of long-range growth policy plans, but so was the state through the auspices of the state planning agency, FDCA, and all eight RPCs. The grand design for planning in the State was based on what has been termed a "top-down" planning process. Regional policy plans and local government comprehensive plans had to be consistent with the state plan. FDCA, as the state planning agency, was charged with the responsibility of determining whether regional comprehensive policy plans and local government comprehensive plans were consistent with the state plan, and in compliance with statutory laws and administrative rules governing comprehensive plans. Because the Florida Keys are designated ACSC, the comprehensive plan must meet not only the requirements of the Local Government Comprehensive Planning Act, but also the Principles for Guiding Development in the Florida Keys as set forth in Section 380.0552 FS.

The State Comprehensive Plan was prepared first and adopted by the Florida Legislature. Next came the regional policy plans and finally local government comprehensive plans. The City of Key West has been involved in plan preparation for a number of years.

The policies set out in the following plan elements can affect water quality in the FKNMS:
- Future Land Use;
- Conservation;
- Coastal Management;
- Solid Waste;
- Wastewater; and
- Drainage.

The City of Key West has submitted an initial plan and received an ORC report on this proposed plan. It has been working with the FDCA Bureau of Local Planning staff and the FDCA field staff located in Key West. The city and FDCA have resolved most of their differences, but the city has yet to officially adopt the proposed plan.

FUNDING: The city comprehensive plan was funded in large part from a FDCA grant. The city also used local funds to underwrite the cost of plan preparation.

STAFFING: Comprehensive planning is conducted out of the city planning office. Staff consists of two planners and secretaries. The Planning Director is responsible for managing all changes related to the comprehensive plan.

TRACKING: All proposed changes to the adopted comprehensive plan are reviewed and processed by the FDCA Bureau of Local Planning for consistency and compliance with adopted state and regional comprehensive policy plans. In addition, because the Florida Keys are designated ACSC, the FDCA field staff also provides comments regarding proposed plan amendments. Once the FDCA Florida Keys staff completes its review, comments are submitted to the Tallahassee Office for inclusion into the department's official ORC response.

The city is required to review its comprehensive plan and make adjustments as necessarily annually, as directed by Chapter 163 FS. In addition, the city is required by Section 163.3191 FS to review its comprehensive plan at least every five years after the plan was adopted. The report that documents the review is known as the Evaluation and Appraisal Report.

3.4.2.2 LAND DEVELOPMENT REGULATIONS

PROGRAM RESPONSIBILITIES: Local governments are required to adopt or amend land development regulations which are consistent with and implement their adopted comprehensive plans. Land development regulations must be incorporated into a single land development code that must contain, at a minimum, regulations that

- Govern the subdivision of land;
- Implement the land use categories (should contain provisions for ensuring appropriate densities and intensities, compatible adjacent land uses, and open spaces);
- Control land uses around identified cones of influence for potable water wells;
- Regulate development in areas subject to seasonal and periodic flooding;
- Ensure adequate drainage facilities to control individual and cumulative impacts of flooding and non-point source pollution;
- Regulate signage;
- Ensure that proposed development meet or exceed adopted levels of service standards, commonly known as concurrency management; and
- Regulate parking.

Further, local governments may include other specific and detailed provisions necessary or desirable to implement the adopted comprehensive plan.

AUTHORITY: Legislative authority directing local governments to prepare land development regulations is set forth in Section 163.3202 FS. Administrative Rule 9J-24 FAC specifies the regulations that must be contained within the single land development code, as well as criteria for determining consistency of the land development regulations in relation to the local government comprehensive plans. In addition, the rule describes the role and rules involving the FDCA, and how substantially affected persons, local governments, and the FDCA may initiate an administrative review of the land development regulations.

OBJECTIVE(S): To utilize and strengthen the existing role, processes, and powers of local governments in regulating the development of the area within their jurisdiction, and ensure that affected persons have a means to assure that land development regulations implement and are consistent with the local comprehensive plan.

JURISDICTION: The provisions of the City of Key West land development regulations apply to all areas within the legally defined boundaries of the city.

OPERATION: The City of Key West implements a number of land development regulations. The existing regulations address such issues as densities and intensities of land use (zoning), signage, parking, and flooding. Although concerns such as hazardous waste and stormwater management are not formally regulated, the city takes these issues into consideration in its site plan review process. However, subsequent to the city adopting its new Comprehensive Plan in 1991, the City contracted with a consultant to update and expand the land development regulations to bring them into compliance with the new Comprehensive Plan and the requirements of Section 163.3161 FS and Chapter 9J-24 FAC.

The Planning Department is responsible for processing site plans and rezoning applications. Although there is no formalized set of administrative review procedures, in practice the City Planning Director seeks input from all appropriate departments within city government depending upon the particular issue in question. The Chief Building official is responsible for ensuring that the project is in compliance with the provisions of the development approval.

Whether a project requires City Council approval depends on whether certain minimum development thresholds have been triggered. In the City of Key West, proposed developments containing less than 9,999 sq. ft and/or less than 20 residential living units are reviewed by city staff and approved by the City Planning Board. Projects larger than these must receive the approval of City Council (T. Strader and J. Castro, City of Key West, personal communication, 1992).

FUNDING: The City's land development regulations are being modified in part through financial assistance (approximately $28,000) received from the State of Florida under the Local Government Comprehensive Planning Assistance Program, Chapter 163 FS. In addition, the city is planning to supplement the state funds by adding in an additional $50,000 to update the land development regulations.

STAFFING: At present, the City Planning Department consists of a secretary and Planning Director. Currently, there is a vacant planner position; however, that position should be filled in the near future. The Chief Building official has four inspectors that report to him. These individuals have the responsibility for ensuring that the conditions set forth in the approved development order are being satisfied.

TRACKING: There is no formal tracking process; however, follow-up is provided by the building official to ensure that the approved development order is in compliance. Formal tracking of development permits will be addressed during the updating of the land development regulations.

3.4.2.3 WASTEWATER TREATMENT

PROGRAM RESPONSIBILITIES: The City of Key West provides sanitary sewer service throughout nearly the entire city. Responsibilities include both operation and maintenance.

AUTHORITY: Legislative authority for the City of Key West to provide for the collection and disposal of sewage and other liquid wastes is contained in Chapter 180 FS. Municipal Public Works. It enables the city to construct sewer systems, trunk sewers, intercepting sewers, pumping stations, and treatment and disposal plants. Further, it allows municipalities to contract with private service providers.

OBJECTIVE(S): To provide an adequate and economically feasible sewage collection, treatment, and disposal system that promotes the public health, safety, and welfare of the residents of the City of Key West.

JURISDICTION: The city has the authority to provide sanitary sewer service to all areas within its corporate boundaries.

OPERATION: Sewer service is provided, with few exceptions, throughout the city. The four isolated areas not presently served will be connected by the mid-nineties. The city's sanitary sewer utility is under the general management of the City Manager and Director of Technical Services. Operation and maintenance of the city's collection system, pump stations, and wastewater treatment facility are performed under a contract operations agreement with a private company, OMI, Inc. OMI, Inc., reports directly to the City Manager and the Director of Technical Services.

The city is exploring, only very preliminarily, the possibility of having the FKAA purchase its wastewater system.

FUNDING: The city's wastewater system operating expenses are paid by user fees. Capital costs are funded by revenue from the city's Renewal and Rehabilitation Fund. Over the next few years, funding from the U.S. Navy will assist to defray some future capital expansion costs. These funds will be used to tie the area presently served by the Navy's Sigsbee Park package plant into the city's wastewater system.

STAFFING: The city has only limited staff involved in the daily wastewater operations. OMI, Inc., is under contract for operation and maintenance.

TRACKING: OMI, Inc., maintains all operating records. The contractor prepares and submits monthly Discharge Monitoring Reports to the city which transmits copies of the reports to EPA in accordance with the provisions of the city's NPDES permit. The city also files similar reports with the FDER.

3.4.3 City of Key Colony Beach

3.4.3.1 COMPREHENSIVE PLAN

PROGRAM RESPONSIBILITIES: The City of Key Colony Beach, like all counties and cities in the State of Florida, has been mandated by law to prepare a long-range comprehensive plan that will serve as a blueprint for anticipated growth, as well as address problems that exist. All local comprehensive plans have to address eight broad areas, each constituting an element of the plan. These areas include future land use, transportation, conservation, recreation and open space, infrastructure (potable water, drainage, solid waste, wastewater, and aquifer recharge), housing, intergovernmental coordination, and capital improvements. In addition, local governments within coastal areas must prepare a coastal management element that addresses special issues such as beach erosion, hurricane evacuation, and estuarine pollution problems.

AUTHORITY: The City of Key Colony Beach Comprehensive Plan has been prepared in accordance with various provisions of the following statutes:

- Section 163.3161 FS — The Local Government Comprehensive Planning and Land Development Regulation Act — Confers on local officials the statutory authority and responsibility to plan and regulate the use of land by adopting local comprehensive plans and land development regulations;
- Section 186.507 FS — Outlines the requirements of regional comprehensive policy plans;
- Chapter 187 FS — The State Comprehensive Plan — A compilation of goals and objectives that Florida is to achieve through the planning process; and
- Section 380.0552 FS — The Florida Keys Area Protection Act — Contains the principles for guiding development that must be addressed in local government comprehensive plans in the Florida Keys.

The administrative rules that local governments are required to satisfy are as follows:

- Chapter 9J-5 FAC — Minimum criteria for review of local government comprehensive plans and determination of compliance;
- Chapter 9J-11 FAC — Submittal requirements for proposed local government comprehensive plans; and
- Chapter 9J-24 FAC — Procedures and criteria for the review of land development regulations.

OBJECTIVE(S): To utilize and strengthen the existing role, processes, and powers of local governments in the establishment and implementation of comprehensive planning programs to guide and control future development.

The local government comprehensive plan process has the potential to significantly affect water quality within the FKNMS based on:

- Maintaining or reducing hurricane evacuation times, which would create restrictions on upland development limiting future growth in the Florida Keys;
- Control of upland land development procedures;
- Stormwater runoff retention level of service requirements; and
- Sanitary sewer and wastewater treatment facilities level of service requirements.

JURISDICTION: The provisions of the City of Key Colony Beach Comprehensive Plan apply to all areas within the legally defined boundaries of the city.

OPERATION: In the State of Florida, not only were local governments required to undertake the preparation of long-range growth policy plans, but so was the state through the auspices of the state planning agency, FDCA, and all eight RPCs. The grand design for planning in the state was based on what has been termed a "top-down" planning process. Regional policy plans and local government comprehensive plans had to be consistent with the state plan. FDCA, as the state planning agency, was charged with the responsibility of determining whether regional comprehensive policy plans and local government comprehensive plans were consistent with the state plan, and in compliance with statutory laws and administrative rules governing comprehensive plans. Because the Florida Keys are designated ACSC, the comprehensive plan must meet not only the requirements of the Local Government Comprehensive Planning Act, but also the Principles for Guiding Development in the Florida Keys as set forth in Section 380.0552 FS.

The State Comprehensive Plan was prepared first and adopted by the Florida Legislature; next came the regional policy plans and finally local government comprehensive plans. The City of Key Colony Beach has been involved in plan preparation for a number of years.

The policies set out in the following plan elements can affect water quality in the FKNMS:

- Future Land Use;
- Conservation;
- Coastal Management;
- Solid Waste;
- Wastewater; and
- Drainage.

The City of Key Colony Beach Comprehensive Plan was found in compliance by the FDCA. It was officially adopted in February 1992.

FUNDING: The city comprehensive plan was funded through a grant from the FDCA.

STAFFING: The city staff is minimal. City planning issues are handled by the Planning and Zoning Chairman. Plan preparation was completed through the use of a consulting firm.

TRACKING: All proposed changes to the adopted comprehensive plan are reviewed and processed by the FDCA Bureau of Local Planning for consistency and compliance with adopted state and regional comprehensive policy plans. In addition, because the Florida Keys are designated ACSC, the FDCA field staff also provides comments regarding proposed plan amendments. Once the FDCA Florida Keys staff completes its review, comments are submitted to the Tallahassee Office for inclusion into the department's official ORC response.

The city is required to review its comprehensive plan and make adjustments as necessarily annually, as directed by Chapter 163 FS. In addition, the city is required by Section 163.3191 FS to review its comprehensive plan at least every five years after the plan was adopted. The report that documents the review is known as the Evaluation and Appraisal Report.

3.4.3.2 LAND DEVELOPMENT REGULATIONS

PROGRAM RESPONSIBILITIES: Local governments are required to adopt or amend land development regulations which are consistent with and implement their adopted comprehensive plan. Land development regulations must be incorporated into a single land development code that must contain, at a minimum, regulations that

- Govern the subdivision of land;
- Implement the land use categories (should contain provisions for ensuring appropriate densities and intensities, compatible adjacent land uses, and open spaces);
- Control land uses around identified cones of influence for potable water wells;
- Regulate development in areas subject to seasonal and periodic flooding;
- Ensure adequate drainage facilities to control individual and cumulative impacts of flooding and non-point source pollution;
- Regulate signage;
- Ensure that proposed development meet or exceed adopted level of service standards, commonly known as concurrency management; and
- Regulate parking.

Further, local governments may include other specific and detailed provisions necessary or desirable to implement the adopted comprehensive plan.

AUTHORITY: Legislative authority directing local governments to prepare land development regulations is set forth in Section 163.3202 FS. Administrative Rule 9J-24 FAC specifies the regulations that must be contained within the single land development code, as well as criteria for determining consistency of the land development regulations in relation to the local government comprehensive plans. In addition, the rule describes the role and rules involving the FDCA, and how substantially affected persons, local governments, and the FDCA may initiate an administrative review of the land development regulations.

OBJECTIVE(S): To utilize and strengthen the existing role, processes, and powers of local governments in regulating the development of the area within their jurisdiction, and ensure that affected persons have a means to assure that land development regulations implement and are consistent with the local comprehensive plan.

JURISDICTION: The provisions of the City of Key Colony Beach Land Development Regulations apply to all areas within the legally defined boundaries of the city.

OPERATION: The City of Key Colony Beach manages the development of land within its jurisdiction through its land development code. The existing code contains provisions that regulate the densities and intensities of land use, development subject to seasonal and periodic flooding, as well as parking and signage. Presently, the code does not contain regulations relative to stormwater; however, Policy 1.43 of the Infrastructure Element of the Comprehensive Plan describes specific drainage standards that must be met by all new development. More specific standards may be developed once the City completes its master stormwater management plan. With the exception of prohibiting boat repairs, bottom scraping, and repainting, hazardous waste issues are not regulated by the city. The city depends upon the FDER, since the Department has statutory responsibility for regulating hazardous waste in Florida. In terms of wastewater, the city requires that all development connect to the city's wastewater plant (W. Botten and J. Sheldon, City of Key Colony Beach, personal communication, 1992).

The city is a very small jurisdiction, both in terms of size (acres) and population; therefore, municipal staff is minimal. In practice, the Building Inspector administers the land development code for the city, and the Planning and Zoning Board reviews and makes recommendations on site plans and rezonings, and submits their findings and recommendations to the City Council for its deliberation. In areas already subdivided, which is the vast majority of the city, development basically occurs on a lot-by-lot basis. Therefore, within the city the Building Inspector is the individual who becomes involved in most development permit applications. However, because the Florida

Keys are designated an ACSC, the FDCA field staff reviews all development permits to ensure they are in compliance with local regulations and consistent with the city's adopted Comprehensive Plan.

FUNDING: The city's land development regulations are being modified in part through financial assistance received from the State of Florida under the Local Government Comprehensive Planning Assistance Program, Chapter 163 FS. In addition, the city has utilized local general revenues to underwrite the costs of updating the land development regulations.

STAFFING: The Building Inspector has sole administrative responsibility with respect to the city land development regulations. This individual reviews development applications for completeness, and packages the development application for review by the Planning and Zoning Commission.

TRACKING: Tracking of development permits is done by the Building Inspector at various designated points during various stages of construction. Since the city is a small community approaching build-out, development activity is not formally tracked through the development approval process as in larger, more rapid growing local governments along Florida's east coast.

3.4.3.3 WASTEWATER TREATMENT

PROGRAM RESPONSIBILITIES: The City of Key Colony Beach provides sanitary sewer service throughout its corporate limits. It is responsible for both the operation and maintenance of the system.

AUTHORITY: Legislative authority for the City of Key Colony Beach to provide for the collection and disposal of sewage and other liquid wastes is contained in Chapter 180 FS, Municipal Public Works. It enables the city to construct sewer systems, trunk sewers, intercepting sewers, pumping stations, and treatment and disposal plants. Further, it allows municipalities to contract with private service providers.

OBJECTIVE(S): To provide an adequate and economically feasible sewage collection, treatment, and disposal system that promotes the public health, safety, and welfare of the residents of the City of Key Colony Beach.

JURISDICTION: Wastewater service extends to all areas within its corporate boundaries.

OPERATION: The city's sanitary sewer utility is under the general management of the Sewer Utility Board. Operation and maintenance of the city's collection system, pump stations, and wastewater treatment facility are performed under a contract operations agreement with a private company, Anti-Pollution Associates.

FUNDING: The city's wastewater system operating expenses are paid for by user fees. They amount to $15 per month per residential unit. In addition, a connection fee of $3,500 is assessed for each new residential unit.

STAFFING: The city's Sewer Utility Board coordinates with the contractor/operator concerning operational and maintenance issues and problems.

TRACKING: The city maintains all operating records. The contractor prepares and submits monthly Discharge Monitoring Reports that are transmitted by the city to EPA in accordance with the provisions of the city's NPDES permit. The city files similar monthly monitoring reports to the FDER.

3.4.4 City of Layton

3.4.4.1 COMPREHENSIVE PLAN

PROGRAM RESPONSIBILITIES: The City of Layton, like all counties and cities in the State of Florida, has been mandated by law to prepare a long-range comprehensive plan that will serve as a blueprint for anticipated growth, as well as address problems that exist. All local comprehensive plans have to address eight broad areas, each constituting an element of the plan. These areas include future land use, transportation, conservation, recreation and open space, infrastructure (potable water, drainage, solid waste, wastewater, and aquifer recharge), housing, intergovernmental coordination, and capital improvement. In addition, local governments within coastal areas must prepare a coastal management element that addresses special issues such as beach erosion, hurricane evacuation, and estuarine pollution problems.

AUTHORITY: The City of Layton Comprehensive Plan has been prepared in accordance with various provisions of the following statutes:

- Section 163.3161 FS — The Local Government Comprehensive Planning and Land Development Regulation Act — Confers on local officials the statutory authority and responsibility to plan and regulate the use of land by adopting local comprehensive plans and land development regulations;
- Section 186.507 FS — Outlines the requirements of regional comprehensive policy plans;
- Chapter 187 FS — The State Comprehensive Plan — A compilation of goals and objectives that Florida is to achieve through the planning process; and
- Section 380.0552 FS — The Florida Keys Area Protection Act — Contains the principles for guiding development that are required to be addressed in local government comprehensive plans in the Florida Keys.

The administrative rules that local governments are required to satisfy are as follows:

- Chapter 9J-5 FAC — Minimum criteria for review of local government comprehensive plans and determination of compliance;
- Chapter 9J-11 FAC — Submittal requirements for proposed local government comprehensive plans; and
- Chapter 9J-24 FAC — Procedures and criteria for the review of land development regulations.

OBJECTIVE(S): To utilize and strengthen the existing role, processes, and powers of local governments in the establishment and implementation of comprehensive planning programs to guide and control future development.

The local government comprehensive plan process has the potential to significantly affect water quality within the FKNMS based on:

- Maintaining or reducing hurricane evacuation times, which would create restrictions on upland development limiting future growth in the Florida Keys;
- Control of upland land development procedures;
- Stormwater runoff retention level of service requirements; and
- Sanitary sewer and wastewater treatment facilities level of service requirements.

JURISDICTION: The provisions of the City of Layton Comprehensive Plan apply to all areas within the legally defined boundaries of the city.

OPERATION: In the State of Florida, not only were local governments required to undertake the preparation of long-range growth policy plans, but so was the state through the auspices of the state planning agency, FDCA, and all eight RPCs. The grand design for planning in the State was based on what has been termed a "top-down" planning process. Regional policy plans and local government comprehensive plans had to be consistent with the state plan. FDCA, as the state planning agency, was charged with the responsibility of determining whether regional comprehensive policy plans and local government comprehensive plans were consistent with the state plan, and in compliance with statutory laws and administrative rules governing comprehensive plans. Because the Florida

Keys are designated ACSC, the comprehensive plan must meet not only the requirements of the Local Government Comprehensive Planning Act, but also the Principles for Guiding Development in the Florida Keys as set forth in Section 380.0552 FS.

The State Comprehensive Plan was prepared first and adopted by the Florida Legislature. Next came the regional policy plans and finally local government comprehensive plans. The City of Layton has been involved in plan preparation for a number of years.

The policies set out in the following plan elements can affect water quality in the FKNMS:

- Future Land Use;
- Conservation;
- Coastal Management;
- Solid Waste;
- Wastewater; and
- Drainage.

The City of Layton has adopted its comprehensive plan; however, the city has not submitted it to the FDCA for compliance determination.

FUNDING: The city comprehensive plan was funded from a grant provided to the city by the FDCA.

STAFFING: Due to the city's very small size, staff is minimal. City planning issues are handled by the local planning agency. Plan preparation was completed through the use of a consulting firm.

TRACKING: All proposed changes to the adopted comprehensive plan are reviewed and processed by the FDCA Bureau of Local Planning for consistency and compliance with adopted state and regional comprehensive policy plans. In addition, because the Florida Keys are designated ACSC, the FDCA field staff also provides comments regarding proposed plan amendments. Once the FDCA Florida Keys staff completes its review, comments are submitted to the Tallahassee Office for inclusion into the department's official ORC response.

The city is required to review its comprehensive plan and make adjustments as necessarily annually, as directed by Chapter 163 FS. In addition, the city is required by Section 163.3191 FS to review its comprehensive plan at least every five years after the plan was adopted. The report that documents the review is known as the Evaluation and Appraisal Report.

3.4.4.2 LAND DEVELOPMENT REGULATIONS

PROGRAM RESPONSIBILITIES: Local governments are required to adopt or amend land development regulations which are consistent with and implement their adopted comprehensive plans. Land development regulations must be incorporated into a single land development code that must contain, at a minimum, regulations that

- Govern the subdivision of land;
- Implement the land use categories (should contain provisions for ensuring appropriate densities and intensities, compatible adjacent land uses, and open spaces);
- Control land uses around identified cones of influence for potable water wells;
- Regulate development in areas subject to seasonal and periodic flooding;
- Ensure adequate drainage facilities to control individual and cumulative impacts of flooding and non-point source pollution;
- Regulate signage;
- Ensure that proposed development meet or exceed adopted level of service standards, commonly known as concurrency management; and
- Regulate parking.

Further, local governments may include other specific and detailed provisions necessary or desirable to implement the adopted comprehensive plan.

AUTHORITY: Legislative authority directing local governments to prepare land development regulations is set forth in Section 163.3202 FS. Administrative Rule 9J-24 FAC specifies the regulations that must be contained within the single land development code, as well as criteria for determining consistency of the land development regulations in relation to the local government comprehensive plans. In addition, the rule describes the role and rules involving the FDCA, and how substantially affected persons, local governments and the FDCA may initiate an administrative review of the land development regulations.

OBJECTIVE(S): To utilize and strengthen the existing role, processes, and powers of local governments in regulating the development of the area within their jurisdiction, and ensure that affected persons have a means to assure that land development regulations implement and are consistent with the local comprehensive plan.

JURISDICTION: The provisions of the City of Layton Land Development Regulations apply to all areas within the legally defined boundaries of the city.

OPERATION: The City of Layton manages the development of land within its jurisdiction through its land development code. The existing code contains provisions that regulate the densities and intensities of land use, the subdivision of land, parking and signage. At present, the city has a separate ordinance that regulates land development subject to seasonal and periodic flooding; however, the flood protection ordinance will be integrated into the single land development regulations that will be developed in the near future. The present land development regulation also addresses environmentally sensitive areas. Parcels of land located in such areas would need to address special provisions set out in the land development regulations that would ensure the protection of the environmental resources; however, the regulation does not contain any specific standards. Presently, the code does not contain regulations relative to stormwater or the management of hazardous materials.

In practice, most development permits are limited to individual single family building permits. These permits are processed and monitored for compliance by the city's Building Inspector. Anything larger than a single family building permit must receive City Council approval. Rezonings or site plans are processed by the City Administrator, and undergo the scrutiny of the City Council which serves as both the Planning and Zoning Commission.

Because the city is within the ACSC, the county must transmit all development permits it approves to the FDCA field office in Key West for review. The state has 45 days from the date the permit is rendered to FDCA to appeal the local action. Permits can range from a roof repair to variance petition, to a new hotel site plan.

FUNDING: The City's land development regulations are being modified in part through financial assistance received from the State of Florida under the Local Government Comprehensive Planning Assistance Program, Chapter 163 FS. In addition, the city will supplement the state funds with local general revenues to defray the costs of updating the land development regulations.

STAFFING: The city has a very small staff. Basically, staff is limited to the City Administrator and the Building Inspector. If complex issues arise, the city employs the services of a consulting firm, as needed.

TRACKING: Tracking of development permits is done by the Building Inspector at various designated points during construction. Since the city is a small community approaching build-out, development activity is not formally tracked through the development approval process as in the larger, more rapid growing local governments along Florida's east coast.

4.0 REFERENCES

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Odum, W.E., C.C. McIvor, and T.J. Smith, III. 1982. The ecology of the mangroves of South Florida: A community profile. U.S. Fish and Wildlife Service, Washington, DC. FWS/OBS-81/24. 144 pp.

Odum, W.E. and C.C. McIvor. 1990. Mangroves. Pp. 517-548 in: R.L. Myers and J.J. Ewol (Eds.) *Ecosystems of Florida*. University Presses of Florida, Gainesville, FL. 765 pp.

APPENDIX A

List of Agencies and People Contacted and Interviewed

LIST OF AGENCIES AND PEOPLE CONTACTED AND INTERVIEWED

Information pertinent to this Institutional and Agency Management Report was collected through various means. Relevant literature, legislative laws, agency administrative rules, and Memorandums of Agreement and Understanding between various agencies were reviewed. Key regulatory agencies at federal, state, regional, and local levels of government were identified and specific contacts within those agencies were established. Survey questionnaires concerning program functions were developed and mailed to key individuals associated with specific water quality regulatory programs. Individuals within identified programs were interviewed either in person or via telephone.

This Appendix provides the names of the agencies and individuals who were identified as potentially having pertinent information for this report. Individuals who were sent but did not return questionnaires have (1) following their names. Individuals who received and returned questionnaires have (2) after their names. Individuals who were interviewed either in person or via telephone have (3) following their names. Individuals with (4) after their name reviewed and commented on the draft Institutional and Agency Management Inventory Report. Acronyms used in the Appendix are defined in the List of Acronyms.

FEDERAL

U.S. ENVIRONMENTAL PROTECTION AGENCY

- Gary Collins - Ocean Dumping (2,3,4)
- Ed Decker - NPDES Enforcement (3)
- Harry Desai - RCRA (2,3,4)
- Roland Ferry - Ocean Discharge (2,3,4)
- Catherine Fox - Ocean Dumping
- Mary Ann Gerber - Nonpoint Sources (2,3,4)
- Mike Hollinger - Underground Injection Control (2,3)
- David Holroyd - Federal Facilities (3)
- Anne Inderbitzin - Dredge and Fill (3)
- John Isbell - Underground Storage Tanks (2,4)
- Ken Kwan - NPDES Enforcement (2,3)
- Jim McGuire - Superfund (2,3)
- Fred McManus - FKNMS Intergovernmental Coordination (2,4)
- Tammy Moore - NPDES Domestic and Industrial Wastewater Permitting (2,4)
- Duncan Powell - Dredge and Fill (2,3,4)
- Mark Robertson - NPDES Federal Facilities (2,3,4)
- Donna Seadler - Underground Storage Tanks (2)
- Chris Thomas - NPDES Storm Water Permitting (2,3,4)
- Tom Welborn - Dredge and Fill (4)
- Lloyd Wise - Gulf of Mexico Program (2,3,4)

U.S. COAST GUARD

- Lt. Robert Garrott - Spills (3,4)
- Petty Officer Steven Hansen - Spills (3)

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

- Billy Causey - Florida Keys National Marine Sanctuary (1,3)
- Ed Lindelof - Sanctuaries and Reserves Division (4)
- Natalie Peter - Coastal Zone Management (3)

U.S. ARMY CORPS OF ENGINEERS
District IV, Jacksonville
Bob Barron - Dredge and Fill (4)
John Hall - Dredge and Fill (3)

STATE

FLORIDA DEPARTMENT OF AGRICULTURE
Jacksonville Office
John Mulrennan - Entomology and Pest Control (3)
Tallahassee Office
Chuck Buddell - Mosquito Control (3)

FLORIDA DEPARTMENT OF COMMUNITY AFFAIRS
Key West Office
Ken Metcalf - Areas of Critical State Concern (3)
Tallahassee Office
Maria Abadal - Local Planning (3)
Alexis McGee - Developments of Regional Impact (3)
Toy Livingston - Areas of Critical State Concern (2,3,4)
Jim Quinn - Areas of Critical State Concern (3)
Charles Pattison - Resource Planning and Management (2)

FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION
Marathon District Branch Office
R. J. Helbling - Storm Water, Solid and Hazardous Waste (3,4)
Lisa Goodwin - Solid Waste, Hazardous Waste (3,4)
Gus Rios - Wastewater, Underground Injection Control (2,3,4)
Ft. Myers District Office
Abdul Ahmadi - Wastewater (2,3)
Phil Barbaccia - Solid Waste, Hazardous Wastes Underground Injection Control (2)
Ron Blackburn - Water Quality Monitoring (2,3)
Bill Krumholtz - Solid Waste (3)
Gordon Romeis - Dredge and Fill (2)
Tallahassee Office
Phil Coram - Industrial Wastewater (2,3,4)
Bruce DeGrove - Point Source Evaluation (2,3,4)
Rodney DeHan - Drinking and Groundwater Management (2)
Richard Drew - Water Facilities (2,3,4)
Doug Fry - Dredge and Fill (2,3)
Vivian Garfein - Surface Water Management (4)
Lynn Griffin - CZMP Federal Consistency (3)
Joe Haberfeld - Underground Injection Control (3)
Jim Hulbert - Ambient Monitoring (4)
Janet Klemm - Standards (2,3,4)
Greg Lee - Emergency Response (3)
Eric Livingston - Storm Water Management (2,3,4)
Peggy Mathews - FKNMS Intergovernmental Coordination (3,4)
Ellen McCarron - Nonpoint Sources (3)
Elsa Potts - Domestic Wastewater (2,3,4)
Marshall Mott-Smith - Storage Tank Regulation (4)
Tom Swihart - Standards and Monitoring (2,3)

FLORIDA DEPARTMENT OF HEALTH AND REHABILITATIVE SERVICES

Monroe County Public Health Unit

Chris Williams - Environmental Health (2,3)

Tallahassee Health Office

Enaix Poule - Environmental Health (3)

Kevin Sherman - Environmental Health (2,3,4)

FLORIDA DEPARTMENT OF NATURAL RESOURCES

Key Largo National Marine Sanctuary

Bill Goodwin - Sanctuaries (3)

Marathon Office

Ann Lazar - Submerged Lands (1,3)

Major Ron McCullers - Florida Marine Patrol (1,3)

Annette Nielson - Submerged Lands, Aquatic Preserves (3)

St. Petersburg Laboratory

Paul Carlson - Research (3)

Ken Haddad - Research (3)

Tallahassee Office

Ernie Barnett - Marine Resources (3)

Dana Bryan - Parks and Recreation (3)

Peter Mallison - State Lands (3)

Fran Manilla - Parks and Recreation (3)

Debbie Parrish - State Lands (3)

Debbie Preble - Oil Spill Emergency Response (3)

Dan Riley - Sanctuaries and Research Reserves (3,4)

FLORIDA GOVERNORS OFFICE

Paul Johnson - Intergovernmental Coordination (3)

David Stage - Data Cataloguing (3)

REGIONAL

FLORIDA KEYS AQUEDUCT AUTHORITY

Paul Mitchell - Engineering (3)

SOUTH FLORIDA REGIONAL PLANNING COUNCIL

Dick Ogburn - Development of Regional Impact (3)

SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Rick Alleman - Planning (3)

Jim Smith - Marathon Office, Local Government Liaison (1,2,3,4)

LOCAL

MONROE COUNTY

Barry Bolbissar - Solid Waste (1,3)

George Garrett - Marine Resources (1,3)

Pat McNeese - Environmental and Comprehensive Planning (3)

Lois Ryan - Mosquito Control (3)

Ty Symvoski - Comprehensive Planning (3,4)

CITY OF KEY WEST

Ray Archer - Engineering (3)
John Castro - Chief Building Official (3,4)
Paul Cates - Technical Services (3)
Chuck Hamlin - Port and Transit Authority (3)
Sally Lewis - City Commissioner (Environmental Liaison) (3)
Ted Strader - Planning Director (1,3,4)
Ken Williams - Consulting Engineer (CH_2M Hill) (3)

CITY OF KEY COLONY BEACH

William Botten - Planning and Zoning Committee (4)
Joan Rinyu - City Clerk (3)

CITY OF LAYTON

Dean Turney - Administrator (3,4)

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1 - Questionnaires were not returned.
2 - Questionnaires were returned.
3 - Interviews occurred.

TASKS 3 AND 4 — ENGINEERING, MANAGEMENT, AND INSTITUTIONAL OPTIONS

CONTENTS

CONTENTS (continued)

CONTENTS (continued)

TABLES

ACRONYMS

ACSC	Area of Critical State Concern
ASR	aquifer storage and recovery
AWT	advanced wastewater treatment
BOD	biological oxygen demand
BOD_5	biochemical oxygen demand
BMP	Best Management Practices
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CETS	Compliance Enforcement Tracking System
CFR	Code of Federal Regulations
COD	chemical oxygen demand
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
FAC	Florida Administrative Code
FDCA	Florida Department of Community Affairs
FDER	Florida Department of Environmental Regulation
FDHRS	Florida Department of Health and Rehabilitative Services
FDNR	Florida Department of Natural Resources
FDOT	Florida Department of Transportation
FKAA	Florida Keys Aqueduct Authority
FKNMS	Florida Keys National Marine Sanctuary
FMP	Florida Marine Patrol
FS	Florida Statutes
FWS	[U.S.] Fish and Wildlife Service
GIS	Geographic Information System
GMS	Groundwater Management System
GPD	gallons per day
I/I	infiltration/inflow
mg/L	milligrams per liter
MGD	million gallons per day
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
NH_3	ammonia
NH_3-N	ammonia nitrogen
NO_3	nitrate
NO_3-N	nitrate nitrogen
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
O & M	operation and maintenance
OSDS	on-site sewage disposal system
PAED	Planning Area Analysis/Enumeration Districts
PCB	polychlorinated biphenyl
PCS	Pollution Control Structures
PE	Professional Engineer
PO_4	phosphate
QA/QC	Quality Assurance/Quality Control
RCRA	The Resource Conservation and Recovery Act
SFWMD	South Florida Water Management District
STEP	septic tank effluent pump
SWIM	Surface Water Improvement and Management
TN	total nitrogen
TP	total phosphorus

ACRONYMS (continued)

TREEO	[University of Florida Center for] Training, Research, and Education for Environmental Occupations
TSS	total suspended solids
ULV	ultra low volume
USACE	U.S. Army Corps of Engineers
USCG	U.S. Coast Guard
WWTP	wastewater treatment plant
WQBEL	water quality-based effluent limitation

TASKS 3 AND 4 — ENGINEERING, MANAGEMENT, AND INSTITUTIONAL OPTIONS

1.0 INTRODUCTION

The objective of Tasks 3 and 4 is to provide a range of options for corrective actions to reduce pollution entering Florida Keys National Marine Sanctuary (FKNMS) waters. As described in the General Introduction, a major goal of the Water Quality Protection Program is to "recommend priority corrective actions and compliance schedules addressing point and nonpoint sources of pollution to restore and maintain the chemical, physical, and biological integrity of the sanctuary." Options presented here will be considered by the Environmental Protection Agency (EPA) for recommendation as priority corrective actions in the Water Quality Protection Program document. In addition, the options will be considered by the National Oceanic and Atmospheric Administration (NOAA) for inclusion in management alternatives being developed for the Sanctuary.

Two caveats must be noted here. First, the options presented here are just that — options — not recommended or approved courses of action. Some options may seem obviously beneficial and innocuous; others may be so expensive or controversial that they would never be implemented. Second, the level of detail provided in this report is sufficient to evaluate the options but not sufficient to implement them. Implementation requirements will be detailed in "Action Plans" prepared by NOAA for any options selected. Environmental and socioeconomic impacts of options eventually included in NOAA's management alternatives for the FKNMS will be evaluated in an environmental impact statement.

Phase I of the Water Quality Protection Program included the identification of known, suspected, and potential pollution sources affecting water quality in the FKNMS. An inventory of pollution sources is given in the Phase I report. An updated pollution source inventory is included here in Appendix A. Based on the available information, pollution sources were targeted for corrective actions involving one or more of three types of options (discussed in more detail in Section 2.0):

- **Engineering options**
  Options designed to reduce pollution directly through engineering methods.

- **Management options**
  Options to reduce pollution directly by prohibiting or restricting certain activities, tightening existing regulations, increasing enforcement, and/or increasing environmental awareness. Other management options are recommendations to make the regulatory/management system work more efficiently and would have little or no direct effect on pollution.

- **Institutional options**
  Options for institutional control of the pollution source (if applicable). These have little or no direct effect on pollution.

The organization of this document is intended to provide the reader with an adequate description and rationale for the options, while providing additional detail in the Appendices:

- **Section 2.0**
  This section reviews pollution sources and loadings, identifies sources targeted for corrective action, and explains types of options considered and how they were developed.

- **Sections 3.0-9.0**
  These sections describe the options for each pollution source targeted for corrective action.

- **Appendices A-E**
  The appendices present detailed supporting data, including pollution sources and loadings and descriptions of engineering methods and options.

2.0 BACKGROUND AND APPROACH

2.1 POLLUTION SOURCES AND LOADINGS

An inventory of pollution sources in and adjacent to the FKNMS is given in Task 2, Section 3.0 of the Phase I report. An updated pollution source inventory is included in **Appendix A** of this Task 3 and 4 report.

For each pollution source identified in **Appendix A**, loadings are quantified for only those pollutants that are of primary concern with respect to adverse effects on receiving water quality, and that can be estimated by reliable means. This approach lays the groundwork for subsequent development of engineering options that focus on removal of the most significant pollutant loadings associated with the various sources. Targeted pollutants associated with the two major source categories are as follows:

Source Category	Pollutant Category
Domestic wastewater	Nutrients
Stormwater	Nutrients, sediment, toxics

The main focus of engineering options in this report is reducing nutrients in wastewater and stormwater. Toxic constituents in stormwater runoff have a relatively high potential for adversely affecting nearshore marine waters, particularly in confined areas. However, because of the great variety of toxic materials, the wide range of concentrations at which specific constituents are toxic, the high variability from site to site, and the lack of stormwater data in the Keys, toxic loadings cannot be quantified with any degree of confidence. Toxic materials are not targeted for pollution sources other than stormwater because there are no data indicating significant or persistent toxicity problems associated with those sources. Oxygen demand is not targeted because oxygen depletion has not been demonstrated to be a significant problem, with the possible exception of some confined waters. There is only one cooling water discharge identified within the FKNMS (Stock Island Steam Plant), and it has not been demonstrated to have adverse thermal or toxic impacts on receiving waters. No adverse salinity effects have been attributed to discharges originating within the FKNMS.

A summary of total nitrogen, total phosphorus, and total suspended sediment loadings to the FKNMS from domestic wastewater and stormwater is given in **Table 3-1**. Calculations of nutrient loadings from various groundwater pollution sources assume that no significant absorption or adsorption of nutrients occurs in the shallow surface soils or underlying limestone formations. While there is some evidence that certain forms of phosphorus are absorbed within the limestones, the evidence is not conclusive and the overall, long-term retention of phosphorus within the formations has not been shown to be significant.

Table 3-1 indicates that wastewater sources account for about 84% of the combined wastewater/stormwater nitrogen loadings and 66% of the combined wastewater/stormwater phosphorus loadings. Atmospheric nutrient inputs have not been estimated for the FKNMS, although rough calculations based on data from Tampa Bay (Fanning 1992) indicate that atmospheric nitrogen loadings to the FKNMS may be 8 to 20 times the combined nitrogen loadings of wastewater and stormwater. Atmospheric nutrient loadings are derived from both anthropogenic and natural sources. Advective nutrient inputs from Florida Bay, Biscayne Bay, and the Florida Current are believed to be potentially significant, but cannot be quantified with existing data. Both atmospheric and advective nutrient inputs are targeted for further study under the Research Program (Task 7). Other human inputs, such as non-wastewater National Pollutant Discharge Elimination System (NPDES) discharges, marinas, landfills, hazardous material spills, and underground storage tanks are not believed to be regionally significant sources of nutrients.

Table 3-1. Summary of nutrient and suspended sediment loadings from domestic wastewater and stormwater.[a]

Source	TN (lb/day)	TP (lb/day)	TSS (tons/day)
DOMESTIC WASTEWATER			
OSDS	1553	377	ND
Cesspits	709	250	ND
Package plants (groundwater discharge)	758	152	ND
Municipal wastewater treatment plants (surface discharge, NPDES)	320	36	ND
Live-aboards	84	30	ND
Total	3424	845	
STORMWATER			
Developed areas	401	364	85
Undeveloped areas	234	75	39
Total	635	439	124

ND: No data.
[a]Calculations are based on the 209 treatment plants listed in the Phase I report (Table 2-5). Recent, unverified information suggests there may be as many as 270 treatment facilities in the Florida Keys.

As indicated in Table 3-1, about 69% of the total estimated stormwater sediment load is from developed areas and 31% is from undeveloped areas (developed areas account for about 29% of the total Keys land mass). A significant portion of toxic constituents present in stormwater runoff will be associated with this sediment load. Advective sediment inputs from Florida Bay, Biscayne Bay, and the Florida Current are believed to be potentially significant, but cannot be estimated with the existing data.

The possibility that nutrient and sediment loadings from external sources may be greater than anthropogenic loadings from wastewater or stormwater sources should not diminish the importance of focusing on anthropogenic nutrient loadings and their effects on water quality. Nutrient loadings from atmospheric sources are diffuse and somewhat evenly distributed over the Sanctuary. Wastewater nutrient loadings emanate from the land/water boundary and may cause concentration increases in nearshore waters well above those caused by atmospheric inputs. Similarly, external advective nutrient or sediment inputs would be more diffuse than their land-based, human-induced counterparts. Understanding the physical processes driving these advective and atmospheric loadings and the effects they may have on water quality within the Sanctuary would require a considerable data collection and analysis effort, and is therefore identified as a topic for further study in the Research Program (Task 7).

Nutrient and sediment loadings in Table 3-1 are based on current population and development intensity. Population growth in the Keys will be limited by the caps of 2552 equivalent residential units in the unincorporated county and 1150 equivalent residential units between Key West, Key Colony Beach, and Layton over the next 20 years (see Section 3.1.2). Using 2.2 persons per household, this would result in a population increase of only 8,144 or 8.5%. Wastewater flows are proportional to population, and the values in Table 3-1 would increase accordingly. Stormwater pollution loadings are not directly proportional to population, but it is reasonable to assume that they are proportional to population in the absence of other data. Population growth is discussed further in Section 3.1.2.

Note: Information received in Florida Department of Environmental Regulation (FDER) comments on the Phase I report indicates that there are 270 wastewater treatment plant (WWTP) permits and 250 active WWTPs in the Keys. Because updated information on the additional WWTPs has not been received, this report and all calculations of nutrient removals and costs will address the 209 WWTPs identified in the Phase I report. The additional WWTPs will affect nutrient removals and costs associated with some engineering options, but only by a relatively small percentage (less than 5% for most options). Overall strategies and structure of the engineering options will not be affected.

2.2 SOURCES TARGETED FOR CORRECTIVE ACTION

Based on the discussion above, the supporting details in Appendix A, and the Phase I report, each pollution source was considered for engineering and/or management options. The types of options developed for each pollution source are summarized in Table 3-2.

2.2.1 Domestic Wastewater

Wastewater discharges originating from land-based sources account for about three quarters of the wastewater/stormwater nutrient loadings from within the FKNMS. Insufficient site-specific data exist to confirm a direct relationship between groundwater disposal of package plant or on-site sewage disposal system (OSDS) effluents and regional nearshore or offshore water quality in the FKNMS. Several studies have suggested relationships between OSDS use and nutrient levels in nearshore and offshore waters of the FKNMS. Limited data have also indicated a relationship between high OSDS densities and poor water quality conditions in semi-confined waters such as dead-end canals. These observations and studies, together with the magnitude and extent of estimated nutrient loadings from wastewater sources are a strong indication that these combined sources are regionally significant. A full range of engineering and management options was developed to reduce pollutant loadings from wastewater. In addition, the existing institutional framework was reviewed, and alternative institutional arrangements were evaluated.

Table 3-2. Types of options developed for pollution sources.

Pollution Source	Engineering Options	Management Options	Institutional Options
Domestic Wastewater	●	●	●
NPDES Discharges other than Wastewater			
Stormwater	●	●	●
Marinas and Live-Aboards		●[a]	
Mosquito Control Program		●	
Landfills		●[b]	
Hazardous Materials		●	
Underground Tanks		●[c]	
External Influences		●	

[a]Only management options are presented for marinas/live-aboards; however, engineering methods would be required to implement some of them.
[b]Only investigative management options are presented for landfills. Engineering options would have to be developed on a case-by-case basis if problems were discovered. An overview of applicable engineering methods is presented.
[c]A separate section of options for underground storage tanks is not presented. However, one management option relevant to underground tanks is included under Hazardous Materials.

2.2.2 Stormwater

Stormwater is a source of nutrients, sediment, and toxic materials to FKNMS waters. Stormwater nutrient loadings constitute about one quarter of the wastewater/stormwater nutrient loadings to the FKNMS. Stormwater also carries significant quantities of suspended sediment to nearshore waters. In areas of heavy vehicular traffic and in commercial or industrial areas, the potential also exists for the discharge of fuel, oil, metals, and other contaminants. These observations, coupled with the low level of stormwater control throughout the FKNMS, indicate that stormwater is a regionally significant source of pollution within the FKNMS. A full range of engineering and management options was developed to reduce these loadings. In addition, the existing institutional framework was reviewed, and alternative institutional arrangements were evaluated.

2.2.3 Marinas and Live-Aboards

Disposal of wastewater by live-aboards represents an estimated 2% of all total stormwater and wastewater nutrient loadings to FKNMS waters. For this reason, detrimental effects of live-aboard wastewater disposal are not likely to be significant from a regional standpoint. However, because of the low level of treatment, the tendency of live-aboards to congregate in certain marinas or anchorages, and potential adverse health effects of discharging untreated wastewater into Sanctuary waters, live-aboard wastewater disposal is a significant localized problem. Methods for collecting wastewater from live-aboards are fairly simple and inexpensive. However, the regulatory or management issues to be addressed in order to implement proper collection and disposal of live-aboard wastes are somewhat complex. For this reason, collection of wastewater from live-aboards is addressed under management options rather than under engineering options.

Marina operations with the potential for polluting water or sediments include boat bottom scraping and painting, fueling operations, residual fuels and oils from engine repairs or bilge cleaning, and the use or disposal of resins and solvents associated with fiberglass construction or repair. Available data are insufficient to quantify loadings of pollutants to waters and sediments or to assess the detrimental effects of bottom painting operations. There are no data documenting detrimental effects from other marina operations — only anecdotal evidence such as visible sheens on waters near fueling operations. Management options (some of which would involve engineering) are presented.

2.2.4 Landfills

For active and recently closed landfills in the Keys, there is no indication of a leaching problem based on existing monitoring data, but more information is needed. Two investigative management options are presented, followed by an overview of remedial engineering methods to be considered if problems are found.

The four U.S. Navy landfills being assessed under the U.S. Navy Installation Restoration Program all show evidence of metals and other contamination in groundwater and soils. The extent of this contamination is continuing to be assessed. If found to warrant remedial actions, those actions would be designed and implemented under the Installation Restoration Program in accordance with the guidelines of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and The Resource Conservation and Recovery Act (RCRA). Given the level of effort toward remediation at these four landfill sites, additional action is not warranted.

2.2.5 Hazardous Materials

Spills of toxic or hazardous materials occur occasionally in the Keys, but little historical information is available on the frequency or severity of spills. Discussions with FDER personnel in Marathon indicate that most spills are minor, involving less than 100 gallons of material. These spills do not appear to regionally significant, but could create local problems. The possibility also remains that a large spill could occur (e.g., tanker grounding), with the potential for regional consequences. Due to the lack of evidence indicating degradation from spills and their unpredictable nature, engineering options addressing toxic or hazardous material spills are not warranted. Management options were developed to decrease the potential for spills and to increase spill response readiness.

2.2.6 Mosquito Control Program

Although the amounts of pesticides used in the Mosquito Control Program are known, little information is available regarding the amounts that reach FKNMS waters. Also, little is known about the environmental concentrations or effects of residual pesticides in the Sanctuary. The use of engineering options for mosquito control (e.g., pumped mosquito impoundments) is being discontinued elsewhere in Florida and would probably not be practical or permittable in the Keys. With no evidence indicating regional degradation from mosquito control operations, and with engineering options being impractical from the outset, the only actions considered were further study [through the Monitoring Program (Task 6) and the Research Program (Task 7)] and management options to refine the existing spraying program or temporarily ban aerial spraying while gathering further information.

2.2.7 External Influences

The Phase I report indicates that there are potentially significant external influences on water quality in the FKNMS. Potentially significant influences in terms of advection (water transport) include Florida Bay, Biscayne Bay, and the Florida Current. In addition, atmospheric loadings could be a substantial contributor to the nutrient budget. These external influences require further study, and are therefore included in the Research Program described under Task 7. However, the need for action regarding water delivery problems in Florida Bay has been strongly stressed by workshop participants and other scientists during the development of the Water Quality Protection Program. Therefore, a management option for working to restore the historical freshwater flow to Florida Bay is included here.

2.3 SOURCES NOT TARGETED FOR CORRECTIVE ACTION

Two pollution sources were not considered for engineering or management options: NPDES discharges other than wastewater, and underground storage tanks. The rationale for not considering these sources is discussed below.

2.3.1 National Pollutant Discharge Elimination System Discharges Other than Wastewater

Only seven NPDES discharges other than wastewater were identified. Of these, four have ceased surface water discharge or have never discharged, two provide emergency or stormwater discharges, and one (the City of Key West Utilities Stock Island Steam Plant cooling water discharge) regularly discharges. Water quality data for the Stock Island Steam Plant discharge do not indicate a significant potential for degradation of receiving waters.

2.3.2 Underground Tanks

Underground tanks constructed prior to current FDER requirements for secondary containment and monitoring have the potential to adversely affect groundwater and surface waters in the Sanctuary. Most of these are fuel tanks associated with service stations or marinas. In 1984, the FDER began a program to retrofit all stationary tanks to achieve secondary containment, provide leak detection capability, and install monitoring systems and overfill protection. When old fuel tanks are replaced under the FDER retrofitting program, soil samples are analyzed and any fuel contamination from the tank is required to be cleaned (e.g., through soil excavation and incineration, floating fuel recovery, etc.). All identified facilities were to have monitoring systems in place by 1989. The lining or replacement of non-approved tanks began in 1985 and is scheduled to be completed by 1998. All identified stationary underground tanks are presumed to be included in this retrofitting program.

The FDER underground storage tank program represents a considerable effort toward resolving water quality problems associated with leaking underground storage tanks, and additional efforts in this area are not warranted. Therefore, a separate group of options for dealing with underground storage tanks was not developed. One management option to hasten the FDER inspection and retrofitting program is included in **Section 7.0.**

2.4 DEVELOPMENT OF OPTIONS

Three types of options were developed for this report: engineering, management, and institutional. The sections below explain what each type of option is designed to do, which pollution sources were targeted for each type of option, and how the options were developed.

2.4.1 Engineering Options

Engineering options are designed to reduce pollution directly through engineering methods. Engineering options were developed for two major pollution sources: domestic wastewater and stormwater. Options were developed under Task 4 by reviewing the existing facilities and the applicable engineering solutions, including both conventional (e.g., advanced wastewater treatment [AWT]) and innovative (e.g., nutrient-removing OSDS) techniques and equipment. Preliminary engineering options were discussed at the Engineering/Management Options Workshop (August 1992). For each engineering option, anticipated construction and operating/maintenance costs and pollution reductions were estimated.

2.4.2 Management Options

Management options include reducing pollution directly by prohibiting or restricting certain activities, tightening existing regulations, increasing enforcement, and/or increasing environmental awareness. Other management options are recommendations to make the regulatory/management system work more efficiently and would have little or no direct effect on pollution. Management options were developed for all of the sources targeted for corrective action: domestic wastewater, stormwater, marinas/live-aboards, landfills, hazardous materials, the Mosquito Control Program, and external influences. The first step in developing management options was conducting an institutional and agency management inventory to identify agencies and institutions with jurisdiction over water quality in the Florida Keys (Task 2). Then, under Task 3, management options were developed through questionnaires and interviews with personnel from federal, state, and local agencies and institutions. Preliminary management options were discussed at the Engineering/Management Options Workshop (August 1992). Because of the nature of most management options, costs and pollution reductions were not quantified.

2.4.3 Institutional Options

Institutional options are for the institutional control of the pollution source (if applicable) and would have little or no direct effect on pollution. Institutional options were developed for two major pollution sources: domestic wastewater and stormwater. The first step in developing institutional options was conducting an institutional and agency management inventory to identify agencies and institutions with jurisdiction over water quality in the Florida Keys (Task 2). Then under Task 3, the existing institutional framework was reviewed, and alternative institutional arrangements were considered. Information was obtained through questionnaires and interviews with personnel from federal, state, and local agencies and institutions. Preliminary institutional options were discussed at the Engineering/Management Options Workshop (August 1992). Because of the nature of the institutional options, costs and pollution reductions were not quantified.

2.5 OPTION NUMBERING

Engineering and management options are numbered within pollution source categories, which are identified by letters:

- W = wastewater
- S = stormwater
- B = marinas/live-aboards
- L = landfills
- H = hazardous materials
- M = Mosquito Control Program
- E = external influences

Table 3-3 lists all of the engineering and management options presented in subsequent sections. Under each topic, the options that are essentially independent are numbered sequentially. For example, the options for hazardous materials are numbered H1, H2, H3, etc. Related options reflecting a gradient of mutually exclusive actions are ordered alphabetically. For example, seven options are presented for dealing with wastewater treatment outside the City of Key West, ranging from upgrading existing systems to current standards (Option W3a) to advanced treatment for almost the entire Keys (Options W3f and W3g).

Unlike the engineering and management options, institutional options are not assigned option numbers because the engineering and management options are all designed to be considered for inclusion into the NOAA management alternatives for the Sanctuary. The option numbering scheme is designed to be similar to NOAA's numbering scheme for water quality "strategies" (=options). Under NOAA's framework, institutional options would be considered matters of implementation and would not appear as "strategies."

3.0 DOMESTIC WASTEWATER

3.1 INTRODUCTION

Domestic wastewater is the largest local anthropogenic source of nutrients to FKNMS waters. Accordingly, a full range of engineering, management, and institutional options was developed for this pollution source. Because of the complexity of the engineering methods and options, most of the details are described in the appendices. The text of **Section 3.0** is organized into five major subsections:

- **Section 3.1 — Introduction**
  This subsection describes the existing wastewater facilities and summarizes the nature of the problem. A discussion of the historic and projected population growth in the Florida Keys is included because this would affect the magnitude of nutrient reductions achieved through engineering options.

Table 3-3. List of engineering and management options for all pollution sources.
Text explains option numbering and details of each option.

DOMESTIC WASTEWATER

Engineering Options: Demonstration Projects
- W1 — Alternate OSDS Demonstration Project
- W2 — AWT Demonstration Project

Engineering Options: Wastewater Treatment Outside Key West
- W3a — Upgrade Existing Systems to Current Standards
- W3b — Upgrade OSDSs to Current Standards and Upgrade Package Plants to AWT
- W3c — Upgrade OSDSs to Alternate, Nutrient-Removing Systems and Upgrade Package Plants to AWT
- W3d — Construct Two Community Wastewater Treatment Plants for Marathon and Key Largo and Use Excess Capacity of Key West Wastewater Treatment Plant in Lower Keys
- W3e — Construct Seven Community Wastewater Treatment Plants for Most Densely Populated Areas
- W3f — Construct Twelve Community Wastewater Treatment Plants for All Areas
- W3g — Construct Three Subregional Wastewater Treatment Plants

Engineering Options: Effluent Disposal, City of Key West
- W4a — Deep well injection
- W4b — Reuse for irrigation outside the Florida Keys
- W4c — Reuse for potable water

Management Options
- W5 — Develop Water Quality Standards
- W6 — Delegate NPDES Program to the State of Florida
- W7 — Require Resource Monitoring
- W8 — Establish Permit Fees
- W9 — Improve Interagency Coordination
- W10 — Improve OSDS Permitting
- W11 — Establish Interagency Laboratory
- W12 — Increase Wastewater Data Management Capacity

STORMWATER

Engineering Options
- S1a — Retrofit Hot Spots
- S1b — Retrofit Hot Spots and Population Centers
- S1c — Retrofit Stormwater Facilities Throughout Sanctuary

Management Options
- S2 — Eliminate Permitting Threshold
- S3 — Enact Stormwater Management Ordinances and Master Plans
- S4 — Institute Best Management Practices

MARINAS AND LIVE-ABOARDS

Engineering/Management Options
- B1 — Establish No-Discharge Zones
- B2 — Establish Mooring Fields
- B3a — Increase Pump-Out Facilities
- B3b — Enforce Pump-Out Use
- B4 — Establish Containment Areas for Boat Maintenance
- B5 — Require Marina Operating Permit
- B6 — Implement Water Quality Environmental Awareness Program

LANDFILLS

Management Options
- L1 — Conduct Historical Landfill Search
- L2 — Intensify Landfill Monitoring

HAZARDOUS MATERIALS

Management Options
- H1 — Continue Response and Preparedness Planning
- H2 — Improve Hazardous Materials Database
- H3 — Improve Small Spill Reporting
- H4 — Speed Up Storage Tank Inspection
- H5 — Change Environmental Crimes from Misdemeanors and Felonies to Civil Offenses
- H6 — Increase Funding for Environmental Crimes Program

MOSQUITO CONTROL PROGRAM

Management Options
- M1a — Reduce Aerial Spraying over Marine Areas
- M1b — Temporarily Ban Aerial Spraying

EXTERNAL INFLUENCES

Management Option
- E1 — Restore Freshwater Flow to Florida Bay

- **Section 3.2 — Engineering Methods**
  This subsection summarizes the engineering methods applicable to domestic wastewater. Details are provided in **Appendix B.**

- **Section 3.3 — Engineering Options**
  This subsection summarizes the engineering options in three categories: demonstration projects, wastewater treatment outside Key West, and effluent disposal for the City of Key West. Estimated costs and nutrient reductions are presented. Details are provided in **Appendix C.**

- **Section 3.4 — Management Options**
  This subsection describes the eight management options for reducing pollution and/or improving the existing management/regulatory system.

- **Section 3.5 — Institutional Options**
  This subsection reviews the existing institutional framework for the management and permitting of domestic wastewater in the Florida Keys. Three options (alternative institutional arrangements) are presented.

3.1.1 Existing Wastewater Facilities

In the Florida Keys, domestic wastewater facilities include regulated OSDSs, unregulated cesspits, small package treatment plants, and municipal WWTPs. The inventory of existing sewage treatment/collection facilities is summarized below.

Facility Type	Approximate Number	Average Flow Treated (MGD)	Percent of Florida Keys Wastewater Treated	Regulatory Agency
OSDSs	24,000	6.00	35	FDHRS
Cesspits	5,000	1.25	7	Unpermitted
Small package plants	200[a]	2.70[a]	16	FDER
Municipal plants	2	7.00	41	FDER

MGD: million gallons per day
[a] Number of package plants and average flow treated will be revised for the final Phase II report based on FDER comments.

OSDSs: Single family residences and duplexes are commonly served by permitted OSDSs, as are some of the older motels, campgrounds, and mobile home parks. OSDS designs include conventional septic tank systems, mound septic tank systems, and aerobic systems. Health officials with the Florida Department of Health and Rehabilitative Services (FDHRS) indicate that the conventional and aerobic OSDS, if properly installed and maintained, provides adequate treatment levels and does not endanger the health of the general populace. However, both systems achieve only minimal nutrient reduction through phosphorus absorption and precipitation in the natural soil system. Some innovative, nutrient-reducing OSDSs are being experimentally tested around the nation, and the engineering options proposed here include a demonstration project to evaluate several of these systems.

Cesspits: Although numerous in the Keys, cesspits are an unacceptable method for domestic wastewater disposal, both from public health and environmental health perspectives. Basically, the liquid waste is discharged into an unlined excavated pit in which sewage is allowed to collect, digest, and seep into the porous limestone formations toward outlets typically at shorelines and canals.

Package plants: Package plants ranging in permitted capacity from 0.0008 to 0.45 MGD serve many facilities such as restaurants, motels, and campgrounds, as well as multiple-family dwellings (condominium and apartment buildings). All of these package plants serve site-specific projects and are privately owned, operated, and maintained.

Municipal plants: The City of Key West uses a 10 MGD capacity central system for collection and treatment of its wastewater. The Key West plant uses an ocean outfall for effluent disposal. The City of Key Colony Beach owns and operates the only other municipal WWTP in the Florida Keys, a 0.175 MGD facility.

3.1.2 Population Growth Considerations

Historical growth in the Florida Keys and reliance upon private development have led to a proliferation of small package treatment plants and a large inventory of individual OSDSs and cesspits. Current wastewater treatment practices combined with soils in the Keys that have high porosity and low organic content, and high land-use densities have resulted in increased potential for groundwater and surface water contamination. As described in the Phase I report, degraded water quality has been documented in confined waters where there are large numbers of OSDSs and/or cesspits (e.g., canal systems in some residential developments). Although it is suspected that wastewater nutrients are also affecting nearshore waters (e.g., beyond canal systems), this has not been documented to the same extent as degradation of confined waters.

If no action is taken to alter current wastewater treatment practices, new developments would continue to use OSDSs or package plants, and retrofitting would only occur where permit applications for additions or remodeling require increased system capacity. Elimination of cesspits would remain passive (i.e., initiated by other permit actions or complaints). Replacement of cesspits with approved OSDSs would continue to occur at a slow rate because of the inability of FDHRS personnel to access private property for inspections.

An understanding of the historical and projected population growth is an important consideration in evaluating the engineering and management options to control wastewater discharges. For example, small percentage reductions in nutrient loadings could eventually be outstripped by population increases. However, projected low population growth in the Florida Keys suggests that it is appropriate to focus on correcting existing conditions rather than centering attention on new development.

Historically, from 1970 to 1990, the Florida Keys experienced significant growth in its resident and tourist population. In 1970, Monroe County had 52,586 permanent residents and by 1990, the number increased to 78,024. Between 1970 and 1980 the population increased annually by approximately 1,100 yearround residents, and between 1980 to 1990 the annual increase was somewhat higher, approximately 1,500 yearround residents. Of equal significance to the historic growth trends in the County is the shift of population centers over this time from the incorporated areas to the unincorporated areas of the County. Because of the County's popularity as a tourist destination, seasonal population has a significant impact on local facilities and services. The estimated 1990 seasonal population in Monroe County was 56,643. In 1990, the combined year-round and seasonal population was 134,667 (Solin 1991; Swarthout 1992; Wallace Roberts & Todd *et al.* 1991).

Future growth in the Florida Keys will not reflect this historical trend. As described in the Phase I report, growth will be dramatically reduced. In Florida, the state land planning agency, the Florida Department of Community Affairs (FDCA), is charged with the responsibility of ensuring that all local comprehensive plans are in compliance with state and regional plans (see Section 163.3161, Florida Statutes (FS) and Rule 9J-5, Florida Administrative Code (FAC). It is through the law and administrative code that FDCA and the local governments have reached or are reaching agreement regarding the future levels of growth for each local government in the Florida Keys. At this time, the following scenario is expected to be adopted by all local governments. The unincorporated County will be able to approve only 2,552 equivalent residential units between 1992-2002 resulting in approximately 255 units per year. The three cities will be able to approve 1.146 equivalent units between 1992-2002, or on average 115 units per year. Therefore, new development will be minor when compared to existing development. Most of the growth is expected to occur as single family homes, built in areas already platted.

If unchecked nutrient loadings cause a downward trend in water quality within the FKNMS, there will be secondary costs associated with the loss of revenue from tourist-related or other businesses that rely on good water quality. The economic impacts of potentially deteriorated water quality may be significant, but quantifying the impacts is difficult. Socioeconomic benefits and costs of all proposed options that are eventually included in NOAA's management alternatives for the Sanctuary will be analyzed as part of an environmental impact statement for the management plan.

3.2 ENGINEERING METHODS

Four general issues must be addressed when considering engineering methods for wastewater: centralization, type and level of treatment, effluent disposal, and method of wastewater collection and transmission. These issues are discussed at length in Appendix B. A brief summary of the first three issues, which are most relevant to the subsequent discussion, is presented below.

3.2.1 Centralization of Facilities

Centralization of wastewater treatment facilities can range from practically none (the existing condition) to full centralization using as few as four subregional WWTPs. During development of wastewater collection and treatment options, three levels of centralization were considered:

- **On-Site Facilities**
  Continue widespread use of OSDS and package plants.

- **Community Facilities**
  Construct relatively small WWTPs with service areas limited to single islands or a small number of islands in close proximity. With this approach, 12 community WWTPs would serve nearly all of the Keys.

- **Subregional Facilities**
  Divide the Keys into three subregions, each with its own subregional collection and treatment systems. The City of Key West WWTP would be the fourth subregional facility.

The decision on centralization of wastewater collection and treatment facilities will largely be dependent on cost. Generally, as the size of a wastewater service area increases, the cost per gallon for treatment decreases and the cost per gallon for collection and transmission increases. These differences are apparent in the cost estimates provided for various engineering options in Section 3.3.

3.2.2 Level and Type of Treatment

There are four general levels of treatment commonly used in engineering practice, as summarized below. Each can be attained by a variety of processes, as discussed in Appendix B.

- **Primary Treatment**
  This method involves physical removal of solids by screening and sedimentation. Removal rates of 35-65% for suspended solids and 30-36% for organic materials can be attained.

- **Secondary Treatment**
  This method uses biological processes in addition to physical processes to attain 80-95% suspended solids removal and 80-95% organics removal.

- **Irrigation Quality Treatment**
  This method adds filtration and high-level disinfection to secondary treatment to attain sufficient quality for irrigation of public access areas.

- **Advanced Wastewater Treatment**
  This method adds tertiary processes to secondary treatment for removal of constituents not adequately reduced by secondary treatment. The most common application of AWT is nutrient (nitrogen and phosphorus) removal.

The level of treatment generally depends on the intended use or disposal method for the treated effluent and there is a significant increase in cost as the level of treatment is increased. Primary treatment is generally used only for pre-treatment and under current regulations cannot be considered a complete treatment process. Secondary treatment is generally adequate when groundwater or deep well disposal is used. However, it may not be adequate for shallow groundwater disposal in the Keys because of the efficient hydraulic connection between effluent disposal sites and nearshore surface waters. Irrigation quality treatment is required for irrigation reuse in public access areas. AWT is used when residual nutrients in secondary-treated effluent present a problem with effluent disposal. AWT is generally used in connection with surface water discharges or high-quality reuse, such as for potable or process water.

3.2.3 Effluent Disposal

Six effluent disposal methods were considered in selection of wastewater options:

- **Ocean Outfalls**
  With this method, the effluent is piped directly to the ocean. This would require a high level of treatment (AWT) and may still have adverse salinity effects. Cost is relatively high.

- **Class V Injection Wells (Boreholes)**
  Boreholes are generally 60 to 90 ft deep and cased to 30 to 60 ft. Current FDER rules require a 90-foot depth and a casing to 60 ft. The effluent enters the borehole by gravity (not under pressure) and flows radially outward through the porous limestone formation. The treatment level should be AWT to minimize nutrient loadings to nearshore waters. Cost is minimal for boreholes but high for AWT.

- **Aquifer Storage and Recovery (ASR)**
  With this method, the effluent is pumped into a shallow, confined aquifer for future withdrawal and reuse. Wells are generally 500 to 600 ft deep. The treatment level should be irrigation quality or higher, depending on intended use. Cost is moderate.

- **Deep Injection Wells**
  These are large diameter wells usually extending 2,500 to 3,000 ft to the boulder zone. The treatment level can be secondary. Cost is relatively high.

- **Reuse for Irrigation**
  This method involves irrigation use of effluent on crops, landscape areas, golf courses, or other areas. The treatment level should be irrigation quality. Cost is moderate to high if the reuse area is close to the WWTP and very high if long transmission distances are involved.

- **Reuse for Potable Water**
  This method involves reuse of the effluent for drinking water. It would require the AWT level of wastewater treatment and extensive retreatment at a potable water treatment facility. Cost is very high, but can be partially offset by revenues generated by the sale of potable water.

3.3 ENGINEERING OPTIONS

Engineering and management options for domestic wastewater are summarized in Table 3-4. The options are divided into three categories:

- **Demonstration Projects**
  This category includes two projects (Options W1 and W2) to evaluate alternate, nutrient-removing OSDSs and to evaluate water quality improvements resulting from replacing OSDSs with a small AWT plant. These projects would be conducted prior to implementing any major, broad-scale engineering options for wastewater treatment outside the City of Key West.

- **Wastewater Treatment Outside the City of Key West**
  This category includes Options W3a-W3g, which offer a range of choices for reducing pollution from domestic wastewater. Areas outside the City of Key West are currently served by OSDSs, cesspits, and small package plants — there are no central collection or treatment systems currently in place.

- **Effluent Disposal, City of Key West**
  This category includes four options for upgrading effluent disposal from the City of Key West WWTP. Currently, the effluent is discharged to surface waters through an ocean outfall.

Appendix C contains detailed descriptions of these options, including the basis for selection, option components, pollution reduction potential, costs, implementation schedules, affected entities, environmental effects, and alternate means of wastewater collection or effluent disposal, with associated increases in cost. Costs and nutrient reductions (excluding the demonstration options) are summarized in Table 3-5.

3.3.1 Demonstration Projects

All of the main engineering options for wastewater involve significant planning and design periods preceding construction. Therefore, it would be advisable to pursue demonstration projects to increase the body of knowledge available for ultimate decisionmaking. Two engineering demonstration options are proposed to evaluate the prospective wastewater treatment processes. One is an in-depth, long-term evaluation of alternate OSDSs with nutrient removal capability. The other is a performance evaluation of an AWT package plant constructed to serve a relatively small area with a high density of OSDSs.

3.3.1.1 OPTION W1 — ALTERNATE ON-SITE SEWAGE DISPOSAL SYSTEM DEMONSTRATION PROJECT

Description: Under this option, three to six alternate OSDSs designed for nutrient removal would be installed and maintained by contractors in a manner consistent with actual residential installations. Influent, effluent, and background/downgradient groundwater quality would be monitored at regular intervals for at least one year. The study would evaluate the long-term nutrient removal capabilities of the various alternate OSDSs in Florida Keys soils. In addition to nutrient removal efficiency, the study would evaluate maintenance and inspection requirements to keep units operating properly, and the feasibility of using these systems in widespread application versus using these systems for isolated areas only.

Table 3-4. Summary of engineering and management options for domestic wastewater.

Engineering Options: Demonstration Projects

- **W1 — Alternate OSDS Demonstration Project**
  Conduct a demonstration project to evaluate the efficacy of alternate, nutrient-removing OSDS.

- **W2 — AWT Demonstration Project**
  Conduct a demonstration project by installing a small, expandable AWT plant in Marathon to serve an area of heavy OSDS use and associated water quality problems.

Engineering Options: Wastewater Treatment Outside Key West

- **W3a — Upgrade Existing Systems to Current Standards**
  Identify and eliminate all cesspits. Identify all non-complying OSDSs and package plants, and retrofit or upgrade to meet current standards.

- **W3b — Upgrade OSDSs to Current Standards and Upgrade Package Plants to AWT**
  Identify and eliminate all cesspits. Upgrade all OSDSs to meet current standards and upgrade all package plants to AWT.

- **W3c — Upgrade OSDS to Alternate, Nutrient-Removing Systems and Upgrade Package Plants to AWT**
  Identify and eliminate all cesspits. Upgrade all package plants to AWT and upgrade all OSDSs to alternate, nutrient-removing systems.

- **W3d — Construct Two Community Wastewater Systems for Marathon and Key Largo and Use Excess Capacity of Key West Wastewater Treatment Plant in Lower Keys**
  Construct two community wastewater systems for Marathon and Key Largo and use excess capacity of the Key West wastewater treatment plant in adjacent areas of the lower Keys. Beyond the areas served by these systems, identify all cesspits and non-complying OSDSs and package plants, and retrofit or upgrade to meet current standards.

- **W3e — Construct Seven Community Wastewater Treatment Plants for Most Densely Populated Areas**
  Construct seven wastewater treatment plants for the most densely populated areas to treat 73% of wastewater flows outside Key West. Beyond the areas served by these systems, identify all cesspits and non-complying OSDS and package plants, and retrofit or upgrade to meet current standards.

- **W3f — Construct 12 Community Wastewater Treatment Plants for All Areas**
  Construct 12 community wastewater treatment plants to treat 94% of wastewater flows outside Key West. Beyond the areas served by these systems, identify all cesspits and non-complying OSDSs and package plants, and upgrade to AWT or equivalent (e.g., nutrient-removing OSDS)

- **W3g — Construct Three Subregional Wastewater Treatment Plants**
  Construct three subregional wastewater treatment plants to treat 94% of wastewater flows outside Key West. Beyond the areas served by these systems, identify all cesspits and non-complying OSDSs and package plants, and upgrade to AWT or equivalent (e.g., nutrient-removing OSDS).

Engineering Options: Effluent Disposal: City of Key West

- **W4 — Upgrade Effluent Disposal: City of Key West WWTP**
  Upgrade effluent disposal for City of Key West plant. Discontinue use of ocean outfall and implement one of the following effluent disposal methods:
  W4a — Deep well injection
  W4b — Reuse for irrigation outside of the Florida Keys
  W4c — Reuse for potable water

Management Options

- **W5 — Develop Water Quality Standards**
  Develop and monitor water quality standards, including nitrogen and phosphorus standards and biocriteria, for permitting of wastewater and stormwater discharges.

- **W6 — Delegate NPDES Program to the State of Florida**
  Delegate administration of the NPDES program for Florida Keys dischargers to the State of Florida. This would streamline the permitting process.

- **W7 — Require Resource Monitoring**
  Require all NPDES-permitted surface dischargers to develop resource monitoring programs. All NPDES dischargers except the City of Key West sewage treatment plant are currently exempt because their discharges occur landward of the baseline (the mean low tide line).

- **W8 — Establish Permit Fees**
  Establish permit fees to support the FDER Point Source Evaluation Program.

- **W9 — Improve Interagency Coordination**
  Improve interagency coordination for industrial wastewater discharge permitting. Reconcile FDER and FDHRS permitting approaches.

- **W10 — Improve OSDS Permitting**
  W10a — Combine OSDS permitting responsibilities for commercial establishments, institutions, and multi-family residential establishments in one agency.
  W10b — Review OSDS permit applications from a "carrying capacity" perspective.
  W10c — Modify current FDHRS policy relative to OSDS permitting fees by having a percentage of the fees returned directly to the county in which the fees were collected.
  W10d — Monitor revised OSDS rules.

- **W11 — Establish Interagency Laboratory**
  Reestablish an FDHRS-certified (or equivalent) laboratory in the Florida Keys to process monitoring and compliance samples.

- **W12 — Increase Wastewater Data Management Capacity**
  Increase the data management capacity of both the FDER district and district branch office levels to reduce lag time in updating the Groundwater Management System and the Compliance Enforcement Tracking System databases.

Note: Base option for all wastewater treatment alternatives involving package AWT plants or community/subregional AWT plants includes effluent disposal by Class V injection wells. Upgraded methods of effluent disposal are discussed in Appendix C.

Table 3-5. Nutrient reductions and cost estimates for wastewater engineering options. [NOTE: Implementation schedules are in Appendix C.]

Option	Wastewater Receiving Advanced Treatment (%)		Reduction in Wastewater Nutrient Loadings (%)		Estimated Cost				Cost Effectiveness[a]	
	Entire Keys	Outside Key West	TN	TP	Initial ($ millions)	20 yr O & M ($ millions)	Total 20 yr ($ millions)	20 yr per connection ($ thousands)	TN	TP
OUTSIDE CITY OF KEY WEST[b]										
W3a — Upgrade existing systems to current standards	0	0	10	17	42	0	42	1-5	4.2	2.5
W3b — Upgrade OSDSs to current standards and upgrade package plants to AWT	16	27	27	24	56	8	64	1-5	2.4	2.7
W3c — Upgrade OSDSs to alternate, nutrient-removing systems and upgrade package plants to AWT	53	87	57	43	306	240	546	2-18	10	13
W3d — Construct 2 community AWT plants for Marathon and Key Largo and use excess capacity of Key West plant in Lower Keys	73	52	43	28	184	105	289	12.9	6.7	10
W3e — Construct 7 community AWT plants	83	73	58	35	265	154	419	14.8	7.2	12
W3f — Construct 12 community AWT plants	96	94	72	43	368	239	607	16.9	8.4	14
W3g — Construct 3 subregional AWT plants	96	94	72	43	418	272	690	19.1	9.6	16
CITY OF KEY WEST ONLY (Effluent disposal options for Key West plant)										
W4a — Deep well injection	40	0	4.7	9.3	7	4.5	12	0.44	2.6	1.3
W4b — Reuse for irrigation outside the Keys	40	0	4.7	9.3	46	31	77	2.8	16	8.3
W4c — Reuse for potable water[c]	40	0	4.7	9.3	80	60	140	5.1	30	15

[a]Cost effectiveness = total cost/percent reduction in nutrients
[b]All options for areas outside the City of Key West include elimination of all cesspits. For community and subregional plant options, all non-complying package plants and OSDSs in areas beyond those served by the proposed AWT plants would be upgraded to current standards (Options W3d, W3e) or to AWT or equivalent (Options W3f, W3g).
[c]Costs for reuse options assume aquifer storage and recovery is used.

Rationale: This option would provide information to help decide the appropriate role, if any, for alternate OSDSs in wastewater management in the Keys. Although some alternate OSDS designs appear promising, it is not appropriate to proceed with broad-scale installation of these systems until an independent evaluation has been conducted. Major concerns include cost, nutrient-removal efficiency, and the degree of inspection and maintenance needed to keep these systems operating properly.

Cost: The cost of the demonstration project is estimated at $105,000 to $210,000, depending on the number of systems selected ($35,000 for each system including monitoring wells, sampling, and analysis).

Nutrient Reduction: (Not applicable; this is a demonstration project).

3.3.1.2 OPTION W2 — ADVANCED WASTEWATER TREATMENT DEMONSTRATION PROJECT

Description: Under this option, a small (5,000 to 10,000 gallons per day [GPD]), expandable AWT package plant would be installed to serve an area of high-density OSDS use in close proximity to semi-confined nearshore waters, preferably where water quality problems have been identified. Initial background groundwater and surface water monitoring would be conducted, and plant influent and effluent would then be monitored for a minimum of one year after the AWT plant is in operation. Surface water and groundwater monitoring would be continued for 3 to 5 years.

Rationale: This option would provide information to help decide whether the replacement of OSDSs with an advanced wastewater treatment system would improve water quality in areas believed to be degraded by nutrients from OSDSs. The study would provide information about the effectiveness of nutrient removal on a package plant scale; short-term or long-term changes in groundwater or surface water quality as a result of discontinuing OSDS use; and current, site-specific cost information for initial construction and operation/maintenance. Most facilities constructed for the demonstration project could be incorporated into a larger system (e.g., under Option W3d) if the results are favorable.

Cost: The cost of the AWT demonstration project is estimated at $350,000 to $700,000, depending on the size of the system (5,000 to 10,000 GPD), including costs for extensive sampling and analyses.

Nutrient Reduction: (Not applicable; this is a demonstration project).

3.3.2 Wastewater Treatment Outside the City of Key West

Seven options were developed for wastewater treatment outside the City of Key West. The simplest, minimum approach (Option W3a) would eliminate cesspits and bring existing OSDSs and package plants to current standards. Beyond that level, two broad approaches were identified:

- **Use existing systems (OSDSs, package plants), but upgrade the level of nutrient removal.**
  Under this approach, either package plants (Option W3b) or both package plants and OSDSs (Option W3c) would be upgraded beyond current standards to enhance nutrient removal.

- **Construct community or subregional AWT plants and associated collection systems.**
  Under this approach, either 2 community plants (Option W3d), 7 community plants (Option W3e), 12 community plants (Option W3f), or 3 subregional plants (Option W3g) would be constructed. These options are presented in order of the increasing percentage of total Florida Keys wastewater flows that would be treated.

The selection of either approach would be based on the results of the demonstration projects (Options W1 and W2) as well as other relevant research findings (e.g., estimates for currently unknown external nutrient loadings). If the OSDS Demonstration Project identified an inexpensive, effective alternate OSDS, then an appropriate strategy might be to upgrade all OSDSs to alternate systems and all package plants to AWT (Option W3c).

In contrast, if the OSDS Demonstration Project showed that a suitable alternate OSDS for broad-scale use could not be identified (e.g., too expensive, too much maintenance and inspection to keep operating properly), then it would be appropriate to choose one of the options from the second approach (constructing community or subregional AWT plants). The simplest of the "community plant" options would involve constructing two community plants (Option W3d), and the next level would involve constructing seven community plants (Option W3e). If either of these limited options were chosen, then outside the service area for those plants, OSDSs would be upgraded to current standards. Data from the OSDS Demonstration Project would have indicated that upgrading the remaining OSDSs further to nutrient-removing OSDSs would not be cost-effective (i.e., to capture the remaining flows, it would be better to build more AWT plants).

If one of the most extensive "community plant" options were implemented (Option W3f or W3g — 12 community plants or 3 subregional plants, respectively), nearly all of the wastewater flows would have been captured by these systems. In that case, it would be feasible to upgrade the remaining OSDSs to alternate, nutrient-removing systems (even if the systems were known to be not very cost-effective), because the remote OSDSs would never be connected to a community or subregional AWT plant.

3.3.2.1 OPTION W3a — UPGRADE EXISTING SYSTEMS TO CURRENT STANDARDS

Description: Under this option, all cesspits would be identified and eliminated, and all non-complying OSDSs and package plants would be upgraded to meet current standards. An aggressive program would be conducted to identify and eliminate cesspits. The present level of OSDS use would be continued, but all systems would be brought into compliance with current FDHRS standards. Package plant use would be continued for individual developments which require them under the current regulations, and all existing package plants would be brought into compliance with FDER regulations for secondary treatment under 1992 standards.

Rationale: This option is a minimal approach to reducing pollution by bringing existing facilities to current standards, rather than constructing any new facilities.

Cost: Initial construction costs are estimated at $42 million (Table 3-5). No increase in operating and maintenance costs is anticipated; therefore, the total 20-year cost is $42 million.

Nutrient Reduction: Nutrient reduction resulting from this option would be limited because of continued widespread OSDS use. The greatest reduction in nutrient loadings (about 5% and 10% for nitrogen and phosphorus, respectively) would be achieved by eliminating and replacing cesspits with approved OSDSs. Smaller additional reductions would be obtained by upgrading non-complying OSDSs and package plants. Total estimated nutrient reductions are 10% for total nitrogen and 17% for total phosphorus (Table 3-5).

Cost Effectiveness: This option is among the most cost-effective options (cost/nutrient reduction) (Table 3-5); however, the total nutrient reduction achieved is low.

3.3.2.2 OPTION W3b — UPGRADE ON-SITE SEWAGE DISPOSAL SYSTEMS TO CURRENT STANDARDS AND UPGRADE PACKAGE PLANTS TO ADVANCED WASTEWATER TREATMENT

Description: Under this option, all cesspits would be identified and eliminated, and all non-complying OSDSs would be upgraded to meet current standards. In addition, the treatment level of the existing and future package plants would be upgraded to AWT to provide further nutrient removal.

Rationale: This option would exceed the minimal approach described in Option W3a by upgrading package plants to AWT. This would be the next logical step because it would further reduce nutrient loadings within the same order of magnitude of total cost.

Cost: Initial construction costs are estimated at $56 million (Table 3-5). Estimated 20-year operating and maintenance costs are $8 million, for a total 20-year cost of $64 million. Although there would be no construction of new facilities, retrofitting package plants to AWT would be very expensive for individual plant owners, costing perhaps as much or more than the existing plants and increasing operating and maintenance costs considerably.

Nutrient Reduction: This option would improve the nutrient reduction obtained in Option W3a by also upgrading package plants to AWT. Package plants currently handle about 27% of wastewater flows outside the City of Key West. AWT would reduce total nitrogen from the 40 mg/L range to less than 6 mg/L and total phosphorus from about 8 mg/L to less than 4 mg/L. Applying these reductions to 27% of the wastewater flows would reduce total nitrogen by 17% and total phosphorus by 7%. Adding these reductions to those obtained by upgrading to existing standards (Option W3a) would yield a total reduction of 27% for nitrogen and 24% for phosphorus (Table 3-5).

Cost Effectiveness: This is the most cost-effective of the options for outside the City of Key West (Table 3-5); however, overall nutrient reductions would still be low — about one-quarter of the wastewater total nitrogen and total phosphorus.

3.3.2.3 OPTION W3c — UPGRADE ON-SITE SEWAGE DISPOSAL SYSTEMS TO ALTERNATE, NUTRIENT-REMOVING SYSTEMS AND UPGRADE PACKAGE PLANTS TO ADVANCED WASTEWATER TREATMENT

Description: Under this option, all cesspits would be identified and eliminated. In addition, the treatment level of existing and future package plants would be upgraded to AWT to provide further nutrient removal, and all OSDSs would be replaced with alternate, nutrient-removing systems.

Rationale: This option would also exceed the minimal approach described in Option W3a by upgrading OSDSs to alternate, nutrient-removing systems, in addition to upgrading package plants to AWT as in Option W3b. This is the most comprehensive option involving existing systems rather than the "community plant" approach (Section 3.3.2). In order for this option to be chosen, the OSDS Demonstration Project (Option W1) would have identified an efficient, reliable, and cost-effective alternate OSDS for widespread use in the Keys.

Cost: Initial construction costs are estimated at $306 million (Table 3-5). Estimated 20-year operating and maintenance costs are $240 million, for a total 20-year cost of $546 million. Most of the construction costs and nearly all of the operating and maintenance costs are because of OSDS upgrading rather than package plant upgrading or cesspit elimination. However, the OSDS costs are tentative and would have to be reevaluated following the OSDS Demonstration Project (Option W1).

Nutrient Reduction: This option would improve the nutrient reduction obtained in Option W3a by also upgrading package plants to AWT and OSDSs to alternate, nutrient-removing systems. Estimated reductions are 57% for total nitrogen and 43% for total phosphorus (Table 3-5). These are the highest nutrient reduction percentages achieved without going to the "community plant" approach.

Cost Effectiveness: The nutrient reductions are achieved at a very high cost, making this one of the least cost-effective options (Table 3-5).

3.3.2.4 OPTION W3d — CONSTRUCT TWO COMMUNITY WASTEWATER SYSTEMS FOR MARATHON AND KEY LARGO AND USE EXCESS CAPACITY OF KEY WEST WASTEWATER TREATMENT PLANT IN LOWER KEYS

Description: This option would involve constructing two community wastewater systems to provide AWT for Marathon and Key Largo. Boreholes would be used for effluent disposal from these plants. In the lower Keys, a community wastewater collection system would be constructed to serve all areas between the City of Key West WWTP service area and the east end of Big Coppitt Key. This wastewater flow would be conveyed to the City of Key West WWTP. Beyond the areas served by these systems, all cesspits would be eliminated and all non-complying OSDSs and package plants would be upgraded to meet current standards.

Rationale: Extending the service area for the City of Key West WWTP as far east as practical, coupled with construction of community AWT systems for the two most populous communities in the upper and middle Keys would provide central sewer service for about 73% of all Florida Keys wastewater flows and 52% of the flows outside the City of Key West. Extension of the service area for the City of Key West WWTP is logical because the plant is expected to increase its excess capacity to 1.9 MGD by 2010 as a result of reducing infiltration and inflow (I/I). Outside the service area for these systems, upgrading the remaining OSDSs to <u>existing</u> standards (rather than to alternate, nutrient-removing systems) would be logical because the selection of this option (W3d) would mean that a cost-effective alternate OSDS had not been identified — i.e., to upgrade the remaining OSDSs, it would be more cost-effective to build more AWT plants (as in Options W3e-g).

Cost: Initial construction costs are estimated at $184 million (Table 3-5). Estimated 20-year operating and maintenance costs are $105 million, for a total 20-year cost of $289 million.

Nutrient Reduction: For the 3.6 MGD combined flow of the Marathon and Key Largo communities, the treatment level would be upgraded from virtually no treatment (cesspits), OSDS treatment, or secondary treatment (package plants) to AWT. Total nitrogen in these waste streams would be reduced from the 30-70 mg/L range to less than 6 mg/L, and total phosphorus from the 8-24 mg/L range to less than 4 mg/L. Estimated nutrient reductions are 43% for total nitrogen and 28% for total phosphorus (Table 3-5).

Cost Effectiveness: This option is the most cost-effective (in terms of nutrient reduction) of the options involving community WWTPs (Table 3-5). Based on the existing data, it is also more cost-effective than upgrading OSDSs to alternate, nutrient-removing systems (as in Option W3c). Although this option is less cost-effective than the first two minimal upgrade options (W3a and W3b), it would result in substantially greater nutrient reduction.

3.3.2.5 OPTION W3e — CONSTRUCT SEVEN COMMUNITY WASTEWATER TREATMENT PLANTS FOR MOST DENSELY POPULATED AREAS

Description: This option would involve the construction of seven community WWTPs for the Key Largo, Marathon, Stock Island to Key Haven, Plantation, Boca Chica, Big Pine, and Cudjoe/Summerland areas. These seven WWTPs would accommodate about 73% of the wastewater flows from the Keys areas, excluding the City of Key West. Boreholes would be used for effluent disposal from these WWTPs. Beyond the areas served by these systems, all cesspits would be eliminated, and all non-complying OSDSs and package plants would be upgraded to meet current standards.

Rationale: The service areas for the seven WWTPs were selected by starting with the highest flow ranking (excluding the City of Key West) and adding areas with successively lower rankings until accounting for at least 70% of the flow. Outside the service area for these systems, upgrading the remaining OSDSs to <u>existing</u> standards (rather than to alternate, nutrient-removing systems) would be logical because selection of this option (W3d) would mean that a cost-effective alternate OSDS had not been identified — i.e., to upgrade the remaining OSDS, it would be more cost-effective to build more AWT plants (as in Option W3f or W3g).

Cost: Initial construction costs are estimated at $265 million (**Table 3-5**). Estimated 20-year operating and maintenance costs are $154 million, for a total 20-year cost of $419 million.

Nutrient Reduction: For the 73% of wastewater flows connected, treatment level would be upgraded from virtually no treatment (cesspits), OSDS treatment, or secondary treatment (package plants) to AWT. Total nitrogen in these waste streams would be reduced from the 30-70 mg/L range to less than 6 mg/L, and total phosphorus from the 8-24 mg/L range to less than 4 mg/L. Estimated nutrient reductions are 58% for total nitrogen and 35% for total phosphorus (**Table 3-5**).

Cost Effectiveness: This option is in the middle in terms of cost-effectiveness among the "community plant" options (W3d-g) (**Table 3-5**). Based on the existing data, it is also more cost-effective than upgrading OSDSs to alternate, nutrient-removing systems (as in Option W3c), while producing comparable nutrient reduction.

3.3.2.6 OPTION W3f — CONSTRUCT 12 COMMUNITY WASTEWATER TREATMENT PLANTS FOR ALL AREAS

Description: This option would involve constructing 12 AWT plants to serve nearly all (94%) of the wastewater flows outside the City of Key West. Boreholes would be used for effluent disposal from these systems. Beyond the areas served by these systems, all cesspits would be eliminated, all package plants would be upgraded to AWT, and all OSDSs would be upgraded to alternate, nutrient-removing systems.

Rationale: This option represents the maximum use of community WWTPs in the Florida Keys, capturing about 94% of the wastewater flows. Essentially, OSDSs and package plants would continue to be used only in low-density or remote areas. Because these remaining OSDSs and package plants would presumably never be connected to a community treatment system, this option would require that they be upgraded to AWT or its equivalent (e.g., alternate, nutrient-removing OSDSs).

Cost: Initial construction costs are estimated at $368 million (**Table 3-5**). Estimated 20-year operating and maintenance costs are $239 million, for a total 20-year cost of $607 million.

Nutrient Reduction: For the 94% of wastewater flows connected, treatment level would be upgraded from virtually no treatment (cesspits), OSDS treatment, or secondary treatment (package plants) to AWT. Total nitrogen in these waste streams would be reduced from the 30-70 mg/L range to less than 6 mg/L, and total phosphorus from the 8-24 mg/L range to less than 4 mg/L. Estimated nutrient reductions are 72% for total nitrogen and 43% for total phosphorus (**Table 3-5**).

Cost Effectiveness: This option and Option W3g provide the highest percentage of reductions in total nitrogen and total phosphorus loadings, but at the highest cost. They are among the least cost-effective options (**Table 3-5**).

3.3.2.7 OPTION W3g — CONSTRUCT THREE SUBREGIONAL WASTEWATER TREATMENT PLANTS

Description: This option would involve constructing three subregional AWT plants to serve nearly all (94%) of the wastewater flows outside the City of Key West. Boreholes would be used for effluent disposal from these systems. Beyond the areas served by these systems, all cesspits would be eliminated, all package plants would be upgraded to AWT, and all OSDSs would be upgraded to alternate, nutrient-removing systems.

Rationale: This option is similar to Option W3f, except that three large, subregional WWTPs would be used rather than 12 smaller, community WWTPs. Selection of 3 subregional WWTPs rather than 12 community WWTPs might be appropriate, for example, if it would be difficult to find suitable locations for 12 community WWTPs. Like Option W3f, this option represents the maximum use of community WWTPs in the Florida Keys, capturing about 94% of the wastewater flows. Essentially, OSDSs and package plants would continued to be used only in low-density or remote areas. Because these remaining OSDSs and package plants would presumably never be connected to a community treatment system, the option would require that they be upgraded to AWT or its equivalent (e.g., alternate, nutrient-removing OSDSs).

Cost: Initial construction costs are estimated at $418 million (Table 3-5). Estimated 20-year operating and maintenance costs are $272 million, for a total 20-year cost of $690 million.

Nutrient Reduction: The estimated nutrient reductions are identical to those for Option W3f; 72% for total nitrogen and 43% for total phosphorus (Table 3-5).

Cost Effectiveness: This option and Option W3f provide the highest percentage reductions in total nitrogen and total phosphorus loadings, but at the highest cost. They are among the least cost-effective options (Table 3-5).

3.3.3 Effluent Disposal for the City of Key West

The City of Key West WWTP has excess capacity through the year 2010 and currently serves about 95% of the wastewater flows generated within the City. Deficiencies in the system include high I/I into the collection system and use of a nearshore ocean outfall that is not in compliance with current regulations. The City of Key West has taken steps to correct both of these deficiencies. An I/I reduction program is in progress and the City's consultant is examining deep well injection as a primary effluent disposal method.

During the assessment of potential engineering options for the City of Key West, it was assumed that long-term use of the existing nearshore ocean outfall was not a viable option. Factors contributing to this assumption were the discharge's close proximity to shore, the fact that the outfall does not come close to meeting current regulations for ocean outfalls, the sensitive marine environment into which it is discharging, and the pressure from regulatory agencies to cease the discharge. Reconstruction of the ocean outfall to meet current requirements was excluded from consideration because it would be more costly than the other alternatives and obtaining permits would be difficult.

3.3.3.1 OPTION W4 — UPGRADE EFFLUENT DISPOSAL FOR THE CITY OF KEY WEST WASTEWATER TREATMENT PLANT

Description: This option would upgrade effluent disposal for the City of Key West WWTP. Use of the ocean outfall would be discontinued, and one of the following effluent disposal methods would be implemented:

- Option W4a — deep well injection
- Option W4b — reuse for irrigation outside the Keys
- Option W4c — reuse for potable water

With any of these options, the existing ocean outfall would be used as an emergency, short-term disposal method. Local reuse for irrigation would be included to the extent practical with each of these options, but because of the limited number of application sites, it would accommodate only a small fraction of the total effluent.

Rationale: This option would reduce direct nutrient loadings to surface waters from the City of Key West WWTP.

Cost: Estimated construction costs range from $7 million to $80 million, depending on the effluent disposal method chosen (Table 3-5). Operating and maintenance costs similarly range from $4.5 million to $60 million, and total costs range from $12 million to $140 million. Deep well injection (Option W4a) is the least expensive effluent disposal option, whereas reuse for irrigation (Option W4b) and reuse for potable water (Option W4c) are the most expensive.

Nutrient Reduction: The estimated nutrient reductions (percentage of total Florida Keys wastewater nutrients) are about 5% for total nitrogen and 9% for total phosphorus (Table 3-5).

Cost Effectiveness: Deep well injection (Option W4a) is the most cost-effective disposal option, whereas reuse for irrigation (Option W4b) and reuse for potable water (Option W4c) are not very cost-effective options (Table 3-5). If revenues generated by the sale of potable water and lower pumping costs of using locally treated water were considered, the cost-effectiveness of reuse for potable water would increase significantly. Potable reuse is also attractive with respect to water conservation. However, in terms of overall reduction in wastewater nutrients, none of the options would produce a substantial decrease in loadings.

3.4 MANAGEMENT OPTIONS

Three agencies have significant roles in wastewater permitting activities in the Florida Keys: EPA, FDER, and FDHRS. EPA's responsibility is limited solely to surface water dischargers through the NPDES program. There are only 10 domestic wastewater plants still actively functioning. At this time, owners of these facilities must receive an operating permit from both EPA and the FDER. Coordination of permit and compliance activities between the two agencies occurs; however, the EPA permit is good for 5 years and the FDER permit approvals last 3 years. As a result of this complexity, owners are continually involved in the permitting process. Currently, the state is trying to have the NPDES program delegated to FDER. If this is accomplished a duplication in the permitting process can be eliminated.

FDER permits all WWTPs in the Florida Keys. The FDER has a Subdistrict office in Marathon which is primarily responsible for compliance and enforcement activities. Until recently, the office operated a FDHRS-certified laboratory; however, certification has lapsed and has jeopardized the enforcement and compliance abilities of the local staff.

Eight management options were developed for domestic wastewater. These are summarized briefly in Table 3-4 and discussed individually below.

3.4.1 *Option W5 — Develop Water Quality Standards*

Description: Under this option, the FDER and EPA would work jointly to develop and monitor water quality standards, including nitrogen and phosphorus standards and biocriteria, for the permitting of wastewater and stormwater discharges.

Rationale: The objective of regulating wastewater and stormwater discharges is to protect and preserve the marine resources of the Sanctuary. Nutrients, particularly nitrogen and phosphorus, are suspected as the major contributors to eutrophication of nearshore and confined waters in the Sanctuary. Water quality standards for nitrogen and phosphorus should be adopted, based on the recognition that minor fluctuations in nutrients in Sanctuary coastal waters may have a greater impact on water quality and marine resources than in most other coastal areas in Florida.

Biocriteria are "numerical values or narrative expressions that describe the reference biological integrity of aquatic communities inhabiting waters of a given designated life use" (EPA 1990). Biocriteria are valuable because they directly measure the condition of the resource at risk, detect problems that other methods (e.g., chemical analyses of water quality) may miss or underestimate, and provide a systematic process for measuring progress resulting from the implementation of water quality programs (EPA 1990). EPA is directing states to adopt narrative biological criteria into state water quality standards over the next few years.

EPA, through its Ocean Discharge Program, has developed monitoring programs to determine the effects of sewage discharges in the marine environment. Monitoring data provide information to determine the nature and extent of the effects of sewage effluents on marine habitats and communities. The FDER Stormwater Management Division has been studying methods, including biomonitoring, to monitor and assess the impacts of nonpoint sources. It has long been known that resident biota in a water body are capable of detecting the effects of both episodic as well as cumulative pollution and habitat alteration. While the Ocean Discharge Program deals with wastewater and the

FDER bioassessment program concerns stormwater, the two approaches seem to provide the regulatory agencies with a valuable tool to assess the health of marine resource habitats.

Responsible Agency: The responsibility for implementing this option would be split. The bioassessment effort should be an EPA responsibility. However, any change to the state's water quality standards will have to be initiated by the FDER.

Implementation Mechanism: EPA annually funds the state of Florida Section 319(h) grants of the Clean Water Act. A portion of the Section 319(h) funds should be allocated to cover staff time used for coordination between the FDER and EPA bioassessment work efforts. Annual joint status reports describing the bioassessment work efforts of the previous year by both the EPA and FDER should be prepared.

Implementation Requirements: Several actions are necessary to implement this option. First, the EPA and FDER should coordinate their efforts with respect to their ongoing studies regarding resource-based standards (biocriteria), in an effort to avoid duplication and maximize the return on public investment. As part of the effort, new information and knowledge should be disseminated through published reports and studies, as well as the annual status report. Proposed research on indicators in the Research Program (Task 7) will provide additional data for development of biocriteria.

Second, research will need to be conducted to establish water quality standards for nitrogen and phosphorus as appropriate for the FKNMS. The research could become a part of the resource-based studies or could be accomplished in an independent study. The inclusion of "no-take" zones should be considered in the study design. These zones would provide reference areas for biomonitoring and assist in the development and implementation of FDER's biological criteria. If performed independently, the study should evaluate the impacts on marine resources by changes in water quality standards. If a conclusion is reached that water quality standards for the FKNMS need to be revised or modified, the FDER will initiate formal rule-making in accordance with Chapter 120 FS — Administrative Procedures Act. Once enacted, the new standards would be implemented at the time new permits were being issued or existing permits reissued.

This rule change would not increase the need for additional staff. The monitoring costs would still be the responsibility of the permittee; however, these costs would be somewhat higher because of the additional parameters being monitored. Prior to the date the rule change would go into effect, the FDER would conduct a workshop for its permitting and enforcement staff so that all staff understand the rule and are able to clearly explain it to applicants and permittees.

3.4.2 Option W6 — Delegate National Pollutant Discharge Elimination System Program to the State of Florida

Description: This option would result in EPA delegating the NPDES program to the state of Florida.

Rationale: Currently, all surface water discharges must receive permits from both the EPA and FDER. In many states where EPA has delegated NPDES authority, the duplicative permit approval process does not exist (as it does in Florida). By becoming a delegated state, Florida would be able to streamline and eliminate unnecessary duplication in the permitting process.

Responsible Agency: The responsible agency would be EPA.

Implementation Mechanism: The EPA and FDER should enter into an MOU that describes the roles and responsibilities of each agency, and the standards of review (e.g., water quality criteria) that must be met by each NPDES applicant.

Implementation Requirements: EPA will need to approve Florida's NPDES application that outlines how the state will implement the program. At this time, the application is being prepared by the FDER Bureau of Wastewater Facilities Regulation.

Once Florida is a delegated NPDES state, there should be no major increase in staffing because Florida already reviews all NPDES permits under the Clean Water Act 401 certification process. Shifting from a non-delegated state to a delegated state should have no change on district and district branch office operations. Because of the shift of responsibilities from federal to state, there may be some administrative changes; however, that will occur at the FDER headquarters and EPA Region IV levels.

3.4.3 Option W7 — Require Resource Monitoring

Description: Under this option, all NPDES-permitted surface water dischargers would be required to develop resource monitoring programs.

Rationale: The NPDES permitting program for surface dischargers focuses on impacts on the water quality standards set out in each NPDES permit. However, in the Florida Keys, where biological communities are highly sensitive to changes in nitrogen and phosphorus levels, a resource-based monitoring approach may be more appropriate. EPA's Ocean Discharge Program uses such a resource-based monitoring approach. However, the Ocean Discharge Program only applies to those areas where surface discharges occur into oceanic waters, defined as waters seaward of the "baseline" (mean low tide mark). This exempts all surface dischargers in the Florida Keys with the exception of the City of Key West WWTP. Requiring all surface dischargers to conduct resource monitoring would provide additional protection of Sanctuary water quality and resources.

Responsible Agency: The responsible agencies would be EPA and FDER.

Implementation Mechanism: The goal of this option could be accomplished in one of two ways. One way would be for EPA to eliminate the baseline exemption for resource monitoring under the Ocean Discharge Program, as it applies to the Florida Keys. This would require a rule change in 40 CFR 125. A second way to accomplish the same goal would be for FDER, through the state of Florida's permitting authority, to require resource monitoring when individual NPDES permits come up for renewal. This approach probably would be easier because it could be accomplished under existing rules.

Implementation Requirements: Implementation of this option would involve adding at least one or possibly two EPA staff to develop a resource monitoring program for all the surface water dischargers remaining in the Florida Keys. The most significant costs would be associated with the ongoing monitoring programs. These costs would be in addition to those already associated with meeting existing water quality monitoring programs as required by NPDES permits.

3.4.4 Option W8 — Establish Permit Fees

Description: This option would establish permit fees to underwrite the administrative costs of the FDER Point Source Evaluation Program. Staff involved with this program would conduct water quality-based effluent limitation (WQBEL) modeling for proposed surface water discharges as compared to the present practice of applicants having their engineering consultants undertake such modeling efforts.

Rationale: Currently, applicants provide the data needed to set WQBEL standards for inclusion in wastewater discharge permits to the FDER Point Source Evaluation Section. However, based on past performance, the FDER staff would rather collect the data and conduct the water quality modeling themselves. These proposed permit fees would assist in defraying staff costs and this method would facilitate the permitting process.

Responsible Agency: The responsible agency should be the FDER.

Implementation Mechanism: The implementation mechanism is Chapter 17-650 FAC — Water Quality Based Effluent Limitations.

Implementation Requirements: The FDER Point Source Evaluation Section would need to undertake a study documenting what the agency's costs would be if FDER staff assumed responsibility for conducting WQBEL modeling. The applicant would continue to collect the data necessary for the modeling as is currently the case, and once the study is completed, the FDER would need to initiate formal rule-making in accordance with Chapter 120 FS — Florida Administrative Procedures Act. The FDER would modify the existing WQBEL administrative rule set out in Chapter 17-650 FAC. Besides permit fees, the modified rule would need to describe the new procedures and responsibilities of both the FDER and the applicant.

The need for staffing increases is unknown at this time; however, the study described above would address this issue. The FDER staff already conducts some WQBEL modeling in instances where the FDER finds an applicant's work unacceptable. If this option is implemented, technical training sessions should be incorporated into the Point Source Evaluation Program.

3.4.5 Option W9 — Improve Interagency Coordination

Description This option would improve the interagency coordination process for industrial wastewater discharge permitting.

Rationale: Coordination between the EPA and FDER needs improvement relative to industrial wastewater discharge permitting and tracking. FDHRS would also be included for special cases such as seafood processing plants discharging to septic systems.

Responsible Agency: The FDER, through the Intergovernmental Coordinating Council, needs to be the responsible agency for implementing this option. Other agencies involved are the EPA, FDHRS, and the South Florida Water Management District (SFWMD).

Implementation Mechanism: At present, much of the interagency coordination and tracking for permitted industrial wastewater discharges are handled through a series of Memorandums of Agreement (MOA) and MOUs. These agreements need to be reviewed, evaluated, and revised specifically with respect to the Florida Keys. Centralization of the collection and tracking of monitoring data is particularly important in relationship to other water quality and monitoring programs being planned within the FKNMS.

Implementation Requirements: No new rules or governmental structures are required to implement this option. Based on the results of the FDER and Intergovernmental Coordinating Council review of the existing MOAs and MOUs, these interagency agreements may need to be revised and updated specifically for the FKNMS area. The data tracking and data management aspects of this program need to be centralized within the framework of the other monitoring and management programs related to the FKNMS.

3.4.6 Option W10 — Improve On-site Sewage Disposal System Permitting

Based on information derived from the earlier program survey questionnaires and personal interviews with FDER and FDHRS staff, it became apparent that a series of management strategies, either treated separately or combined into an options package, could enhance the OSDS permitting program in the Florida Keys. The four parts of this option package are described below.

3.4.6.1 OPTION W10a — COMBINE ON-SITE SEWAGE DISPOSAL SYSTEM PERMITTING RESPONSIBILITIES

Description: This option would combine the FDER and FDHRS wastewater permitting responsibilities for commercial establishments, institutions, and multi-family residential establishments into one agency.

Rationale: Under current regulations, there is a gap in the OSDS regulatory/permitting process as it pertains to aerobic wastewater treatment units. The Monroe County Public Health Unit is authorized to permit the aerobic treatment unit, the filter unit, and the underground injection well (commonly called the borehole) for residential units. For commercial establishments, institutions, and multi-family residential uses having total daily flows of no more than 5,000 gallons, the Monroe County Public Health Unit has permit authority for the aerobic treatment unit and the filter unit. The FDER permits the borehole for such facilities.

The effluent from aerobic systems permitted by the FDHRS does not meet the more stringent wastewater treatment standards defined for secondary treatment facilities permitted by the FDER. The aerobic units meet the nationally accepted wastewater quality standards set by the National Sanitation Foundation (a not-for-profit research, education, and service organization that develops standards and criteria for equipment, products, and services that relate to health).

Responsible Agency: The responsible agency would be the FDER.

Implementation Mechanism: The FDER and FDHRS need to enter into a MOU that delineates the roles and responsibilities of each agency regarding OSDSs.

Implementation Requirements: The FDER and FDHRS would need to agree on the same requirements regarding levels of treatment for existing and new or innovative OSDS units to be permitted in the Florida Keys. Once an agreement is reached, the administrative rules regarding the quality of wastewater being discharged into underground injection wells should be amended.

3.4.6.2 OPTION W10b — REVIEW ON-SITE SEWAGE DISPOSAL SYSTEM PERMIT APPLICATIONS FROM A "CARRYING CAPACITY" PERSPECTIVE

Description: Under this option, OSDS permit applications would be reviewed from a cumulative "carrying capacity" perspective.

Rationale: In the Florida Keys there are an estimated 24,000 permitted OSDSs and 5,000 cesspits. Although one OSDS may not have a dramatic impact on nearshore and confined waters, where there are concentrations of OSDSs, a cumulative adverse impact on the adjoining water has been documented. If new OSDS units are continued to be permitted, it should be based on some type of carrying capacity criteria that reflects the unique situation present in the Florida Keys.

Responsible Agency: The FDCA currently has the commitment of funds for a federal research grant to undertake a program that will address this option (T. Livingston, FDCA, personal communication, 1992). Monroe County will soon have the OSDS database in a Geographic Information System (GIS) format that will allow review of OSDS density patterns throughout the Florida Keys.

Implementation Mechanism: The first step in implementing this option is the development of an MOU between the FDCA, FDHRS, and Monroe County for a joint research effort to assess the problems caused by high densities of OSDSs at a specific site in the Florida Keys.

Implementation Requirements: As soon as the FDCA has the required funding available, it should begin work with the Monroe County Health Department and FDHRS to select and implement the program.

3.4.6.3 OPTION W10c — MODIFY ON-SITE SEWAGE DISPOSAL SYSTEM PERMIT FEES

This option has been deleted because administrative procedures have recently been changed to assure that OSDS permitting fees that are collected by the Monroe County Public Health Unit are used to underwrite the costs of enforcement and compliance activities of the Environmental Health Division.

Description: This option would modify the current FDHRS policy, relative to OSDS permitting fees, by having a percentage of the fees returned directly to the county in which the fees were collected. This would provide local public health units with some additional funding to increase enforcement and compliance activities.

3.4.6.4 OPTION W10d — MONITOR REVISED ON-SITE SEWAGE DISPOSAL SYSTEM RULES

Description: This option would involve designing and implementing a monitoring program to determine the effectiveness of recent revisions in Part II of Chapter 10D-6 FAC.

Rationale: Permitting standards for OSDSs have been changed in the past year. Data are needed to evaluate whether these changes are achieving their desired effect. The two key rule changes specifically targeted to the Florida Keys include making the use of underground injection wells (boreholes) an option of last resort and requiring placement of a minimum 12-in.-thick filter layer of quartz sand below the drainfield absorption surface of the OSDS.

Responsible Agency: The responsible agency would be the FDHRS.

Implementation Mechanism: The implementation mechanism is the FDHRS budget. Specific funds in the FDHRS budget should be earmarked to allow the Environmental Administrator of the State Health Office to implement the suggested option.

Implementation Requirements: Under the supervision of the Environmental Administrator of the State Health Office, a comparative study should be made that determines whether or not the rule modifications make a significant difference. The study will require the identification of participants (homeowners) willing to allow their OSDS to be a part of the study. Possibly, incentives might be awarded to those who participate. Because the study will need to be conducted in the Florida Keys, and because the environmental health section of the Monroe County Public Health Unit is understaffed to carry out its present mandates, an additional staff position should be created and funded (possibly through special grant funds) to implement the research study.

3.4.7 Option W11 — Establish Interagency Laboratory

Description: Under this option, an interagency laboratory would be established in the Florida Keys with the capability of processing compliance monitoring samples. The laboratory would be certified by FDHRS and/or the quality assurance (QA) section of the FDER. The new state office building in Marathon has space allocated for such facilities.

Rationale: The FDER Marathon District Branch Office and district laboratories are no longer FDHRS-certified. All water quality samples taken by the FDER staff are sent for analysis to the FDER's only FDHRS-certified laboratory located in Tallahassee. Because of the distance between Tallahassee and the Florida Keys, it routinely takes longer than 24 h for samples to reach the Tallahassee laboratory. For laboratory analyses to be valid, they must adhere to FDHRS-certified quality assurance/quality control (QA/QC) protocols. Certain water quality parameters, such as fecal coliform and biological oxygen demand (BOD), must be analyzed within 24 h from the time of sample collection according to FDHRS-certified QA/QC protocols. If these protocols are not followed, the results of the tests can be jeopardized. Because there is no other governmental entity that operates FDHRS-certified laboratories in the Florida Keys, the only option, other than sending the samples to Tallahassee and hoping they arrive in time to be tested according to QA/QC protocols, is to send the samples to a private laboratory in Miami — an expensive alternative.

Further, the FDHRS Monroe County Public Health Unit has needs similar to those of the FDER, and it too has no laboratory facilities within the Florida Keys. However, the FDER District Branch Office will be moving into the new state office center that is currently under construction in Marathon and space within the new FDER District Branch Office has been allocated for a laboratory. With funds being scarce, the FDER and FDHRS should consider jointly funding a publicly-operated, FDHRS-certified (or equivalent) laboratory in the FDER offices in Marathon.

Responsible Agency: The responsible agency should be the FDER.

Implementation Mechanism: The implementation mechanism is the state budgetary process. If the facility is operated jointly by the FDER and FDHRS, a MOU should be developed that defines the roles, technical responsibilities, and method of cost sharing.

Implementation Requirements: The first and foremost implementation requirement is to have the FDER laboratory re-certified according to FDHRS requirements. In terms of staffing, at a minimum, one qualified technician needs to be hired. Additional staff would be added as demand warrants. In addition, some upgrading of existing equipment will be necessary to ensure a quality field monitoring program.

3.4.8 Option W12 — Increase Wastewater Data Management Capacity

Description: This option would increase the data management capacity of both the FDER district and district branch office levels to reduce lag time in updating the Groundwater Management System (GMS) and the Compliance Enforcement Tracking System (CETS) databases.

Rationale: At present, the state's databases can be quite out of date. This situation results primarily from the lack of staff — more staff are needed to continually update and QC the databases. In addition, some type of enhanced interaction among agency branches needs to be established to ensure all critical data are available and reviewed in connection with new permit requests.

Responsible Agency: The responsible agency should be the FDER.

Implementation Mechanism: This option does not require the creation of a new program, but it will expand the department's existing data management capacity. Therefore, the implementation mechanism is the FDER budget.

Implementation Requirements: Based on interviews with FDER staff at district and district branch offices, creating a new staff position at each office would enable data to be integrated more quickly into the two databases. The district branch office is in need of a technical support position. One of the primary duties of this position would be to assist in computer data entry and maintenance/updating of compliance tracking systems. A similar need exists for the district office.

The Marathon District Branch Office has only a rudimentary computer capability. At present, the office has one word processing computer and is understaffed in terms of inspectors. By providing better computer facilities, the limited staff would be able to work more efficiently and respond more quickly to resident's needs whether they be complaints or requests for information about the FDER programs.

3.5 INSTITUTIONAL OPTIONS

Most of the management options discussed in Section 3.4 are regulatory; they describe ways that existing regulatory agencies can improve the permitting, compliance, and enforcement activities. However, most of the proposed engineering options will require an institutional mechanism for implementation.

3.5.1 Existing Institutional Framework

Two local governments operate wastewater treatment facilities: the City of Key West and the City of Key Colony Beach. The City of Key West operates the largest facility whose service area is limited primarily to the City; however, if the City is able to correct the serious groundwater infiltration problem, the excess capacity could serve much of the Lower Keys. For the City of Key Colony Beach facility, like the City of Key West facility, the service area is limited to the City; however, because of the plant's small capacity, it cannot be expected to serve much more than its own population. The other 207 wastewater package plants are owned and operated by individuals or homeowner associations. Individual septic systems are handled differently. Throughout the Florida Keys, OSDSs are permitted by the FDHRS Monroe County Public Health Unit.

The Florida Keys Aqueduct Authority (FKAA) has the legislative authority to provide wastewater treatment; however, it has not exercised this portion of its legislative mandate. The FKAA provides potable water to the Florida Keys.

Three institutional options are recommended for consideration. To implement either the community or regional wastewater options effectively, a more centralized approach is desirable. The options outlined enable control to remain local and, therefore, closer to the people the utility serves. We believe this encourages entities to be more sensitive to its users. Consolidation also can achieve economies of scale, both in terms of maintenance as well as administrative support.

3.5.2 Options

The following range of institutional options can be used to manage domestic wastewater treatment.

3.5.2.1 FLORIDA KEYS AQUEDUCT AUTHORITY

Description: Under this option, the FKAA would manage, operate, and maintain all wastewater treatment facilities in the Florida Keys. OSDSs would still remain under FDHRS jurisdiction.

Rationale: The FKAA is the only existing governmental entity within the Florida Keys that has the statutory authority to manage and/or provide central wastewater collection and treatment service to both the incorporated and unincorporated areas of Monroe County.

Responsible Agency: The responsible agency would be the FKAA.

Implementation Mechanism: Although the FKAA has the legislative authority to operate centralized wastewater treatment systems in the Florida Keys, it will not initiate action to become such a provider. To commence the process will require that one of two actions be undertaken. Either local governments within the Florida Keys would approach and petition the FKAA to become the wastewater provider to areas within their jurisdiction, or the Florida Governor would direct the FKAA to initiate actions which would result in the FKAA assuming total responsibility for the development and operation of neighborhood collection and treatment systems. Prior to local governments approaching the FKAA, they could seek to place a referendum on the ballot to acquire a general sense of whether or not this option is viable in the minds of the Florida Keys residents. This type of effort would also require a well-devised public outreach effort.

Imple nentation Requirements: A wastewater master plan that identifies operational standards and procedures for package plants, collection systems, pump stations, and disposal wells needs to be developed. The plan would include other operational aspects such as staffing needs, facilities maintenance strategy, interagency coordination (e.g., involvement in the local government's site development review process), and billing procedures.

The FKAA would have to hire several technical staff to oversee the development and daily operation of the wastewater treatment facilities and collection systems. Because the implementation of the various engineering wastewater options would take place over a period of years, the hiring of staff would follow a similar pattern. For each new wastewater facility, the FKAA would need to hire a treatment facility supervisor, two FDER-trained operators, and a collection and distribution supervisor with a lift station mechanic. Because the FKAA has been providing potable water to the Florida Keys residents for years, staff is already in place that could reduce start-up costs. The FKAA has a director, a communications system, a billing and collection staff, as well as individuals trained in vehicle and equipment repair.

3.5.2.2 COUNTY WASTEWATER UTILITY — ADMINISTRATIVE AND OPERATIONAL

Description: Monroe County could develop an administrative and facility operational capacity for managing all aspects of wastewater treatment in the unincorporated County. Selecting this option would require the County to make a major commitment that is considerably more significant than the administrative-only option described in **Section 3.5.2.3**. The administrative and operational option requires the County to develop an operational program and hire and train staff to carry out administrative and planning activities and develop competency and adequate support (staff and equipment) to cost-effectively operate the Keys-wide wastewater system. Currently, the Monroe County Public Works Department has maintenance facilities based on Stock Island, Marathon, and Plantation Key.

The City of Key West and City of Key Colony Beach would continue to have management oversight responsibility for their publicly-owned wastewater facilities. Private state-certified contractors would continue to operate and maintain the municipality-owned wastewater facilities as well as the few privately-owned facilities still operating in the City of Key West.

The OSDSs would still remain under FDHRS jurisdiction.

All the engineering options outlined in **Section 3.3** (e.g., existing systems, subregional plants, regional plants) can be accommodated by this proposed institutional option.

Rationale: By limiting wastewater facility management to Monroe County, the City of Key West, and the City of Key Colony Beach, rather than for 209 individually operated and managed systems, this option provides a more streamlined management scheme resulting in a higher degree of uniformity in service reliability. Historically, publicly-owned wastewater facilities function more reliably, partly because of a better and more frequent schedule of facility maintenance. This option also provides a more efficient institutional framework within which the FDER and EPA can function. Currently, the FDER must handle 209 separate entities, while the EPA permits and monitors compliance for approximately 10 active facilities that discharge domestic wastewater.

Responsible Agency: This option does not lend itself to a responsible agency; however, it does limit the management of wastewater facilities to three local governments:

- Monroe County (all unincorporated areas)
- City of Key West
- City of Key Colony Beach

Implementation Mechanism: This option does not require the City of Key West or the City of Key Colony Beach to alter their operating procedures unless service by either system is expanded into unincorporated areas, or the facilities are to be purchased by the County and brought under the auspices of the County. To initiate this option, the County needs to authorize a feasibility study for implementing a wastewater treatment utility. If the results of the study support the implementation of the County wastewater utility concept, the Monroe County Commission needs to authorize the creation of such an entity by an ordinance action.

Implementation Requirements: If this is the desired option, the Monroe County Commission should assign the responsibility for the coordination of all activities related to the implementation of a County wastewater utility program to a specific individual. Further, the commission needs to fund an operational implementation plan that details exactly how the County will establish such service. This plan would include recommending where this function should be located within the structural framework of County government. Options would be to house the function within the Public Works Department or to create a new department that deals solely with wastewater treatment. The plan should also specify staffing needs by expertise; equipment needs; a billing and collection procedure; a long-range plan that identifies which existing wastewater plants will become a part of the Monroe County sewer program and/or where new regional or subregional plants will be located; a schedule of key milestones identifying when facilities will be brought on line; and a funding program. Without a plan, it is difficult to identify staffing needs for the department; however, if the County initiates service with one subregional WWTP, the following rule of thumb provides a reasonable estimation of staffing needs.

Once a subregional plant comes "on-line," approximately 11 people would be needed: a utility director; a secretary; a treatment facility supervisor with two FDER-trained and -certified operators and two operator trainees; a collection and distribution supervisor with a lift station mechanic; and a billing supervisor and a clerk who would be responsible for billings and collections. Certainly at the outset, some individuals would serve several functions; however, as the wastewater operation expands, there would be an increase in specialization among plant personnel. In staffing the plant, the County needs to make sure that at least one person has a Florida Professional Engineer (PE) license. Engineered drawings are frequently needed and must be sealed by a PE. As additional plants are added, staff will need to be increased accordingly, especially in the areas of plant operations, and maintenance of collection and treatment.

To ensure quality and reliability in staff performance, the County needs to incorporate a training component. Currently, the University of Florida Center for Training, Research and Education for Environmental Occupations, commonly known as TREEO, as well as the Water Environment Federation and the Florida Water Pollution Control Operators Association offer courses that update and expand the technical knowledge of individuals working in the wastewater treatment management arena.

Minimum equipment needs would include a car for the director. For each subregional facility, a complement of vehicles might include two or three pickup trucks, one two-ton truck with a hydraulic lift, a backhoe on a trailer, and a portable electric generator. Adequate computer equipment and software need to be available for general administrative operations and for maintaining billing and collections records. The County is establishing a GIS and the physical location and size of the wastewater facilities and collection systems should be made a part of that system. The GIS would be a useful management tool for the utility.

3.5.2.3 COUNTY WASTEWATER UTILITY — ADMINISTRATIVE ONLY

Description: This option, like the one described in Section 3.5.2.2, would involve placing all wastewater plants located in the unincorporated County under the management control of Monroe County. The wastewater facilities would be operated by private, state-certified operators (as is currently done). The County would have responsibility for long-range planning, responding to customer inquires, billing, submitting required discharge monitoring reports to the EPA and/or FDER, as well as overseeing plant operations and dealing with individual plant operators. All the engineering options outlined in Section 3.3 (e.g., existing systems, subregional plants, regional plants) can be accommodated by the proposed management option.

The two publicly-owned wastewater treatment systems (City of Key West and City of Key Colony Beach) would remain under the management authority of their respective jurisdictions. Both cities would continue to have management oversight responsibility. Private, state-certified contractors would continue to operate and maintain the various wastewater facilities.

This option envisions OSDSs remaining under FDHRS jurisdiction with the Monroe County Public Health Unit serving as the local permitting and compliance point of contact.

Rationale: There are only two publicly-owned wastewater treatment systems in the Keys, in the City of Key West and the City of Key Colony Beach. All others are privately-owned, the vast majority by homeowners associations. There are 209 wastewater treatment facilities located in unincorporated Monroe County. Creation of a centralized wastewater management authority within unincorporated Monroe County would allow the County to have better regulation and management control of package plants with minimal staffing costs.

Responsible Agency: This option does not lend itself to a responsible agency; however, it does limit the management of wastewater facilities to three local governments as follows:

- Monroe County (all unincorporated areas)
- City of Key West
- City of Key Colony Beach

Implementation Mechanism: This option does not require the City of Key West or the City of Key Colony Beach to alter its operating procedures; therefore, no formal implementation mechanism is required. Prior to initiating this option, the County should undertake a wastewater treatment feasibility implementation study. Because the County has no operational responsibility for wastewater treatment, the County should enact an ordinance that describes the roles and responsibilities of the County under this option.

Implementation Requirements: If this is the desired option, the Monroe County Commission should assign the responsibility to coordinate all activities related to the implementation of a County wastewater treatment management program to a specific individual. Further, the commission needs to fund an operational implementation plan that details how this option will be executed. The plan needs to include where the function will be located in County government, either within an existing department or within a new department. The plan should also specify staffing needs by expertise; equipment needs; a billing and collection procedure; a long-range plan that identifies which existing wastewater plants will become a part of the Monroe County sewer program and/or where new regional or subregional plants will be located; a schedule identifying key milestones of when facilities will be brought on line; and a funding program.

Because the actual operation of the facilities would be handled by the private state-certified contractor operators, staffing needs are more limited. Primarily, staffing needs fall in the area of administrative management. The entity will need to have a utility director, secretary, billing supervisor and clerk, and possibly a state-certified facilities operator who would oversee and coordinate with the private contractor operators. In this particular instance, with a minimum of staff, the utility director should be a trained engineer with a Florida PE license. Engineered drawings are frequently needed and must be sealed by a PE.

To ensure quality and reliability in staff performance, the County needs to incorporate a training component. Currently, the University of Florida TREEO as well as the Water Environment Federation and the Florida Water Pollution Control Operators Association offer courses that update and expand the technical knowledge of individuals working in the wastewater treatment management arena.

Minimum equipment needs would include a car for the director and a small pickup truck for the individual overseeing the contractor operators. Adequate computer equipment and software need to be available for general administrative operations and for maintaining billing and collections records.

4.0 STORMWATER

4.1 INTRODUCTION

There are few effective stormwater management systems in the Florida Keys, for several reasons:

- Many of the larger subdivisions or developments were constructed before SFWMD stormwater permitting requirements were in place.
- Most developments constructed after SFWMD stormwater regulations were in place fell below the thresholds for those regulations (10 acres total or 2 acres of impervious surface).
- Prior to 1986, Monroe County had no ordinance regulating stormwater management. The 1986 ordinance was largely unenforceable because of its stringent requirements with insufficient guidelines for implementation, and difficulties of enforcing compliance on residential lots.
- The lack of available lands for detention or retention areas generally made voluntary stormwater management difficult.

Typical drainage in many areas consists of direct runoff to the nearest surface water, with some attenuation provided by high infiltration rates. There are several engineered stormwater management systems using one or more boreholes for disposal; most of these systems are in the City of Key West or Marathon. In July 1992, there were a total of 11 such systems using 43 boreholes. Most other noticeable stormwater management improvements are in the U.S. 1 right-of-way, such as the extensive swales located throughout much of Key Largo.

Because of the limited regulation of stormwater management in the Keys, the end result is largely uncontrolled stormwater runoff. If there is no organized effort toward the improvement of stormwater management in the Keys, the degradation of nearshore waters by stormwater runoff will continue. The current estimate for average stormwater pollutant loading from developed areas is 401 lbs/day total nitrogen, 364 lbs/day total phosphorus and 85 tons/day total suspended solids (see Table A-7, Appendix A). As noted previously, effective population of the Keys should only increase about 8.5% over the next 20 years. Although stormwater pollutant loadings are not directly proportional to population, it is reasonable to assume proportionality in the absence of other data. If the intensity of stormwater management efforts is not increased, the projected population increase will result in a slight increase in loading of sediment, toxics, and nutrients to nearshore waters of the Sanctuary.

Three related engineering options and three management options to improve stormwater pollution control in the Florida Keys are presented below.

4.2 ENGINEERING OPTIONS

Engineering options presented in this section represent varying levels of intensity or commitment in using the stormwater engineering methods discussed in Appendix D and summarized in Table 3-6. These methods are commonly used throughout Florida.

Engineering options for stormwater management are described briefly below and in detail in Appendix E. Because of the similarity of the options, they are discussed together, rather than separately as in Appendix E. Estimated costs, reductions in nutrient and sediment loadings, and cost effectiveness of the stormwater engineering options are presented in Table 3-7.

- **Option S1a - Retrofit "Hot Spots"**
  Identify and retrofit hot spots by using grass parking, swales, exfiltration trenches, pollution control structures, and detention/retention facilities. Eliminate stormwater runoff in areas handling toxic and hazardous materials. Install swales and detention facilities along limited sections of U.S. 1.

Table 3-6. Engineering methods for stormwater pollution control.
Details are provided in Appendix D.

Grassed Swales, Waterways, and Filter Strips
These controls are applied as alternatives to curb and gutter drainage systems. Grassed swales consist of slightly sloped grassed valleys with dam-like structures made of stone and railroad ties that increase infiltration and flow attenuation. Filter strips consist of grass or other close-growing vegetation designed to accept overland sheet flows of runoff. They are usually composed of dense vegetation such as grass or wood, combined with underlying stone layers for infiltration.

Curb Elimination
Curb elimination allows runoff to disperse over a greater area rather than being channeled into collection facilities. This dispersal over adjoining land, which is usually covered by vegetation, also aids in reducing runoff velocity and sedimentation of solids.

Catch Basins
Catch basins are part of an underground stormwater collection, treatment, and disposal system. Stormwater runoff may be diverted to an inlet or catch basin. They are designed to capture grit, gravel, and debris and protect the remainder of the storm drainage system. Combined with a swale system where the inlet of the catch basin is raised above the surrounding swale, the catch basin acts as a pretreatment device.

Exfiltration Trenches
These are below-grade trenches with perforated pipe inside a rock envelope used to disperse stormwater below grade. In many areas where land costs are so prohibitive that the use of retention or detention basins is excluded or severely limited, exfiltration trenches are commonly used with catch basins or other types of outlets to prevent clogging.

Pollution Control Structures
These are baffled, velocity-reducing structures used to remove coarse sediment and floating pollutants from parking lot and street runoff.

Detention/Retention Facilities
These are storage basins used to attenuate peak flows and settle suspended solids. Detention facilities are emptied slowly through a bleeder opening on the control structure. Retention facilities discharge contents by percolation. Some nutrient removal can be attained if littoral vegetation is used.

Class V Injection Wells (Boreholes)
These are shallow (60 to 90 ft deep) wells used for gravity disposal of stormwater.

Aquifer Storage and Recovery
This is a relatively new technique involving pumping treated water to a confined shallow aquifer (about 500 ft deep) for future use. The pumped water forms a bubble, displacing native saline water. Differences in densities and restrictions of the aquifer formation minimize mixing of pumped and native waters. Recovery can take place either immediately or in the future for irrigation or other uses.

Deep Injection Well
This is a deep (2,500 to 3,000 ft) well used for disposal of stormwater or wastewater. Deep well injection has historically been used primarily for disposal of wastewater and reverse osmosis brine.

Cisterns
These are tanks used to hold rain water for subsequent potable or irrigation uses. Cisterns can be a stormwater retention device, storing the water for irrigating during dry periods. Although cisterns provide no stormwater treatment, the capture of runoff and delayed application to surrounding vegetation provides a beneficial use of water and the vegetation provides treatment.

Porous Pavement
Porous pavement is an innovative stormwater practice with limited applicability for parking areas not subject to sand and mud carried on tires. Paving with porous concrete allows water to percolate into the underlying soil.

Pervious Surfaces
Grassed or other pervious areas such as grassed or gravel parking lots allow infiltration of water.

Irrigation Reuse
This method involves storage of stormwater in a retention basin or in aquifer storage and recovery wells, with subsequent reuse for irrigation.

Table 3-7. Nutrient and sediment reductions and cost estimates for stormwater engineering options.

Option	Reduction in Loadings (%)			Estimated Cost			Cost Effectiveness[b]		
	Nutrients (Stormwater Only)[a]	Nutrients (Stormwater + Wastewater)[a]	Sediment (Stormwater)	Initial ($ millions)	20 yr O & M ($ millions)	Total 20 yr ($ millions)	Nutrients (Stormwater)	Nutrients (Stormwater + Wastewater)	Sediment (Stormwater)
SIa — Retrofit hot spots	0.2-0.5	0.04-0.1	0.5-1.0	80	120	200	400-1000	2000-5000	200-400
SIb — Retrofit hot spots and population centers	5-12	1.0-2.4	20-50	370	440	810	67-162	337-810	16-40
SIc — Retrofit stormwater facilities throughout Sanctuary									
Borehole disposal	20-50	4.0-10.0	40-60	530	680	1210	24-60	121-302	20-30
Deep well disposal	20-50	4.0-10.0	40-60	680	1000	1680	34-84	168-420	28-42

O & M: Operation and maintenance

[a]Nutrient reduction is calculated as a percentage of both stormwater and combined (stormwater + wastewater) nutrient loadings. Stormwater nutrient loadings are estimated to average about 20% of combined (stormwater + wastewater) loadings, based on Table 3-1.

[b]Cost effectiveness = total cost/percent reduction in nutrient or sediment loadings. Nutrient reductions are calculated as a percentage of both stormwater and combined (stormwater + wastewater) nutrient loadings.

- **Option S1b - Retrofit Hot Spots and Population Centers**
  Identify hot spots, and retrofit hot spots and population centers by using grass parking, swales, exfiltration trenches, pollution control structures, and detention/retention facilities. Eliminate stormwater runoff in areas handling toxic and hazardous materials. Install swales and detention facilities along the majority (developed area) of U.S. 1.

- **Option S1c - Retrofit Stormwater Facilities Throughout Sanctuary**
  Identify hot spots, and retrofit hot spots, population centers, and other developed areas throughout the Sanctuary by using grass parking, swales, exfiltration trenches, pollution control structures, and detention/retention facilities. Eliminate stormwater runoff in areas handling toxic and hazardous materials. Install swales and detention facilities along U.S. 1. Include ultimate disposal of stormwater via boreholes or deep wells for high-flow areas.

Description: The options represent a range of applications for the same engineering methods. At the first level (Option S1a) engineering methods are applied only to identifiable hot spots, where stormwater pollutant loadings are high and degradation of receiving waters is obvious or already documented. In the mid-level option (Option S1b), engineering methods are extended to population centers and other developed areas. In the highest level option (Option S1c), the same methods are applied throughout the Keys in nearly all developed areas.

Rationale: Retrofitting of stormwater hot spots with control and treatment methods (Option S1a) would reduce loadings of sediment, toxics, and nutrients to Sanctuary waters. Application of the same methods to population centers and other developed areas (Option S1b) and Sanctuary-wide (Option S1c) would result in successively greater pollution reductions.

Cost: Estimated construction costs and 20-year operating/maintenance costs for each option are summarized in **Table 3-7**. Construction costs range from $80 million (Option S1a) to $680 million (Option S1c with deep well disposal). Twenty-year operating/maintenance costs range from $120 million (Option S1a) to $1 billion (Option S1c with deep well disposal). Total costs range from $200 million (Option S1a) to $1.68 billion (Option S1c with deep well disposal).

Pollution Reduction: The effectiveness of stormwater control/treatment facilities is not well known and is very site specific. Nutrient removal is highly dependent on site conditions, engineering methods, and level of maintenance, therefore, estimates in **Table 3-7** are approximate.

Estimated reductions in nutrient loadings (percentage of total stormwater nutrients) are 0.2-0.5% for Option S1a, 5-12% for Option S1b, and 20-50% for Option S1c. However, stormwater nutrient loadings are much smaller than wastewater nutrient loadings. In terms of total wastewater and stormwater nutrients, the stormwater engineering options would result in a small reduction in nutrients, at a very high cost.

Estimated reductions in sediment loadings range from 0.5-1.0% for Option S1a, 20-50% for Option S1b, and 40-60% for Option S1c. Because stormwater runoff is probably a major source of sediment loadings to Sanctuary waters, these are significant reductions, albeit at a very high cost. Loadings of toxics (e.g., metals and hydrocarbons) have not been estimated, and therefore the reductions cannot be quantified. However, stormwater control methods would reduce loadings of toxics into Sanctuary waters.

Implementation: **Section 4.4** discusses the existing and alternative institutional frameworks for stormwater management in the Florida Keys that would be relevant to implementing Options S1a-S1c. While the FDER has statewide responsibility for stormwater management, the department has delegated its responsibilities in the Florida Keys to the SFWMD. Options for implementing Keys-wide stormwater control would include continuing with SFWMD as the responsible agency, creating an independent stormwater utility, and leaving stormwater management to local governments (e.g., Monroe County, City of Key West). Other agencies that would be involved would include the Florida Department of Transportation (FDOT), EPA, and FDER.

4.3 MANAGEMENT OPTIONS

Three management options are presented for stormwater:

- **Option S2 — Eliminate Permitting Threshold**
  Eliminate the current minimum threshold acreage (less than 10 acres total or less than 2 acres of impervious surface) required for developments to obtain a stormwater permit.

- **Option S3 — Enact Stormwater Management Ordinances and Master Plans**
  S3a — Require and set deadlines for local governments to enact and implement stormwater management ordinances and comprehensive stormwater management master plans.
  S3b — Require and set deadlines for local governments to enact and implement stormwater management ordinances and comprehensive stormwater management master plans. As a backup in the event that these ordinances and master plans are not enacted and implemented in a timely manner, EPA would be petitioned to include the Florida Keys in the stormwater NPDES program.

- **Option S4 — Institute Best Management Practices**
  Institute a series of Best Management Practices (BMPs) and a public education program to prevent pollutants from entering stormwater runoff. The programs include street sweeping; public education and ordinances aimed at controlling fertilizer application on public and private landscaping; collection locations and a public education program for the proper use and disposal of fertilizers, pesticides, motor oil, and other hazardous chemicals; and strenuous litter control programs.

4.3.1 Option S2 — Eliminate Permitting Threshold

Description: This option would require that stormwater management ordinances in the Florida Keys contain no threshold (minimum) acreage for obtaining a stormwater management permit.

Rationale: Currently, the only stormwater runoff regulatory controls are those administered by the SFWMD. Under the SFWMD's rules, development projects under 10 acres in size and/or having less than 2 acres of impervious surface are exempt from the permitting process. Individuals or companies developing property must adhere to all SFWMD stormwater management rules and regulations. However, because the SFWMD does not have the staff or resources to monitor each single family home built in the Florida Keys, stormwater essentially goes unregulated.

With no change in the existing SFWMD policy or adoption of stormwater management ordinances by local governments, stormwater will continue to go unchecked and will continue to contribute to the water quality degradation. Some local governments are in the midst of implementing a stormwater management ordinance or anticipate enacting one in the near future. Local ordinances should not exempt <u>any</u> development from the stormwater permitting process.

Responsible Agency: Each local government would be the responsible agency in implementing its own ordinance within its jurisdictional limits. As the state land planning agency for a designated Area of Critical State Concern (ACSC), the FDCA has an oversight responsibility to ensure that local development regulations adequately protect the area's natural resources and are consistent with those of their neighbors.

Implementation Mechanism: This option could be implemented through a change in SFWMD policy or through local stormwater management ordinances.

Implementation Requirements: When drafting their stormwater management ordinances, local governments need to avoid exempting any development from the regulatory processes dealing with stormwater runoff.

4.3.2 Option S3 — Enact Stormwater Management Ordinances and Master Plans

Description: This option consists of two parts. Option S3a would require and set deadlines for local governments to enact and implement stormwater management ordinances and comprehensive stormwater management plans. Option S3b would further provide that, in the event that these ordinances and master plans are not enacted and implemented in a timely manner, the FDER would petition EPA to include the Florida Keys in the stormwater NPDES program.

Rationale: All adopted government comprehensive plans have stated that local governments will prepare stormwater management master plans. This option would require the development of and adherence to an implementation schedule culminating in 1994. All stormwater plans should address not only water quantity but also water quality issues. While few data exist, the comprehensive plans indicate that unregulated stormwater runoff has most likely contributed to nearshore nutrient and sediment loading.

The possibility of petitioning EPA to include the Keys in the stormwater NPDES program has been included as a backup in the event that local governments do not enact and implement stormwater management ordinances and master plans in a timely manner. Due to its population size, Monroe County (which includes its municipalities) falls below the population threshold which would trigger the County's inclusion into the EPA stormwater NPDES program for municipal separate storm sewer systems. However, states may petition EPA to include a local government in the stormwater NPDES program.

Responsible Agency: Under the authorities of Sections 163.3161 and 380.05 FS, the FDCA has the responsibility for ensuring that programs and regulatory rules enacted by local governments in Monroe County are consistent with the legislative growth management principles described in the above-mentioned sections of the Florida Statutes. However, each local government will be responsible for developing their own stormwater management ordinance. Subsequent modifications to each ordinance may be necessary once each local government adopts its stormwater management master plan.

The responsible agency for petitioning EPA to include the Florida Keys in the stormwater NPDES program, should that become necessary, would be the FDER.

Implementation Mechanism: Stormwater master plans have been recommended in each local government's comprehensive plan. From a legal viewpoint, local comprehensive plans carry the force of law. This statutory provision requires local governments to implement their policies and actions set forth in their comprehensive plans. The local government stormwater ordinances will result from legislative actions taken by the governing board or council.

If the NPDES route becomes necessary, the FDER would submit a petition that describes the existing situation and identifies why Monroe County and its municipalities warrant inclusion in the program. EPA would make the decision on whether or not the County and/or municipalities are brought under the stormwater NPDES permitting process.

Implementation Requirements: A major implementation requirement is funding. No local government has the capability of preparing such plans in-house. The use of consultants may be necessary; however, another option could involve using FDER and SFWMD staff. This approach is more applicable to Monroe County and the City of Key West, which already have a certain level of expertise on this issue. The SFWMD, FDER, FDCA, or EPA would earmark funds that could serve as seed funds or an incentive to implement such a master plan and/or regulation. This is not unusual; the SFWMD is providing funding to the City of Key Colony Beach to assist in the development of its stormwater management master plan.

4.3.3 Option S4 — Institute Best Management Practices

Description: This option would institute a series of BMPs and a public education program to prevent pollutants from entering stormwater runoff. Programs would include street sweeping involving mechanical brush and vacuum removal of grit, debris, and trash from highway surfaces; public education and ordinances aimed at controlling fertilizer application on public and private landscaping; collection locations and a public education program for the proper use and disposal of fertilizers, pesticides, motor oil, and other hazardous chemicals; and strenuous litter control programs to remove leaves, lawn clippings, pet waste, and trash before they can be washed into marine habitats.

Rationale: Relative to domestic wastewater, stormwater is not a significant pollution problem in the Florida Keys. The problem results from the pollutants (nutrients, hydrocarbon products, toxic chemicals, etc.) in the waste stream that generally discharge into marine habitats. There are a number of terrestrial BMP-type programs which will reduce the amount and types of pollutants available for stormwater transport.

Responsible Agency: The responsible agency should be Monroe County, in coordination with the municipalities.

Implementation Mechanism: The County and respective cities can initiate intensified street cleaning and litter control programs. Fertilizer, herbicide, pesticide, and used oil programs aimed at the general public will require public awareness and public education campaigns. NOAA, through the FKNMS Sanctuary Office, should assist by including such elements in their general FKNMS-related public education efforts. In addition, the County and the municipalities should seek FDER assistance. The FDER's Nonpoint Source Management Section has completed extensive work dealing with BMPs, and has worked with local governments around the state in developing public education programs.

Implementation Requirements: Some new funds will be required at the County and city levels if a vigorous street cleaning program is to be undertaken. However, public education and public awareness is the single most important element in initiating any BMP with respect to stormwater runoff.

4.4 INSTITUTIONAL OPTIONS

4.4.1 Existing Institutional Framework

While an existing institutional framework exists for stormwater management, in practice, only minimal attention has been given to controlling this pollution source. No local government has developed either a stormwater master plan (although the City of Key Colony Beach is currently doing so) or a stormwater management ordinance. While there are no formally adopted rules regarding stormwater management, Monroe County, through its Development Review Committee, addresses the issue for those projects that require site plan approval. The Planning Director for the City of Key West addresses stormwater issues when deemed appropriate. As the coordinator for development approvals, the Planning Director seeks the input of the City Engineer or other pertinent city officials as needed.

From an operational viewpoint, Monroe County and the City of Key West are involved in stormwater management. Each, through their public works departments, maintains the swales and drainage ditches in their corporate limits. Monroe County Public Works Department headquarters is located on Stock Island with two branch operations located in Marathon and Plantation Key.

While the FDER has statewide responsibility for stormwater management, it has delegated its responsibilities in the Florida Keys to the SFWMD while retaining oversight responsibility. The SFWMD has regulatory responsibility for stormwater management; however it exempts certain development from the permitting process. Development projects under 10 acres in size and/or having less than 2 acres of impervious surface are exempt from SFWMD review.

4.4.2 Options

This section discusses three alternatives to the existing institutional framework for stormwater management in the Florida Keys.

4.4.2.1 SOUTH FLORIDA WATER MANAGEMENT DISTRICT

Description: Under this option, the SFWMD would have the sole responsibility for permitting all stormwater activities in the Florida Keys. The SFWMD would also have the responsibility for maintaining all publicly-owned stormwater facilities in the unincorporated County.

Rationale: The SFWMD is currently responsible for permitting stormwater management applications; however, the SFWMD reviews only those developments 10 acres in size or greater or projects with greater than 2 acres of impervious surface. Instead of each local government developing the capacity to permit stormwater activities, the SFWMD would review all site plans. The SFWMD also has responsibility for maintaining all stormwater facilities owned by the SFWMD.

The SFWMD recently established an office in Marathon. This location is relatively central for Florida Keys residents, and more importantly makes the SFWMD more accessible.

Responsible Agency: The responsible agency would be the SFWMD.

Implementation Mechanism: The implementation mechanism would be a MOU between the SFWMD and each local government or local governments as a group. It should describe the responsibilities of each government entity and those of the SFWMD.

Implementation Requirements: Prior to implementing this option, the SFWMD and participating local governments would need to prepare an operational management plan outlining the roles and responsibilities of all parties (the plan should shape the contents of the MOU) and the permitting and review procedures. This is especially important because the SFWMD would be reviewing stormwater management plans for development projects in four different governmental entities. Once the process is mutually agreeable to all parties, each local government should enter into a five-party stormwater management intergovernmental agreement or individual agreements with the SFWMD.

The SFWMD would need to augment the present staff level at the Marathon office. Because most of the work would be permitting, the office should include an engineer, technician, and secretary. In addition, the office should have computer linkage to the SFWMD central facility in West Palm Beach. A truck should be assigned to the office for compliance inspections.

4.4.2.2 STORMWATER UTILITY

Description: This option would establish a stormwater utility to permit and manage all stormwater matters in the Keys. The utility would review all development applications for permits, operate and maintain stormwater facilities, submit all monitoring compliance reports to the appropriate state and federal agencies, and construct or oversee the construction of all stormwater facilities approved by the stormwater utility. This entity would also have the authority to set fees.

Rationale: The stormwater utility would have Keys-wide responsibility. An advantage of this option is that entities having a sole function generally provide a high level of service. However, there are disadvantages to this option. First, it would require the establishment of a new entity, which would involve a major outlay of funds as compared with building on an existing entity. The entity would have no organizational structure, physical equipment, or manpower already in place. Further, it is not clear whether stormwater is such a significant problem in the Florida Keys that it warrants establishing a new entity to carry out stormwater management.

Responsible Agency: The responsible agency would be Monroe County.

Implementation Mechanism: Implementation could be accomplished either through a legislative act or a directive of the Governor (the method by which the FKAA was created).

Implementation Requirements: The most feasible approach would be to implement this option by enacting state legislation. Local governments, as a unified group, would need to petition the Monroe County state legislative delegation and request that the delegation sponsor and introduce enabling legislation that would provide the authority needed to establish a Keys-wide stormwater utility.

Before any commitment is made to implement this option, local governments would need to undertake a feasibility study to determine the cost of setting up such a utility.

4.4.2.3 LOCAL GOVERNMENT MANAGEMENT

Description: Under this option, local governments would develop a stormwater management capability and implement a local program.

Rationale: This option is based on the idea of maintaining local control. Instead of having either the FDER, SFWMD, or a multi-jurisdictional authority (such as a stormwater utility) regulate stormwater discharges, the County and each city would develop their own technical capability to regulate stormwater management.

While there is no department within either the City of Key West or Monroe County whose function is solely stormwater management, both entities have departments that deal with stormwater concerns. Although there is no stormwater management ordinance, the County and City consider stormwater ramifications when reviewing site plans for development projects other than single family residences. In terms of the operational side of stormwater management, the City of Key West Public Works Department has the responsibility for such matters. In Monroe County, the Road Department within the Public Works Division maintains the swales and drainage ditches in the unincorporated area other than those that are the responsibility of the FDOT (such as drainage areas along U.S. 1). Also housed within the Public Works Division is the Engineering Department and Central Services Department (vehicle maintenance). The division's main office is located on Stock Island, with branch locations in Marathon and Plantation Key. Because of the small size of the City of Key Colony Beach and the City of Layton, in terms of jurisdictional area as well as population, neither local government has a public works department.

Responsible Agency: This option does not lend itself to a responsible agency. All local governments would need to be responsible for stormwater within their own jurisdictional limits.

Implementation Mechanism: Because the City of Key West and Monroe County have particular sections within local government carrying out stormwater management activities, it appears that no official ordinance action would need to be taken to formally assign stormwater management responsibility. However, to formalize the assignment of stormwater management, the elected boards of the City of Key West and Monroe County could take an ordinance action formalizing the present arrangement. The City of Key Colony Beach and the City of Layton would continue to contract for services when necessary, or contract with the County to provide such services.

Implementation Requirements: According to the various Monroe County local government comprehensive plans, stormwater management ordinances will be enacted by 1993. Each local government should assess its capability for implementing its ordinance in terms of staff (includes number and expertise needs), equipment, space needs, and training requirements.

Initially, the City of Key West and Monroe County might be able to manage with their present resources because both departments already deal with stormwater management matters in terms of facility construction and maintenance, engineering, and planning perspectives. The City of Layton and the City of Key Colony Beach could continue to hire private contractors on an as-needed basis, or they might consider entering into an arrangement with Monroe County. If one or both of the cities decide to do so, they would need to enter into an interlocal agreement outlining both procedural and financial details.

5.0 MARINAS AND LIVE-ABOARDS

5.1 INTRODUCTION

A live-aboard is defined as "an individual(s) whose continual residence is a boat, not necessarily at a fixed location, for a period of time of more than two months" (Antonini *et al.* 1990). As described in the Phase I report, live-aboards can be found throughout the Florida Keys. Most are located in clusters in a few areas such as Card Sound, Largo Sound, Matecumbe Harbor, Marathon, and Key West. There is currently little regulation of live-aboards; what regulation there is comes from the Florida Marine Patrol (FMP) and the U.S. Coast Guard (USCG), but this has to do with seaworthiness and navigation more than wastewater discharge.

The live-aboard population in the Florida Keys has increased significantly in recent years. As discussed in the Phase I report, local water quality problems have been detected in some confined waters where live-aboards congregate, but there is no scientific evidence of widespread water quality degradation or adverse effects on Sanctuary resources from live-aboards.

Marina operations with the potential for polluting water or sediments include boat bottom scraping and painting, fueling operations, residual fuels and oils from engine repairs or bilge cleaning, and the use or disposal of resins and solvents associated with fiberglass construction or repair. As noted in the Phase I report, a small number of samples collected from paint scrapings and bottom sediments at marinas in the Florida Keys have indicated the presence of metal contamination. Available data are insufficient to quantify pollutant loadings or to assess the detrimental effects from bottom painting operations. There are no data documenting the detrimental effects from other marina operations — only anecdotal evidence such as visible sheens on waters near fueling operations.

Based on the existing data, six management options have been developed that would help to reduce pollution from marinas and live-aboards. Additional data concerning pollutant concentrations in water and sediments of marinas and live-aboard areas will be collected through the monitoring program described under Task 6. These data should indicate the severity and extent of water quality problems and whether there is a need for further pollution control measures.

- **Option B1 — Establish No-Discharge Zones**
  Designate no-discharge zones where vessels congregate and there is also a history of water quality violations.

- **Option B2 — Establish Mooring Fields**
  Establish mooring fields in places having significant concentrations of live-aboard vessels.

- **Option B3 — Increase Pump-Out Facilities and Usage**
  B3a — Increase the number and accessibility of pump-out facilities in the Florida Keys, including permanent land-based facilities and/or mobile pump-out vessels.
  B3b — Increase the number and accessibility of pump-out facilities in the Florida Keys, including permanent land-based facilities and/or mobile pump-out vessels. Require boaters to use pump-out facilities and develop an enforcement program to ensure that they use them.

- **Option B4 — Establish Containment Areas for Boat Maintenance**
  Establish paved and curbed containment areas for boat maintenance activities such as hull scraping and repainting, mechanical repairs, fueling, and lubrication. Create secondary containment, generally in the form of curbing or synthetic liners, for areas where significant quantities of hazardous or toxic materials are stored. Evaluate procedures to avoid or reduce fuel spillage during refueling operations.

- **Option B5 — Require Marina Operating Permit**
  Require all marinas in the Florida Keys to obtain a single operating permit from the FDER. This would simplify the existing permitting process and require older marinas to comply with new standards for BMPs, thereby reducing pollution.

- **Option B6 — Implement Water Quality Environmental Awareness Program**
  Formalize and expand the existing FMP District 9 environmental education program to heighten awareness of how human activities contribute to water quality problems.

The first three options apply to live-aboards and would attempt to reduce pollution by restricting areas where discharges may occur (Option B1), concentrating live-aboards in areas where wastewater treatment facilities can be provided (Option B2), or increasing the availability and usage of pump-out facilities (Options B3a and B3b). Options B4 and B5 pertain to marinas; Option B4 would reduce pollution by requiring containment areas for boat maintenance, whereas Option B5 could lead to pollution reduction through simplified permitting. Option B6 pertains to boaters and marinas in general, and would reduce pollution through education and increased environmental awareness.

5.2 MANAGEMENT OPTIONS

5.2.1 Option B1 — Establish No-Discharge Zones

Description: Under this option, EPA would designate no-discharge zones in accordance with provisions of marine sanitation devices where live-aboard vessels congregate and there is also a history of water quality violations.

Rationale: This option is applicable to specific hot spot areas rather than to the FKNMS as a whole. This management option could be used to reduce pollution in areas having severe water quality degradation due to concentrated boating activities.

Responsible Agency: EPA would be the responsible agency in designating the no-discharge zones, but the request would have to come from the state of Florida or a private petitioner. Normally the USCG would enforce such no-discharge zones, but in this case enforcement might be delegated to the state of Florida if the state so requests.

Implementation Mechanism: The legislative mechanism to implement this option is in place in terms of declaring no-discharge zones. Enforcement procedures and responsibilities need to be worked out if the option is to be effective; therefore, an MOU among the USCG, FMP, and the NOAA Sanctuary Office needs to be developed.

Implementation Requirements: The NOAA Sanctuary Office should undertake a study to evaluate the need for no-discharge zones in the Florida Keys. Need should be based on the ability to achieve or maintain the state-adopted water quality standards and/or a documented deterioration of habitat in the proposed zones. Other aspects that should be considered include water circulation, concentration of boats in the area, percent of boats with Type I or II marine sanitation devices, and impacts on fishing and swimming areas.

Implementation of this option will require adequate manpower, equipment (e.g., boats), and funding to achieve adequate enforcement. The number of additional enforcement officers is dependent upon the number of no-discharge zones established. This effort will require the cooperation and coordination among the USCG, FMP, and NOAA Sanctuary Office.

5.2.2 Option B2 — Establish Mooring Fields

Description: This option would establish designated mooring fields or anchorage areas in places having significant concentrations of live-aboard vessels. Used in conjunction with shore-based or mobile pump-out facilities, mooring fields could provide an effective means of controlling waste discharges from live-aboard boats.

Rationale: Mooring fields have been proposed to restrict non-marina live-aboards to certain anchorage areas in order to concentrate waste collection efforts and reduce the areal extent of potential pollution sources. With the ever-increasing number of live-aboards in the Florida Keys that do not use marinas, mooring fields would facilitate waste collection and allow the monitoring of impacts created by this use of the FKNMS.

Mooring fields can be used to organize the live-aboards in a manner that benefits the local governments as well as the live-aboard population. Implementing this concept would make inspection and enforcement functions easier for local government and could offer several advantages to the live-aboard boater as well. Currently, the live-aboard community receives few or no public services. By adopting this concept, government can more easily plan for and implement a package of public services that meets the needs of the live-aboard population. In addition to wastewater collection, this may include such amenities as land access for dinghies, garbage collection, shower/toilet facilities, and parking.

Responsible Agency: The FDER, Florida Department of Natural Resources (FDNR), and USCG would all have to assist in implementing this option by providing sufficient technical expertise and jointly processing required permits. Monroe County, the City of Key West, or the NOAA Sanctuary Office would have to take the lead in attempting to set up designated mooring fields at specific locations.

Implementation Mechanism: Legal designation of mooring fields requires a permit or land lease from the FDNR Bureau of Submerged Lands and Preserves. It also requires a USCG permit because it affects navigable waters. The FDER interacts with the FDNR in terms of making environmental inspections of selected sites and issuing resource evaluations and impact assessments to the FDNR.

Implementation Requirements: Implementing this option would require locating and permitting suitable sites, designing mooring fields, and acquiring and constructing the shore-based amenities mentioned above. Locations for mooring fields must have adequate depth and must be located where they will not impede navigation. Permanent moorings anchored to the bottom must be provided to prevent damage from boat anchors. There are also questions of liability and implied responsibility that need to be reviewed by the sponsoring entity before such a program is undertaken. The live-aboard community should be involved in the implementation of this option.

5.2.3 Option B3 — Enhance Pump-Out Facilities and Usage

This option would reduce pollution by increasing the availability and usage of pump-out facilities in the FKNMS. Two levels of the option are presented. The first (Option B3a) would simply increase the availability of pump-out facilities, on the theory that if more facilities were available, more people would use them. The second (Option B3b) would increase the facilities and require boaters to use them.

5.2.3.1 OPTION B3a — INCREASE PUMP-OUT FACILITIES

Description: This option would increase the number and accessibility of pump-out facilities in the Florida Keys, including permanent land-based facilities and/or mobile pump-out vessels.

Rationale: There are only eight pump-out facilities along the Florida Keys. Several are located in private marinas and are not available to the general public. If pump-out facilities were more numerous and accessible, presumably more people would use them.

Both permanent, land-based pump-out facilities and a mobile pump-out service should be considered. A mobile pump-out service would have two advantages:

- It would make pumping out easy for live-aboard boaters or any vessel with a marine sanitation device.
- It would establish a database that could help the FMP Environmental Crimes Unit, NOAA Sanctuary Officers, or some other law enforcement agency, to identify and prosecute violators.

Responsible Agency: Because most of the land area along the Florida Keys is within the unincorporated County, the responsible agency should be Monroe County, working in conjunction with the NOAA Sanctuary Office and the FDNR.

Implementation Mechanism: This option could be implemented entirely by Monroe County. The County could pass an ordinance requiring all marinas offering overnight docking to boats over a given length to have stationary or mobile equipment to pump the holding tanks of such vessels. The same option could be implemented at the state or even the federal level, but implementation at these levels would be legislatively more complex and would take substantially longer to put into practice.

No new legislation or legal authority is needed for the County to develop a mobile pump-out service. A prototype study could be conducted to determine how many live-aboard boaters in a given area would voluntarily subscribe to such a service. If the idea appeared to be economically viable, the County could advertise for suppliers of the service and sell franchises on a bid basis.

Implementation Requirements: The development and operation of pump-out facilities would be the responsibility of the individual marina owners. The operational costs could be recovered by user fees. These fees could also defray development costs. If the user fee approach is considered to be a desirable alternative, the County should incorporate protection against the setting of unreasonable user fees by marina owners. Another possible funding source to assist in the development of these facilities was recently enacted. In November 1992, the Congress enacted the Clean Vessel Act. This legislation has authorized funds for the development of pump-out facilities. Administrative responsibility of this program rests with the FWS.

To be effective, the pump-out facility should be easily accessed. Ultimate accessibility can be provided by a mobile pump-out cart with capability to traverse docks and pump from moored boats. A less convenient option would be to require all live-aboards to move their vessels to dockside pump-out facilities at specified intervals. Solid waste collection facilities should be provided in conjunction with all sanitary waste collection facilities.

To implement a mobile pump-out service, the County would have to provide some form of centralized collection and treatment for the sewage collected by the mobile pump-out vessels.

5.2.3.2 OPTION B3b — ENFORCE PUMP-OUT USE

Description: Under this option, an enforcement program would be developed to ensure that pump-out facilities are used. The FMP, Monroe County Sheriff's Department, and FKNMS officers would develop an enforcement program to ensure that all vessels with marine sanitation devices use available pump-out facilities. Prior to beginning such a program, more pump-out facilities would have to be made available (as in Option B3a) so that conscientious boaters would be able to comply with the law.

Rationale: Even where pump-out facilities exist, minimal use of the facilities occurs. Laws exist which allow the USCG to restrict discharges from marine sanitation devices, but a workable system of coordinated enforcement procedures has never been developed. There are several ways to approach this problem, but essentially all involve funding for additional law enforcement.

Responsible Agency: Considering this situation as a FKNMS-wide problem, the NOAA Sanctuary Office is the logical agency to take the responsibility for this issue. This office will need close coordination with the USCG, FMP, and "boating rights" representatives from the Florida Keys.

Implementation Mechanism: Developing the legal framework to implement this option would be relatively simple if the EPA's powers of delegating no-discharge zones were used. The state of Florida in conjunction with the NOAA Sanctuary Office could request that the entire FKNMS be declared a no-discharge zone. Enforcement, however, would still be a difficult task.

Implementation Requirements: For this option to be effective, a carefully thought-out enforcement strategy must be developed. This strategy development effort must include the boating public as well as the agencies that will ultimately be responsible for the law enforcement. One possible enforcement tool is to issue a large visible sticker to all boats anchored or passing through the FKNMS. Each time a vessel's holding tanks were pumped out, the sticker would be stamped with the date and time of pump-out. If the vessel had not had its holding tanks pumped out within a given length of time based on its size and carrying capacity, a citation could be issued. A variation of this option would be to set up a number of public or private mobile pump-out vessels throughout the Keys that could visit anchored vessels and pump the holding tanks onsite for a reasonable fee.

5.2.4 Option B4 — Establish Containment Areas for Boat Maintenance

Description: This option would involve establishing of containment areas wherever boat hulls are scraped and repainted, or mechanical repairs are made. Secondary containment, generally in the form of curbing or synthetic liners, would be constructed for areas where significant quantities of hazardous or toxic materials are stored. Procedures to avoid or reduce fuel spillage during refueling operations would be evaluated.

Rationale: There are more than 180 marinas in the Florida Keys and the services provided by each vary widely. Some only sell food provisions, boating supplies, and/or contain a restaurant; however, others offer boat maintenance services such as scraping and repainting of boat hulls, mechanical repairs, as well as fueling services. Independently, these activities may not have a significant impact; however, the cumulative effect, especially where there are a number of marinas in close proximity, can definitely affect water quality unless special precautions have been taken to eliminate such pollutants from reaching coastal waters.

Little effort is now directed toward containing and collecting wastes associated with bottom scraping and painting or mechanical repairs. Providing a curbed area would contain paint chips or dust and other wastes so that they could be removed and disposed of properly.

Responsible Agency: The responsible agency should be EPA.

Implementation Mechanism: The EPA NPDES stormwater discharge rule is the mechanism to implement this option. In 1990, EPA enacted rules to control stormwater discharges from a variety of uses. The rule is known as the NPDES Permit Application Regulations for Stormwater Discharges. Marinas that are involved in boat maintenance activities (including vessel rehabilitation, mechanical repairs, painting, fueling, and lubrication) or equipment cleaning operations are considered industrial activities according to 40 CFR 122.26. Therefore, all marinas involved in such activities must apply for an NPDES stormwater permit. These permits require applicants to address how they plan to eliminate pollutants such as toxics from the stormwater runoff generated as a result of their marina activities. The applicants have to identify the BMPs they intend to use. One alternative is to construct containment areas, and restrict all marine repair and boat hull reconstruction to the containment areas.

Implementation Requirements: Outdoor containment areas would require drains, sumps, and pollution control devices (grease traps) and should be swept at regular intervals to minimize pollutants in runoff discharge. Detention or retention between pollution control devices and the outlet to surface water or groundwater (borehole) would provide a high level of treatment for these areas. Secondary containment, generally in the form of curbing or synthetic liners, would need to be constructed for areas where significant quantities of hazardous or toxic materials are stored. Outdoor areas would require valved drains that are normally closed, but could be opened to remove stormwater in the absence of any spills. Indoor areas would not have drains or outlets, but should provide means of absorbing or collecting spills. The County should work with marina operators to ensure that there are means available to them, at a reasonable cost, to have their hazardous waste by-products collected and transported to an authorized hazardous waste disposal facility.

5.2.5 Option B5 — Require Marina Operating Permit

Description: All marinas in the Florida Keys would be required to have an operating permit.

Rationale: The coastal waters in the Florida Keys are environmentally sensitive to impacts from marina activities such as uncontrolled wastewater discharges from vessels, scraping and repainting of boat hulls, and gas and oil spills resulting from fueling operations. Marina operations are already subjected to numerous permits and permit review processes. One overall FDER operating permit would simplify matters for the marina operator, allow the implementation of BMPs, and help reduce pollutant loadings reaching adjacent coastal waters.

Responsible Agency: The responsible agency should be the FDER.

Implementation Mechanism: New marinas would be permitted under the new standards for pump-out facilities, secondary containment, separate boat maintenance work areas with catchment basins, and other BMPs. Older marinas could be forced to update or come into compliance when their FDNR submerged lands leases come up for renewal.

Implementation Requirements: The FDER, FDNR, and EPA should consider implementing a joint permitting process. The FDER needs to work with EPA to make Florida a delegated state regarding NPDES stormwater discharge regulatory authority. This would avoid duplication in the permitting process.

New permitting legislation and accompanying rules would be necessary to implement this option. Once such new legislative authority is established, additional enforcement/compliance monitoring personnel must be hired or the existing staff priorities redirected. Additional funding would be required.

5.2.6 Option B6 — Implement Water Quality Environmental Awareness Program

Description: This option would formalize the FMP District 9 environmental education program and incorporate an element that heightens the environmental awareness of how human activities adversely affect water quality in the Florida Keys.

Rationale: Practices such as discarding fish carcasses in the water, tossing litter and trash overboard, and operating water craft in shallow areas have contributed to the polluting of Florida Keys waters. The FMP already has an environmental awareness program that has produced significant results in the past. If this program were expanded, additional reductions in pollution could be anticipated.

Responsible Agency: FDNR would be the responsible agency for expanding the existing program operated by the FMP.

Implementation Mechanism: Nothing is required to implement this option other than additional funding allowing the FMP to improve and increase the range of its existing program.

Implementation Requirements: This option is tied directly to an existing water quality and environmental awareness program directed at the general boating public. All that is required to expand the program is additional funding and management directive from the FDNR. All water quality and public awareness programs should be coordinated with the efforts of the NOAA Sanctuary Office.

6.0 LANDFILLS

6.1 INTRODUCTION

According to the Phase I report, there is only one active landfill operation in the FKNMS, at Stock Island (serving the City of Key West). This facility will cease its operations by November 1993. Three other landfills, at Cudjoe Key, Long Key, and Key Largo, were active in 1990 but have ceased accepting waste. As of December 1990, Monroe County contracted Waste Management, Inc. to haul solid waste out of the County, and the closed landfills serve as subdistrict transfer locations. A seven-acre, synthetically lined expansion of the Cudjoe Key landfill, completed in December 1990, is being kept in reserve for emergency or future use.

In addition to these four recently active landfills, FDER files indicate that there are four older landfills that have been closed for some time. These are the old Key Largo, Saddlebunch Key, Fleming Key, and Boot Key landfills. Four U.S. Navy landfills in the Keys are being assessed and, if necessary, will be remediated under the Navy's Installation Restoration Program. Also, according to knowledgeable state and local government personnel, there are a number of smaller abandoned landfills and casual dumping sites, many on private property, within the Florida Keys.

All landfill sites in the Florida Keys (with the exception of the Cudjoe Key expansion) were developed prior to current regulations requiring bottom liners and leachate collection. At many sites, filling with solid waste probably occurred below the water table in the early stages. Consistent with common practice at the time, there was probably little or no control over materials deposited in these landfills. These conditions indicate a significant potential for contamination of groundwater and surface waters from these inactive landfills.

Although the potential exists for problems, monitoring data do not indicate leaching from landfills or water quality degradation in areas adjacent to landfills. Therefore, no corrective actions are proposed. However, two investigative management options are proposed to ensure that landfills are not causing water quality problems:

- **Option L1 — Conduct Historical Landfill Search**
  Conduct a comprehensive search for abandoned landfills and dumps. Evaluate each site to determine if they contain hazardous materials or are causing environmental problems. If problems are discovered, evaluate and implement appropriate remedial actions such as boring or mining, upgrading closure, collecting and treating leachate, constructing slurry walls, or excavating and hauling landfill contents.

- **Option L2 — Intensify Landfill Monitoring**
  Intensify existing monitoring programs around landfills to ensure that no leaching is occurring into marine waters. Identify and monitor old landfills that were never permitted and therefore have no closure plans or closure permits. If problems are discovered, evaluate and implement appropriate remedial actions such as boring or mining, upgrading closure, collecting and treating leachate, constructing slurry walls, or excavating and hauling landfill contents.

These two options are described below in Section 6.2. Based on the findings of these investigations, additional monitoring and/or options for remedial action could be designed on a case-by-case basis. Section 6.3 presents an overview of engineering methods that could be used if problems are discovered.

6.2 MANAGEMENT OPTIONS

6.2.1 Option L1 — Conduct Historical Landfill Search

Description: This option would involve conducting a comprehensive search for abandoned landfills and dumps. Each site would be evaluated to determine if it contains hazardous materials or is causing environmental problems. If problems were discovered, appropriate remedial actions would be evaluated and implemented.

Rationale: According to knowledgeable state and local government personnel, there are a number of abandoned landfills and dumps, many on private property, within the Florida Keys. A comprehensive program needs to be set up to locate, map, and evaluate these historic casual dump sites to determine if they contain hazardous materials or are causing environmental problems.

Responsible Agency: The responsible agency should be Monroe County in conjunction with the FDER.

Implementation Mechanism: Monroe County already has a fairly complete inventory of historic landfill sites within the Florida Keys. The old sites where significant amounts of casual dumping have taken place are less well known. This option would be implemented by searching historical data and conducting interviews with long-time residents to locate and map the potential problem sites. A one-time survey of all sites would then be made to see if they are actually causing environmental problems. For those sites where problems are detected, or those that have a high potential for causing problems in the future, long-term monitoring programs could be designed. If necessary, remedial actions could be taken.

Implementation Requirements: No new statutes or legislative authority are required for this option. All that is required is either a reassignment of agency management priorities (in the form of staff time dedicated to this issue) or additional funding to hire new staff for this purpose.

6.2.2 Option L2 — Intensify Landfill Monitoring

Description: This option would involve intensifying the existing monitoring programs around landfills to ensure that no leaching is occurring into marine waters. Old landfills that were never permitted and therefore have no closure plans or closure permits would be identified and monitored, as appropriate. If problems were discovered, appropriate remedial actions would be evaluated and implemented.

Rationale: Monitoring data from existing landfills in the Florida Keys do not indicate a leaching problem. However, the number of monitoring locations is small and the number of locations should be increased to ensure that no leaching is occurring around these landfills.

Responsible Agency: The responsible agencies should be the FDER and Monroe County.

Implementation Mechanism: Several activities need to take place to successfully and cost-effectively implement this option. First, all closure permits for the existing landfills need to be reviewed to determine if their proposed monitoring plans are adequate. Because almost all landfill areas in the Florida Keys are adjacent to marine waters, monitoring programs should consider the study of adjacent marine waters and habitats for signs of contamination. Closure permits should include an adequate number of paired monitoring wells with one drilled to shallow depths and the other into deeper strata. A one-time, intensive baseline program should be conducted immediately after closing a landfill. Then, depending on those results, a long-term, low-intensity monitoring plan should be put into place. The need for additional manpower is unknown until an assessment of the adequacy of the closure permits is completed.

Many of the old landfills in the Florida Keys were never permitted. Consequently, there are no closure plans or closure permits. These landfills should be identified and monitored as well.

Implementation Requirements: No new legislative authority is required to implement this option. However, if this option is to be implemented, it will require a shift in agency staff time and management priorities or additional funding to hire more staff.

6.3 REMEDIAL ENGINEERING METHODS

Engineering methods for controlling pollutant migration from landfills are most effective when incorporated into landfill design. Methods such as use of impervious bottom liners, leachate collection systems, leachate treatment and disposal systems, and control of stormwater runoff from active and inactive areas are effective in controlling pollution from landfills.

With inactive or closed landfills, the pollution control objectives are similar to those for new landfills, but the objectives are much more difficult to accomplish. Containment or collection of leachate at landfills without a bottom liner requires construction of slurry walls, collection trenches, wells (vertical or horizontal), or a combination of these facilities. Leachate treatment is generally feasible, but the volume of groundwater treated is generally greater than if it was collected above an impervious liner. Proper closure, including impervious top liner, vegetative cover, gas venting, and stormwater control can significantly reduce the pollution potential of landfills that are not designed to current standards. If proper closure and leachate containment or withdrawal/treatment are not sufficient to reduce pollutant loadings from landfills, excavation of the site may be necessary.

Engineering methods for controlling the migration of pollutants from existing landfill sites are described below. These methods may be used in future engineering options addressing pollution from landfills. They are included here for discussion purposes only, because existing landfill monitoring data have not indicated a need for remedial action.

6.3.1 Boring or Mining

Landfill boring and mining are investigative procedures to determine the types of wastes or materials contained in the fill. Use of either method is usually considered only when landfill monitoring data indicate that a significant problems exists.

Landfill boring is analogous to soil boring investigations; samples of the fill can be collected and analyzed at discrete depth intervals. Leachate entering the borehole can also be analyzed. Boring is of limited value in landfill areas containing numerous large objects such as automobiles.

Landfill mining is a more intensive investigative procedure. Portions of the landfill are excavated and contents of the fill are analyzed. A qualitative assessment of materials contained in the landfill is obtained, as well as soil and leachate samples.

Landfill boring and mining can be useful for determining corrective methods that may be appropriate for a particular landfill site. Either method should be used with caution because disturbing the landfill can, in some cases, accelerate leachate generation by stirring up pollutants or releasing liquids from previously confined areas.

6.3.2 Upgrading Landfill Closure

Closure of the older inactive landfill sites in the Florida Keys generally consisted of applying whatever local cover materials were available. Little consideration was given to perviousness of the cover, grassing, or overall drainage at the sites. Exceptions to this are the recently closed landfill sites at Stock Island, Long Key, Cudjoe Key and Key Largo. Closure plans for these sites are nearly complete and all will include top liners and runoff control.

With older landfill sites, basic closure can usually be accomplished with minimal difficulty. This would include regrading the site (which may require fill from off-site), installing an impervious top liner, gas venting, and runoff control. If basic closure does not reduce leachate migration to acceptable levels, additional engineering methods may be necessary.

6.3.3 Leachate Collection and Treatment

Leachate from the landfill can be captured through a subsurface collection system. A collection system containing a series of horizontal or vertical perforated pipes designed to intercept leachate flow is installed around the landfill. Leachate is then collected and pumped to a treatment facility, which reduces the contaminants to acceptable levels. Treatment methods would depend on the specific types of contaminants to be removed.

6.3.4 Construction of Slurry Walls

Another method of containing leachate movement is by constructing slurry walls. Slurry walls are formed by systematic pressure grouting. The grout is injected into a series of boreholes and the concrete forms a wall or barrier in place. The use of slurry walls is a difficult and expensive, but effective option. Their use might be limited because of the large areas and volumes of the landfills.

6.3.5 Excavation

Another possible remedial option is to relocate a landfill to a less environmentally sensitive area. The waste and fill would be excavated and hauled offsite. With this method, it is possible to recycle and reclaim part of the waste either before or after relocation.

7.0 HAZARDOUS MATERIALS STORAGE, TRANSPORT, AND SPILLS

7.1 INTRODUCTION

The Florida Keys are surrounded by environmentally sensitive marine resources. The handling, storing and managing of hazardous materials in this type of environment poses a heightened level of risk. As described in the Phase I report, small vessel spills, small facility spills, tanker truck spills, and leaching from underground storage tanks do occur in the FKNMS. Because of the island structure of the Florida Keys, even small spills can potentially have a significant impact on groundwater and surface water contamination. In addition, there is a risk of catastrophic oil spills from tankers passing through the Straits of Florida.

The present management arrangement appears to be functioning adequately; however, based on the interviews conducted during the Phase II effort, there are some actions that could be taken to further reduce the potential for accidental spills. These management options would enhance spill response efficiency, improve data documentation, and heighten enforcement effectiveness.

- **Option H1 — Continue Response and Preparedness Planning**
  Continue current measures to improve response and preparedness planning. Expand the use of interactive computer modeling as a decision-making tool for response scenarios (e.g., dispersant use on oil spills). Bring more oil spill containment equipment into staging areas in or near the Sanctuary.

- **Option H2 — Improve Hazardous Materials Database**
  Improve recordkeeping and location mapping of all industries using or stockpiling hazardous materials in the Florida Keys. Enter locations in the Monroe County GIS and tie into the Florida Emergency Response Program in the Keys.

- **Option H3 — Improve Small Spill Reporting**
  Update and standardize criteria for documenting small spills. Establish a method of conveniently tracking small spills within the Sanctuary.

- **Option H4 — Speed Up Storage Tank Inspection**
  Increase funding and personnel for the FDER Marathon District Branch Office and the Monroe County Public Health Unit to speed up inspecting, enforcing, and retrofitting of surface and underground storage tanks.

- **Option H5 — Change Environmental Crimes from Misdemeanors and Felonies to Civil Offenses**
  Change the environmental crimes category associated with small spills from a misdemeanor or felony to a civil offense, thereby removing the need to prove criminal intent.

- **Option H6 — Increase Funding for Environmental Crimes Program**
  Increase the funding for and the status of the Environmental Crimes Program within both the Monroe County Sheriff's Office and the FMP.

7.2 MANAGEMENT OPTIONS

7.2.1 Option H1 — Continue Response and Preparedness Planning

Description: This option would continue current measures to improve response and preparedness planning; expand the use of interactive computer modeling as a decision-making tool for response scenarios (e.g., dispersant use on oil spills); and bring more oil spill containment equipment into staging areas in or near the Sanctuary.

Rationale: Some improvements could be made in spill response planning and preparedness with respect to (1) the predetermined use of dispersants under specific conditions and (2) equipment in place to handle an oil spill. Interactive modeling is an effective technique for developing and testing the decision-making process. Because the FKNMS is an environmentally sensitive area with unique marine resources, techniques need to be implemented to increase spill preparedness and reduce response time should a spill occur.

Responsible Agency: The responsible agency would be the USCG in coordination with the South Florida Environmental Task Force and the Florida Emergency Response Program.

Implementation Mechanism: The interagency coordination mechanism to implement this option is already in place and appears to be functioning well. Steps are already in progress to develop area-specific response plans for the FKNMS. All that is necessary to implement this option are selected policy decisions on the part of the USCG and representatives of the Florida Emergency Response Program.

Implementation Requirements: The USCG must designate specific sites within the Florida Keys as storage and staging areas for spill response equipment. A USCG Marine Safety Office is also needed within the Keys, rather than in Miami as is the present situation. A Marine Safety Office once existed in the Keys; however, it recently was closed because of budgetary cutbacks.

7.2.2 Option H2 — Improve Hazardous Materials Database

Description: This option would improve recordkeeping and location mapping of all industries using or stockpiling hazardous materials in the Florida Keys. Locations would be entered in the Monroe County GIS and tied into the Florida Emergency Response Program in the Keys.

Rationale: The 1983 Water Quality Assurance Act required each county to conduct a local hazardous waste assessment. The assessment provided an inventory of information on the quantity of hazardous waste generated by both small and large quantity generators, and the management practices used by these generators. This is an ongoing activity and information is updated annually. However, information regarding hazardous materials is limited and needs to be expanded. Expansion of the database could help to answer questions about temporal or spatial considerations, or compliance and enforcement efforts. Improvements in record keeping, inspections, and mapping of all industries using or storing hazardous materials within the Florida Keys is needed. Existing Monroe County programs need to be expanded and hazardous material locations entered on the Monroe County (and possibly FDNR) GIS databases covering the Florida Keys and FKNMS.

Responsible Agency: The County through its Planning Department should have the responsibility; however, its efforts must be coordinated closely with the FDER, FDHRS, and Monroe County Health Department.

Implementation Mechanism: Monroe County currently maintains lists of most businesses generating or using hazardous materials in normal operations. These lists need to be reviewed and updated with the exact addresses and geographic coordinates assigned so that they may be entered into the County's GIS and tied into the Florida Emergency Response Program in the Florida Keys. There is little additional expense associated with implementing this option. Monroe County is already in the process of establishing a GIS, and the additional data can be entered along with the other databases already planned. Updating and obtaining exact locations of businesses generating or using hazardous materials can be done in conjunction with the normal licensing and inspection services performed by the Monroe County Public Health Unit.

Implementation Requirements: Depending upon the time frame desired to implement this option, additional staff at the County level may or may not be required. No additional legislative authority is necessary. Because Monroe County is already establishing its GIS, no additional major capital outlay for equipment is required.

7.2.3 Option H3 — Improve Small Spill Reporting

Description: This option would focus more attention on the problem of small spills (e.g., petroleum products). Criteria for documenting small spills within the Sanctuary would be updated and standardized.

Rationale: Small spills of petroleum products occur frequently in the Florida Keys and may be a significant factor in degrading habitat quality within confined waters. More attention needs to be focused on this problem, and better methods for documenting such small spills need to be developed to better understand the scope and severity of the problem. While some data is collected regarding spills, many experts during Phase I testified that there is a need for substantial improvement in spill documentation. Establishing a comprehensive database could help to answer questions about temporal and spatial considerations, severity, major spill constituents, water quality effects, and compliance and enforcement efforts. This would enable those responsible for responding to such events to have a better understanding and increase the speed and effectiveness of the cleanup effort.

Responsible Agency: The responsible agency would be the FDNR through its Office of Coastal Protection.

Implementation Mechanism: The FDNR is already moving toward adopting this option. The FDNR has now established the Office of Coastal Protection (moving this program from the FMP) and has developed new and more effective reporting forms for use in the field. The FDNR, primarily through its Marine Patrol District Commanders, needs to stress the importance of gaining accurate information of all reported small spills to field officers.

Implementation Requirements: No new legislation or policy is required to implement this option. The importance of completely and accurately filling out the new Pollution Discharge Reports and investigating all small spills to the maximum extent possible must be stressed. This is essentially the responsibility of the Commanders of the various FMP districts, but a coordinated program between the Office of Coastal Protection and the FMP environmental crimes offices explaining the importance of the small spill reporting program would be the best way to achieve maximum cooperation at the patrolling officer level.

If data collected by the small spill reporting program are to be used effectively, additional computerization of the database must be undertaken by the Office of Coastal Protection. Information to identify hot spots of possible petroleum pollution needs to be available on a database management system. Such data would also make it possible to identify chronic offenders, such as marinas where a high number of small spills occur, for corrective action.

7.2.4 Option H4 — Speed Up Storage Tank Inspection

Description: This option would speed up existing efforts to inspect and retrofit surface and underground fuel storage tanks and to clean up contaminated areas. It would increase funding and the number of personnel available to the FDER Marathon District Branch Office and Monroe County Public Health Unit to speed up inspection, enforcement, and retrofitting.

Rationale: This program currently exists and is functioning well. With increased funding, the overall objective of inspecting and retrofitting fuel storage tanks throughout the Keys could be accomplished more quickly.

Responsible Agency: The responsible agency should be the FDER. Inspection and compliance is subcontracted to the FDHRS through the Monroe County Public Health Unit.

Implementation Mechanism: This program already exists and appears to be functioning well. Interagency coordination is reported to be good. This option only requires additional funding for implementation.

Implementation Requirements: The key to accelerating the inspection program is funding. With increased funding, the existing inspection staff could be augmented, thus increasing the rate of storage tank inspections. The benefit of implementing this option is that the inspection, retrofitting, and cleanup of contaminated sites could be accomplished more rapidly.

7.2.5 Option H5 — Change Environmental Crimes from Misdemeanors and Felonies to Civil Offenses

Description: This option would change the environmental crimes category associated with small spills from a misdemeanor or felony crime to a civil offense, thereby removing the need to prove criminal intent.

Rationale: Currently, it is difficult to prove criminal intent for actions such as accidently discharging fuel or pumping out a shipboard sewage holding tank. Therefore, in practice, law enforcement officers focus more attention on other crimes that require a less rigorous burden of proof. By shifting environmental crimes from being a misdemeanor or felony crime to a civil offense, an increased level of enforcement of environmental laws could be expected. This conclusion was supported by the law enforcement community in the Florida Keys. Civil penalties could take the form of major fines for such accidents without considering the intent of the individual involved. Major fines would encourage chronic offenders to be more careful.

Before revising any Florida Statutes specific to environmental crimes, careful consideration needs to be taken before changing it from a misdemeanor or felony crime to a civil crime. There needs to be avenues to prosecute serious repeat offenders under criminal penalty. In addition, fines collected for environmental crimes should be redirected to where the violation occurred and used to restore the resource that was damaged.

Responsible Agency: The responsible agency should be the FDNR through the FMP.

Implementation Mechanism: This option would require changes in the Florida Statutes and the Florida Administrative Code.

Implementation Requirements: Implementation of this option would require changes in Florida legislation. Mr. Billy Causey (NOAA FKNMS, personal communication, 1992) has pointed out that FKNMS public laws involving environmental crimes are already civil rather than felony statutes. Therefore, cross-deputization of FKNMS officers and Florida law enforcement officers may be a simpler way of achieving the same goal. However, there is no guarantee that fines assessed under Federal Statutes would be returned to Florida or to the FKNMS itself. Under current policy, fines assessed under federal statutes are not returned to the specific state where the offense took place. The question of who receives fines assessed for environmental crimes in Florida and the FKNMS needs to be resolved if the cross-deputization route is chosen for implementing this option.

7.2.6 Option H6 — Increase Funding for Environmental Crimes Program

Description: This option would seek to reduce pollution by enhancing the existing Environmental Crimes Program. Through a process of increased funding and public education, environmental crimes enforcement efforts would be made more visible in the Sanctuary.

Rationale: Within Monroe County there has been an effort to heighten the awareness and effectiveness of enforcing environmental laws and regulations. This new emphasis is reflected by the creation of an interagency Environmental Crimes Task Force (representation consists of all law enforcement organizations in the Florida Keys), and the creation of a specialized environmental section within the FMP Marathon District office. These programs could be expanded through NOAA funding. In addition, the status of environmental crimes as a law enforcement priority within the Florida Keys should continue to rise in importance with both officers and the general public.

Responsible Agency: The FDNR and Monroe County, as the agencies responsible for the FMP and Monroe County Sheriff's Department, would take the responsibility in implementing this option. Environmental crime is such a key area of law enforcement within the FKNMS that NOAA should aid in implementing this option through "pass-through" funding and any other means available.

Implementation Mechanism: The Monroe County Sheriff's Department Environmental Crimes Task Force and the FMP District 9 Environmental Crimes Program are working well in coordinating efforts with other agencies responsible for enforcing environmental law within the Florida Keys (U.S. Fish and Wildlife Service [FWS], FDER, FDHRS, etc.). Through a process of public education, increased funding, and increased visibility, environmental crimes enforcement efforts need to become more visible in the FKNMS.

Implementation Requirements: The Monroe County Sheriffs's Department, FMP, and NOAA need to coordinate efforts and work out details for heightening the awareness of the importance of preventing environmental crimes both among individual law enforcement officers and among the general public. Enforcement procedures and funding for presenting environmental crimes should be divided among local, state, and federal agents to achieve maximum use of existing infrastructure without duplication of effort.

8.0 MOSQUITO CONTROL PROGRAM

8.1 INTRODUCTION

As described in the Phase I report, ground spraying by truck is the present method of choice for controlling the adult mosquito population in Monroe County. Aerial spraying is used only when the mosquito population reaches a specific threshold as determined by mosquito landing counts per minute at given test sites within the County. The Mosquito Control Program is administered by the Monroe County Mosquito Control District.

There are no data indicating that the Mosquito Control Program is causing water quality problems in the FKNMS. However, there is little existing information on environmental concentrations and/or effects of pesticides in the FKNMS. Additional data concerning pesticide concentrations in sediments and biological tissue throughout the FKNMS will be collected through the Water Quality Monitoring Program (Task 6). In addition, the Research Program (Task 7) includes proposed research on biological effects of water quality parameters, including pesticides. These monitoring and research efforts should show whether mosquito spraying is affecting water quality or biological resources in the FKNMS.

Based on the considerations discussed above, options for major changes to the Mosquito Control Program are not appropriate at this time. Additional data from the monitoring and research programs will help to determine whether major changes are warranted. Two mutually exclusive management options are presented below — one to continue the existing program with refinements, the other to temporarily ban aerial spraying while pesticide effects are studied:

- **Option M1a — Reduce Aerial Spraying Over Marine Areas**
  Refine the aerial spraying program to further reduce aerial spraying over marine areas. This includes a review of threshold levels used to initiate aerial spraying, development of a more refined plan for flight lines, and use of improved equipment. Further, as is done in nearly all Florida counties, eliminate thermal fog for aerial spraying and replace it with one known as ultra low volume (ULV). Reconsider the use of mosquito larvicides in breeding areas, including those in currently restricted areas, to reduce the need for aerial spraying of adult mosquito populations.

- **Option M1b — Temporarily Ban Aerial Spraying**
  Ban all aerial spraying of mosquito adulticides for a 2-year period (with exceptions in the event of a health emergency) to collect and review data on both mosquito populations and pesticides appropriate for use in the Sanctuary and around sensitive terrestrial arthropod and gastropod populations. Modify the Mosquito Control Program on the basis of research findings as necessary.

8.2 MANAGEMENT OPTIONS

8.2.1 Option M1a — Reduce Aerial Spraying over Marine Areas

Description: The Monroe County Mosquito Control Program would be refined to minimize spraying of marine areas. This could include switching from thermal fog to ULV, reviewing (and possibly raising) threshold levels used to initiate aerial spraying, and purchasing equipment to give pilots better navigational control and faster response time in shut-off mechanisms for adulticide release. In addition, all agencies involved in mosquito control would reconsider using ground spraying of mosquito larvicides in breeding areas, even those on state and federal lands.

Rationale: Although the Monroe County Mosquito Control District attempts to avoid marine areas when aerially spraying, it is believed that with a more refined plan for flight lines and use of improved equipment, the amount of spray released over water could be reduced. The agency could also reduce aerial spraying over marine areas by reviewing the statutory threshold for initiating aerial spraying. If a change would be warranted, legislation would need to be enacted to modify the threshold. Presently, Monroe County is one of the only counties in Florida still aerial spraying utilizing the thermal fog technique. Most counties now employ the ULV technique. By switching techniques, the fog oil and diesel fuel that is presently mixed with the Dibrom would be completely eliminated, although the amount of insecticide will remain the same. Dr. John Mulrennen of the Florida Department of Agriculture and Entomology indicated that Dibrom by itself decomposes rather quickly. However, when combined with diesel fuel and fog oil, the insecticide remains in the environment longer. Thus the benefit would be two-fold: less toxics would enter the coastal waters and the insecticide would decompose more rapidly. Because Dibrom is clear, unlike the thermal fog which leaves a cloud, a training program would be needed to allow the pilots working for the District to work with pilots experienced in ULV applications.

Responsible Agency: The responsible agency for refining the aerial spraying program should be Monroe County through the Mosquito Control District. For a reconsideration of larvicide use, the FDCA should be the responsible agency to coordinate affected agencies. The Florida Department of Agriculture Bureau of Entomology and Pest Control should organize and present data on available larvicides and the desirability of using larvicides in state and federal lands currently off-limits to mosquito control. State agencies that will need to be involved in this decision include the Monroe County Mosquito Control Program, Florida Department of Parks, and Bureau of State Lands. An additional group that should be represented at such discussions is the Citizens of Monroe County.

Implementation Mechanism: The implementation mechanism for refining the aerial spraying program is policy review and planning by the Monroe County Mosquito Control District. For a reconsideration of larvicide use, one key agency needs to organize a meeting to discuss this issue. The FDCA is recommended because of the overview-type function it serves in coordinating various state agencies responsible for the comprehensive planning process. The FDCA has functioned as an interagency coordinating group on Florida Keys issues in the past. It is mandatory that the Florida Coordinating Council on Mosquito Control be involved in this effort because the group has the greatest amount of technical expertise with mosquito control matters.

Implementation Requirements: Following a review by the Mosquito Control District, some additional equipment may need to be purchased to give pilots better navigational control when on a designated flight line, and fast response time in shut-off mechanisms for adulticide release.

8.2.2 Option M1b — Temporarily Ban Aerial Spraying

Description: Aerial spraying of mosquito adulticides would be banned for a 2-year period (with exceptions in the event of a health emergency) in order to collect and review data on both mosquito populations and on pesticides appropriate for use within the FKNMS and around sensitive terrestrial arthropod and gastropod populations. The Mosquito Control Program would be modified as necessary on the basis of research findings.

Rationale: There are a number of pesticide-sensitive arthropod and gastropod species living in the Florida Keys. Aerial spraying of mosquito adulticides would be stopped for 2 years to review the possible adverse effects that pesticides may have on these populations. This moratorium on aerial spraying may also be used to review other possible control strategies in areas currently off-limits to mosquito control.

Responsible Agency: The FDER should take the responsibility in requesting the 2-year ban. The Florida Department of Agriculture Bureau of Entomology and Pest Control should coordinate pesticide review and evaluation with the FDER, while the FDCA and Monroe County Mosquito Control District should work together to evaluate alternative methods of mosquito control.

Implementation Mechanism: The proposed ban would have to be requested by the FDER and approved by the Bureau of Entomology and Pest Control as well as the Monroe County Mosquito Control District. The FDHRS, through the Monroe County Public Health Unit, would have the authority to declare a health emergency and request the Mosquito Control District to begin aerial spraying again.

Implementation Requirements: The purpose of this proposed 2-year ban or moratorium on aerial spraying is to evaluate possibly threatened species populations and to conduct research in more environmentally sound methods of mosquito control in the Florida Keys. If this ban is to be beneficial, specific research projects addressing the stated problems need to be designed and funded as part of the Research Program (Task 7).

9.0 FLORIDA BAY/EXTERNAL INFLUENCES

The Phase I report indicates that there are potentially significant external influences on water quality in the Sanctuary. Potentially significant influences in terms of advection (water transport) include Florida Bay, Biscayne Bay, and the Florida Current. In addition, atmospheric loadings could be a substantial contributor to the nutrient budget. These external influences require further study, and are therefore included in the Research Program described under Task 7. However, the need for action to deal with water delivery problems in Florida Bay has been strongly stressed by workshop participants and other scientists during the development of the Water Quality Protection Program. Therefore, a management option for working to restore freshwater flow to Florida Bay is included here. In addition, Task 7 includes proposed research to further document the influence of Florida Bay on water quality and biological resources in the Sanctuary. This research should supply additional scientific evidence to support the need for action.

- **Option E1 — Restore Freshwater Flow to Florida Bay**
  The Steering Committee for the Water Quality Protection Program should take a leading role in restoring historical freshwater flow to Florida Bay. In addition, Sanctuary representatives should work with appropriate federal, state, and local agencies to ensure that restoration plans and surface water improvement and management plans for South Florida and the Everglades are compatible with efforts to maintain water quality within the Sanctuary.

Description: Under this option, the Steering Committee for the Water Quality Protection Program would take a leading role in water management issues affecting Florida Bay. The Steering Committee includes high-level representatives of all relevant agencies dealing with these water management issues. In addition, the FKNMS Advisory Council would state clearly its concerns over the issue of freshwater allocations to Florida Bay to the Governor and Cabinet of the state of Florida as well as state and federal agencies. Both short- and long-term solutions would be pursued at high levels of management in both state and federal agencies.

Also under this option, Sanctuary representatives would participate in the review and revision of restoration plans and water management plans for Florida Bay and adjacent areas to ensure that these proposals and/or actions will enhance and complement water quality improvement efforts undertaken in the Sanctuary. These plans include, but are not limited to, the Shark River Slough GDM, C-111 basin, Taylor Slough Restoration, West Dade Wellfield, U.S. 1 widening, National Park Service Everglades Restoration Plan, Lower East Coast Water Supply Plan, and Everglades Surface Water Management and Improvement Plan.

Rationale: Severe water quality and ecological problems have developed in Florida Bay in recent years. Problems include a massive seagrass die-off, phytoplankton blooms, sponge die-offs, mangrove die-backs, and all of the potential cascading ecological effects of these phenomena. Since 1987, much of Florida Bay has been affected by a massive, unprecedented seagrass die-off that has left tens of thousands of acres of denuded sediments. Through the resulting sediment resuspension and nutrient release, the seagrass die-off may be the cause of massive phytoplankton blooms that have affected the Bay during recent years. Sponge die-offs caused by phytoplankton blooms may have serious impacts on juvenile spiny lobsters, which reside by day under sponges for protection from predation.

Many experts believe that recent ecological problems in Florida Bay are the result of long-term reduction in freshwater flow from the Everglades. The mechanism has not been documented, but high salinities *per se* and a long-term change from an estuarine to a marine system may be contributing factors.

These problems in Florida Bay must be viewed as a potential threat to water quality and resources in the Sanctuary. Water quality and natural resources in Florida Bay are tightly linked to those of the Sanctuary. The Florida Institute of Oceanography has documented boluses or filaments of Florida Bay water, identified by slightly elevated temperature and salinity, moving across Hawk Channel onto the reef tract. The indications of these filaments are sporadic, and there does not appear to be a regular stream of Florida Bay water across Hawk Channel. According to coral expert Dr. James Porter, this water may be contributing to coral declines on the reef tract, but the degree of stress is unknown at this time.

Responsible Agency: The responsible agencies will be EPA and FDER, which administer the Water Quality Protection Program. NOAA will have a primary role because of its overall responsibility for managing the Sanctuary. All other agencies represented on the Steering Committee will have a primary role. These are the National Park Service, FWS, U.S. Army Corps of Engineers (USACE), FDCA, SFWMD, and FKAA.

Implementation Mechanism: This option could be implemented by actions of the Steering Committee for the Water Quality Protection Program. Because the Steering Committee includes high-level representatives of all relevant agencies, it could therefore take a leading role. The Steering Committee may also need to designate individuals or a subcommittee to participate in various discussions regarding individual restoration plans and surface water improvement and management plans. NOAA's FKNMS Advisory Council would take the lead in presenting concerns about water management issues to the Governor and Cabinet of the state of Florida.

Implementation Requirements: Both the Steering Committee and the Advisory Council are existing entities. Additional costs and staffing requirements for representing the Sanctuary's concerns about water management issues and Florida Bay are expected to be minimal.

10.0 REFERENCES

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APPENDIX A

Pollution Source Inventory and Loadings

POLLUTION SOURCE INVENTORY AND LOADINGS

A.1 BACKGROUND AND APPROACH

An extensive inventory of existing pollution sources in and adjacent to the Florida Keys National Marine Sanctuary (FKNMS) is given in Task 2, Section 3.0 of the Phase I report. This Phase II pollution source inventory summarizes that information and provides additional information on the operational characteristics and pollution potential of each source. The Phase I pollution source inventory was updated concurrently with the preparation of this Appendix.

Pollution sources can be categorized as either point sources or nonpoint sources. Point sources are generally defined as pollutants emanating from a single location or point. Examples are discharges from pipes or other outlet structures, such as domestic wastewater treatment plants (WWTPs), and stormwater from an outlet structure, ditch, or canal. Nonpoint pollution sources are more diffuse and enter a receiving body over a widespread and often undefinable interface or boundary. Examples of nonpoint pollution sources are sheet flow runoff, atmospheric deposition, nutrient loadings from aquatic vegetation die-off, and all groundwater discharges. Though some groundwater discharges originate at a single point (e.g., an injection well), the discharge to a receiving water body is diffuse and influenced by a number of variables.

Pollutants discharging to surface waters from both point and nonpoint sources can be grouped into six general categories: nutrients, oxygen-demanding constituents, toxic constituents, sediment, salinity changes, and thermal changes. Nitrogen and phosphorus are the major nutrients required for plant growth and one or the other is typically the limiting nutrient in marine or aquatic systems. Marine systems within the FKNMS are phosphorus limited. Nutrients can degrade water quality by stimulating algal blooms, which in turn can create toxic by-products, increase turbidity, and deplete oxygen as they decay. The presence of oxygen-demanding constituents in a discharge is measured as biochemical oxygen demand (BOD_5) or chemical oxygen demand (COD). With significant amounts of BOD or COD in a discharge, biochemical or chemical processes will exert that demand and result in lower levels of dissolved oxygen (DO) in the water column. Sediment is generally associated with stormwater discharges and its harmful effects include increased turbidity, decreased light penetration, and covering of benthic flora and fauna. Toxic constituents can be present in any discharge, and estimating effects or loadings requires site-specific data for specific toxic compounds. Salinity is a consideration for freshwater or hypersaline discharges into marine waters, where some marine flora and fauna have a narrow range of salinity tolerance. Thermal pollution is the result of elevated temperature in process or cooling waters and can stimulate algal blooms or affect the distribution of species with narrow ranges of thermal tolerance.

For each source identified in this report, loadings are quantified for only those pollutants that are of primary concern with respect to adverse effects on receiving water quality, and that can be estimated by reliable means. This approach lays the groundwork for the subsequent development of engineering options that focus on removal of the most significant pollutant loadings associated with the various sources. Targeted pollutant categories associated with the two major source categories are:

Source Category	Pollutant Category
Domestic wastewater	Nutrients
Stormwater	Sediment, Nutrients, (Toxic constituents)

Toxic constituents in stormwater runoff have a relatively high potential for adversely impacting nearshore marine waters, particularly in confined areas. However, because of the great variety of toxic materials, the wide range of concentrations at which specific constituents are toxic, the high variability from site to site, and the lack of significant stormwater data in the Keys, toxic loadings cannot be quantified with any degree of confidence. Toxic materials are not targeted for pollution sources other than stormwater because there are no data indicating significant or persistent toxicity problems associated with those sources. Oxygen demand is not targeted because oxygen depletion has not been demonstrated to be a significant problem, with the possible exception of some confined waters. There is only one cooling water discharge identified within the FKNMS (Stock Island Steam Plant), and it has not been demonstrated to have adverse thermal or toxic impacts on receiving waters. Toxicity testing will be required with the pending Florida Department of Environmental Regulation (FDER) permit for the Stock Island Steam Plant. No adverse salinity effects have been attributed to discharges originating within the FKNMS.

Calculations of nutrient loadings from various groundwater pollution sources in the following sections assume that no significant attenuation of nutrients occurs in the shallow surface soils or underlying limestone formations. While there is some evidence that certain forms of phosphorus are absorbed within the limestones, the evidence is not conclusive and the overall, long-term retention of phosphorus within the formation has not been shown to be significant.

The Monroe County Year 2010 Comprehensive Plan divided unincorporated Monroe County into 22 "Planning Area Analysis/Enumeration Districts" (PAEDs), shown in **Figures A-1** through **A-3**. These PAEDs are utilized to distribute population and wastewater flows for the pollutant loading estimates in this section.

A.2 POINT SOURCES

Point sources addressed in this section are limited to regulated (permitted) point sources. All significant point sources are assumed to be regulated. Numerous, small, unregulated point sources associated primarily with local drainage, swimming pool overflows, etc. are certain to be present throughout the Florida Keys. Identification or characterization of these minor point sources is not within the scope of this report. The great majority of unpermitted point sources are believed to be associated with stormwater. Loadings of sediment and nutrients from these point sources are included with overall nonpoint source stormwater loadings for the Keys, discussed in Section A.3.2 of this appendix.

Twenty-four point sources were inventoried in the Phase I report (see Phase I report, Tables 2-2 and 2-3). All of these facilities were identified through their National Pollutant Discharge Elimination System (NPDES) permits. Of the 24 permitted facilities, 10 are institutional, municipal, or tourist-related wastewater facilities; 6 are federal (U.S. Coast Guard or U.S. Navy) facilities, and 8 are commercial/industrial facilities. Only 19 of the 24 facilities were actively discharging as of November 1991, and several of these were planning to cease surface water discharges in the near future.

With the exception of the Key West WWTP and the Key West Utilities Stock Island Steam Plant, all of these 24 surface water discharges are relatively small. The Key West WWTP reports a flow range of 5.6 to 7.5 million gallons per day (MGD). The Stock Island steam facility is a cooling water discharge with flows in the 15 to 36 MGD range. Of the remaining 22 facilities, only five discharges are in excess of 0.1 MGD.

A.2.1 Domestic Wastewater National Pollutant Discharge Elimination System Discharges

The Phase I report identified five non-federal and five federal facilities that discharge treated domestic wastewater to surface waters. These facilities typically use the extended aeration or contact stabilization activated sludge process to treat wastewater to meet secondary standards (mean annual BOD and total suspended solids (TSS) of effluent less than 20 mg/L). The total average daily flow for the 10 facilities is 6.9 MGD. The Key West WWTP and U.S. Navy Sigsbee Park WWTP (soon to be connected to the Key West WWTP) account for 6.6 MGD, or 94% of the total combined flow. Of the remaining 8 facilities, only the Key Colony Beach WWTP (0.175 MGD) and U.S. Navy Boca Chica WWTP (0.131 MGD) exceed 0.035 MGD flow. Typical effluent quality and loading rates for the 10 domestic wastewater facilities that discharge to surface waters are shown in **Table A-1**.

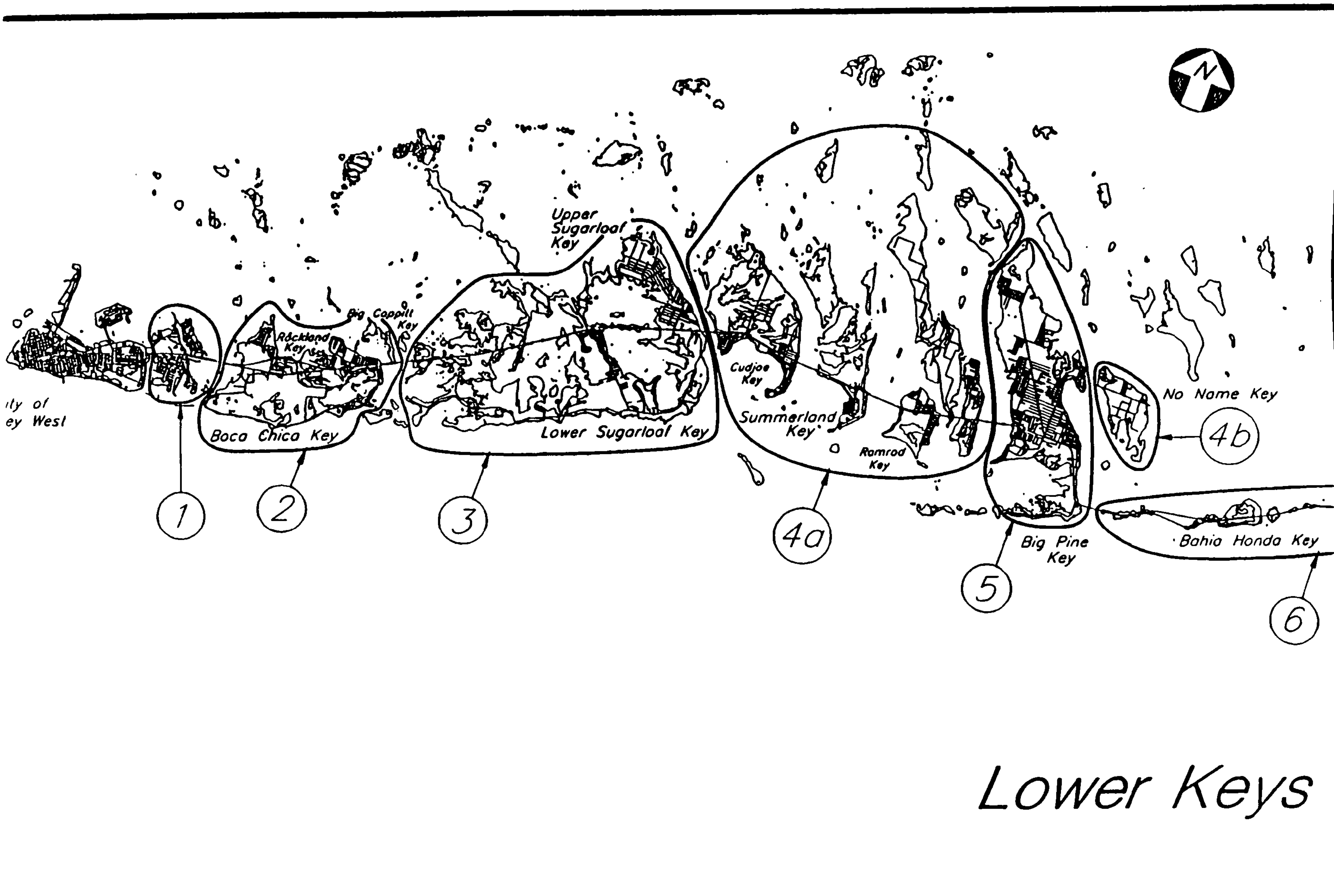


Figure 4-1. Monroe County Planning Area Analysis/Enumeration Districts - Lower Keys (Scale: 1" = 6000').

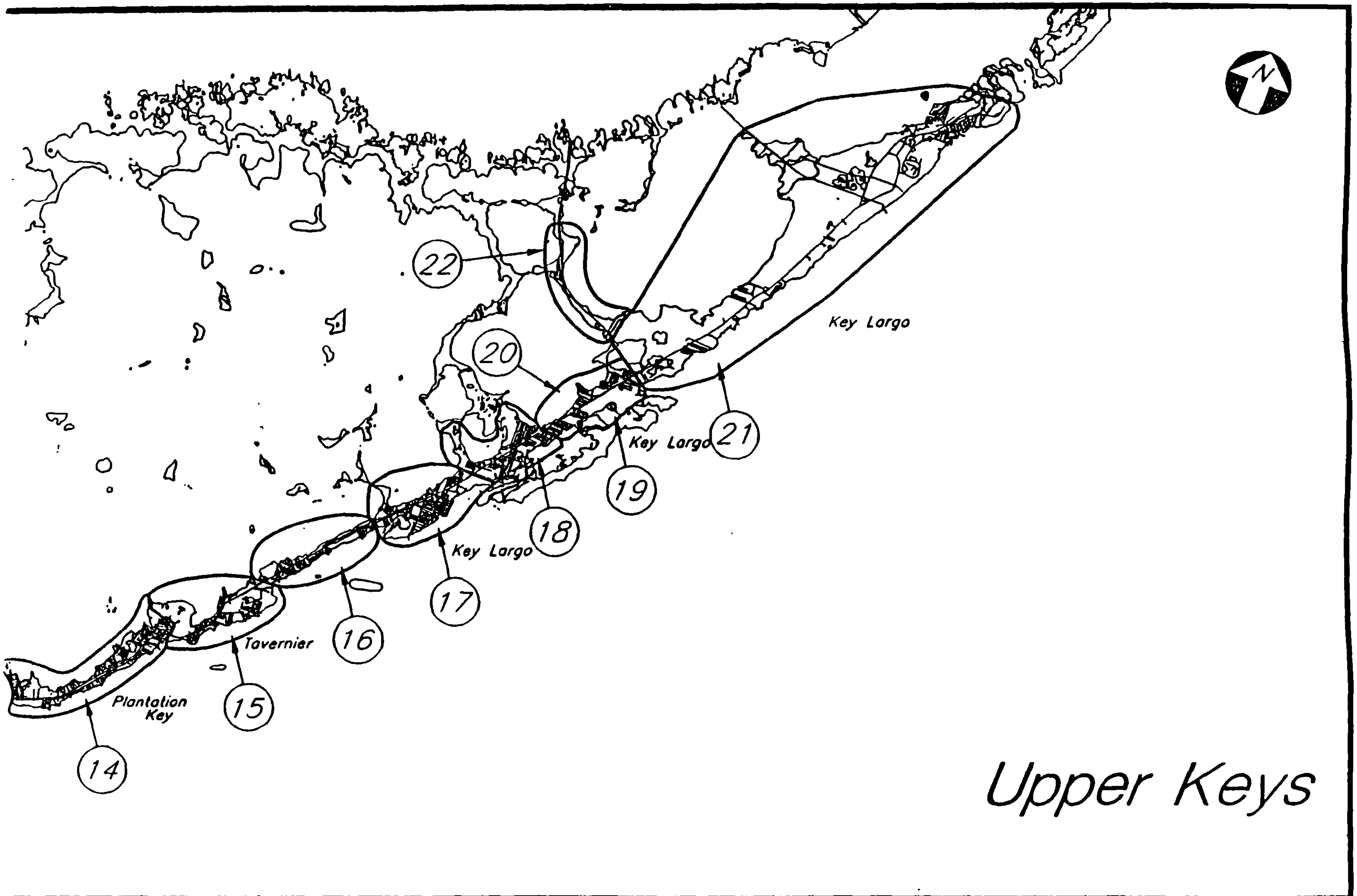
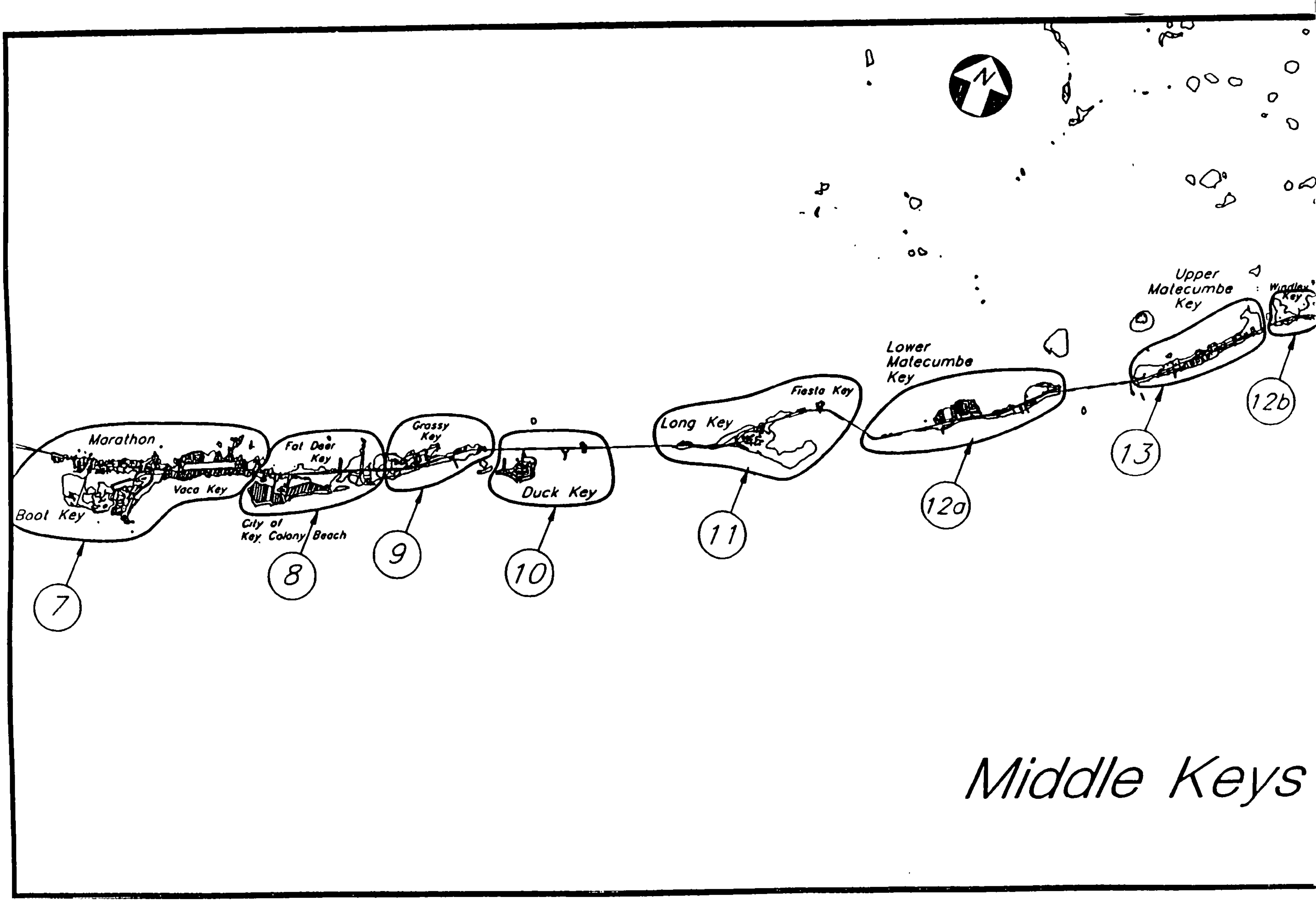


Figure A-3. Monroe County Planning Area Analysis/E ation Districts - Upper Keys (Scale: 1" = 6000').


N
Marathon
Boot Key
Vaco Key
Fat Deer Key
City of Key Colony Beach
Grassy Key
Duck Key
Long Key
Fiesta Key
Lower Matecumbe Key
Upper Matecumbe Key
Windley Key
7
8
9
10
11
12a
12b
13
Middle Keys

[illegible]

Table A-1. Summary of estimated pollutant loadings from sanitary WWTPs discharging to surface waters within the FKNMS.[a]

PAED[b]	Key Areas	Number of WWTPs	Total Design Capacity[c] (MGD)	Total Average Daily Flow[c] (MGD)	Estimated Pollutant Loading (lbs/day)[d]				
					TSS	BOD	NH_3-N	NO_3-N	1
	LOWER KEYS								
NA	City of Key West	4	10.627	6.582	440	329	109	98	137
1	Stock Island, Cow & Key Haven	0							
2	Boca Chica, Rockland, Big Coppit & Geiger	1	0.400	0.131	22	22	5	38	9
3	Saddlebunch, Upper & Lower Sugarloaf	0							
4	Cudjoe, Summerland, Ramrod, Torch Keys & No Name Keys	1	0.070	0.033	6	6	1	10	2
5	Big Pine Key	1	0.002	0.001	neg.[e]	neg.[e]	neg.[e]	neg.[e]	neg.[e]
6	Spanish Harbor, Bahia Honda, Ohio, Missouri, Little Duck & Pigeon	0							
	SUBTOTAL	7	11.099	6.747	468	357	115	146	148
	MIDDLE KEYS								
7	Knight, Vaca (Marathon), Stirrup & Boot	1	0 003	0.002	0.3	0.3	0.1	0 6	0.1
8	Fat Deer (including Coco Plum), Crawl & Little Crawl	1	0 200	0.175	29	29	7	51	12
9	Grassy	0							
10	Duck & Conch	0							
11	Long & Fiesta	0							
12	Lower Matecumbe, Craig & Windley	0							
13	Upper Matecumbe	0							
	SUBTOTAL	2	0.203	0.177	29	29	7	51	12
	UPPER KEYS								
14	Plantation	1	0.005	0.002	0.3	0.3	0.1	0.6	
15	Lower Key Largo (Tavernier)	0							
16	Key Largo (Dove)	0							
17	Key Largo (Rock Harbor)	0							
18	Key Largo (Tarpon Basin)	0							
19	Key Largo (Largo Sound)	0							
20	Key Largo (Blackwater Sound)	0							
21	N. Key Largo (Port Bougainville to Angelfish), Cape Sable	0							
22	Cross Key to Dade County Line	0							
	SUBTOTAL	1	0.005	0.002	0.3	0.3	0.1	0.6	0.1
	TOTAL	10	11.307	6.926	497	386	122	198	160

NA: Not applicable

[a]Recent information obtained from FDER indicates that there are 250 active WWTP permits in the Keys and another 20 facilities that are permitted but not on line. Upon receiving appropriate FDER documentation regarding the number of WWTPs and corresponding flow, this table may be revised accordingly.

[b]Planning Area Analysis/Enumeration District as delineated in Monroe County Year 2010 Comprehensive Plan

[c]Source: City of Key West Comprehensive Plan and Monroe County Year 2010 Comprehensive Plan

[d]Estimate calculated using average daily flow. Assumed pollutant concentrations discharged to surface water are

Pollutant	Assumed Concentration: City of Key West WWTPs	Assumed Concentration: Monroe County WWTPs
TSS	8	20
BOD	6	20
	2	5
	1.8	35
	2.5	8
Source	City of Key West Comp. Plan	FKNMS Phase I Report, Table 2-6

[e]Negligible

A.2.2 Other National Pollutant Discharge Elimination System Discharges

Other (non-domestic) NPDES wastewater discharges are identified as "Industrial" discharges in the Phase I report (Table 2-2), with the exception of the U.S. Naval Air Station Key West facility ("federal" designation). Of the seven non-domestic NPDES discharges, four have ceased surface water discharge or have never discharged, two provide emergency or stormwater discharges, and one (the Key West Utilities Stock Island Steam Plant) discharges regularly (see Phase I report, Table 2-3). The desalination plant brine discharge from the Ocean Reef Club (0.287 to 0.411 MGD) is the most recent NPDES discharge that has been eliminated. That facility now discharges to Class V injection wells (boreholes).

The Stock Island Steam Plant utilizes shallow saline groundwater for cooling purposes and discharges between 14.8 and 36.0 MGD. Water quality data for this discharge do not indicate any significant potential for adverse toxic or thermal effects. The pending FDER permit for this facility will require toxicity testing quarterly for the first year to further evaluate potential toxicity associated with this discharge.

A.2.3 Stormwater Discharges

Point source stormwater discharges consist of outlet structures associated with South Florida Water Management District (SFWMD) surface water management permits and unpermitted stormwater discharge structures. The Phase I report listed 58 SFWMD surface water management permits in unincorporated Monroe County and summarized location, acreage, land use, and receiving water bodies for 47 permits located in SFWMD files (see Phase I report, Table 2-14). Listed acreages ranged from less than one acre to 197 acres. No water quality or discharge quantity data were available for these point sources.

In addition to SFWMD-permitted stormwater facilities, there are numerous unpermitted culverts and other control structures discharging stormwater into the FKNMS. No records of structure types, numbers, or drainage areas served are available for these structures.

The City of Key West Comprehensive Plan indicates that approximately 37 stormwater outfalls serve the city's drainage system (see City of Key West Comprehensive Plan, Map IV-3). No information is available at this time on drainage areas or water quality for these outfalls. Several SFWMD surface water management permits exist within the City of Key West, but information on these permits was not obtained. The total area served by these permits is relatively small.

Because of the lack of adequate data for point source stormwater discharges, no attempt was made to specifically quantify pollutant loadings from these sources. A general analysis of stormwater nutrient loadings for the entire Keys is discussed in Section A.3.2 of this appendix.

A.3 NONPOINT SOURCES

Nonpoint sources of pollution affecting the FKNMS include sources that are internal and external to the FKNMS. Each source can be further categorized as anthropogenic (man-induced), natural, or a combination of anthropogenic and natural inputs. The discussion in this section deals with anthropogenic, internal, nonpoint sources. These include Class V injection wells (boreholes), absorption fields, cesspits, stormwater runoff, waste discharges from boats, mosquito spraying, landfills, and spills of toxic or hazardous materials. Detailed descriptions of these sources are given in Task 2, Section 3.2 of the Phase I report.

Additional internal nonpoint pollution sources that may be significant from an overall loading standpoint include atmospheric deposition and release of nutrients into the water column from decomposition of organic material. Data are not available to quantify inputs from these sources.

External nonpoint pollution sources potentially affecting the FKNMS include freshwater discharges from mainland Florida (e.g., Canal-111 and Model Land Canal), marine waters surrounding the FKNMS, and atmospheric deposition from frontal or other regional air mass movements. Marine waters with significant potential for affecting water quality within the FKNMS include Florida Bay, Biscayne Bay, the Gulf Stream, and nearshore ocean waters of the lower east coast and lower west coast of Florida. Data are not sufficient to allow characterization of pollutant loadings from these potential pollution sources.

A.3.1 Groundwater Discharges

A.3.1.1 CLASS V INJECTION WELLS

The Phase I report indicates that 557 Class V injection wells, commonly referred to as boreholes, are used for wastewater and stormwater disposal within the FKNMS. A typical borehole is an 8-in. diameter hole drilled to a total depth of 60 to 90 ft and cased to a depth of 30 to 60 ft. Current FDER rules require boreholes to be drilled to a depth of 90 ft and cased to 60 ft. All boreholes are permitted by the FDER. Of the 557 permitted boreholes in July, 1992, 324 were used by package wastewater treatment plants, 186 by aerobic on-site sewage disposal systems (OSDS), 43 for stormwater disposal, and 4 for laundry waste disposal. Since these figures were tabulated, the Ocean Reef Club desalination plant brine discharge (0.287 to 0.411 MGD) has been converted from surface water discharge to borehole discharge.

According to the Phase I report, there are 209 wastewater treatment facilities operating within close proximity to the FKNMS (see Phase I report, Table 2-5 and note below), 199 of which discharge to groundwater via 324 boreholes. The remaining 10 plants discharge to surface waters and are discussed in **Section A.2.1** of this appendix. In addition to these facilities in unincorporated Monroe County and Key Colony Beach, there are seven active package plants within the City of Key West that discharge to groundwater. A summary of estimated pollutant loadings for all 199 wastewater treatment plants discharging to groundwater is given in **Table A-2.** Total estimated nutrient loadings for these plants are 152 lbs/day orthophosphate, 96 lbs/day ammonia nitrogen and 660 lbs/day nitrate nitrogen.

Class V injection wells are also used as an effluent disposal method for 186 aerobic OSDSs. Each aerobic OSDS is typically served by a single borehole. With the exception of two boreholes in Marathon and eight in Tavernier, all boreholes serving aerobic OSDSs are located in the Big Pine Key to lower Sugarloaf Key area. This area corresponds to Monroe County PAEDs 3, 4, and 5. Pollutant loading associated with aerobic systems discharging to boreholes is included with overall OSDS loadings discussed in the following section.

Note: Information received in FDER comments on the Phase I report indicates that there are 270 WWTP permits and 250 active WWTPs in the Keys. Because updated information on the additional WWTPs has not been received, this appendix and all calculations of nutrient removals and costs will address the 209 WWTPs identified in the Phase I report. The additional WWTPs will affect nutrient removals and costs associated with some engineering options, but only by a relatively small percentage (less than 5% for most options). Overall strategies and structure of the engineering options will not be affected.

A.3.1.2 ABSORPTION FIELDS

Absorption fields, commonly referred to as drainfields, are the most common means of effluent disposal for traditional OSDSs. According to the Monroe County Year 2010 Comprehensive Plan, there are an estimated 29,000 OSDSs in the Keys. Of these, 24,000 are Florida Department of Health and Rehabilitative Services (FDHRS) permitted septic tank or aerobic systems and 5,000 are cesspits. The Phase I report figures show that of the 24,000 permitted OSDSs, only 350 are aerobic systems and that 164 of these systems discharge to absorption fields. The remaining 186 aerobic systems discharge to boreholes. In order to simplify calculation of overall OSDS nutrient

Table A-2. Estimated pollutant loadings from sanitary WWTPs discharging to groundwaters within the FKNMS[a].

PAED[b]	Key Areas	Number of WWTPs	Total Design Capacity[c] (MGD)	Total Average Daily Flow[c] (MGD)	Estimated Pollutant Loading (lbs/day)[d,e] TSS & BOD	NH_3-N	NO_3-N	PO_4
	LOWER KEYS							
NA	City of Key West	7	0.368[f]	0.294[f]	49	12	86	20
1	Stock Island, Cow & Key Haven	7	0.181	0.145	24	6	42	9
2	Boca Chica, Rockland, Big Coppit & Geiger	3	0.445	0.145	24	6	42	10
3	Saddlebunch, Upper & Lower Sugarloaf	5	0.071	0.023	4	1	7	2
4	Cudjoe, Summerland, Ramrod, Torch Keys & No Name Keys	3	0.084	0.041	7	2	12	3
5	Big Pine Key	4	0.043	0.020	3	1	6	1
6	Spanish Harbor, Bahia Honda, Ohio, Missouri, Little Duck & Pigeon	4	0.077	0.049	8	2	14	3
	SUBTOTAL	33	1.269	0.717	119	30	209	48
	MIDDLE KEYS							
7	Knight, Vaca (Marathon), Stirrup & Boot	51	0.750	0.251	42	10	73	17
8	Fat Deer (including Coco Plum), Crawls & Little Crawl	4	0.073	0.020	3	1	6	1
9	Grassy	2	0.045	0.012	2	0.5	4	1
10	Duck & Conch	1	0.050	0.045	8	2	13	3
11	Long & Fiesta	7	0.124	0.065	11	3	19	4
12	Lower Matecumbe, Craig & Windley	11	0.150	0.038	6	2	11	3
13	Upper Matecumbe	22	0.321	0.096	16	4	28	6
	SUBTOTAL	98	1.513	0.527	88	23	154	35
	UPPER KEYS							
14	Plantation	14	0.284	0.119	20	5	35	8
15	Lower Key Largo (Tavernier)	7	0.204	0.144	24	6	42	10
16	Key Largo (Dove)	8	0.335	0.186	31	8	54	12
17	Key Largo (Rock Harbor)	14	0.357	0.210	35	9	61	14
18	Key Largo (Tarpon Basin)	12	0.269	0.136	23	6	40	9
19	Key Largo (Largo Sound)	5	0.096	0.040	7	2	12	3
20	Key Largo (Blackwater Sound)	5	0.029	0.010	2	0.4	3	1
21	N. Key Largo (Port Bougainville to Angelfish), Cape Sable	2	0.460	0.178	30	7	52	12
22	Cross Key to Dade County Line	1	0.003	0.001	0.2	0.04	0.3	0.07
	SUBTOTAL	68	2.037	1.024	172	43	299	69
	TOTAL	199	4.819	2.268	379	95	662	152

NA: Not applicable

[a] Recent information obtained from FDER indicates that there are 250 active WWTP permits in the Keys and another 20 facilities that are permitted but not on line. Upon receiving appropriate FDER documentation regarding the number of WWTPs and corresponding flow, this table may be revised accordingly.

[b] Planning Area Analysis/Enumeration District as delineated in Monroe County Year 2010 Comprehensive Plan

[c] Source: Monroe County Year 2010 Comprehensive Plan, Table 10-4

[d] Assumed pollutant concentrations are as listed in Table 3-1 for Monroe County WWTPs

[e] Estimates utilize average daily flow

[f] ...e: City of Key West Comprehensive Plan

loadings, the 186 aerobic systems discharging to boreholes are not addressed separately and are included with systems discharging to absorption fields.

To distribute OSDS pollutant loading geographically, it is assumed that OSDS use in a given area is proportional to resident population (a study currently underway by Monroe County to map all OSDSs within the Keys was not complete as of this writing). Estimated pollutant loadings for FDHRS-permitted OSDSs in Key West and all Monroe County PAEDs are given in **Table A-3**. The total estimated nutrient loadings from absorption fields are 377 lbs/day orthophosphate and 1,553 lbs/day ammonia nitrogen.

A.3.1.3 CESSPITS

According to the Monroe County Year 2010 Comprehensive Plan, there are an estimated 5,000 active cesspits in the Keys. Cesspits are typically excavated into the Key Largo Limestone or Miami Oolite at the ground surface. Cesspits vary in size from 100 cu ft to more than 1,000 cu ft and are generally 4 to 8 ft deep. The pit is usually covered with a concrete slab and receives raw, untreated waste. Liquid waste components are discharged through the porous limestone formations toward outlets typically at shorelines or canals, and solid wastes are retained in the cesspit. Though some pumping of solid wastes from cesspits may occur, it is believed that when solid wastes accumulate to the point where function is impeded, the cesspit is abandoned and a new one is constructed.

Because there is presently no useful information on geographic distribution of cesspits throughout the Keys, it is assumed that cesspit distribution is proportional to resident population in the various PAEDs. **Table A-4** is a tabulation of estimated pollutant loadings from cesspits throughout the Keys. Pollutant loadings are based on typical residential raw wastewater characteristics as listed in Table 2-10 of the Phase I report and footnote "e" of **Table A-4**.

Nutrient loading estimates for cesspits include 127 lbs/day ammonia nitrogen, 12 lbs/day nitrate nitrogen, 709 lbs/day total nitrogen, 156 lbs/day phosphate, and 250 lbs/day total phosphorus. There is also a high potential for bacteriological contamination from cesspits. Raw wastes come into direct contact with the porous soils or rock into which the pits are excavated. The potential for migration of bacteriological contamination to surface soils or adjacent surface waters is high.

A.3.2 Stormwater

Nonpoint source stormwater discharges are defined as discharges to surface waters by overland flow, not through structures. The vast majority of stormwater discharges throughout the FKNMS are nonpoint. Land uses with a high potential for stormwater pollutant loading include highways, commercial areas, high-density residential areas, and construction areas.

Very little information is available on the quantity or quality of stormwater runoff in the Keys. In the interest of estimating the significance of nutrient loadings to the FKNMS from stormwater runoff, typical runoff coefficients and literature values of nutrient concentrations for stormwater runoff from general land use categories were used. Nutrient concentrations and runoff coefficients used in this analysis are summarized in **Table A-5**. A breakdown of general land use categories for the upper, middle, and lower Keys is given in **Table A-6**. **Table A-7** summarizes estimated stormwater loadings of nitrates, total nitrogen, orthophosphate total phosphate, and total suspended sediment for general land use categories in the upper, middle, and lower Keys. Total estimated loadings from all land areas are 635 lbs/day total nitrogen, 364 lbs/day total phosphorus, and 124 tons/day TSS. Total estimated loadings from all developed areas are 410 lbs/day total nitrogen, 364 lbs/day total phosphorus, and 85 tons/day TSS.

Table A-3. Summary of estimated pollutant loadings from FDHRS-permitted on-site sewage disposal systems to groundwaters within the FKNMS.

'AED[a]	Key Areas	1990 Resident Population Projection[b]	Estimated Number Septic Tanks[d]	Estimated Septic Tanks[f] (MGD)	Estimated Pollutant Loading[g] (lbs/day) TSS	BOD	NH_3-N	NO_3-N	PO_4
	LOWER KEYS								
N/A	City of Key West	NA[c]	50[e]	0.013	4	6	3	0	1
1	Stock Island, Cow & Key Haven	4541	2089	0.522	156	244	135	0	33
2	Boca Chica, Rockland, Big Coppit & Geiger	3106	1429	0.357	108	167	92	0	22
3	Saddlebunch, Upper & Lower Sugarloaf	1786	825	0.205	61	96	53	0	12
4	Cudjoe, Summerland, Ramrod, Torch Keys & No Name Keys	3983	1833	0.459	138	214	119	0	29
5	Big Pine Key	4208	1937	0.484	145	226	125	0	31
6	Spanish Harbor, Bahia Honda, Ohio, Missouri, Little Duck & Pigeon	441	203	0.051	15	24	13	0	3
	SUBTOTAL	18065[h]	8366	2.091	627	977	540	0	131
	MIDDLE KEYS								
7	Knight, Vaca (Marathon), Stirrup & Boot	8861	4079	1.019	306	476	264	0	63
8	Fat Deer (including Coco Plum), Crawls & Little Crawl	697	321	0.081	24	37	31	0	5
9	Grassy	1086	500	0.125	37	59	33	0	8
10	Duck & Conch	629	290	0.072	22	34	18	0	5
11	Long & Fiesta	356	164	0.041	12	19	11	0	3
12	Lower Matecumbe, Craig & Windley	1096	505	0.126	37	59	33	0	8
13	Upper Matecumbe	1220	562	0.140	42	65	36	0	9
	SUBTOTAL	13945	6421	1.604	480	749	416	0	101
	UPPER KEYS								
14	Plantation	4405	2027	0.507	153	237	132	0	32
15	Lower Key Largo (Tavernier)	2433	1120	0.280	84	131	72	0	17
16	Key Largo (Dove)	2287	1053	0.263	79	123	68	0	16
17	Key Largo (Rock Harbor)	2465	1135	0.284	85	132	74	0	18
18	Key Largo (Tarpon Basin)	4127	1900	0.475	143	222	123	0	30
19	Key Largo (Largo Sound)	908	418	0.105	32	49	27	0	7
20	Key Largo (Blackwater Sound)	1549	713	0.179	54	84	46	0	12
21	N. Key Largo (Port Bougainville to Angelfish), Cape Sable	1787	823	0.205	61	96	53	0	13
22	Cross Key to Dade County Line	61	28	0.007	2	3	2	0	0.4
	SUBTOTAL	20022	9127	2.305	693	1077	597	0	145
	TOTAL	52032	24004	6.000	1800	2803	1553	0	377

NA: Not applicable

[a]Planning Area Analysis/Enumeration District as delineated in Monroe County Year 2010 Comprehensive Plan

[b]Source: Monroe County Year 2010 Comprehensive Plan, Table 3-27

[c]Estimated number of septic tanks in the City of Key West are not based on population

[d]Assumes 23,000 septic tank systems throughout the FKNMS, distributed proportional to population

[e]Source: FKNMS Phase I report

[f]Assumes 100 GPD per capita and 2.5 occupants per unit, or 250 GPD per dwelling unit

[g]Estimate utilizes average daily flow. Assume following pollutant concentrations which are averages of ranges given in Table 2-11 of the Phase I report: 36 mg/L TSS, mg/L BOD, 31 mg/L NH_3-N (70% of Total Nitrogen), 13 mg/L NO_3-N (30% of Total Nitrogen), and 7.5 mg/L PO_4.

[h]Lower Keys subtotal does not include the City of Key West

Table A-4. Summary of estimated pollutant loac ings from cesspits to groundwaters within FKNMS.

PAED[a]	Key Areas	1990 Resident Population Projection[b]	Estimated Number of Cesspits[c]	Estimated Total of Cesspits Flow[d] (MGD)	Estimated Pollutant Loading lbs/day[e] TSS & BOD	NH$_3$-N	NO$_3$-N	TN	TP	PO$_4$
	LOWER KEYS									
NA	City of Key West	NA	20	0.005	10	1	0.04	3	1	1
1	Stock Island, Cow & Key Haven	4541	435	0.109	222	11	1	62	14	22
2	Boca Chica, Rockland, Big Coppit & Geiger	3106	297	0.074	152	7	1	42	9	15
3	Saddlebunch, Upper & Lower Sugarloaf	1786	171	0.043	87	4	0.04	24	5	9
4	Cudjoe, Summerland, Ramrod, Torch Keys & No Name Keys	3983	381	0.095	195	10	1	54	12	19
5	Big Pine Key	4208	403	0.101	206	10	1	57	13	20
6	Spanish Harbor, Bahia Honda, Ohio, Missouri, Little Duck & Pigeon	441	42	0.011	22	1	0 1	6	1	2
	SUBTOTAL	18065	1749	0 438	894	44	4	248	55	88
	MIDDLE KEYS									
7	Knight, Vaca (Marathon), Sutrup & Boot	8861	848	0.212	433	21	2	120	27	42
8	Fat Deer (including Coco Plum), Crawls & Little Crawl	697	67	0.017	34	2	0.1	9	2	3
9	Grassy	1086	104	0.026	53	3	0.2	15	3	5
10	Duck & Conch	629	60	0.015	31	2	0.1	9	2	3
11	Long & Fiesta	356	34	0.009	17	1	0.1	5	1	2
12	Lower Matecumbe, Craig & Windley	1096	105	0.026	54	3	0.2	15	3	[illegible]
13	Upper Matecumbe	1220	117	0.029	60	3	0.2	17	4	6
	SUBTOTAL	13945	1335	0.334	682	35	3	190	42	66
	UPPER KEYS									
14	Plantation	4405	422	0.105	215	11	1	60	13	21
15	Lower Key Largo (Tavernier)	2433	233	0.058	119	6	0.4	33	7	12
16	Key Largo (Dove)	2287	219	0.055	112	5	0.5	31	7	11
17	Key Largo (Rock Harbor)	2465	236	0 059	121	6	0.5	33	7	12
18	Key Largo (Tarpon Basin)	4127	395	0.099	202	10	1	56	12	20
19	Key Largo (Largo Sound)	908	87	0.022	44	2	0.2	12	3	4
20	Key Largo (Blackwater Sound)	1549	148	0.037	76	4	0.3	21	5	7
21	N. Key Largo (Port Bouganville to Angelfish), Cape Sable	1787	171	0.043	87	4	0.4	24	5	9
22	Cross Key to Dade County Line	61	6	0.002	3	0.1	0.01	1	0.2	0.3
	SUBTOTAL	20022	1917	0.480	979	48	4	271	59	96
	TOTAL	52032	5001	1.252	2555	127	12	709	156	250

NA: Not applicable

[a] Planning Area Analysis/Enumeration District as delineated in Monroe County Year 2010 Comprehensive Plan

[b] Source: Monroe County Year 2010 Comprehensive Plan, Table 3-27

[c] Estimated number of cesspits for the City of Key West is based on 1992 personal communication with Chris Williams, FDHRS. For unincorporated Monroe County, the distribution of cesspits is assumed proportional to population. It is assumed that 5,000 cesspits exist in the Keys, as stated in the Monroe County Year 2010 Comprehensive Plan.

[d] Assumes 250 GPD per cesspit

[e] Assumes following pollutant concentrations which are averages of ranges given in Table 2-8 of the Phase I report: 245 mg/L TSS, 245 mg/L BOD, 12 mg/L NH_3-N, 1 mg/L NO_3-N, 68 mg/L Total N, 15 mg/L PO_4, and 24 mg/L Total P

Table A-5. Typical stormwater runoff coefficients and stormwater pollutant concentrations for general land use categories.

	Typical Pollutant Concentration[a] (mg/L)					Average Runoff Coefficient[b]		
Land Use Category	NO_3-N	TN[c]	PO_4	Total P	TSS	Surface Runoff[b]	Shallow Infiltration	Total
Single Family	0.75	1.5	0.31	1.76	400	0.35	0.25	0.60
Multi-Family	0.89	1.8	0.38	2.68	600	0.50	0.15	0.65
Commercial/Public	0.78	1.6	0.28	0.62	900	0.70	0.05	0.75
Open	0.32	0.6	0.16	0.19	200	0.15	0.25	0.40

[a]Sources: City of Key West Comprehensive Plan, Table IV-21 and SFWMD St. Lucie Basin Assessment, Table 4-1
[b]Source: FDER Florida Development Manual — Stormwater Management (February 1992)
[c]TN: NO_3-N ratio is assumed to be 2:1

Table A-6. General land use distribution for Lower, Middle and Upper Keys.[a]

Keys Area	Areas of General Land Use Categories (acres)			
	Single Family	Multi-Family	Commercial	Open
Lower Keys	2951	689	4337	22151
Middle Keys	2037	510	1467	4446
Upper Keys	3391	1212	1135	17017
TOTAL	8379	2411	6939	43614

[a]Source: Monroe County Year 2010 Comprehensive Plan, Table 3.1

Table A-7. Estimated stormwater pollutant loading to waters of the FKNMS from the Lower, Middle and Upper Keys.

Key Area[a]	Total N (lbs/day					Total P (lbs/day)					TSS (tons/day)				
	SF	MF	COMM	OPEN	TOTAL	SF	MF	COMM	OPEN	TOTAL	SF	MF	COMM	OPEN	TOTAL
Lower	59	14	116	119	308	70	27	45	38	180	7.9	3.0	32.7	19.8	63
Middle	41	10	39	24	114	48	20	15	8	91	5.5	2.2	11.1	4.0	23
Upper	68	24	30	91	213	80	47	12	29	168	9.1	5.3	8.6	15.2	38
TOTAL	168	48	185	234	635	198	94	72	75	439	23	10	52	39	124
Total[b] Developed					401					364					85

SF: Single family
MF: Multi-family
COMM: Commercial/public
[a]Key areas are as delineated in the Monroe County Year 2010 Comprehensive Plan
[b]Nutrient loading estimates utilize nutrient concentrations and runoff/infiltration coefficients in Table A-5 and general land use distribution in Table A-6. The total annual precipitation is assumed to be 36 in.
[c]Excludes "open" land areas

A.3.3 Marinas and Live-Aboards

The Phase I report indicates that there are 192 marinas in the Keys with a total of 2,707 wet slips. An additional 2,295 dry slips were reported. Because of the generally smaller size of boats using dry slips and the more intermittent nature of their use, dry slips present a much lower potential for waste discharge than wet slips. The Phase I report also showed that in 1988 there were 1,410 live-aboard boats in the Keys with a total live-aboard population of 3,000 individuals. Of this total number of live-aboard boats, approximately 300 were anchored at various locations throughout the Keys and the remainder were tied up in marinas.

General marina operations can also contribute to water quality degradation. Marina operations with the potential to contribute to pollutant loadings include fueling operations, mechanical repairs, boat-bottom scraping and painting, and the use or disposal of fiberglass resins and solvents.

A.3.3.1 LIVE-ABOARD WASTE DISPOSAL

Of the 192 marinas listed in the Phase I report, only 8 have waste pumpout facilities. Because of the lack of pumpout facilities, the great majority of live-aboards must use whatever waste treatment and disposal systems they have on board. Standard practices include on-board pretreatment and discharge, holding tank storage with subsequent shore-side pumpout, and direct discharge of raw waste. Because of the limited number of pumpout facilities, shore-side pumpout probably accounts for a very small percentage of live-aboard waste volume. The Phase I report states that pretreatment devices typically attain 30% BOD_5 reduction. Improper disposal of solid waste by live-aboards also contributes to the accumulation of trash in nearshore waters.

Estimates of nutrient loadings to the FKNMS from live-aboard waste disposal practices were obtained by assuming a daily wastewater generation rate of 25 gallons per day and by multiplying the literature concentrations for raw domestic wastewater (as stated in the Phase I report) by a factor of 4.0. The rationale behind this approach is that live-aboards use much less water for flushing, but produce nearly the same mass of waste solids as their shoreside counterparts. The distribution of nutrient loadings between the lower, middle, and upper Keys was proportioned according to the number of wet slips in each area, as noted in the Phase I report. A summary of this nutrient loading estimate is given in **Table A-8.**

A.3.3.2 MARINA OPERATIONS

Data are not sufficient to quantify pollutant loadings from marina operations. The most significant pollutants are heavy metals from leaching and scraping of bottom paints; spilled fuel from fueling operations; fuel, oil and grease from bilge pumping; and resins or solvents used for fiberglass repair or construction.

A.3.4 MOSQUITO CONTROL PROGRAM

A description of the Mosquito Control Program in the Florida Keys is given in Task 2, Section 3.2.4 of the Phase I report. Aerial and ground applications dispense insecticides over developed areas and areas of standing water. Application of insecticides is restricted or prohibited on nearly all federal properties, national recreational parks, and state fish and wildlife preserves within the Keys. These "no spray" areas are discussed in the Phase I report.

Total insecticide usage for mosquito control in the Keys during 1990 is summarized in **Table A-9**. A total, which reflects repeat applications, of 80,654 gallons of liquid insecticides was applied during the year to a cumulative total of 47,677 square miles. Additional solid insecticides in briquet, pellet, or powder form were applied to 63 square miles (cumulative). Some general toxic effects of several pesticides are discussed in the Phase I report, but little definitive data exist to permit evaluation of the effects of the Mosquito Control Program on deteriorating ecological or environmental systems within the FKNMS.

Table A-8. Estimated wastewater nutrient loadings from live-aboard boats to surface waters of the FKNMS.

Key Area[a]	Number of Wet Slips[a]	Estimated Number of Live-Aboard Boats[b]	Estimated Pollutant Loading (lbs/day)[c]					
			TSS & BOD	NH_3-N	NO_3-N	TN	PO_4	TP
Lower	589	326	67	3	0.3	18	4	7
Middle	1284	712	145	7	0.6	40	9	14
Upper	834	462	94	5	0.4	26	6	9
TOTAL	2707	1500	306	15	1	84	19	30

[a]Source: FKNMS Phase I Report

[b]Number of live-aboards in each area is assumed to be proportional to the number of wet slips. A total of 1500 live-aboard boats in the Keys is assumed.

[c]Assumes pollutant concentrations are four times the midpoint of the ranges given in Table 2-8 of the FKNMS Phase I report for raw domestic wastewater (which were 245 mg/L TSS, 245 mg/L BOD, 12 mg/L NH_3-N, 1 mg/L NO_3-N, 68 mg/L TN, 15 mg/L PO_4, and 24 mg/L TP). An average discharge of 25 GPD per boat is assumed. This approach assumes that live-aboards discharge the same quantity of solids as shore-side residents, but in a reduced volume of wastewater.

Table A-9. Quantities of insecticides used for mosquito control in the Florida Keys during 1990.[a]

Insecticide	Quantity	Area Treated
Baytex	290,460 oz	39,209 mi
Scourge (180)	36,054 oz	1,878 sq. mi
Malathion	3,492 oz	129 mi
Biomist	1,680 oz	46 mi
Permanol	897 oz	17 mi
Vectobac 12	655 oz	41 acres
Dibrom 14 - Diesel fuel (4:100)	55,401 gal	443,208 acres
Vectobac G	22,000 gal	2,998 acres
Abate 5G	650 gal	260 acres
Altosid briquets	608,874 briquets	33,811 mi
Bactimos briquets	19,183 briquets	165 acres
Teknar concentrate		
(2 oz/gal)	4 briquets	1 acre
(8 oz/gal)	88 briquets	11 acres
(16 oz/gal)	1,294 briquets	58 acres
(8.5 oz/gal)	128 briquets	15 acres
(10.6 oz/gal)	16 briquets	2 acres
Altosid pellets	472 briquets	229 acres

[a]Source: FKNMS Phase I Report, Table 2-13

A.3.5 LANDFILLS

A total of 12 landfill sites has been identified within the Keys. A summary of the approximate location, area, capacity, status, and ownership of these sites is given in **Table A-10**. Three sites are owned by Monroe County, one by the City of Key West, five by the U.S. Navy, and three by private interests. None of these landfills has a bottom liner or a leachate collection system. Because of the unlined construction, close proximity to the water table, and poor control over types of waste placed in these landfills, all have significant potential to degrade groundwater and adjacent surface waters.

Because of declining landfill capacity and the difficulty in permitting new landfill sites within the Keys, both the City of Key West and Monroe County have decided to have all solid waste and most incinerator ash hauled out of the Keys by contractors. As a result of this decision, the three Monroe County landfills (Cudjoe Key, Long Key, and Key Largo) recently have been deactivated. The City of Key West Stock Island landfill is only used for disposal of relatively small quantities of incinerator ash. All four of these landfills are in the closure process. Closure plans for the Monroe County landfills were submitted to the FDER in June 1992, but were not approved as of this writing. Closure of the Stock Island landfill is scheduled to be completed by May 1993. Closure plans for all four landfills include installation of a membrane top liner to reduce leachate production.

All four Monroe County and City of Key West landfills have active groundwater monitoring programs. Three to five shallow monitoring wells are installed at each site (see **Table A-10**). Some additional sampling of adjacent surface waters has occurred, but no surface water locations are monitored on a regular basis. Monitoring data collected to date do not indicate any significant potential for degradation of groundwater or adjacent surface waters. However, because of the small number of monitor wells at each site, there may be some questions as to the level of confidence that can be placed on groundwater monitoring data for these sites.

Five of the landfill sites listed in **Table A-10** are owned by the U.S. Navy. Four of these sites (Truman Annex, Fleming Key North, Fleming Key South, and Boca Chica) are being assessed under the U.S. Navy's Installation Restoration Program. The initial assessment phase of the program indicated metal contamination at all four sites and some isolated occurrences of polychlorinated biphenyls (PCB), organics, and pesticides. Data are insufficient to determine overall loading of pollutants to groundwaters or surface waters. As of this writing, contracts were being prepared to proceed with remedial action investigations for all four sites. Assessment and cleanup of these four U.S. Navy landfill sites will continue to be pursued under the Installation Restoration Program.

The fifth U.S. Navy-owned site on Saddle Bunch Key is not being investigated under the Installation Restoration Program. Though the site is owned by the U.S. Navy, it was operated by a private contractor. No records of disposal practices, storage area, closure, or monitoring were found.

The remaining three landfills listed in **Table A-10** (Middle Torch and Boot Key 1 and 2) are in private ownership. No records of disposal practices, storage area, closure, or monitoring were found. These three landfills and the Saddle Bunch Key landfill apparently have inadequate, pervious cover and are not monitored. Because of the high variability of leachate between different landfill sites, it is not practical to estimate pollutant loadings from these inactive sites.

A.3.6 Toxic or Hazardous Material Spills

Spills of toxic or hazardous materials have the potential to create nonpoint source pollutant loading to the FKNMS. Because of the unpredictability of such spills, assessment of their pollution potential can not be quantified. Likely source areas are transportation over waterways and roads, and facilities that handle or store toxic or hazardous materials.

Table A-10. Capacities, areas, and status of landfill sites in the Florida Keys.

Site	Mile Marker	Area (acres)	Facility Type	Previous Capacity (tons/day)	Status	Ownership	Number o Monitor Wi
Long Key	68	30	Landfill/Incinerator	112	Inactive[a]	Monroe County	3[b]
Cudjoe Key	21	20	Landfill/Incinerator	75	Inactive[a]	Monroe County	5[b]
Key Largo	[c]	15	Landfill/Incinerator	112	Inactive[a]	Monroe County	3[b]
Stock Island	5	19	Landfill/Incinerator	150	Active[d]	City of Key West	3[b]
Truman Annex	0	7	Landfill	Unknown	Inactive	U.S. Navy	7[e]
Fleming Key North	0	30	Landfill	15	Inactive	U.S. Navy	8[e]
Fleming Key South	0	45	Landfill	25	Inactive	U.S. Navy	10[e]
Boca Chica	8	Unknown	Landfill	Unknown	Inactive	U.S. Navy	9[e]
Saddle Bunch	15	Unknown	Landfill	Unknown	Inactive	U.S. Navy[f]	0
Middle Torch	27	Unknown	Landfill	Unknown	Inactive	Private	0
Boot Key 1	48	Unknown	Landfill	Unknown	Inactive	Private	0
Boot Key 2	48	5-10	Landfill	Unknown	Inactive	Private	0

[a]Landfills at these sites are currently inactive, but sites are being utilized as transfer facilities.
[b]Wells are monitored quarterly with results submitted to FDER
[c]No data available
[d]The current operating cell of the Stock Island Landfill is utilized only for disposal of some ash from the adjacent incinerator
[e]Wells are utilized for initial assessment and follow-up monitoring under the U.S. Navy Installation Restoration Program. These landfills are not in the FDER quarterly monitoring program.
[f]This site is owned by the U.S. Navy, but a private contractor operates the Saddle Bunch Landfill

A.3.7 Underground Tanks

Underground tanks that were constructed prior to current FDER requirements for secondary containment and monitoring have the potential to adversely affect groundwater and surface waters in the FKNMS. The majority of such tanks are fuel tanks associated with service stations or marinas. In 1984, the FDER initiated a program to retrofit all stationary tanks to provide leak detection capability, and to install monitoring systems and overfill protection. All identified facilities were to have monitoring systems in place by 1989. Lining or replacement of non-approved tanks commenced in 1985 and is scheduled to be completed by 1998. Existing tanks are now required to have secondary containment by 1998. All stationary underground tanks are presumed to be included in this retrofitting program.

The locations of nearly all underground storage tanks are known and some leaking tanks have been identified. When leaking or old fuel tanks are replaced under the FDER retrofitting program, soil samples are analyzed and any fuel contamination from the tank is required to be cleaned (e.g., soil excavation and incineration, floating fuel recovery, etc.). The FDER underground storage tank program represents a considerable effort towards resolving problems associated with leaking underground storage tanks and additional efforts in this area are not warranted.

A.4 EXTERNAL SOURCES

External sources of pollutant loading to the FKNMS are described in Task 2, Section 3.3 of the Phase I report. These external sources have the potential to degrade water quality within the Sanctuary by transporting pollutants advectively through Florida Bay or the Atlantic Ocean, or by atmospheric deposition. Pollutants may include suspended solids, thermal changes, nutrients, salinity changes, or toxic materials.

A.4.1 Areas Adjacent to the Sanctuary

A.4.1.1 FLORIDA BAY AND EVERGLADES NATIONAL PARK

Florida Bay is a potential source of poor water quality that could adversely affect waters of the FKNMS. Causes of poor water quality within Florida Bay include wind-driven transport of suspended particulates, the presence of soluble nutrients, decomposition of seagrass, and low dissolved oxygen at night resulting from plant respiration. The information available is not sufficient to quantify the effects poor water quality in Florida Bay may have on the Sanctuary's reef tract. The Phase I report indicates that the reduced flow of freshwater from the Everglades and its probable effect on increased hypersalinity in Florida Bay is a prevalent anthropogenic water quality problem in Florida Bay.

A.4.1.2 BISCAYNE BAY

North Biscayne Bay receives runoff from large urban areas, including manufacturing and large boat building and repair facilities. This portion of the Bay receives flow from numerous tributaries with heavily-developed urban watersheds, including the severely-degraded Miami River. If the proposed plans to dredge the Miami River and dispose of sediments offshore are implemented, water quality within the FKNMS may be affected. The Metro-Dade County offshore sewage outfall also has the potential to adversely affect waters of the FKNMS.

South Biscayne Bay receives inputs from agricultural areas in South Dade County, the Homestead Air Force Base and the Black Point Landfill site. The Phase I report documented heavy nitrate loading and the presence of pesticides in two of the major agricultural canals discharging to the south bay. Homestead Air Force Base and Military Canal were identified as significant sources of metals and organic compounds. Plans to dredge Military

Canal by the U.S. Air Force have been delayed indefinitely, but if the plans move forward, dredging would pose a significant threat to water quality within the FKNMS.

A.4.1.3 ATMOSPHERIC DEPOSITION

Wet or dry atmospheric deposition may be a significant source for loadings of nutrients and other pollutants to waters of the FKNMS. Studies in Tampa Bay indicate atmospheric nitrogen loading is within the range of 546 to 1466 mg $N/m^2/yr$. Application of these figures to the water surface area of the FKNMS (9.811×10^9 m^2), yields an atmospheric nitrogen loading estimate of 32,000 to 87,000 lb N/d .

A.4.2. Areas Distant from the Sanctuary

As discussed in Task 2, Section 3.3.2 of the Phase I report, there is some potential for contaminant loading in the FKNMS transported from distant sources via gulf or ocean currents. Pollutant sources as distant as the Mississippi River and the Orinoco River (South America) may be major sources of contaminants. These contaminants may at times be entrained by the Loop Current, which flows from the Yucatan Peninsula generally clockwise around the Gulf of Mexico to the Florida Straits, where it flows east and north as the Florida Current. Data are not sufficient to quantify pollutant loadings from these distant sources.

APPENDIX B

Engineering Methods for Domestic Wastewater Collection, Treatment, and Disposal

ENGINEERING METHODS FOR DOMESTIC WASTEWATER COLLECTION, TREATMENT, AND DISPOSAL

This Appendix examines engineering methods available for reduction of wastewater pollutant loadings into waters of the Florida Keys National Marine Sanctuary (FKNMS). Methods discussed include most of those used in common engineering practice for collection, treatment, and disposal of domestic wastewater. Also included are some proven methods that have not been widely applied in the state of Florida.

Management of wastewater is an important environmental factor for the Florida Keys. The treatment and disposal of wastewater within unincorporated Monroe County has traditionally been accomplished through septic tanks or package plants. These two on-site treatment schemes have been used by single households, housing developments, condominiums, hotels, and commercial developments. Population growth in the Florida Keys and the reliance upon private development have led to a proliferation of small package treatment plants and a large inventory of individual septic tanks. Current wastewater treatment practices combined with soils in the Keys that have high porosity and low organic content, and high land use densities have resulted in increased potential for groundwater and surface water contamination.

B.1 EXISTING FACILITIES

Sanitary sewer facilities operating in unincorporated Monroe County consist of regulated and unregulated on-site sewage disposal systems (OSDS) and package treatment plants. The City of Key West uses a 10-million gallons per day (MGD) central system for collection and treatment of its wastewater. At the present time approximately 44% of all Florida Keys wastewater flow is treated by OSDSs, 16% is treated by package treatment plants, and 40% is treated by the City of Key West wastewater treatment plant (WWTP). The City of Key Colony Beach owns and operates the only other municipal WWTP in the Florida Keys, a 0.175 MGD facility.

Existing sewage treatment/collection facilities in the Keys are characterized below:

Type	Approximate Number	Regulatory Agency
Septic Tanks	24,000	Florida Department of Health and Rehabilitative Services (FDHRS)
Small Package Plants	200	Florida Department of Environmental Regulation (FDER)
Cesspits	5,000	Unpermitted & unregulated

Many facilities (such as restaurants, motels, and campgrounds) and multiple-family dwellings (condominium and apartment buildings) are served by package plants, ranging in capacity from 0.0008 to 0.45 MGD. With the exception of the City of Key Colony Beach WWTP, all of these package plants serve site-specific projects and are privately owned, operated, and maintained. One- and two-family dwellings commonly use septic tanks, as do many campgrounds and mobile home parks.

B.2 WASTEWATER TREATMENT METHODS

Two general issues must be addressed when considering wastewater treatment methods for an area. The first issue is whether central or local treatment facilities will be used. The second issue is the level of treatment that will be attained by treatment facilities.

B.2.1 Centralization of Facilities

The Florida Keys are a unique string of islands formed by an ancient coral reef system. The Florida Keys straddle two worlds, one of fragile Caribbean-type islands and the other of busy tourist resorts with vehicular access.

As development in the Keys occurred, the methods used for treating wastewater evolved. The first methods used were cesspits and septic tanks. As larger development moved in, package plants began being used. Finally, in Key West, the only area where the population density was large enough, a single municipal wastewater treatment plant was constructed and used.

The choices for facility centralization are:

- Continue the existing level of service.
- Construct community facilities to serve moderate size service areas.
- Construct subregional facilities to serve large service areas.

B.2.1.1 CONTINUE THE EXISTING LEVEL OF SERVICE

Factors that have contributed to the existing level of service include:

- Ease of facility construction
- Present and past regulatory controls or lack of controls
- Topography of the land
- Development patterns
- Best available and most economical technologies at the time of development
- Site conditions (soil, vegetation)
- Adjacent development
- Availability of infrastructure to support new development, or lack of that availability

Factors that may contribute to the decision to continue with the existing level of services are:

- Perception that existing facilities and current methods are adequate
- Represents the lowest cost option in terms of initial capital cost outlay
- Decision to wait for definitive scientific solutions to sewage and stormwater handling concerns
- Delay decision until a more politically opportune time
- Environmental impacts may be perceived to be unproven without other concrete evidence

Factors that may contribute to the decision to change the existing level of service are:

- Prices for capital improvements may be inflated in the future
- More stringent regulation in future may drive costs higher
- Continued pollutant loadings in surface waters and groundwaters
- Impacts to native flora, fauna, and coral reefs
- Loss of tourist dollars because of pollution degradation of Florida Keys and reefs

B.2.1.2 CONSTRUCT COMMUNITY FACILITIES

With the exception of Key West, the population in the Florida Keys is widely distributed. In order to centralize the facilities, many miles of force mains and numerous lift stations would have to be constructed. The balance between constructing force mains and lift stations for central facilities versus using smaller, local treatment facilities is demonstrated by the centralization approaches discussed in the following sections.

Central sewer service areas may potentially serve the largest population centers. The top 12 population centers (communities) are listed in **Table B-1**. The community rankings and groupings are discussed in more detail with option descriptions in Appendix C. The remaining areas that are not ranked as potential central sewer service areas could be developed as smaller collection and treatment zones or allowed to develop as currently regulated. The advantages of a centralized system with community plants include:

- Centralized systems provide for better wastewater treatment and reduction of nutrient loadings.
- The unit cost per gallon of treated wastewater is lower for larger plants versus smaller plants.
- Larger plants require less staff for operation and maintenance per gallon of treated wastewater.
- Larger plants tend to be more reliable with respect to final effluent quality and are less likely to be upset by varying flows and treatment loadings.
- Larger plants have the staffing necessary to effectively accomplish reuse water treatment for irrigation purposes.
- Community or subregional plants and their collection systems tend to eliminate the use of septic tanks and stop the proliferation of package plants.

The disadvantages of the centralization of collection and treatment facilities for the Florida Keys include:

- Requires the public to eliminate septic systems and hook-up to sanitary sewer (greater cost and inconvenience)
- Construction and maintenance costs associated with larger wastewater collection systems, including transmission from source, force mains, and lift stations.

B.2.1.3 SUBREGIONAL FACILITIES

Further centralization of collection and treatment can be accomplished by constructing three new subregional facilities in addition to the plant at Key West. Areas served by these facilities are:

Subregional Facility	Proposed Location	Potential Service Areas
Lower Keys (Except Key West)	Upper Sugarloaf	Stock Island, Cow, Key Haven, Boca Chica, Rockland, Big Coppitt, Geiger, Saddlebunch, Upper & Lower Sugarloaf, Cudjoe, Summerland, Ramrod, Torch, No Name, and Big Pine Keys
Middle Keys	Marathon	Knight, Vaca (Marathon), Stirrup, Boot, Fat Deer, Lower and Upper Matecumbe and Windley Keys
Upper Keys	Tavernier	Plantation Key, Lower Key Largo (Tavernier), Key Largo (Dove, Rock Harbor, Tarpon Basin, Largo Sound, Blackwater Sound, N. Key Largo) Port Bouganville to Anglefish, Cape Sable

Table B-1. Ranking of the top 12 Monroe County planning area/enumeration districts (PAED)[a] by population.

Top 12 Population Centers	PAED	Key Areas		1990 R[illegible]sident Population Projection
		LOWER KEYS		
1	NA	City of Key West		24,652
4	4	Cudjoe, Summerland, Ramrod, Torch Keys & No Name Keys		4,983
8	2	Boca Chica, Rockland, Big Coppit & Geiger		3,106
12	3	Saddlebunch, Upper & Lower Sugarloaf		1,786
5	1	Stock Island, Cow & Key Haven		4,541
7	5	Big Pine Key		4,208
	6	Spanish Harbor, Bahia Honda, Ohio, Missouri, Little Duck & Pigeon		441
			SUBTOTAL	42,717
		MIDDLE KEYS		
3	7	Knight, [illegible]s (Marathon), Stirrup & Boot		8,861
	8	Fat De[illegible]luding Coco Plum), Crawl & Little Crawl		697
	9	Grassy		1,086
	10	Duck & [illegible]ch		629
	11	Long & F[illegible]a		356
10	12 & 13	Lower & [illegible]per Matecumbe, Craig & Windley		2,316
			SUBTOTAL	13,945
		UPPER KEYS		
6	14	Plantation		4,405
9	15	Lower Ke[illegible]argo (Tavernier)		2,433
2	16, 17, 18, 19 & 20	Key Larg[illegible]ove, Rock Harbor, Tarpon Basin, Largo Sound & Blackwater Sound)		11,336
11	21	N. Key [illegible]o (Port Bouganville to Angelfish), Cape Sable		1,787
	22	Cross K[illegible]o Dade County Line		61
			SUBTOTAL	20,022
			TOTAL	79,684

NA: Not applicable
[a]Planning Area Analysis/Enumeration District as delineated in Monroe County Year 1020 Comprehebnsive Plan

Areas that might not be included in the three new subregional facilities are Spanish Harbor, Bahia Honda, Ohio, Missouri, Little Duck, Pigeon, Crawl & Little Crawl, Grassy, Duck & Conch, Long & Fiesta, Craig and Cross Key to Dade County Line.

The strong possibility exists that once the Key West WWTP controls and reduces infiltration and inflow to its collection system, it could handle flows from Stock Island to Big Coppitt Key. The sizes and configurations of subregional WWTPs are subject to further planning and study. With any proposed centralization of facilities a certain portion of the population living in outlying and sparsely populated areas would not be served. These remote units would have to rely on OSDSs or package plants for treatment of wastewater.

B.2.2 Treatment Level

The wastewater treatment process is designed to remove solid and organic constituents from raw sewage by physical/chemical and biological means. The essential differences between treatment types are the final product or system effluent. Depending on the proportion of materials removed, treatment processes are generally grouped into one of the following levels:

- **Primary Treatment** — Primary treatment involves the physical removal of solids from the waste stream by screening and sedimentation. Primary treatment physically removes discrete particles (rocks, pebbles, sand, grit, etc.), 35 to 65% of suspended solids, and between 30 to 36% of organic materials. Biological or chemical degradation in primary treatment is usually unintentional and incidental.

- **Secondary Treatment** — Secondary treatment follows primary treatment and generally requires multiple steps involving one biological process and one or more physical processes to remove suspended solids. Secondary treatment removes between 85 to 95% of total organic materials and suspended solids from raw sewage. The actual removal capability of secondary treatment is affected by the type of process units chosen for each application, design of units, hydraulic loading rates, organic loading rates, and system operation. Secondary treatment is more expensive than primary treatment.

- **Irrigation Quality Treatment** — Irrigation quality treatment is used for effluent that will be used to irrigate areas with public access. Additional treatment steps beyond secondary treatment include high-level disinfection and filtration to achieve TSS below 5 mg/L.

- **Advanced Wastewater Treatment (AWT)** — AWT follows secondary treatment and is also referred to as tertiary treatment. The most common applications of tertiary processes are nutrient removal and the removal of soluble phosphorous and nitrogen compounds. The release of treated wastewater containing high concentrations of these compounds to an environment that has little ability to absorb and assimilate them may degrade water quality. Tertiary treatment may involve one or more unit process such as chemical addition, coagulation, sedimentation, filtration, or activated carbon.

  AWT may produce treated water of sufficient purity to be acceptable for discharge directly into surface waters. Standards for AWT are set by law (Section 403.086 Florida Statutes [FS]) in Florida. While AWT standards are very stringent, achieving this level of treatment gives a utility certain legal rights to discharge directly into surface waters. Currently, less than 0.05% of wastewater treatment facilities in the state of Florida meet the AWT treatment standards. AWT is the most expensive method of treatment, because of the additional plant and operations costs. The expense of AWT is dependent on the effluent treatment removal/level desired and the type and amount of pollutants in the influent wastewater stream.

B.2.3 Wastewater Treatment Facilities

B.2.3.1 ON-SITE SEWAGE DISPOSAL SYSTEMS

The OSDS is the most common treatment method used in the Florida Keys. If designed, installed, operated and maintained properly, OSDSs generally treat wastewater to near secondary standards. OSDSs can be categorized into one of the following:

- Cesspits
- Conventional Septic Tanks
- Alternative OSDSs

B.2.3.1.1 Cesspit Systems

Cesspits are used throughout the Florida Keys for domestic wastewater disposal. It is estimated that 5,000 unregulated and unpermitted cesspits exist today. Most of these are unlined and were constructed by cutting or excavating a pit out of the native limestone and covering it with a concrete lid. The sewage is allowed to collect, digest, and seep underground. Liquid waste components are discharged through the porous limestone formations toward outlets typically at shorelines or canals, and solid wastes are retained in the cesspit. Though some pumping of solid wastes from cesspits may occur, it is believed that when solid wastes accumulate to the point where function of the cesspit is impeded, the pit is abandoned and a new one is constructed. Cesspits can be differentiated from outhouses and latrines only because they are connected to indoor plumbing. Cesspits can be considered out-dated for developed districts and environmentally sensitive areas and are not considered an acceptable engineering treatment method for wastewater.

B.2.3.1.2 Conventional Septic Tank Systems

A septic tank system usually consists of a house sewer, a septic tank, a distribution device, and a soil absorption system. The septic tank itself has three functions:

- Solid waste removal (solid wastes settle to the bottom or float at the top of the tank)
- Biological treatment (solid wastes decompose in the tank)
- Solid waste storage (sludge and floating scum accumulations are stored in the tank until proper disposal following pump-outs).

Septic tanks and drainfields typically produce effluents that can be characterized as less than secondary treatment but better than primary treatment. Nutrient removals are highly variable, being dependent on design of the tank and drainfield. Literature values for removal of nitrogen and phosphorous can be overly-optimistic for drainfields in the Florida Keys. Soil type is the primary cause for the differences in the reported values. Typical Florida Keys conditions, including tidal pumping, high groundwater, prevalence of sand/limerock, rainfall patterns and drainage conditions, are not found on the mainland. Because septic tanks themselves provide only minimal treatment, additional components that provide treatment by means of polishing and/or disposal are vital and are integral parts of a properly-functioning treatment/disposal system. These components may include units such as sand filters and soil absorption systems. Factors affecting septic tank performance include tank geometry, hydraulic loading, inlet and outlet arrangements, the number of compartments, temperature, and operation and maintenance practices.

Prior to 1984, the predominant type of OSDS installed in Monroe County was the conventional septic tank with absorption beds. While the use of absorption beds has decreased in recent years, use of conventional systems with elevated absorption beds or mounds has increased as has the use of alternate home aerobic units that utilize drainfields or boreholes. Since 1986, FDHRS has required use of aerobic units where site conditions are not favorable for conventional OSDSs.

Septic tank systems, if properly designed, constructed, and maintained, can be efficient and economical alternatives to centralized wastewater treatment systems when site conditions are favorable and unit densities are low. Table B-2 summarizes effluent concentrations and removal efficiencies for a "typical" septic tank system. Under unfavorable site conditions, such as high septic tank density, high seasonal rainfall, shallow groundwater, or highly permeable soils, OSDSs can be a significant source of nutrient and bacterial groundwater contamination. Studies in the Florida Keys have indicated that virtually 100% of the soils in Monroe County are severely limited for conventional OSDS practices.

In Florida, the most common alternative to the conventional soil absorption system is the mound system. A properly constructed mound system, using acceptable fill material, may be more efficient than an equally well constructed conventional system in marginal or unsatisfactory natural subsurface soils. The objective of the mound system is to effectively treat sewage before it reaches groundwaters or surface waters. This is done by raising the absorption field above natural soils and increasing the distance between the water table and the drainfield by using suitable fill material. Mounds can be used to provide effluent treatment and disposal from a septic tank, aerobic unit, or other treatment unit. Minimum requirements for construction and criteria for the location of mounds are contained in Chapter 10D-6 Florida Administrative Code (FAC).

Mound systems have certain advantages, including:

- Creation of a deeper aerobic zone in which nutrient uptake can occur.
- Leaving a mound, percolating effluent enters the more permeable natural upper soil over a large area and can spread laterally until it is absorbed by the less permeable subsoil (not applicable to the Keys).
- The clogging zone that eventually develops at the bottom of a drainfield may not clog the sand mound fill as rapidly as it would in naturally very fine textured soils (not applicable to the Keys).
- Smearing and compacting, which can occur when excavating wet fine textured subsoils, can be avoided (not applicable to the Keys).

It should be pointed out that FDHRS requires excavation and replacement of natural soils that are not considered suitable for receiving effluent from mound systems. This is because the typical Florida systems are not technically mound systems but, in most cases, are elevated drainfields.

As reported by FDER in the 1988 Wastewater Treatment and Design Manual: "When able to percolate downward through suitable soils, most pollutants are removed from effluents within relatively short distances. If there is insufficient depth of suitable soil between the drainfield and the groundwater table or an impervious layer, the partially treated effluent will enter the groundwater system or flow laterally and break out into surface waters or drainage ditches. Pollutants have been found to travel great distances from their source when aided by the flow of groundwater."

B.2.3.1.3 Alternative On-site Sewage Disposal Systems

Alternative on-site wastewater disposal systems have been developed to enhance or replace the conventional septic tank. Figure B-1 illustrates schematic diagrams of typical alternative OSDS systems. An in-depth discussion of the Alternative OSDS components, design and performance will not be given here. Some of these systems are:

- Aerobic Treatment Units
- Rotating Biological Contractors
- Incinerating Toilets
- Composting Toilets
- Peat Filters
- RUCK Systems
- Recirculating Sand Filters

Table B-2. Typical effluent concentrations from septic tank systems [From Canter and Knox 1985].

Parameters (mg/L)	Septic Tank Effluent	Drainage System Effluent Drain System	Percent Removed from Drain System
Suspended Solids	75	18-53	29-76
BOD_5	140	28-84	40-80
COD	300	57-142	53-81
Total Nitrogen	40	10-78[a]	—
Total Phosphorous	15	6-9	40-60

[a]Reported as ammonia nitrogen

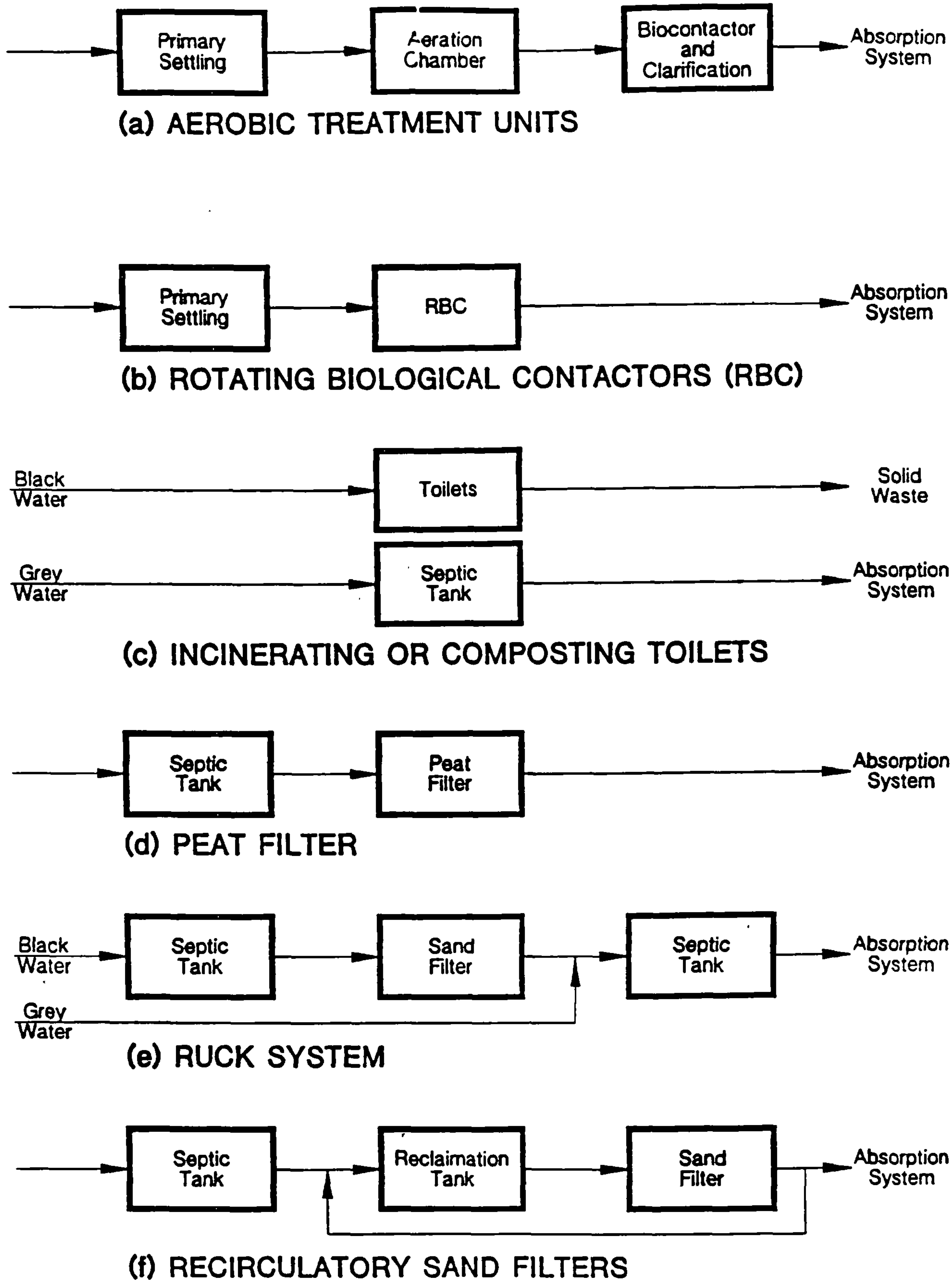


Figure B-1. *Alternative OSDS process schematics.*

Alternative OSDSs produce secondary treated effluents. Some systems use fixed sand filters to improve the quality of typical septic tank effluents. These systems are characterized as advanced secondary treatment. Higher treatment levels have been reported for these systems in studies conducted in controlled areas outside the Florida Keys. A summary of reported nutrient reduction capabilities and costs for selected alternative OSDSs is given in **Table B-3**. Additional information is needed to verify whether any OSDSs can consistently produce nutrient levels below 4 to 6 mg/L in the Florida Keys. The costs to install and operate these systems must be weighed against the costs to build central sewer systems and compared to the appropriate treatment levels.

Wastewater treatment plants can consistently produce AWT quality effluent. It is yet to be demonstrated that OSDSs can produce the same treatment level with the same reliability for less cost per household over extended periods of use in field conditions. The sheer number of existing septic tanks and cesspits argues against their widespread use because of the difficulty in regulating and controlling them to ensure adequate treatment. If installation and operation costs are nearly equal to or greater than those for a centralized system, and OSDS treatment level cannot match that of central WWTPs, OSDS use should be limited to isolated areas.

Aerobic treatment units have been touted as nutrient removal systems that use soil absorption systems or injection wells and are sometimes used in place of conventional septic tanks. Fixed media filters can be used in combination with either septic tanks or aerobic units for providing additional treatment of effluent. Several types of sand filter systems are currently available. The performance of individual aerobic wastewater treatment units generally meet FDER secondary treatment standards, producing effluent having a 30-day average of 20 mg/L for BOD_5, 20 mg/L for total suspended solids (TSS), and a pH range of 6.0 to 9.0. There are no state or federal nutrient reduction requirements for these units.

Alternative OSDSs have been shown to generally provide improved treatment of sewage relative to conventional septic tanks (see **Table B-2 and B-3**). Nitrogen and phosphorous concentrations in wastewater may be reduced through specifically designed systems, but removals are not necessarily guaranteed. Such systems may be used for OSDSs. They must be carefully designed, constructed, operated, and maintained to achieve the desired results. They are inherently more sophisticated and require a substantially higher level of care than conventional OSDSs and small treatment plants.

B.2.3.2 SECONDARY WASTEWATER TREATMENT PLANTS

The most common type of centralized treatment system used in the Florida Keys is the "package plant." These plants range in capacity from 800 GPD to 0.45 MGD. All package treatment plants are required to provide secondary treatment of wastewater. There are 209 permitted package treatment plants operating in Monroe County, 198 of which are in unincorporated parts of the county.

Package treatment plants are regulated by FDER under provisions of Chapter 17-600 FAC, which provides minimum design, waste treatment, and disinfection standards. Wastewater treatment plants permitted for construction after January 1, 1982 and plants existing prior to January 1, 1982 that have had modifications requiring compliance for reclaimed water under 17-600 FAC must be operated by Rules 17-600.440 and 17-600(1) FAC. Treatment plants existing prior to January 1, 1982 must, at a minimum, meet reclaimed water effluent limitations as specified in the facilities permit.

At a minimum, all new domestic facilities and modifications to existing facilities are required to be designed to achieve a 90% removal of BOD_5 and TSS from the wastewater, or to produce an after-disinfection effluent containing not more than 20 mg/L BOD_5 and 20 mg/L TSS, whichever is more stringent.

The activated sludge treatment process, which provides the resident biological organisms with an environment in which they can digest the organic materials contained in the effluent, is the most common process used. Modifications of the activated sludge process include conventional activated sludge, step aeration, contact

Table B-3. Literature values for nutrient reduction capabilities of alternate on-site sewage disposal systems (OSDSs) and estimated retrofitting costs.[a]

Alternate System	Total System Retrofit Cost[b]			Nutrient Removal Ranges[c] (%)
	Initial ($)	20 Year O&M ($)	Total 20 Year ($)	
Rotating Biological Contactors or Aerobic Treatment Units	10,000	8,000	18,000	60-90
Incinerating Toilet	6,500[d]	36,400	42,900	60-90
Composting Toilet	7,500[d]	4,000	11,500	60-90
Peat Filter	4,800	2,000[e]	6,800	30-90
RUCK	9,800	4,000[e]	13,800	40-80
Recirculating Sand Filter	7,400	2,600[e]	10,000	40-70
Recirculating Sand Filter with Anaerobic Filter and Carbon Source	12,300	10,000	22,300	60-95

O&M: Operation and maintenance

[a]Adapted from literature searches, as well as, *Nitrogen* [illegible] *moval On-Site Wastewater Treatment Systems* by WBNERR, Nitrogen Removal Conference, Feburary 1992

[b]Retrofit of existing residential plumbing to separate g[illegible] water and blackwater is assumed to be $2,500 per house. Existing septic tanks are assumed to require no maintenance regardless of desig[illegible] r or age.

[c]Higher values have been reported for systems in othe[illegible] ologic areas with better soil conditions and specifically designed for tightly controlled conditions.

[d]For 2 units—Costs shown assume existing OSDS is u[illegible] for greywater disposal.

[e]Assumed media replacement every 10 years

stabilization, extended aeration oxidation ditches, and sequencing batch reactors. The primary process used by package treatment plants is the extended aeration process, which provides an aeration detention time of at least 24 h.

B.2.3.3 REUSE/IRRIGATION QUALITY-WATER WASTEWATER TREATMENT PLANTS

The reuse of treated wastewater for irrigation purposes is becoming commonplace throughout Florida, and is encouraged by FDER and the South Florida Water Management District (SFWMD). Because potable water is imported from the mainland and groundwater is virtually non-existent, reuse water is the most convenient source of irrigation water in the Florida Keys, especially for golf courses, parks, playgrounds, traffic medians, and other public areas.

Irrigation offers the advantages of conserving potable water supplies while recharging the groundwater system. The technical requirements of Chapters 17-6 and 17-610 FAC govern development, permitting and implementation of reuse projects. Recent revisions to Chapter 17-40 FAC provide for a program of mandatory reuse of reclaimed water. Reuse is required within areas having existing critical water supply problems and in those areas where water supply problems are projected to develop within the next 20 years. The SFWMD is responsible for identifying these areas (such as the Florida Keys) through its management planning process.

Requirements for reuse/irrigation-quality water are:

- A high level of disinfection shall be obtained.
  - Daily sampling for fecal coliforms must occur.
  - At least 75% of the samples shall have no detectable fecal coliform.
  - No sample shall contain more than 25 fecal coliforms/mL.
- TSS shall be less than 5 mg/L.
- Treatment plants cannot be smaller than 0.1 MGD.
- Treatment plants must have Class I reliability.
- An operator must be in attendance during irrigation-quality water discharge from plants.
- Continuous on-line turbidity and disinfectant residual monitors must be in operation.
- Automatic rejection of water not meeting monitored parameters must occur.
- Treatment plants must provide for three-day wet weather storage of effluent.
- Treatment plants having an approved alternate disposal method must provide for one-day storage of rejected water; plants not having another alternate disposal method must provide for up to 30 days of storage.
- Buffer zones, backflow prevention, cross-correction control programs, limited access, groundwater monitoring, etc. for the irrigation system must be provided.

B.2.3.4 ADVANCED WASTEWATER TREATMENT

The following list summarizes possible AWT processes to attain desired pollutant removals.

Pollutant	Unit Process
Suspended solids	Polishing filter beds — microstrainers
Phosphorous	Chemical precipitation — alum, ferric chloride, lime
Nitrogen	Ammonia air stripping by pH adjustment and carbonation; nitrification and denitrification with addition of methanol or other carbon source; breakpoint chlorination; anion/ion exchange (softening) algal ponds
Inorganic salts	Reverse osmosis or membrane softening, electrodialysis
Dissolved solids	Activated carbon filtration (trace organics or ozonation refractory substances)

Within this appendix, AWT will refer only to nutrient (nitrogen and phosphorus) removal. Below are descriptions of AWT schemes which are most commonly used for nutrient removal.

- **Ammonia stripping (air stripping) method —** Lime is added to water to increase its pH. The water is passed through a packed tower into which air is blown, stripping the ammonia out of the water. Recarbonation follows to remove the excess lime.

- **Nitrification and denitrification process —** Bacteria oxidize ammonium ions to nitrate and nitrite in an aeration tank kept at low BOD_5 loading ratios. The nitrites are further oxidized to nitrates, which are then reduced to molecular nitrogen in an anoxic environment.

- **Chemical precipitation of phosphorus —** Common additives used are alum, ferric chloride and lime. Disposal of this additional sludge must be addressed when using chemical precipitation.

B.3 WASTEWATER COLLECTION METHODS

The basic types of collection systems available include gravity sewers, force mains, septic tank effluent pumping (STEP) systems, grinder pump systems, vacuum systems, individual/OSDSs.

B.3.1 Gravity Sewers

A gravity sewer collection system is composed of a network of sewer pipes that collect wastewater from individual establishments and convey it to a central location for treatment. The collection network is generally laid out in a pattern roughly analogous to the branching of a tree. Sewage flow within the network is from the periphery toward the treatment plant. Sewers are identified according to their location within the network Interceptors are defined as sewers that connect directly to and convey sewage to the treatment plant. Trunk mains are defined as sewers that connect directly to and convey to an interceptor.

Gravity sewer systems work best in areas with hilly terrain and low groundwater. For level terrain, pumping systems are required to "lift" wastewater to create additional gravity flow or to convey sewage under pressure. Gravity sewers have very limited use in the Florida Keys because of the region's high groundwater, the high cost of excavation, infiltration problems, and the long distance between many service areas.

B.3.2 Force Mains

Force mains carry wastewater from lift or pumping stations to a treatment plant, another lift station, or another point in the collection system. Practically all wastewater systems in Florida contain force mains because of the relatively flat topography in the state. The use of force mains will be an important tool in conveying wastewater to the point of treatment in any option using community or subregional wastewater systems.

B.3.3 Septic Tank Effluent Pump Systems

Septic tank effluent pump (STEP) systems take advantage of existing on-site equipment and are attached to the downstream side of septic tanks. These systems pump septic tank effluent through a low pressure force main to the point of treatment or to another higher pressure lift station that conveys effluent through a force main to the point of treatment. Advantages of STEP systems are that they do not require modification to household plumbing, require little space, eliminate drainfields, use small diameter piping, reduce organic loading to the treatment plant, and are less expensive to install than gravity sewers. A disadvantage of STEP systems is that they are somewhat maintenance-intensive. They also create septic conditions in collection systems with associated gas, odor, and corrosion problems.

B.3.4 Grinder Pump Systems

Grinder pump systems are similar to STEP systems however, the grinder pump station replaces the septic tank and acts as a small lift station. Sewage is pumped from the holding basin directly into collector force mains. Grinder pump systems usually have higher operating pressures than STEP systems, thus the two cannot be used simultaneously.

Grinder pump systems have further advantages over STEP systems:

- No septic tank and no septage disposal or handling is necessary.
- Force main pressures are higher and there is less likelihood of vapor lock occurring in the mains.
- There is less clogging of pumps by rags and solids.
- Grinder pumps are more heavy-duty and require less maintenance than septic tank effluent system pumps.
- Grinder pumps can be installed inside existing septic tanks.
- Septic conditions in collection systems are reduced.

The disadvantages of grinder pump systems include:

- Higher initial costs for pumps and force mains
- Higher BOD_5 loading to treatment plants
- The requirement for 240 volt service (single phase).

B.3.5 Vacuum Systems

Vacuum systems have been described as curious mixtures of small diameter gravity lines and multiple air lift stations. Vacuum systems depend on a central vacuum source and small diameter collection mains sloped downstream. Numerous short lifts (steps or transport pockets) divide the main into separate gravity sections. A vacuum pressure of 15 to 20 in Hg periodically propels the liquid pockets, called slugs, through the transport lift at a high velocity. The differential pressures and the nature of slugs and gravity flow combine to produce an operating system. The system can be constructed in shallow conditions and around subsurface obstructions.

The advantages of vacuum systems over STEP and grinder pump systems include:

- No pumps are installed on private property.
- STEP and grinder pump systems are replaced with less expensive individual collection valve pits.
- Dissolved oxygen (DO) in the wastewater is higher.
- There is centralized power utilization at vacuum stations.
- Vacuum systems have fewer mechanical components to maintain.

The disadvantages of vacuum systems over STEP and grinder pump systems include:

- Vacuum systems are not very cost effective for smaller, isolated developments.
- Power usage must be borne by a public entity.
- Vacuum systems need more exact grade alignments during installation.
- Vacuum systems require larger line sizes and have higher installation costs.
- There are limitations on allowable lift sizes because of the vacuum pressures available.
- The potential for infiltration is greater.
- Vacuum systems have less tolerance to flows that exceed design capacity.

B.3.6 On-site Sewage Disposal Systems

OSDSs typically serve single residential units. The collection system is typically a gravity sewer discharging into the septic tank. Septic tanks should be inspected every two to three years and pumped out every three to five years. The septage is usually trucked to a wastewater facility for treatment and disposal (or composting).

B.4 EFFLUENT DISPOSAL OPTIONS

Effluent is the treated wastewater that flows out of a treatment plant. Proper effluent disposal is essential to protect surface waters and groundwaters from environmental degradation. Effluent disposal options include:

- Ocean outfalls
- Class V injection wells (boreholes)
- Aquifer storage and recovery (ASR)
- Deep injection wells
- Reuse for irrigation
- Reuse for potable water

On November 12, 1975, Monroe County adopted the following resolutions concerning wastewater treatment in the unincorporated parts of the county:

> "Monroe County or the developer will provide for adequate wastewater treatment in existing and new development."

> "Centralized public treatment facilities will be developed in urbanized areas as economic feasibility is evidenced. The Plan (Land Use Plan Update) will require phasing out of septic tanks and package treatment plants, with hook-ups to these new treatment plants as they become available."

> "In new residential subdivisions where planned densities are sufficient to eventually support a central treatment facility, the use of septic tanks will be permitted only on an interim basis until sufficient development has occurred to permit the installation of the central treatment system by the developer. New developments will be required to strictly conform to county and state design and operating standards for septic tanks and package treatment plants. Development in which private central treatment facilities will be required, will be responsible

for prov ding collection, treatment, and disposal methods that meet design and performance standards established by the county. New development in areas where public central treatment is available will be required to provide collection lines at the developer's expense."

B.4.1 Ocean Outfalls

Because of the Outstanding Florida Waters (OFW) designation in Monroe County, it is very difficult to obtain a new permit from the FDER and Environmental Protection Agency (EPA) to construct an outfall to surface waters to use as a method of effluent disposal. There are currently six wastewater treatment facilities discharging effluent via outfall to surface waters in unincorporated Monroe County.

B.4.2 Class V Injection Wells (Boreholes)

Boreholes range in depth from 60 to 90 ft. These shallow Class V injection wells are used in the county as the prevailing sewage disposal method for centralized systems such as package plants. As reported by the FDER in January 1988, the secondarily treated effluent being disposed of via these injection wells in the Florida Keys is of relatively good quality for disposal into Class G-III groundwater. Though additional monitoring of injection wells by the FDER is scheduled, no violations of the "minimum criteria" for groundwater were found in 20 effluent samples collected by the FDER in 1988. Further, data collected locally by the FDER Marathon district office has shown that effluent disposed of in encased wells will have less effect on surface waters than effluent disposed of in drainfields.

B.4.3 Aquifer Storage and Recovery

ASR is a relatively new technique that involves pumping treated effluent to a confined shallow aquifer (~ 500 ft deep) for future use. The treated effluent forms a "bubble," displacing the native groundwater. The native groundwater is usually saline, so mixing is minimal. Recovery can take place in the future for irrigation use or potable retreatment. The advantage of ASR is that no storage facility needs to be constructed for future use.

B.4.4 Deep Injection Wells

Deep injection wells are large diameter wells (generally 24-36 in) that extend into the boulder zone 2500 to 3000 ft below the land surface. Because of the cavernous nature of the boulder zone, deep injection wells usually have high disposal capacity. Deep injection wells are much more expensive than Class V injection wells (boreholes), and if used as a primary method of effluent disposal, two are required by FDER. Use of deep injection wells for disposal of secondary effluent in the Keys would have to be preceded by geotechnical investigations to assure that effluent discharged to the boulder zone will not impact nearshore waters.

B.4.5 Reuse for Irrigation

Reuse of water through irrigation is preferred over other methods of effluent disposal that do not reuse or conserve the water resource or provide additional treatment (see preceding discussion under **Section B.2: Wastewater Treatment Methods**). The advantages of water reuse for irrigation are:

- Application to land removes nutrients from treated wastewater.
- Pollutant loadings in surface water and groundwater are reduced.

- Groundwater recharge is provided.
- Potable water that might otherwise be used as irrigation water is conserved.

Irrigation reuse potential in the Keys is limited by the number of suitable large-scale application sites available.

B.4.6 Reuse for Potable Water

The reuse of wastewater effluent as a source of drinking water is a viable method of effluent disposal. At present, there are several communities that have potable reuse facilities, but none of any size is located in Florida. The City of El Paso, Texas has been using a 12 MGD potable reuse facility since 1985. Potable reuse requires an intensive, multi-step treatment process, with close monitoring of water quality between treatment units. Advantages of potable reuse include water conservation and the generation of revenues from sale of potable water.

APPENDIX C

Engineering Options for Domestic Wastewater Collection, Treatment, and Disposal

ENGINEERING OPTIONS FOR DOMESTIC WASTEWATER COLLECTION, TREATMENT, AND DISPOSAL

C.1 ENGINEERING DEMONSTRATION OPTIONS

Two engineering demonstration options are proposed, one to evaluate alternative (nutrient removal) on-site disposal systems (OSDSs) and the other to evaluate the replacement of OSDSs with advanced water treatment (AWT) wastewater treatment plants (WWTPs). The purpose of these demonstration projects is to evaluate the effectiveness of these technologies on a small scale prior to implementing them on a large scale.

C.1.1 Option W1 — Alternate On-site Sewage Disposal System Demonstration Project

C.1.1.1 DESCRIPTION

Three to six of the most promising systems should be selected and then installed according to manufacturer's specifications. The systems should be maintained for a period of at least one year by contractors currently performing these services. The level of maintenance should be no greater than that normally given these systems and the manufacturer's involvement should be limited to input requested for specific problems that are identified. Monitoring should be conducted or supervised by Florida Department of Health and Rehabilitative Services (FDHRS) personnel and should include characterization of the influent and effluent waste streams and monitoring of background (if feasible) and downgradient groundwater quality. Influent and effluent characterization should use multiple composite sampling of single-day use periods (16 to 18 h) and may require special collecting chambers and pumps. Parameters analyzed should include all forms of nitrogen and phosphorus, BOD_5, total suspended solids (TSS), pH, and fecal coliform. The market potential for an effective system may encourage manufacturers to participate in sharing the costs of installing the demonstration systems.

C.1.1.2 RATIONALE

At present there are no alternate OSDSs that have been proven to attain consistently high nutrient reduction levels over the long term in soils of the Florida Keys. To evaluate what role alternative OSDSs should play in overall wastewater treatment strategies for the Keys, a long-term evaluation of their nutrient removal capabilities in typical Keys installations should be performed.

C.1.1.3 COST

The cost of a one-year OSDS demonstration project is estimated to be $35,000 per system. This cost includes installation of the system and peripheral sampling devices, monitoring wells, sampling and analyses, and data interpretation and synthesis. The total cost for evaluating three to six alternate OSDSs is estimated to be $105,000 to $210,000.

C.1.2 Option W2 — Advanced Wastewater Treatment Demonstration Project

C.1.2.1 DESCRIPTION

A relatively compact subdivision or portion of a subdivision currently using an OSDS for wastewater disposal would be selected. Areas where degraded water quality in nearshore or confined waters has been identified and where OSDS use is suspected to be a primary cause of degraded water quality should be given priority consideration. Wastewater from individual residences would be collected with septic tank effluent pump systems (STEP) stations and pumped to one or more intermediate lift stations. If an appropriate site is available, the reuse of wastewater for irrigation should be considered for effluent disposal. Boreholes would be used for effluent disposal if an appropriate reuse site cannot be found. Monitoring should include 24-h composite characterization of WWTP influent and effluent on a regular basis, background and downgradient groundwater monitoring, and monitoring of confined surface waters adjacent to areas of formerly heavy septic tank use (e.g., dead-end canals). Parameters analyzed should include all forms of nitrogen and phosphorus, BOD_5, TSS, pH, and fecal coliform. Most facilities constructed in this demonstration project could be incorporated into a larger system in the future.

C.1.2.2 RATIONALE

Data linking OSDS use to degradation of nearshore water quality are very limited. A demonstration project involving replacement of OSDSs with a package AWT plant and monitoring of its performance will provide valuable information regarding the practicality and benefits of utilizing AWT package plants.

C.1.2.3 COST

The cost of an AWT demonstration project will be highly dependent on the site selected and size of the system installed. The total cost of a 5,000 to 10,000 gallons per day (GPD) system is estimated to be $350,000 to $700,000.

C.2 OPTIONS FOR AREAS OUTSIDE THE CITY OF KEY WEST

Engineering options described in this Appendix use methods or groups of methods discussed in Appendix B to address sources of wastewater pollution throughout the FKNMS. A wide range of options is considered for each category of pollution sources. Options generally are listed in order of increasing level of effort and cost of implementation.

Discussions of options in this Appendix address the City of Key West separately from the rest of Monroe County. The City of Key West Comprehensive Plan indicates that the City's WWTP is currently providing a high level of secondary treatment and has adequate capacity to serve that area well beyond 2010. The city is extending service to all incorporated areas, eliminating OSDS and package plant use. Because of the program being implemented to reduce the unusually high infiltration and inflow, the existing WWTP will have excess capacity through the Year 2010. Because of these circumstances, the only engineering options considered for wastewater within the City of Key West are upgrades in effluent disposal. Consideration is given to using excess capacity at the City of Key West WWTP to treat wastewater from Planning Area Analysis/Enumeration Districts (PAEDs) 1 and 2 (Stock Island to Big Coppitt Key).

The remaining seven options address wastewater collection and treatment in all Monroe County areas outside the City of Key West, including the Cities of Layton and Key Colony Beach. The City of Key Colony Beach owns and operates a wastewater collection and treatment system. Some, or most, of the Key Colony Beach facilities may be incorporated into community or subregional facilities associated with proposed engineering options. However, because of the relatively small size of the Key Colony Beach system (0.175 million gallons per day [MGD]), it should not be a significant factor in the cost of developing a community or subregional wastewater collection and treatment system. Options considered for unincorporated Monroe County areas include upgrading existing OSDSs and package plants to current FDHRS and Florida Department of Environmental Regulation (FDER) standards or to nutrient removal/AWT levels, constructing community systems in Marathon and Key Largo and using the excess capacity of City of Key West wastewater treatment plant to serve PAEDs 1 and 2, constructing seven community systems to serve 73% of total wastewater flows, constructing 12 community systems to serve the entire area, or constructing three subregional systems to serve the entire area.

New WWTPs using effluent disposal options that the have potential for discharge to nearshore waters (boreholes), or effluent disposal options requiring high-quality water for potable reuse are assumed to incorporate AWT for nitrogen and phosphorus removal in the treatment process. Where effluent disposal methods have little or no potential for discharge to nearshore waters (e.g., deep injection wells or irrigation use out of the Florida Keys), secondary treatment is assumed to be used. For the purpose of determining reductions in nutrient loading by increasing treatment levels to AWT, it was assumed that all AWT plants produced effluent with a maximum of 6 mg/L total nitrogen and 4 mg/L total phosphorus.

PAEDs, as delineated in the Monroe County Year 2010 Comprehensive Plan, are used to estimate potential service areas for wastewater collection and treatment systems. Where PAEDs are in close proximity and not separated by long bridge crossings (e.g., Key Largo area and Upper/Lower Matecumbe), they are aggregated into single "communities." **Table C-1** shows wastewater flows for these population centers and the rankings of these centers by population and by wastewater flow.

C.2.1 Option W3a — Upgrade Existing Systems to Current Standards

C.2.1.1 DESCRIPTION

This option consists of identifying all non-complying OSDSs and package WWTPs and retrofitting or upgrading these facilities to meet current standards. Specific components of this option are:

- Continue present level of OSDS use, but bring all systems into compliance with FDHRS current standards. This would require an extensive OSDS inspection and evaluation program.
- Continue package plant use for individual developments that require them under current regulations and bring all existing plants into compliance with FDER regulations for secondary treatment under 1992 standards.
- Initiate an aggressive program for the identification and elimination of all cesspits.

C.2.1.2 RATIONALE

The rationale for selecting Option W3a would be that if existing substandard wastewater systems are upgraded to current FDHRS or FDER standards, a significant, cost-effective improvement in water quality over the "No Action" option would occur. Additionally, a judgment would have to be made that this level of improvement in water quality would contribute to acceptable long-term water quality conditions within the FKNMS. Additional monitoring and studies will be required to select this option.

C.2.1.3 POLLUTION REDUCTION

Nutrient reductions associated with this option are summarized in **Table C-2**. The overall effectiveness of the option would be limited because of continued widespread OSDS and cesspit use. The greatest amount of pollutant loading reduction would result from elimination of cesspits and retrofitting these facilities with FDHRS-permitted OSDSs. Lowering total nitrogen and phosphorus from raw sewage levels currently entering cesspits to levels attained by proper OSDS treatment would reduce total man-induced (wastewater and stormwater) nitrogen and phosphorus loadings to the FKNMS by an estimated 5% and 10%, respectively.

Nutrient loading reductions from upgrading non-complying OSDSs and package WWTPs cannot be estimated with any certainty. Because there are only a small number of non-complying FDER-permitted package WWTPs, upgrading these few facilities would provide local benefits but would not have a significant impact on overall nutrient loadings to the FKNMS. The number of non-complying OSDSs is not known and cannot be determined without an extensive inspection and evaluation program. If it is assumed that 25% of existing OSDSs are deficient

Table C-1. Average daily flow for Florida Keys wastewater facilities (1991-1992).

PAED[a]	Key Areas	WWTP Surface Water Discharge (MGD)	WWTP Ground Water Discharge (MGD)	OSDS (MGD)	Cesspits (MGD)	TOTAL (MGD)	Rank	
							Population	F
	LOWER KEYS							
NA	City of Key West	6.558	0.294	0.013	0.005	6.870	1	1
1	Stock Island, Cow & Key Haven	0.017	0.138	0.522	0.109	0.786	5	4
2	Boca Chica, Rockland, Big Coppit & Geiger	0.131	0.145	0.357	0.074	0.707	8	6
3	Saddlebunch, Upper & Lower Sugarloaf	0.033	0.023	0.205	0.043	0.304	12	12
4	Cudjoe, Summerland, Ramrod, Torch Keys & No Name Keys		0.041	0.459	0.095	0.595	4	8
5	Big Pine Key		0.020	0.484	0.101	0.605	7	7
6	Spanish Harbor, Bahia Honda, Ohio, Missouri, Little Duck & Pigeon		0.049	0.051	0.011	0.111	16	17
	SUBTOTAL	6.739	0.710	2.091	0.438	9.978		
	MIDDLE KEYS							
7	Knight, Vaca (Marathon), Stirrup & Boot	0.002	0.251	1.019	0.212	1.484	3	3
8	Fat Deer (including Coco Plum), Crawl & Little Crawl	0.175	0.020	0.081	0.017	0.293	14	13
9	Grassy		0.012	0.125	0.026	0.163	13	15
10	Duck & Conch	0.045	0.045	0.072	0.015	0.177	15	
11	Long & Fiesta	0.031	0.065	0.041	0.009	0.146	17	
12 & 13	Lower & Upper Matecumbe, Craig & Windley	0.004	0.134	0.266	0.055	0.459	10	10
	SUBTOTAL	0.257	0.527	1.604	0.334	2.722		
	UPPER KEYS							
14	Plantation	0.002	0.199	0.507	0.105	0.733	6	5
15	Lower Key Largo (Tavernier)		0.144	0.280	0.058	0.482	9	9
16, 17, 18, 19 & 20	Key Largo (Dove, Rock Harbor, Tarpon Basin, Largo Sound & Blackwater Sound)		0.582	1.306	0.272	2.160	2	2
21	N. Key Largo (Port Bouganville to Angelfish), Cape Sable		0.178	0.205	0.043	0.426	11	11
22	Cross Key to Dade County Line		0.001	0.007	0.002	0.010	18	18
	SUBTOTAL	0.002	1.104	2.305	0.480	3.811		
	TOTAL	6.998	2.341	6.000	1.252	16.511		
	TOTAL FLOW: 6 Community WWTPs[b]	0.152	1.335	4.195	0.873	6.475		
	TOTAL FLOW: 12 Community WWTPs[c]	0.364	1.875	5.691	1.184	9.03		

NA: Not applicable
[a]Planning Area Anlaysis/Enumeration district as delineated in Monroe County Year 2010 Comprehensive Plan
[b]Calculated using flows from Key areas ranked 2 through 7
[c]Calculated using flows from Key areas ranked 2 through 13

Table C-2. Estimated costs and nutrient loading reductions for wastewater Options W3a, W3b and W3c: Upgrade existing systems to current or higher treatment standards.

Effluent Disposal Options	N Reduction[a] (%)	P Reduction[a] (%)	Estimated Cost				Cost Effectiveness[f]	
			Initial[b] ($ millions)	20 Year O&M[c] ($ millions)	Total 20 Year[d] ($ millions)	20 Year per Connection[e] ($)	TN	TP
OPTION W3a: Upgrade existing systems to current standards	10	17	42	0	42	1,000-5,000	4.2	2.5
OPTION W3b: Upgrade OSDS to Current Standards and Upgrade Package Plants to AWT	27	24	56	8	64	1,000-5,000	2.7	1.1
OPTION W3c: Upgrade Package Plants to AWT and Upgrade OSDS to Alternate, Nutrient-Removing Systems	57	43	306	240	546	2,200-18,000	10	13

O&M: Operation and maintenance

[a]Reduction shown is for man-induced loading, including domestic wastewater, live-aboards, and stormwater from developed areas. Stormwater loads from undeveloped areas, atmospheric deposition, or other nonpoint sources are not included.

[b]Initial costs include land acquisition, initial WWTP construction, WWTP capacity increases to serve 20-year demands, and construction of all collection systems.

[c]Costs include labor, administration, repair/replacement, power and chemicals.

[d]Present worth only; no financing costs included

[e]Cost shown is for present worth of single 250 GPD service connection share of the total cost.

[f]Cost Effectiveness = Total Cost/Percent of Nutrient Removal

and that retrofitting will result in a 50% decrease in nutrient loadings for those systems, an overall reduction of 4% in nutrient loadings to the FKNMS would be realized. Adding this estimated reduction to that estimated for the replacement of cesspits with OSDSs would yield an overall reduction in total nitrogen and phosphorus loadings of 10% and 17%, respectively. Although this is a rough estimate, it is probably reasonable for Option W3a.

C.2.1.4 COST

The cost of this option is difficult to estimate. The number of substandard systems or actual number of cesspits cannot be known until an extensive inspection program is completed. To provide a reasonable order-of-magnitude estimate for this option, the following assumptions were made:

- 5,000 cesspits would be replaced with OSDSs at an average cost of $5,000 each
- 25% of the 24,000 OSDSs would require retrofitting at an average cost of $2,500 each
- 40 package WWTPs would require upgrades at an average cost of $50,000 each

The above assumptions yield an estimated implementation cost of $42 million for this option. This estimate does not include costs for regulatory agencies to implement additional programs, such as the inspection program that would presumably be undertaken by FDHRS. It also does not include operation and maintenance costs, which should not increase significantly over existing costs. Costs and pollution reductions associated with all options under Option W2 are shown in Table C-2.

C.2.1.5 IMPLEMENTATION SCHEDULE

A proposed implementation schedule for Option W3a is shown in Figure C-1. This schedule represents a fast-track, but reasonable approach toward implementation.

C.2.1.6 AFFECTED ENTITIES

Entities that would be affected by this option include owners of non-complying systems and the agencies responsible for enforcing compliance. Property owners with non-complying systems would be faced with expenses in the $2,000 to $3,000 range for upgrading an OSDS or in the $4,000 to $6,000 range for replacing a cesspit with a permitted OSDS. These costs would be significantly higher for owners of larger commercial systems.

Regulatory agencies affected by this option include the FDER, FDHRS, and possibly Monroe County. The FDER is responsible for regulatory compliance of package WWTPs and is currently pursuing non-complying facilities. The FDER is also responsible for permitting boreholes (Class V injection wells) used in conjunction with commercial aerobic OSDSs. Some increase in FDER staff within the Florida Keys may be necessary to effectively implement this option.

The FDHRS is responsible for OSDS permitting. Under this option, FDHRS would presumably be responsible for the identification and inspection of suspected non-complying systems. In addition to establishing the authority to make these inspections, FDHRS staff in the Florida Keys would have to be increased significantly to implement the inspection program. Monroe County may become involved in this option if county regulations or programs are established for identifying and requiring the retrofitting of non-complying systems.

C.2.1.7 ENVIRONMENTAL EFFECTS

The environmental effects associated with implementing this option would be limited to temporary disturbance of small areas associated with package WWTP or OSDS upgrading or replacement. Adverse water quality effects

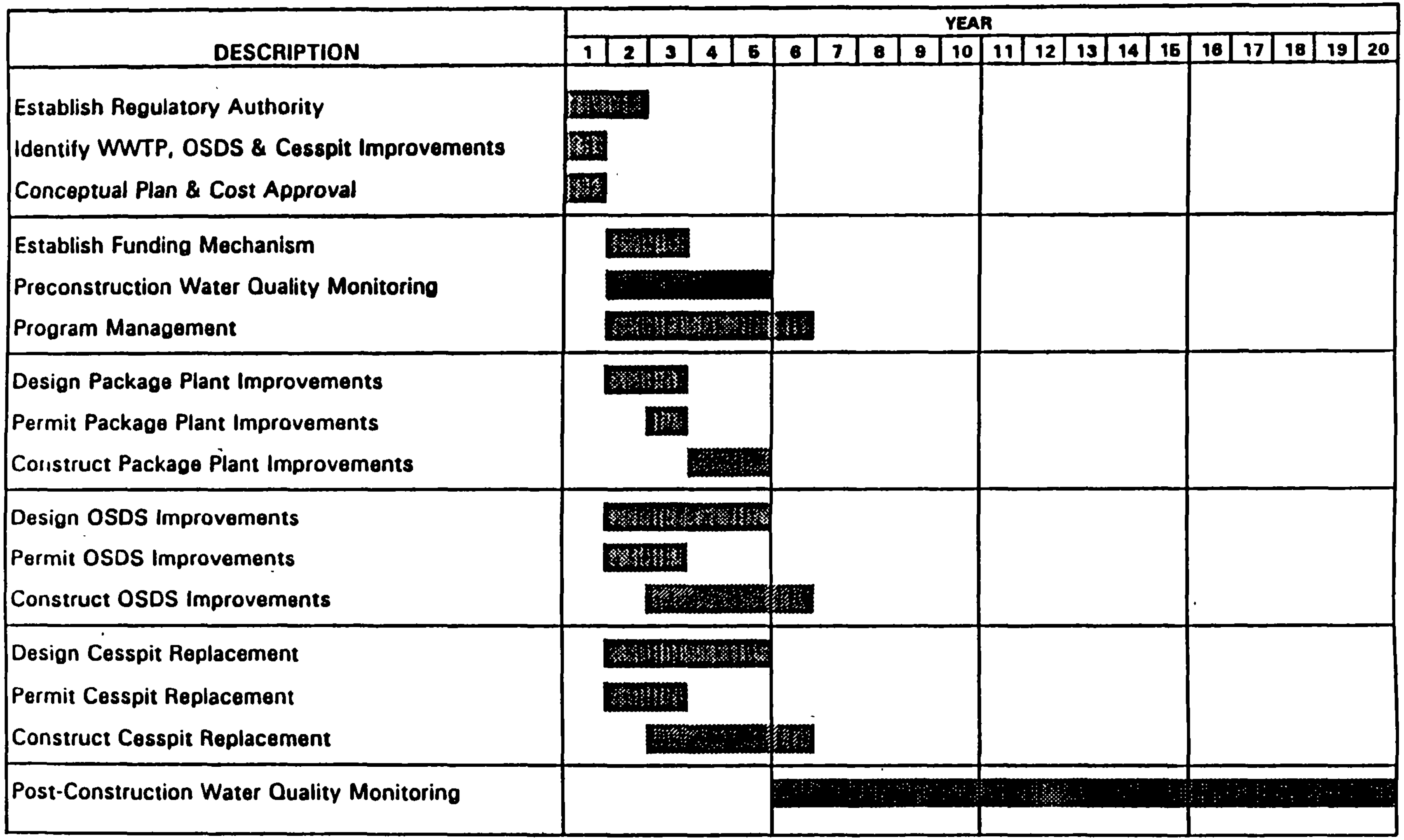


Figure C-1. Implementation schedule for Wastewater Option W3a: Upgrade existing facilities.

could be minimizec by following proper construction practices and by stabilizing disturbed areas immediately after completing an installation. No significant adverse environmental effects are anticipated with this option.

C.2.1.8 ADDITIONAL MONITORING

If this option is selected, monitoring programs should be designed to provide a greater understanding of:

- The effects of widespread use of boreholes for effluent disposal on nearshore water quality, shallow nearshore bottom habitat, and coral reef systems
- The effects of the City of Key West WWTP ocean outfall on nearshore water quality, offshore water quality, shallow nearshore bottom habitat, and coral reef systems
- The relative contribution of stormwater, wet and dry atmospheric deposition, and other nonpoint sources toward nutrient loading to waters of the FKNMS

C.2.2 Option W3b — Upgrade On-site Sewage Disposal Systems to Current Standards and Upgrade Package Plants to Advanced Wastewater Treatment

C.2.2.1 DESCRIPTION

Option W3b consists of identifying all non-complying OSDSs and package WWTPs and upgrading substandard OSDSs to current standards and package WWTPs to AWT. Specific components of this option are:

- Continue the present level of OSDS use, but bring all systems into compliance with current standards of the FDHRS. This would require an extensive OSDS inspection and evaluation program.
- Continue package plant use for individual developments which require them under current regulations and bring all existing and future plants into compliance with FDER AWT standards.
- Initiate an aggressive program for the identification and elimination of all cesspits.

C.2.2.2 RATIONALE

The rationale for selecting Option W3b would be that if existing substandard OSDS systems are upgraded to current HRS standards and all package plants are upgraded to FDER AWT standards, a significant and cost-effective improvement in water quality over that attained by Option W3a would occur. Additionally, a judgement would be made that this improvement in water quality would contribute to acceptable long-term water quality conditions within the FKNMS. Additional monitoring and studies will be required to select this option.

C.2.2.3 POLLUTION REDUCTION

Upgrading package WWTPs to AWT under this option would provide significant additional nutrient reduction. Package WWTPs represent about 27% of present total wastewater flows in the Florida Keys (excluding Key West). AWT would reduce total nitrogen from the 40 mg/L range to less than 6 mg/L and would reduce total phosphorus from about 8 mg/L to less than 4 mg/L. applying these reductions to 27% of total wastewater flows for Monroe County, total nitrogen and phosphorus loadings to the FKNMS would be reduced by 17% and 7%, respectively, over reductions attained by Option W3a. This would result in estimated Sanctuary-wide total nitrogen and phosphorus reductions of 27 and 24 percent, respectively, as shown in Table C-2.

C.2.2.4 COST

The cost of retrofitting a package plant for AWT is relatively high; often as high as the original cost of the entire plant. A unit cost of $6.00 per gallon of wastewater treated was assumed for retrofitting to package plants to AWT. Cost estimates for Option W3b are shown in **Table C-2.**

C.2.2.5 IMPLEMENTATION SCHEDULE

A proposed implementation schedule for Option W3b is shown in **Figure C-2.** This schedule represents a fast-tract, but reasonable approach toward implementation.

C.2.2.6 AFFECTED ENTITIES

Entities affected by this alternative would be the same as those affected by Option W3a. Residents or commercial facilities served by package WWTPs would be impacted more than under Option W3a if users of the system share in the cost of AWT upgrades.

C.2.2.7 ENVIRONMENTAL EFFECTS

The environmental effects of Option W3b would be nearly the same as those listed for Option W3a. These effects would be limited to temporary disturbances of small areas associated with package WWTP or OSDS upgrading or replacement. Slightly larger areas would be impacted as a result of additional treatment units required for AWT upgrades to package WWTPs.

C.2.2.8 ADDITIONAL MONITORING

Before Option W3b is considered, the proposed AWT Demonstration Project (Option W2) should be implemented. Data acquired during the AWT demonstration project would be useful in determining whether upgrading package WWTPs to AWT will provide significant, cost-effective benefits with regard to confined or near-shore water quality. In addition to implementing Option W2, monitoring programs should be designed to provide a greater understanding of:

- The effects of widespread use of boreholes for effluent disposal on nearshore water quality, shallow nearshore bottom habitat, and coral reef systems
- The effects of the Key West WWTP ocean outfall on nearshore water quality, offshore water quality, shallow nearshore bottom habitat, and coral reef systems
- The relative contribution of stormwater, wet and dry atmospheric deposition, and other nonpoint sources toward nutrient loading to waters of the FKNMS

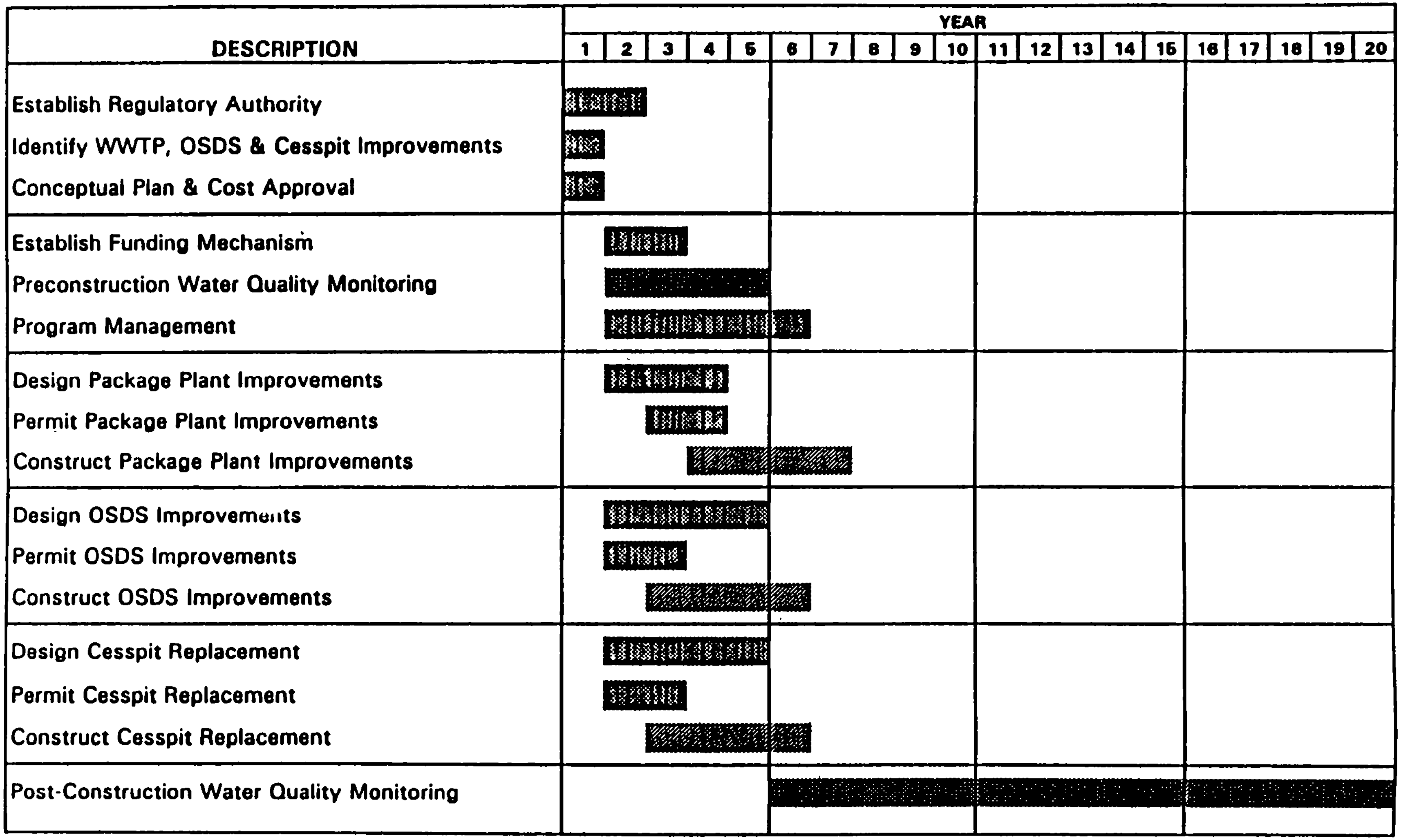


Figure C-2. Implementation schedule for Wastewater Option W3b: Upgrade OSDSs to current standards and package WWTPs to AWT.

C.2.3. Option W3c — Upgrade On-site Sewage Disposal Systems to Alternate, Nutrient-Removing Systems and Upgrade Package Plants to Advanced Wastewater Treatment

C.2.3.1 DESCRIPTION

Option W3c consists of identifying all non-complying OSDSs and package WWTPs and upgrading substandard OSDSs to nutrient-removal systems and package WWTPs to AWT standards. Specific components of this option are described:

- Continue present level of OSDS use, but retrofit all systems to alternate, nutrient-removal systems. This would require an extensive OSDS inspection and evaluation program.
- Continue package plant use for individual developments that require them under current regulations and bring all existing and future plants into compliance with FDER AWT standards.
- Initiate an aggressive program for the identification and elimination of all cesspits.

C.2.3.2 RATIONALE

The rationale for selecting Option W3c would be that if existing package WWTPs are upgraded to AWT standards and all OSDSs are upgraded to nutrient-removal systems, a significant and cost-effective improvement in water quality over that attained by Option W3b would be achieved. Additionally, a judgement would be made that this improvement in water quality would contribute to acceptable long-term water quality conditions within the FKNMS. Additional monitoring and studies will be required to select this option.

C.2.3.3 POLLUTION REDUCTION

Independent evaluations of aerobic systems such as the RUCK®, Klargester®, Multi-Flow®, or Norweco® systems indicate nutrient reductions in the 30% to 90% range for total nitrogen. Phosphorus removal can be accomplished with most of these systems and removals as high as 95% are claimed by manufacturers. These high nutrient reduction rates have not been documented for systems in use in the Keys. In order to achieve the higher end of nutrient reduction ranges, most of these systems must be upgraded and costs are increased accordingly. Replacing all OSDSs in the Florida Keys with alternative nutrient removal OSDSs would reduce total nitrogen and phosphorus loading to the FKNMS by about 30% and 19%, respectively, over the reductions attained by Option W3b. This would result in estimated Sanctuary-wide, man-induced total nitrogen and phosphorus reductions of 57% and 43 %, respectively, as shown in **Table C-2.**

C.2.3.4 COST

The cost of retrofitting package plants to AWT is estimated at $6.00 per gallon of wastewater treated. Alternate, nutrient-removal systems range in cost from $6,000 (if substantial portions of the existing OSDS are used) to $15,000. The system(s) used would depend on outcome of the OSDS demonstration project. To estimate costs for this option, a mid-range initial cost of $10,000 per system was used. Current contract operating costs for these systems are about $400 per year. A summary of estimated costs for Option W3c based on these assumptions is shown in **Table C-2.**

C.2.3.5 IMPLEMENTATION SCHEDULE

A proposed implementation schedule for Option W3c is shown in Figure C-3. This schedule represents a fast-track, but reasonable approach toward implementing this option.

C.2.3.6 AFFECTED ENTITIES

Entities affected by this alternative are similar to those listed for Option W3a, but the effects will be much more widespread. Virtually all residential and commercial wastewater facilities would be required to undergo expensive upgrades, with a good portion of the cost presumably borne by the system owners. Regulatory agencies with responsibility for implementing this option (FDER for package plants and FDHRS for OSDSs) would require substantial staffing increases. Monroe County would most likely be affected also, depending on the role the County assumes in implementing this option.

C.2.3.7 ENVIRONMENTAL EFFECTS

The environmental effects of Option W3c would consist primarily of temporary disturbances to all areas served by OSDSs during retrofitting or replacement with nutrient-removal systems. Because of the number of individual sites affected (nearly 24,000), these numerous disturbances would have potential for elevating sediment levels in nearshore waters. Construction impacts could be minimized by controlling runoff on construction sites and stabilizing construction areas upon completion. Package plant AWT upgrades would affect somewhat larger sites, but because of the smaller number of package plants, the overall impact should be considerably less than OSDS retrofitting.

C.2.3.8 ADDITIONAL MONITORING

Prior to considering Option W3c, the proposed AWT Demonstration Project (Option W2) and the proposed OSDS Demonstration Project (Option W1) should be implemented. Data acquired during the AWT Demonstration Project would be useful in determining whether upgrading package WWTPs to AWT will provide significant, cost-effective benefits with regard to confined or near-shore water quality. The OSDS Demonstration Project is necessary to determine whether alternate, nutrient-removal OSDS(s) are available that will achieve long-term, consistent nutrient reduction in soils of the Keys. This project will provide nutrient removal data that can be used to compare OSDS nutrient removal and costs with package AWT WWTP or community AWT WWTP nutrient removals and costs. In additional to implementing Options W1 and W2 demonstration projects, monitoring programs should be designed to provide a greater understanding of:

- The effects of widespread use of boreholes for effluent disposal on nearshore water quality, shallow nearshore bottom habitat, and coral reef systems
- The effects of the City of Key West WWTP ocean outfall on nearshore water quality, offshore water quality, shallow nearshore bottom habitat, and coral reef systems
- The relative contribution of stormwater, wet and dry atmospheric deposition, and other nonpoint sources toward nutrient loading to waters of the FKNMS

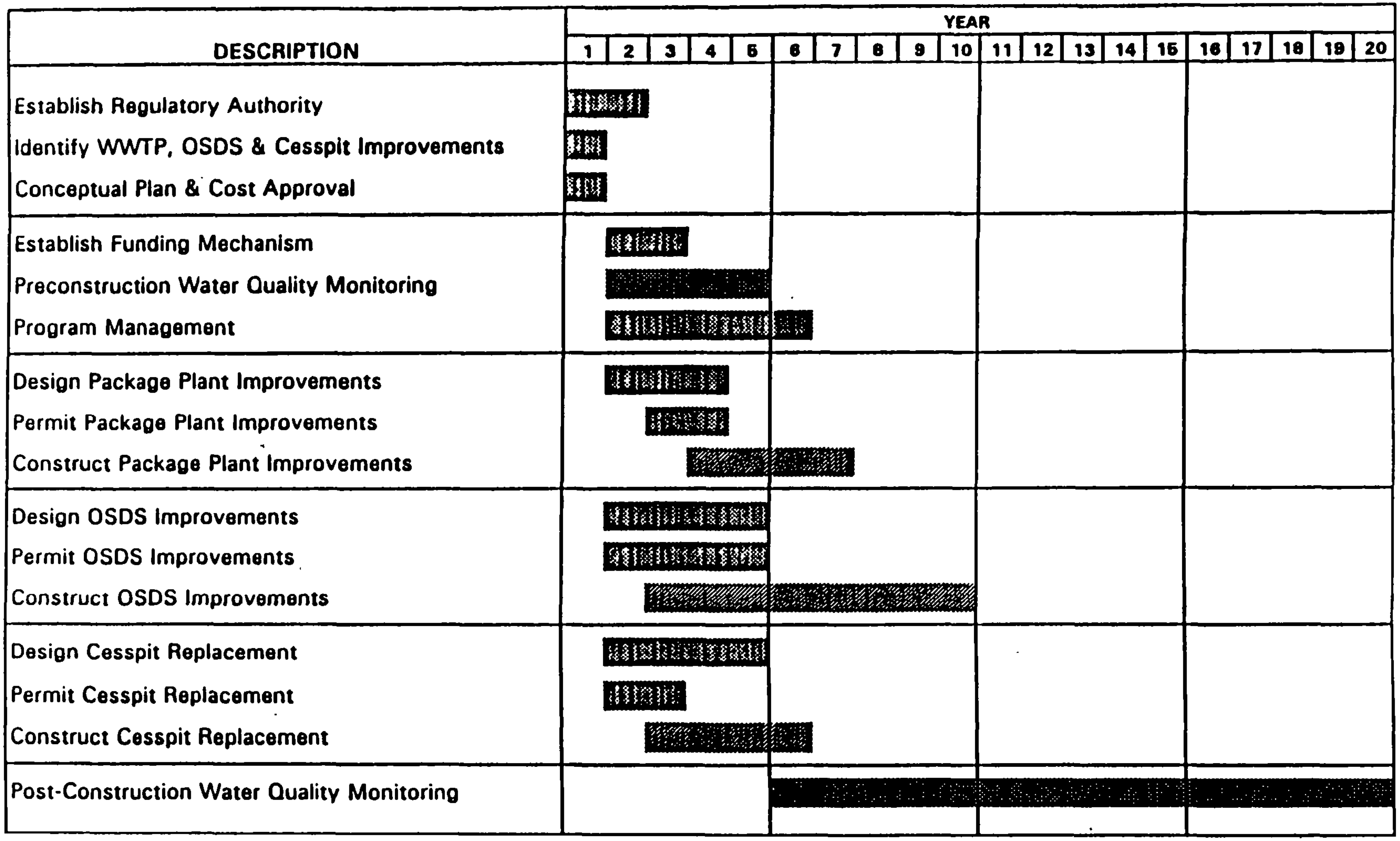


Figure C-3. Implementation schedule for Wastewater Option W3c: Upgrade OSDSs to alternate, nutrient-removing systems and package WWTPs to AWT.

C.2.4 Option W3d — Construct Two Community Wastewater Systems for Marathon and Key Largo and Use Excess Capacity of Key West Wastewater Treatment Plant in Lower Keys

C.2.4.1 DESCRIPTION

Option W3d involves the construction of two community wastewater collection and treatment systems to serve the Marathon and Key Largo areas. A wastewater collection system would be constructed in the lower Keys to serve areas from Key West to Big Coppitt Key and convey these flows to the City of Key West WWTP. This option would provide AWT for 52% of wastewater flows outside the City of Key West. Essential features of this option are:

- Construct two community wastewater collection systems and AWT WWTPs to serve the Marathon and Key Largo areas (PAED 7 and 16-20, respectively). Use STEP Systems to replace drainfields for residences currently served by septic tanks.
- Continue an infiltration/inflow reduction program for City of Key West WWTP on an accelerated schedule.
- Construct a community wastewater collection system serving all areas between Key West WWTP service area and east end of Big Coppitt Key (PAED 1 & 2). Utilize STEP system in areas presently served by septic tanks. This wastewater flow would be conveyed to the City of Key West WWTP for treatment.
- Use aquifer storage for effluent disposal at Key West; use boreholes for effluent disposal at Marathon and Key Largo.
- Continue OSDS/package plant use in all areas outside subregional plant service areas. Upgrade all existing OSDSs and package plants to meet current regulations.
- Initiate an active program for the identification and elimination of all cesspits. Development using cesspits would either be served by OSDSs/package plants or community WWTPs, depending on location.
- Collection system suboptions:
  (a) Grinder pump system transmission from source
  (b) Vacuum system collection from source
- Effluent disposal suboptions:
  (a) Aquifer storage (all three systems)
  (b) Deep well injection (reduce treatment level to secondary)
  (c) Reuse for potable water with aquifer storage and recovery
  (d) Reuse for irrigation (reduce treatment level to secondary/irrigation quality)

Service areas for the three community wastewater systems are shown in Figures C-4 through C-6. Cost estimates for Option W3d assume 100% connection of wastewater flows within the PAEDs served. There may be a small number of residences in outlying areas within the PAEDs served that may not be practical to connect to the community wastewater system. Continued service by existing or upgraded OSDSs to the small number of outlying residences will not significantly impact nutrient removal or cost estimates.

C.2.4.2 RATIONALE

According to the City of Key West Comprehensive Plan (Tables IV-7 and IV-8), the Key West WWTP will have 0.4 MGD excess capacity in 1995 and 1.9 MGD excess capacity in 2010. The projected increases in excess capacity allow for increases in sanitary flows and are created by reducing infiltration and inflow to the WWTP.

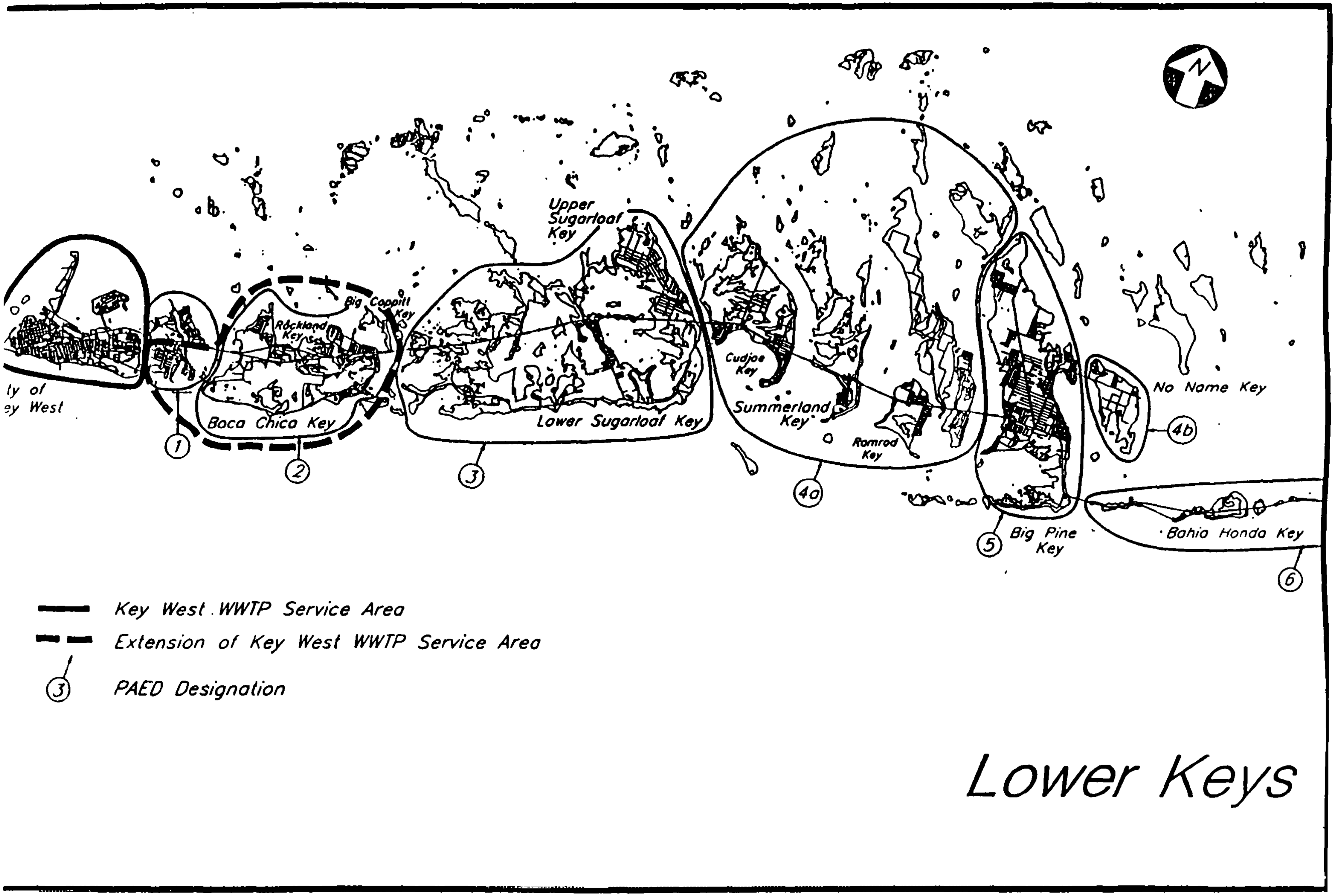


Figure C-4. Wastewater Option W3d: Construct two community WWTPs - Lower Keys (Scale: 1" = 6000').

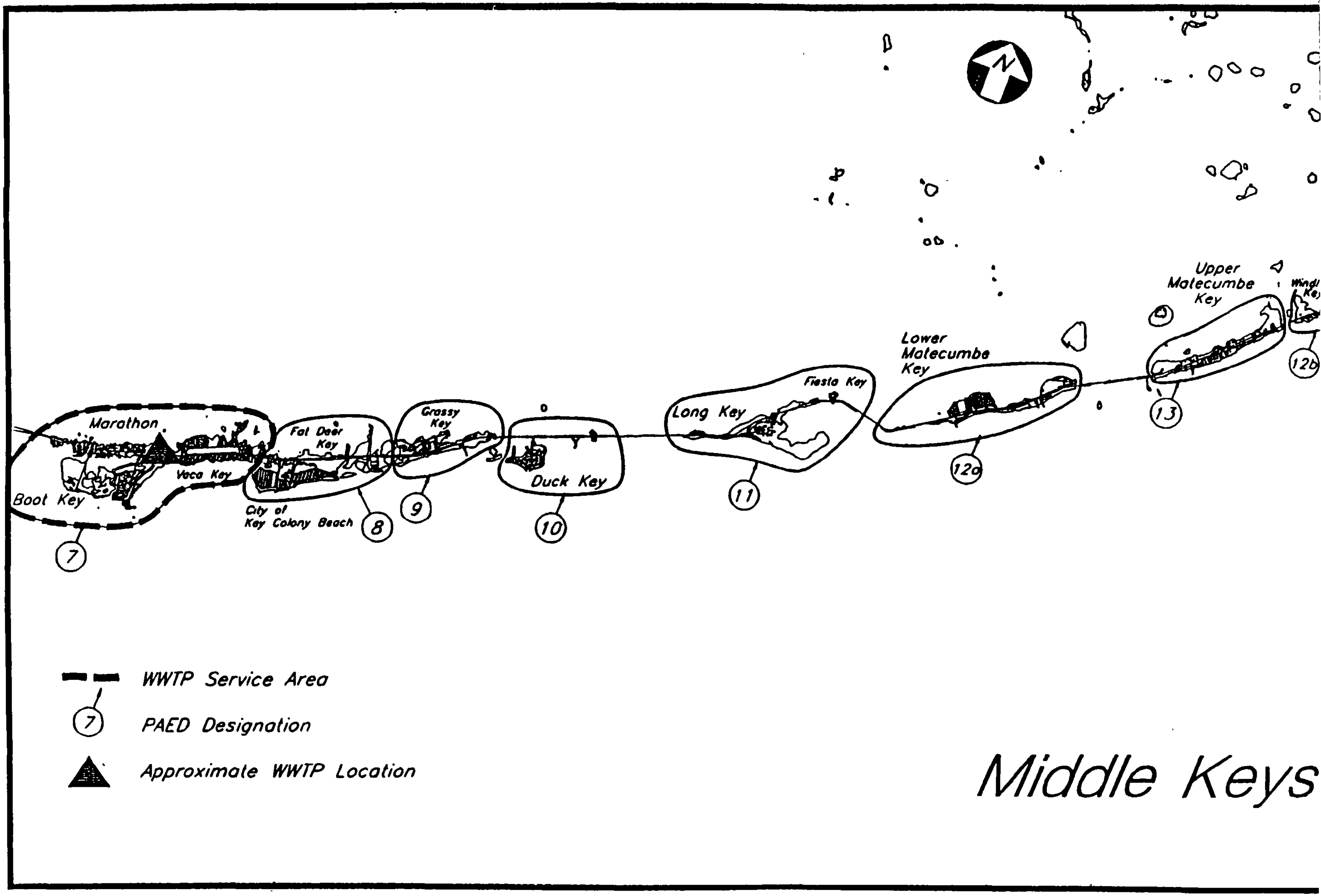


Figure C-5. Wastewater Option W3d: Constr co ity WWTPs - Middle (Scale: 1" = 6000').

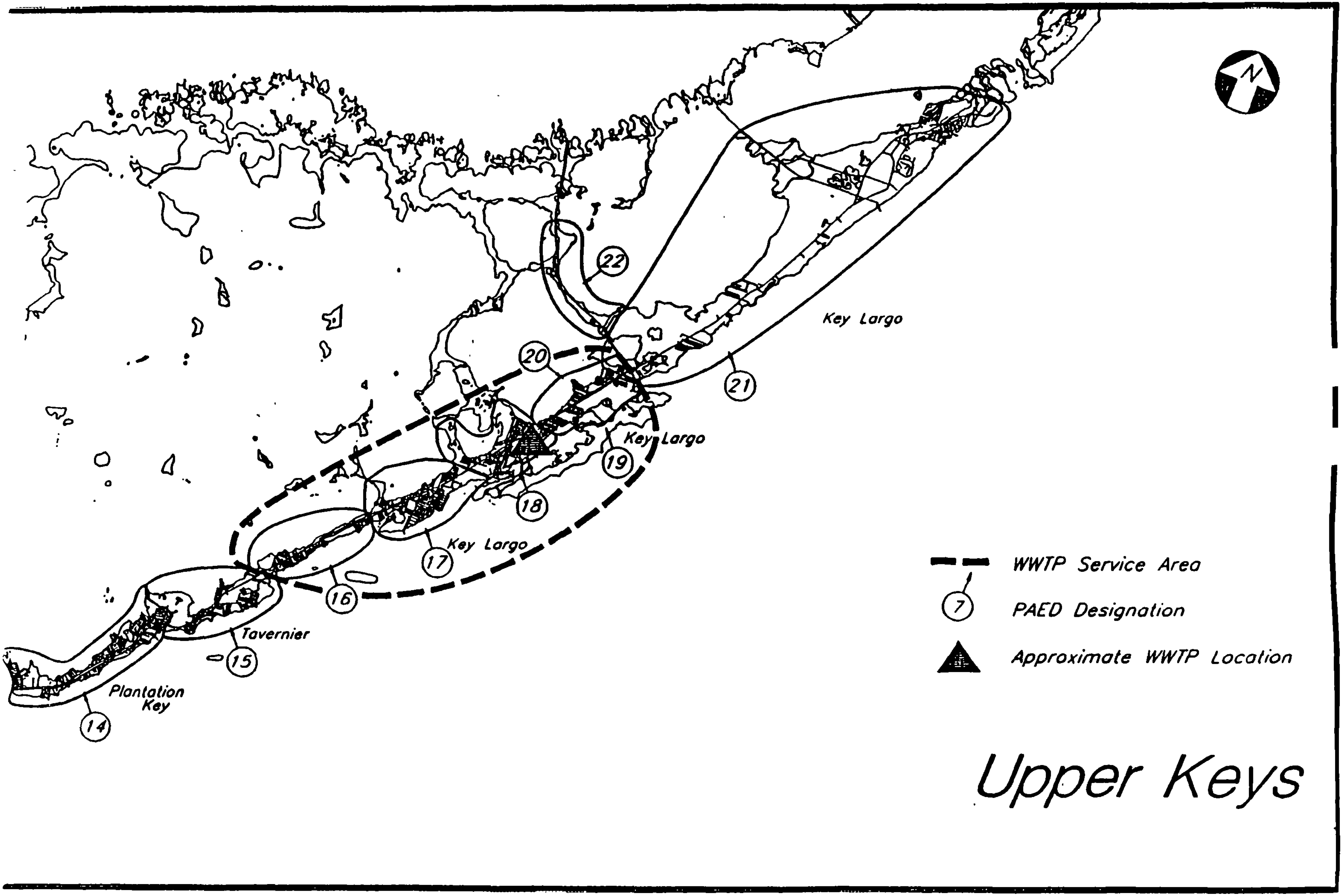


Figure C-6. Wastewater Option W3d: Construct two community WWTPs - Upper Keys (Scale: 1" = 6000').

The Key West WWTP is experiencing very high infiltration and inflow, which is currently estimated to be 36% of total flow. Excess capacity at the Key West WWTP may be sufficient to serve much of the lower Keys. Extending the service area for the Key West WWTP as far east as practical, coupled with construction of community AWT wastewater systems for the two most populated communities in the middle and upper Florida Keys (Marathon and Key Largo) would provide central sewer service for about 73% of all wastewater flows in the Florida Keys and 52% of wastewater flows outside the present City of Key West service area. The rationale for selecting this option would be that by providing AWT for 52% of wastewater flows outside the City of Key West, a significant long-term improvement in water quality would be realized over that attained by implementing Option W3c. It would also have to be demonstrated that Option W3d is more cost-effective than Options W3a, W3b and W3c. Additional monitoring and studies would have to be completed to select this option.

C.2.4.3 POLLUTION REDUCTION

For the 3.6 MGD combined flow of the Marathon and Key Largo communities, treatment level would be upgraded from virtually no treatment (cesspits), OSDS treatment or secondary treatment to AWT. Total nitrogen in these waste streams would be reduced from the 30-70 mg/L range to less than 6 mg/L. Total phosphorus would be reduced from the 8-24 mg/L range to less than 4 mg/L. Nutrient reductions for the base option are estimated to be 43% for total nitrogen and 28% for total phosphorus.

If aquifer storage, deep well injection or reuse for potable water is selected for these two systems, nutrient loadings from effluent disposal would be effectively reduced to zero. Nutrient loadings from reuse for irrigation can be minimized by optimization of application rates. For the 1.8 MGD combined flow that would be connected in the Key West to Big Coppitt Key area, aquifer storage of treated effluent would effectively isolate nutrients from waters of the FKNMS and that nutrient loading to the FKNMS would cease.

A summary of pollution reduction estimates for all suboptions included under Option W3d is given in **Table C-3**.

C.2.4.4 COST

The total estimated 20-year cost of the base option would be about $289 million. This cost includes $184 million in initial costs for land acquisition, WWTP construction, WWTP capacity increases to serve 20-year demands, STEP systems, force mains, and lift stations. It also includes the estimated present worth for 20-year operation and maintenance cost, $105 million. Estimates for operation and maintenance are based on a 6% annual inflation rate and include labor, administration, repair/replacement, power and chemicals. Estimated costs for all suboptions associated with this option, including equivalent a 20-year share for a single 250 GPD connection, are summarized in **Table C-3**.

C.2.4.5 IMPLEMENTATION SCHEDULE

A proposed implementation schedule for base Option W3d is shown in **Figure C-7**. This is a fast-track schedule, but it could be compressed or extended as priorities and funding may dictate. Aquifer storage or deep well injection disposal suboptions would not impact the schedule significantly, but reuse for potable water would extend the schedule an estimated two years.

C.2.4.6 AFFECTED ENTITIES

Entities affected by this option include users of the wastewater systems (wastewater generators) and regulatory agencies involved in permitting and monitoring compliance of the systems. The main effect this option would have on users of the system would be sharing the costs of construction and operation. The degree to which residential

Table C-3. Estimated costs and nutrient loading reductions for wastewater Option W3d: construct two community wastewater systems for marathon and Key Largo and utilize excess capacity of Key West WWTP in Lower Keys.

Effluent Disposal Options	N Reduction[a] (%)	P Reduction[a] (%)	Estimated Cost				Cost Effectiveness[f]	
			Initial[b] ($ millions)	20 Year O&M[c] ($ millions)	Total 20 Year[d] ($ millions)	20 Year per Connection[e] ($)	TN	TP
BASE OPTION[g]	43	28	184	105	289	12,900	6.7	10
COLLECTION SYSTEM OPTIONS								
Grinder Pump Stations	0	0	+11	-4	+7	310	N/A	N/A
Vacuum Systems	0	0	+9	-6	+3	+130	N/A	N/A
EFFLUENT DISPOSAL OPTIONS								
All Deep Well Injection[h]	+5	+12	-4	-2	-6	-30	-1.2	-0.5
All Potable Reuse[i,j]	+5	+12	+42	+32	+74	+3,600	1.5	6.2
All Irrigation Reuse[j]	+4	+9	+16	+12	+28	+1,250	7	3.1

O&M: Operation and maintenance
[a]Reduction shown is for man-induced loading, including domestic wastewater, live-aboards, and stormwater from developed areas. Stormwater loads from undeveloped areas, atmospheric deposition, or other nonpoint sources are not included.
[b]Initial costs include land acquisition, initial WWTP construction, WWTP capacity increases to serve 20-year demands and construction of all collection systems.
[c]Costs include labor, administration, repair/replacement, power and chemicals.
[d]Present worth only, no financing costs included
[e]Cost shown is for present worth of single 250 GPD service connection share of the total cost.
[f]Cost Effectiveness = Total Cost / Percent of Nutrient Removal
[g]Base Option W3d includes STEP collection, borehole effluent disposal for Marathon & Key Largo and aquifer storage effluent disposal for the City of Key West.
[h]Costs for deep well injection option include reduction in treatment costs from reducing treatment level from AWT to Secondary.
[i]Costs for potable reuse do not include revenues from the sale of potable water.
[j]Costs for reuse options assume aquifer storage and recovery will be used.

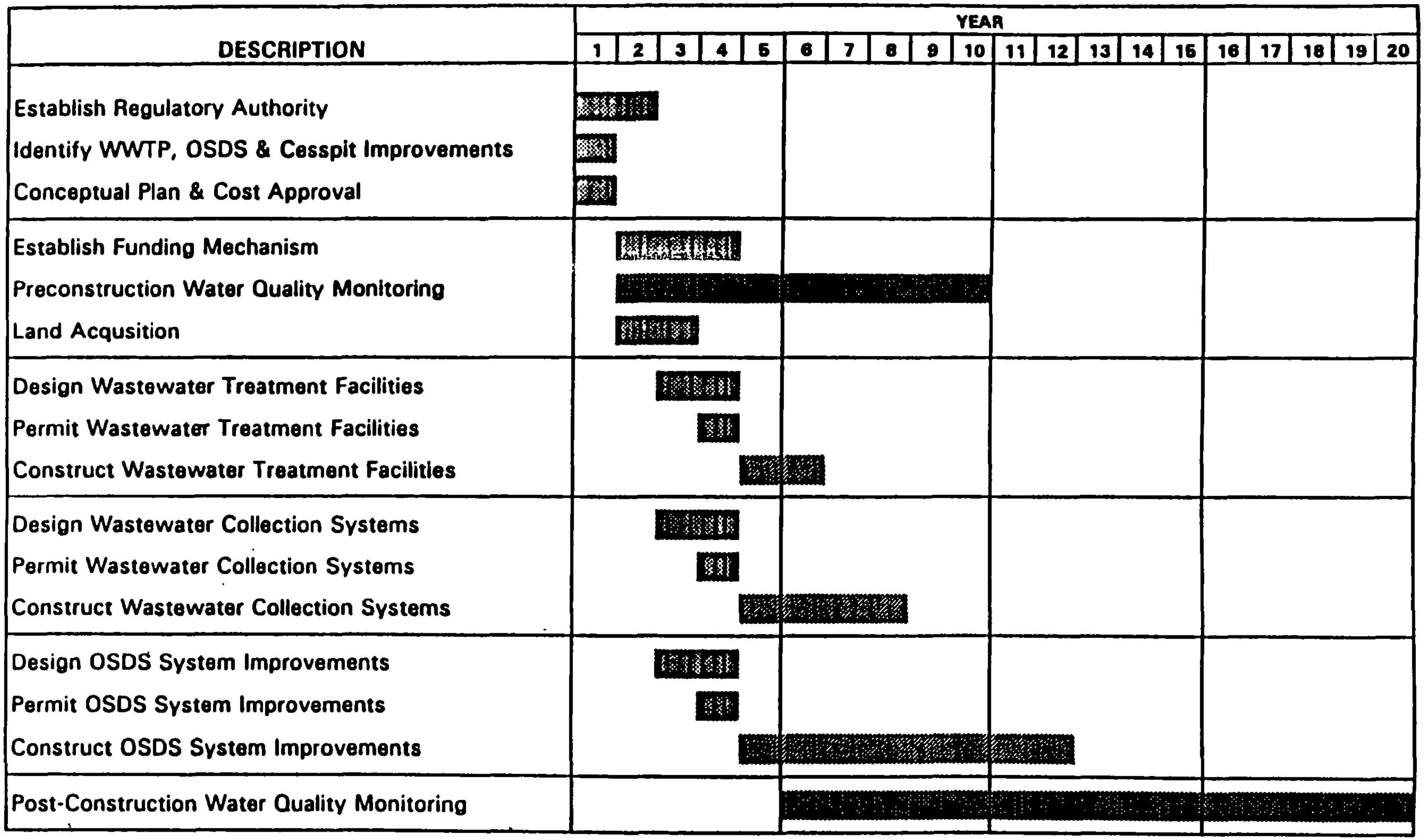


Figure C-7. Implementation schedule for Wastewater Option W3d: Construct two community WWTPs.

and non-residential users would participate in this cost sharing depends on funding mechanisms established to implement this option.

Primary areas of regulatory responsibility and authority would be:

- Florida Department of Community Affairs (FDCA) — reviewing wastewater master plans for consistency with comprehensive plan goals, policies, and objectives

- Monroe County — deciding whether county, Florida Keys Aqueduct Authority (FKAA), or another entity, will assume responsibility for a regional utility and the issuance of building and utility right-of-way permits required for construction

- FDER — permitting of wastewater collection and treatment systems and compliance/enforcement once system is in operation.

- Environmental Protection Agency (EPA) — only involved if NPDES permits are issued for emergency discharges or reuse for potable water option is selected

- Florida Department of Transportation (FDOT) — permitting of bridge crossings and facilities on FDOT right-of-way

- Cities — issuance of building and utility right-of-way permits required for construction

- Florida Keys Aqueduct Authority (FKAA) — major role if delegated responsibility of wastewater utility by Monroe County or if reuse for potable water option is selected; minor role in resolving utility conflicts with potable water systems if not delegated responsibility of wastewater utility

- FDHRS — identifying and retrofitting substandard OSDSs and cesspits outside the service areas of subregional WWTPs; would require an increase in personnel.

C.2.4.7 ENVIRONMENTAL EFFECTS

The environmental effects of implementing this option would be limited to relatively short-term impacts associated with construction activities. Overall land requirements would be low (probably in the 8-12 acre range) and, with proper sizing, should constitute a very minor effect. Construction of WWTPs and the extensive collection systems would create the potential for increased sediment loads in runoff. These would be short-term effects that could be minimized with prudent construction practices (e.g., use of sediment control devices, where appropriate, and re-establishment of cover on disturbed areas). The deep well injection suboption would preclude any reuse of effluent (permanent loss of resource), while aquifer storage or reuse suboptions maximize use of water resources.

C.2.4.8 ADDITIONAL MONITORING

There is abundant circumstantial evidence and some scientific evidence indicating that nutrients discharged from wastewater treatment and disposal systems within the Florida Keys are adversely affecting water quality within the FKNMS. Under ideal circumstances, it would be desirable to determine whether reducing nutrient loading to levels attained by this option would have a significant positive effect on nearshore water quality, shallow nearshore bottom habitat, and coral reef systems. Unfortunately, obtaining a clear understanding of exactly what extent of water quality degradation within the FKNMS can be attributed to wastewater would be very expensive and may take years of study or may not be possible at all.

Considering the difficulty, cost, and time constraints of pinpointing cause-and-effect relationships between wastewater systems and FKNMS water quality, a more practical approach should be considered. A decision as to what methods of wastewater treatment and disposal are acceptable for the Florida Keys may have to be based on existing knowledge and data. Since most "action" options have significant planning and design periods preceding construction, it would be advisable to pursue OSDS and AWT demonstration projects (Options W1 and W2) on a fast track to increase information available for future decision-making.

In addition to these demonstration projects, monitoring in other areas would be beneficial with regard to increasing the current database and providing additional information for future decision-making. Areas where additional information would be helpful include:

- FKNMS background water quality
- The effects of widespread use of boreholes for effluent disposal on nearshore water quality, shallow nearshore bottom habitat, and coral reef systems
- The effects of cesspit and OSDS use on nearshore water quality, shallow nearshore bottom habitat, and coral reef systems
- The relative contribution of stormwater, wet and dry atmospheric deposition, and other natural nonpoint sources toward nutrient loading to waters of the FKNMS.

If this option is selected, a post-implementation monitoring program should be developed to determine the effects of reduced nutrient loading on nearshore water quality, shallow nearshore bottom habitat, and coral reef systems.

C.2.5 Option W3e — Construct Seven Community Wastewater Treatment Plants for Most Densely Populated Areas

C.2.5.1 DESCRIPTION

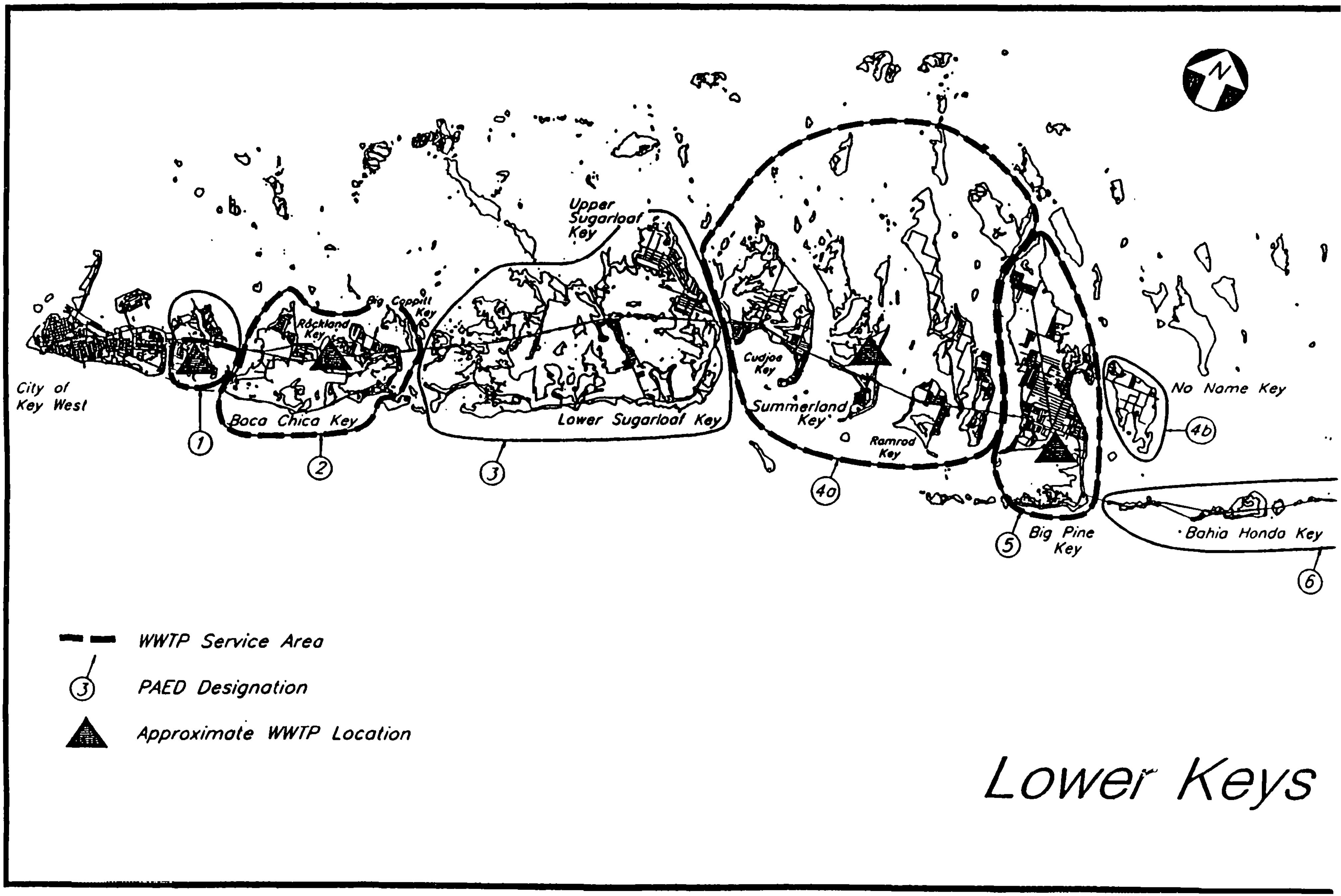
The seven service areas for community wastewater systems in unincorporated Monroe County were selected by starting with the highest flow ranking (excluding Key West) and adding areas with successively lower rankings until at least 70% of the flow was accounted for. These areas and the estimated design flows for the community plants serving them are shown in Table C-4. Service areas and plant locations are shown in Figures C-8 through C-10. The essential features of this option are:

- Construct seven community AWT WWTPs for the Key Largo, Marathon, Stock Island to Key Haven, Plantation, Boca Chica, Big Pine, and Cudjoe/Summerland areas. These seven plants would accommodate about 73% of wastewater flows from Keys areas, excluding Key West.
- Construct wastewater collection systems within the service areas of each community plant. Collection systems for the areas presently served by OSDSs would utilize STEP systems to replace drainfields and boreholes. Use of gravity sewers would be limited to service laterals or short collectors to lift stations on compact commercial or multi-family residential development.
- Use boreholes for effluent disposal.
- Continue OSDS/package plant use in all areas outside community plant service areas. Upgrade all existing OSDSs and package plants to meet current regulations.
- Initiate an active program for the identification and elimination of all cesspits. Development using cesspits would either be served by OSDSs/package plants or community plants, depending on location.

Table C-4. Design capacities of seven community WWTPs serving 73% of unincorporated Monroe County wastewater flow, excluding the City of Key West.

Key Areas	PAED[a]	1992 Average Daily Flow (MGD)	Rank		
			1992	2002	2012
Key Largo	16-20	2.16	3.2	3.9	4.5
Knight, Vaca (Marathon), Stirrup & Boot	7	1.48	2.2	2.6	3.1
Stock Island, Cow & Key Haven	1	0.79	1.2	1.4	1.6
Plantation	14	0.73	1.1	1.3	1.5
Boca Chica, Rockland, Big Coppit & Geiger	2	0.70	1.1	1.3	1.4
Big Pine Key	5	0.61	0.9	1.1	1.3
Cudjoe, Summerland, Ramrod, Torch Keys & No Name Keys	4	0.60	0.9	1.1	1.2
TOTAL		7.07	10.6	12.7	14.6

[a]Planning Area Analysis/Enumeration District as delineated in Monroe County Year 2010 Comprehensive Plan


N
City of Key West
Rockland Key
Big Coppitt Key
Boca Chica Key
Upper Sugarloaf Key
Lower Sugarloaf Key
Cudjoe Key
Summerland Key
Ramrod Key
Big Pine Key
No Name Key
Bahia Honda Key
1
2
3
4a
4b
5
6
WWTP Service Area
3
PAED Designation
Approximate WWTP Location
Lower Keys

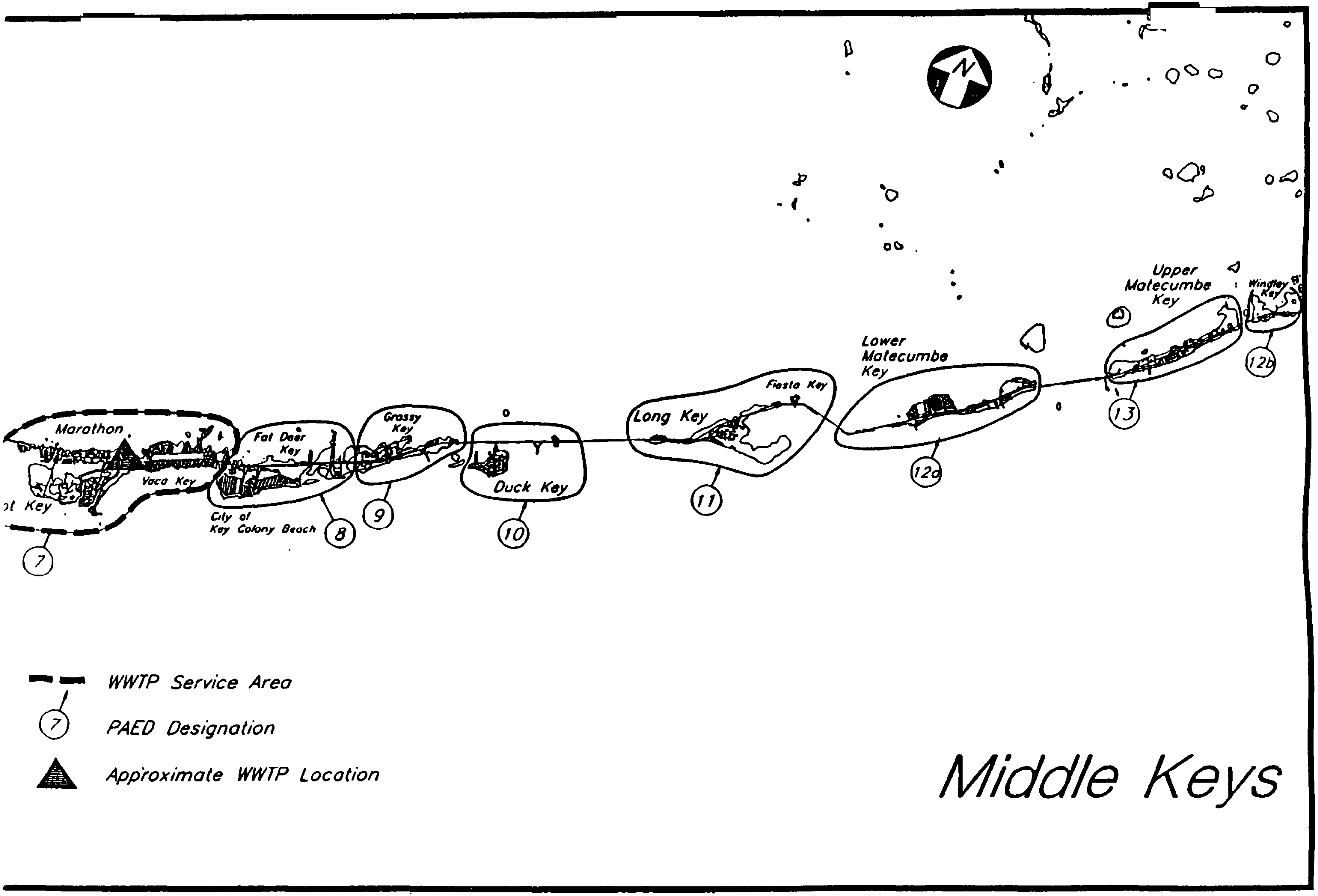
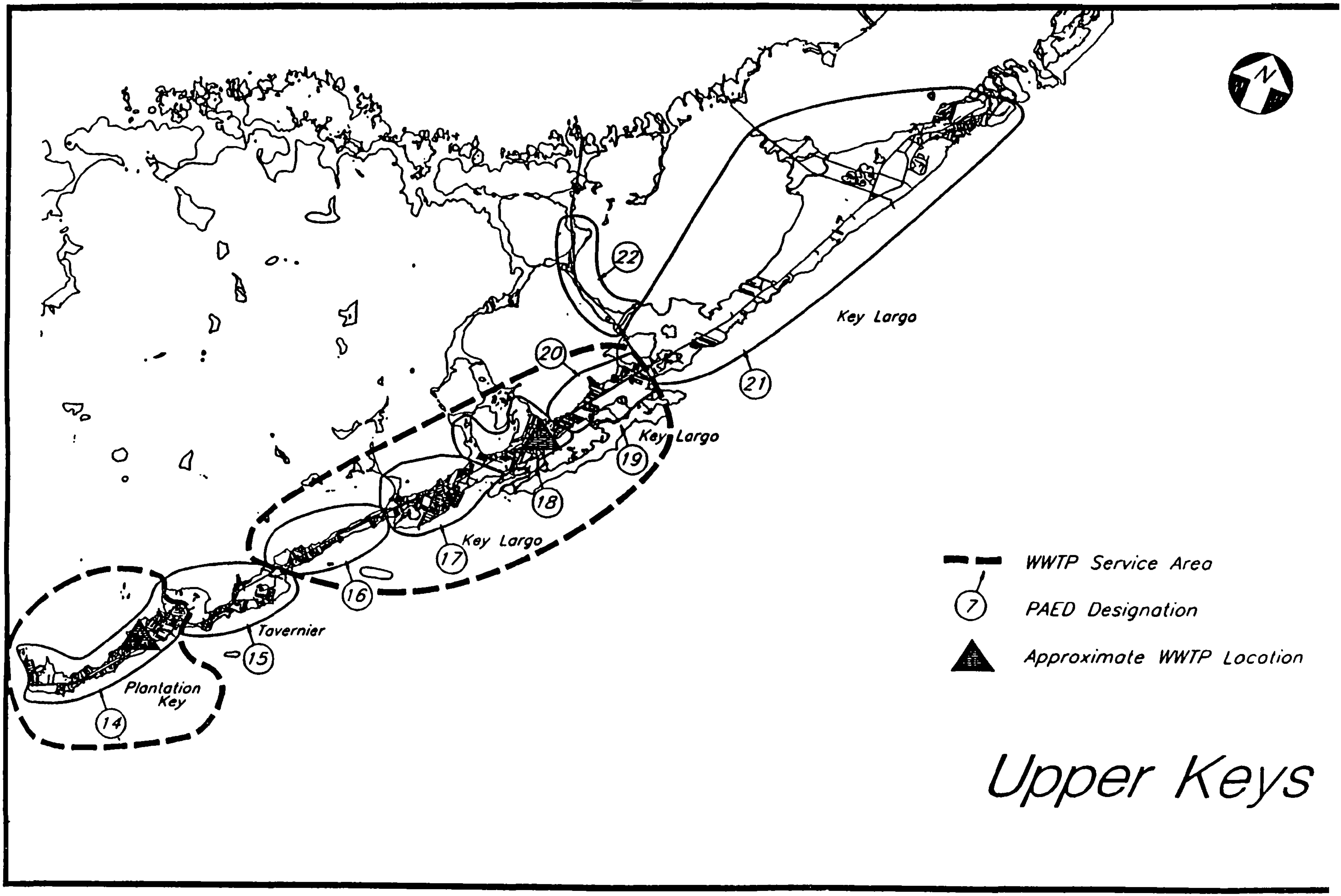


Figure C-9. Wastewater Option W3e: Construct seven community WWTPs - Midd! ys (Scale: 1" = 6000').


N
22
20
21
Key Largo
Key Largo
19
18
17
Key Largo
16
15
Tavernier
14
Plantation Key
WWTP Service Area
7
PAED Designation
Approximate WWTP Location

Upper Keys

- Collection System Suboptions:
  - (a) Grinder pump transmission from source
  - (b) Vacuum system collection from source

- Treatment Suboption: Use excess capacity at City of Key West WWTP to serve PAEDs 1 and 2.

- Effluent Disposal Suboptions:
  - (a) Aquifer storage
  - (b) Deep well injection (reduce treatment level to secondary)
  - (c) Reuse for irrigation within Keys (reduce treatment level to secondary/irrigation quality)
  - (d) Reuse for irrigation in areas outside Keys (reduce treatment level to secondary/irrigation quality)
  - (e) Reuse for potable water

As with Option W3d, there may be outlying residences within the service areas of community WWTPs that would be more practically served by existing or upgraded OSDSs than by community systems. This small number of residences utilizing OSDSs will not affect pollutant reduction or cost estimates for this option.

C.2.5.2 RATIONALE

The rationale for selecting Option W3e would be that the increased level of wastewater collection and treatment over that afforded by Option W3d would produce a significant, long-term increase in FKNMS water quality. Additionally, a judgment would have to be made that this level of improvement in water quality would result in acceptable long-term water quality conditions within the FKNMS. Additional monitoring and studies will have to be completed to select this option.

C.2.5.3 POLLUTION REDUCTION

For the 73% of wastewater flows connected to the plants, treatment level would be upgraded from virtually no treatment (cesspits), OSDS treatment, or secondary treatment to AWT. The effectiveness of this option for nutrient removal increases significantly if optional disposal methods are used that minimize the potential for entry of effluent into shallow groundwater or nearshore waters. Deep wells, reuse for irrigation in areas outside Keys, or reuse for potable water will effectively prohibit treated effluent from entering the waters of FKNMS. Nutrient loading reductions associated with various suboptions for Option W3e are summarized in Table C-5. The base option will reduce overall man-induced nitrogen and phosphorus loading to the FKNMS by an estimated 58% and 35%, respectively.

C.2.5.4 COST

The total estimated 20-year cost of the base option with STEP system collection from septic tanks is $419 million. This cost includes $265 million initial costs and $154 million for 20-year operation and maintenance. Suboptions included with Option W3e for wastewater collection and effluent disposal have a significant effect on the total cost. A summary of cost and nutrient removal effectiveness for all suboptions included with this option is given in Table C-5.

Table C-5. Estimated costs and nutrient loading reductions for wastewater Option W3e: construct seven community WWTPs.

Effluent Disposal Options	N Reduction[a] (%)	P Reduction[b] (%)	Estimated Costs				Cost Effectiveness[f]	
			Initial[b] ($ millions)	20 Year O&M[c] ($ millions)	Total 20 Year[d] ($ millions)	20 Year per Connection[e] ($)	TN	TP
BASE OPTION[g]	58	35	265	154	419	14,800	7.2	12
COLLECTION SYSTEM OPTIONS								
Grinder Pump Stations	0	0	+27	-5	+22	+780	N/A	N/A
Vacuum Systems	0	0	+15	-8	+7	+250	N/A	N/A
TREATMENT OPTION Utilize City of Key West WWTP Excess Capacity for PAED's 1 & 1	0	0	-18	-13	-31	-1,100	N/A	N/A
EFFLUENT DISPOSAL OPTIONS								
Deep Well Injection[h]	+8	+16	+11	+8	+19	+671	24	1.2
Irrigation Reuse within Keys[i]	+8	+16	+90	+60	+150	+5,300	25	13
Irrigation Reuse out of Keys[i]	+6	+12	+48	+32	+80	+2,800	10	5
Potable Reuse[i,j]	+8	+16	+63	+46	+109	+3,900	14	6.8

O&M: Operation and maintenance

[a]Reduction shown is for man-induced loading, including domestic wastewater, live-aboards, and stormwater from developed areas Stormwater loads from undeveloped areas, atmospheric deposition, or other nonpoint sources are not included.

[b]Initial costs include land acquisition, initial WWTP construction, WWTP capacity increases to serve 20-year demands and construction of all collection systems.

[c]Costs include labor, administration, repair/replacement, power and chemicals.

[d]Present worth only; no financing costs included

[e]Cost shown is for present worth of single 250 GPD service connection share of the total cost.

[f]Cost Effectiveness = Total Cost/Percent of Nutrient Removal

[g]Base Option W3e includes STEP collection and borehole effluent disposal.

[h]Costs for deep well injection option include reduction in treatment costs for reducing treatment level from AWT to secondary.

[i]Costs for reuse options assume aquifer storage and recovery will be used.

[j]Costs for potable reuse do not include revenues from sale of potable water.

C.2.5.5 IMPLEMENTATION SCHEDULE

A fast-track implementation schedule for Option W3e is shown in **Figure C-11**. This schedule could be compressed or extended as priorities and funding dictate. If intensive effluent disposal suboptions such as the reuse of effluent for potable or irrigation water are selected, the schedule would be extended an estimated two years.

C.2.5.6 AFFECTED ENTITIES

Entities affected by Option W3e are identical to those affected by Option W3d (see Section C.2.4.6). These entities are primarily wastewater generators (cost effects) and regulatory agencies (program implementation, permitting, and compliance).

C.2.5.7 ENVIRONMENTAL EFFECTS

The environmental effects of Option W3e are similar to but greater in extent than those of Option W3d (see Section C.2.4.7). Overall land requirements for facility construction would be in the 28 to 42 acre range. Short-term construction effects could be minimized with prudent construction practices.

C.2.5.8 ADDITIONAL MONITORING

The monitoring needs for this Option are the same as those listed for Option W3d (see Section C.2.4.8).

C.2.6 Option W3f — Construct 12 Community Wastewater Treatment Plants for All Areas

C.2.6.1 DESCRIPTION

This option is similar to Option W3e, except that 12 community WWTPs with the potential to serve all the Florida Keys areas outside of Key West would be constructed. The base option provides sewer service with STEP system collection for 94% of wastewater flow generated in the Florida Keys, excluding the City of Key West. Suboptions are considered for source collection (grinder pumps or vacuum systems). General service areas and estimated design flows for the 12 community plants are shown in **Table C-6**. Service areas and plant locations are shown in **Figures C-12 through C-14**. Essential features of this option are:

- Construct 12 subregional plants to serve the 12 highest flow areas in the Keys (See Appendix B, Table B-1). These 12 plants would accommodate about 94% of wastewater flows from Keys areas excluding Key West.

- Construct wastewater collection systems within service areas of each subregional plant. Use STEP systems for transmission of wastewater from sources. Suboptions are included to replace the entire OSDS with grinder pump stations or vacuum collection systems. Limit the use of gravity sewers to service laterals or short collectors to lift stations on compact commercial or multi-family residential development.

- Use boreholes for effluent disposal.

- Continue OSDS/package plant use only in low-density or remote areas. Upgrade all existing OSDSs and package plants to meet nutrient removal standards or AWT.

- Initiate an active program for the identification and elimination of all cesspits. Development utilizing cesspits would either be served by OSDSs/package plants or subregional plants, depending on location.

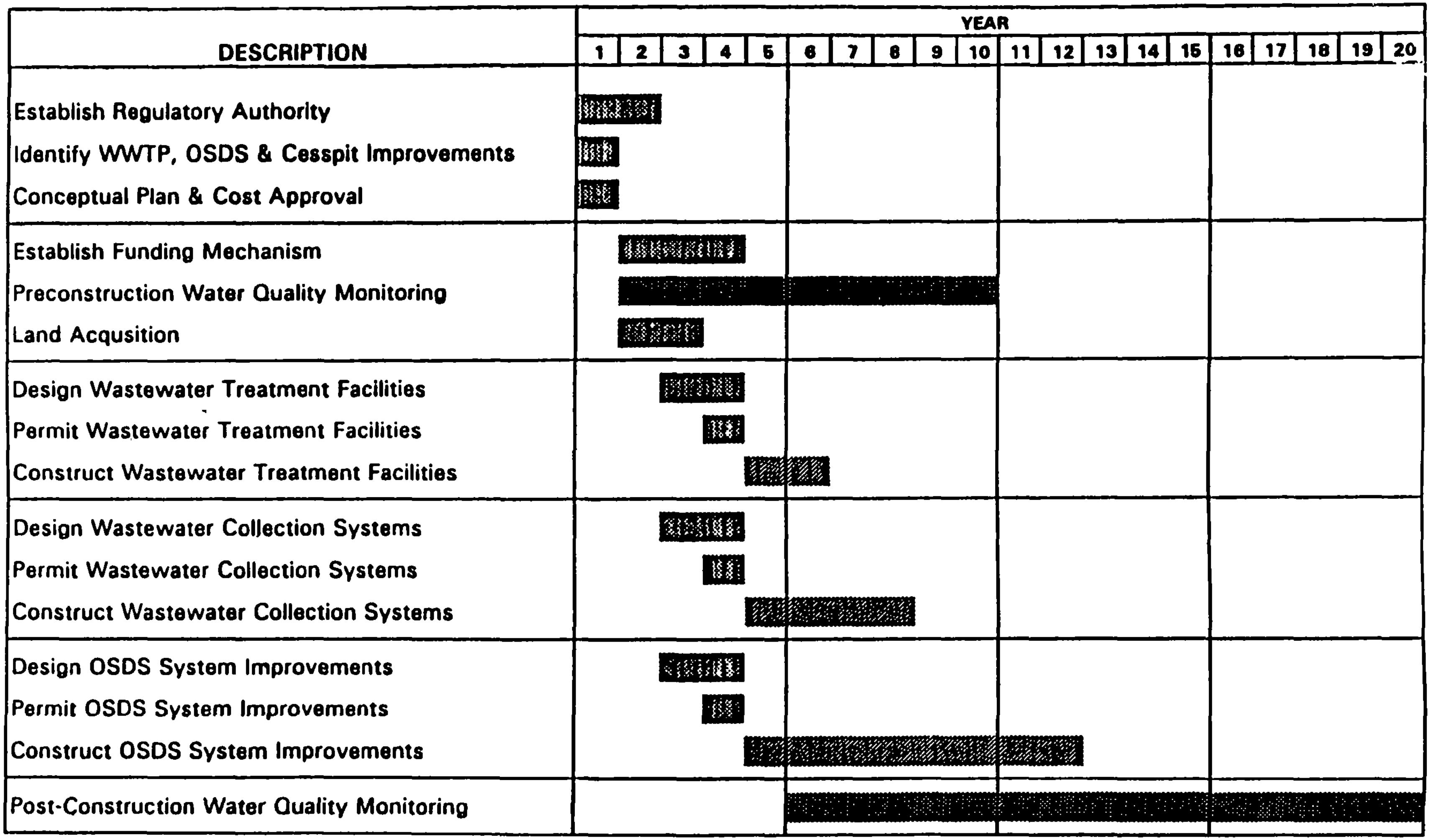


Figure C-11. Implementation schedule for Wastewater Option W3e: Construct seven community WWTPs.

Table C-6. Design capacities of twelve community WWTPs serving 94% of unincorporated Monroe County wastewater flow, excluding the City of Key West.

Key Areas	PAED[a]	1992 Average Daily Flow (MGD)	Rank		
			1992	2002	2012
Key Largo	16-20	2.16	3.2	3.9	4.5
Knight, Vaca (Marathon), Stirrup & Boot	7	1.48	2.2	2.6	3.1
Stock Island, Cow & Key Haven	1	0.79	1.2	1.4	1.6
Plantation	14	0.73	1.1	1.3	1.5
Boca Chica, Rockland, Big Coppit & Geiger	2	0.70	1.1	1.3	1.4
Big Pine Key	5	0.61	0.9	1.1	1.3
Cudjoe, Summerland, Ramrod, Torch Keys & No Name Keys	4	0.60	0.9	1.1	1.2
Lower Key Largo (Tavernier)	15	0.48	0.72	0.86	1.0
Lower & Upper Matecumbe	12 & 13	0.46	0.69	0.82	0.95
North Key Largo	21	0.43	0.65	0.77	0.89
Saddlebunch, Upper & Lower Sugarloaf	3	0.30	0.45	0.53	0.62
Fat Deer	8	0.29	0.44	0.52	0.60
TOTAL		9.03	13.55	16.20	18.66

[a]Planning Area Analysis/Enumeration District as delineated in Monroe County Year 2010 Comprehensive Plan

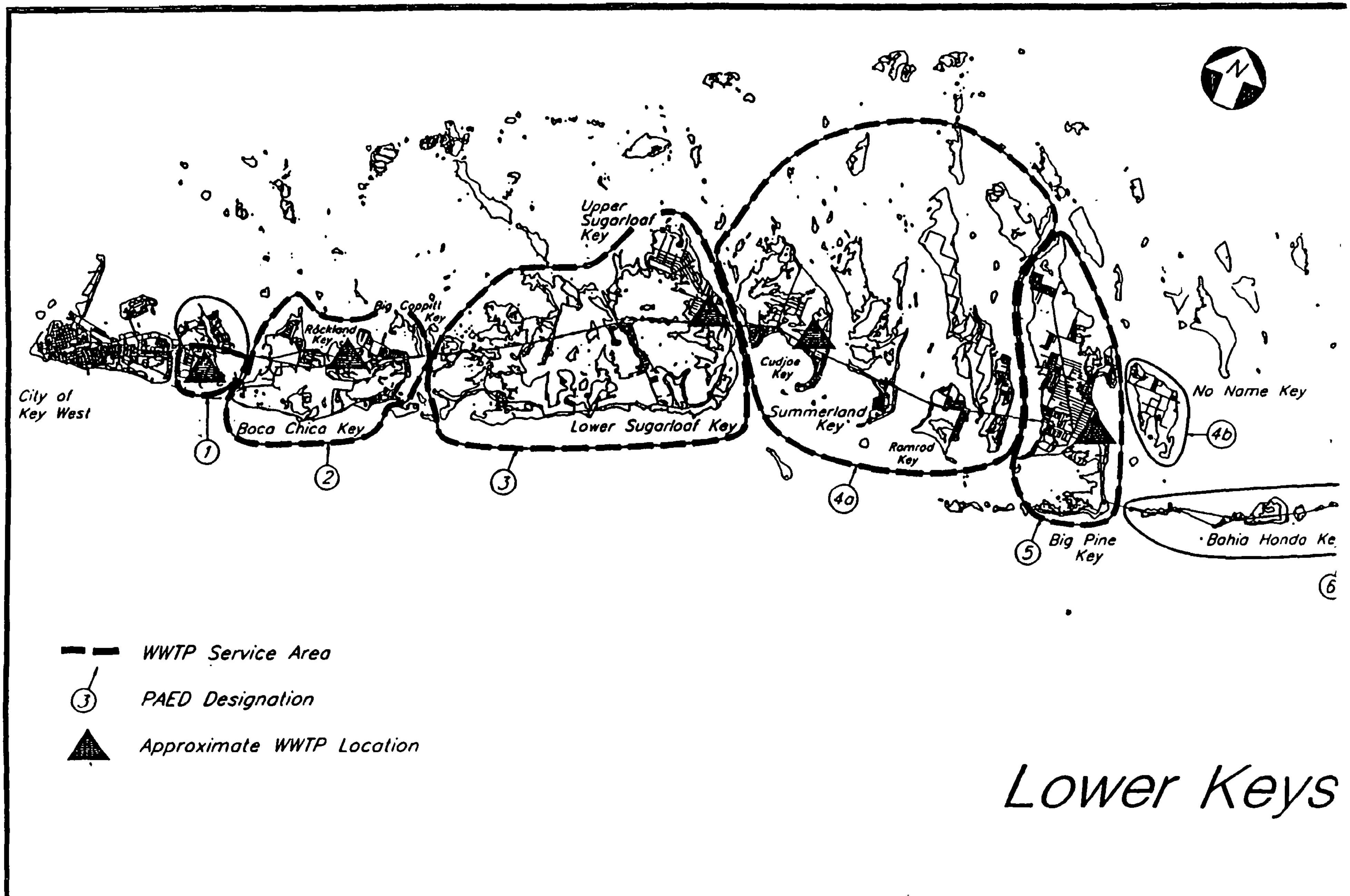


Figure C-12. Wastewater Option W3f: Construct 12 community WWTPs - Lower Keys (Scale: 1" = 6000').

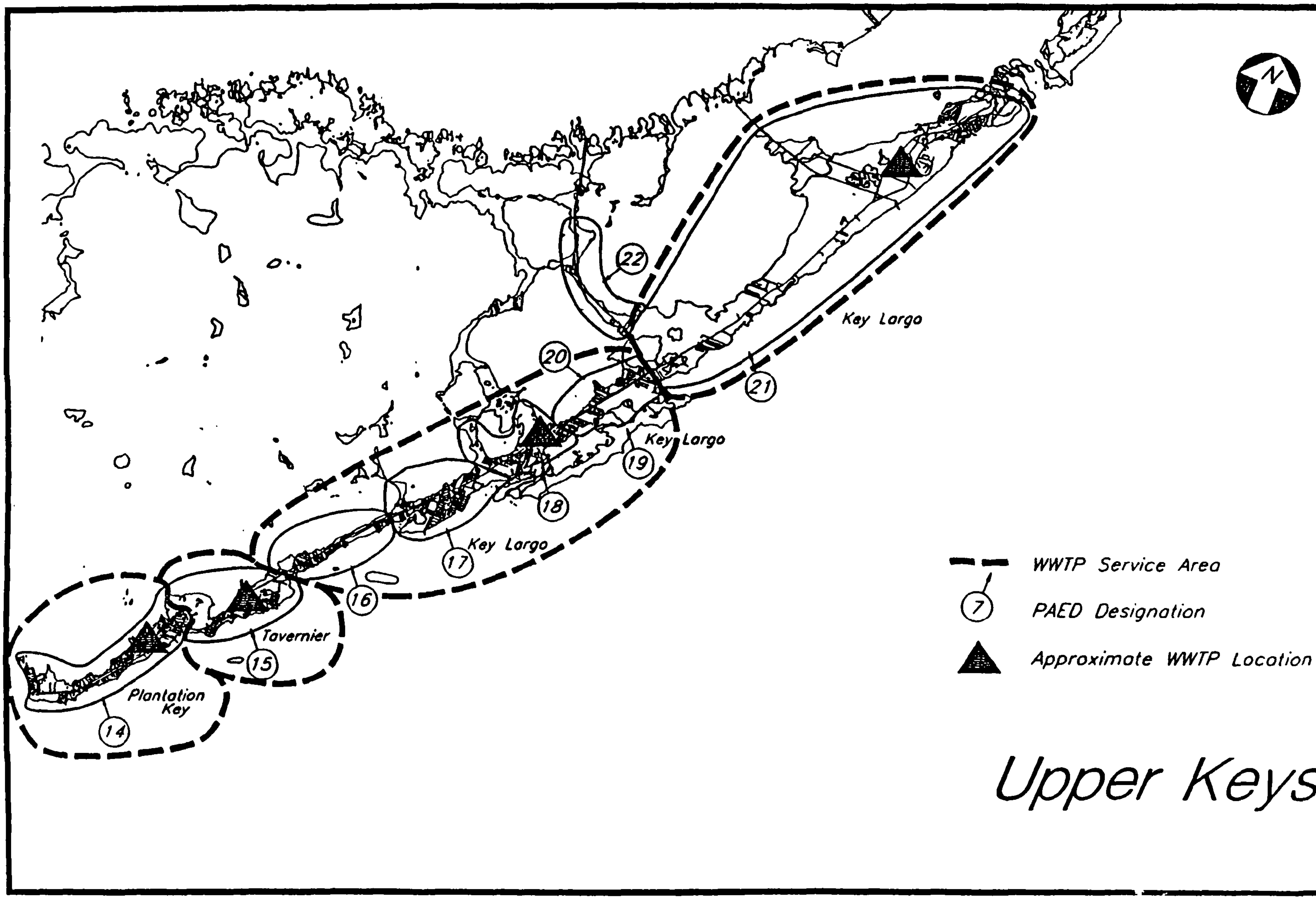


Figure C-14. Wastewater Option W3f: Const[illegible] community WWTPs - Upper Keys (Scale: 1" = 6000').

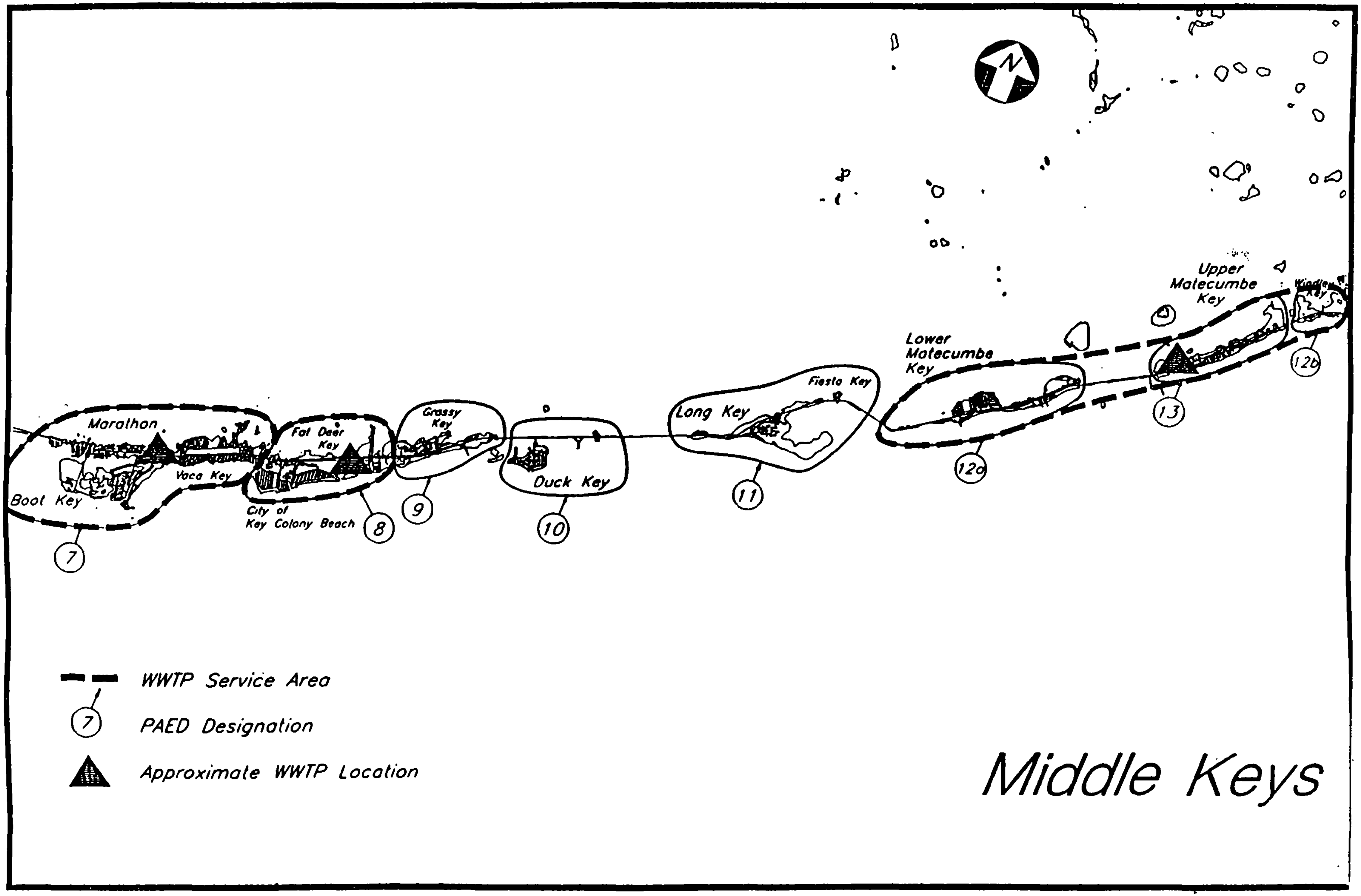


Figure C-13. Wastewater Option W3f: Construct 12 c[illegible]ty WWTPs - Middle Keys (Scale: 1" = 6000').

- Collection System Suboptions:
  - (a) Grinder pump transmission from source
  - (b) Vacuum system collection from source
- Treatment Suboption: Use excess capacity at City of Key West WWTP to serve PAEDs 1 and 2
- Effluent Disposal Suboptions:
  - (a) Aquifer storage
  - (b) Deep well injection (reduce treatment level to secondary)
  - (c) Reuse for irrigation within Keys (reduce treatment level to secondary/irrigation quality)
  - (d) Reuse for irrigation in areas outside Keys (reduce treatment level to secondary/irrigation quality)
  - (e) Reuse for potable water

C.2.6.2 RATIONALE

The rationale for selecting Option W3f would be that nearly all wastewater flows within the Keys should be connected to community systems and given a higher level of treatment than that provided by Option W3e to achieve the desired level of water quality in the FKNMS. Additionally, a judgment would have to be made that this level of improvement in water quality would contribute significantly to acceptable long-term water quality conditions in the FKNMS. Additional monitoring and studies will be required to select this option.

C.2.6.3 POLLUTION REDUCTION

For the base option, treatment level for 94% of wastewater flows from unincorporated Monroe County would be upgraded from virtually no treatment (cesspits), OSDS treatment, or secondary treatment to AWT. Overall nutrient loading reductions for each option associated with Option W3f are summarized in Table C-7. The base option would reduce overall man-induced nitrogen and phosphorus loading in the FKNMS by an estimated 72% and 43%, respectively.

C.2.6.4 COST

The total estimated 20-year cost of the base option with STEP system collection from septic tanks would be about $607 million. This cost includes $368 million initial cost and $239 million for 20-year operation and maintenance costs. Suboptions included for wastewater collection and effluent disposal have a significant affect on cost and nutrient loading reduction estimates for Option W3f. A summary of costs and nutrient removal effectiveness associated with these suboptions is given in **Table C-7**.

C.2.6.5 IMPLEMENTATION SCHEDULE

A fast-track implementation schedule for Option W3f is shown in Figure C-15. This schedule could be compressed or extended as priorities and funding dictate. If intensive effluent disposal suboptions such as the reuse of effluent for potable or irrigation water are selected, the schedule would be extended an estimated two years.

Table C-7. Estimated costs and nutrient loading reductions for wastewater Option W3f: construct twelve community WWTPs.

Effluent Disposal Options	N Reduction[a] (%)	P Reduction[a] (%)	Estimated Cost				Cost Effectiveness[f]	
			Initial[b] ($ millions)	20 Year O&M[c] ($ millions)	Total 20 Year[d] ($ millions)	20 Year per Connection[e] ($)	TN	TP
BASE OPTION[g]	72	43	368	239	607	16,900	8.4	14
COLLECTION SYSTEM OPTIONS								
Grinder Pump Stations	0	0	30	-7	+23	+640	N/A	N/A
Vacuum Systems	0	0	17	-10	+7	+200	N/A	N/A
TREATMENT OPTION								
Utilize City of Key West WWTP Excess Capacity for PAEDs 1 & 1	0	0	-18	-13	-31	-900	N/A	N/A
EFFLUENT DISPOSAL OPTIONS								
Deep Well Injection[h]	+11	+20	+40	+25	+65	+1,800	5.9	3.3
Irrigation Reuse within Keys[i]	+7	+15	+120	+80	+200	+5,500	29	13
Irrigation Reuse out of Keys[i]	+11	+20	+48	+32	+80	+2,200	7.3	4
Potable Reuse[i,j]	+11	+20	+80	+50	+130	+3,600	12	7

O&M: Operation and maintenance
[a]Reduction shown is for primarily man-induced loading, including domestic wastewater, live-aboards, and stormwater from developed areas. Stormwater loads from undeveloped areas, atmospheric deposition, or other nonpoint sources are not included.
[b]Initial costs include land acquisition, initial WWTP construction, WWTP capacity increases to serve 20-year demands and construction of all collection systems.
[c]Costs include labor, administration, repair/replacement, power and chemicals.
[d]Present worth only; no financing costs included
[e]Cost shown is for present worth of single 250 GPD service connection share of the total cost.
[f]Cost Effectiveness = Total Cost/Percent of Nutrient Removal
[g]Base Option W3f includes STEP collection and borehole effluent disposal.
[h]Costs for deep well injection option include reduction in treatment costs for reducing treatment level from AWT to secondary.
[i]Costs for reuse options assume aquifer storage and recovery will be used.
[j]Costs for potable reuse do not include revenues from sale of potable water.

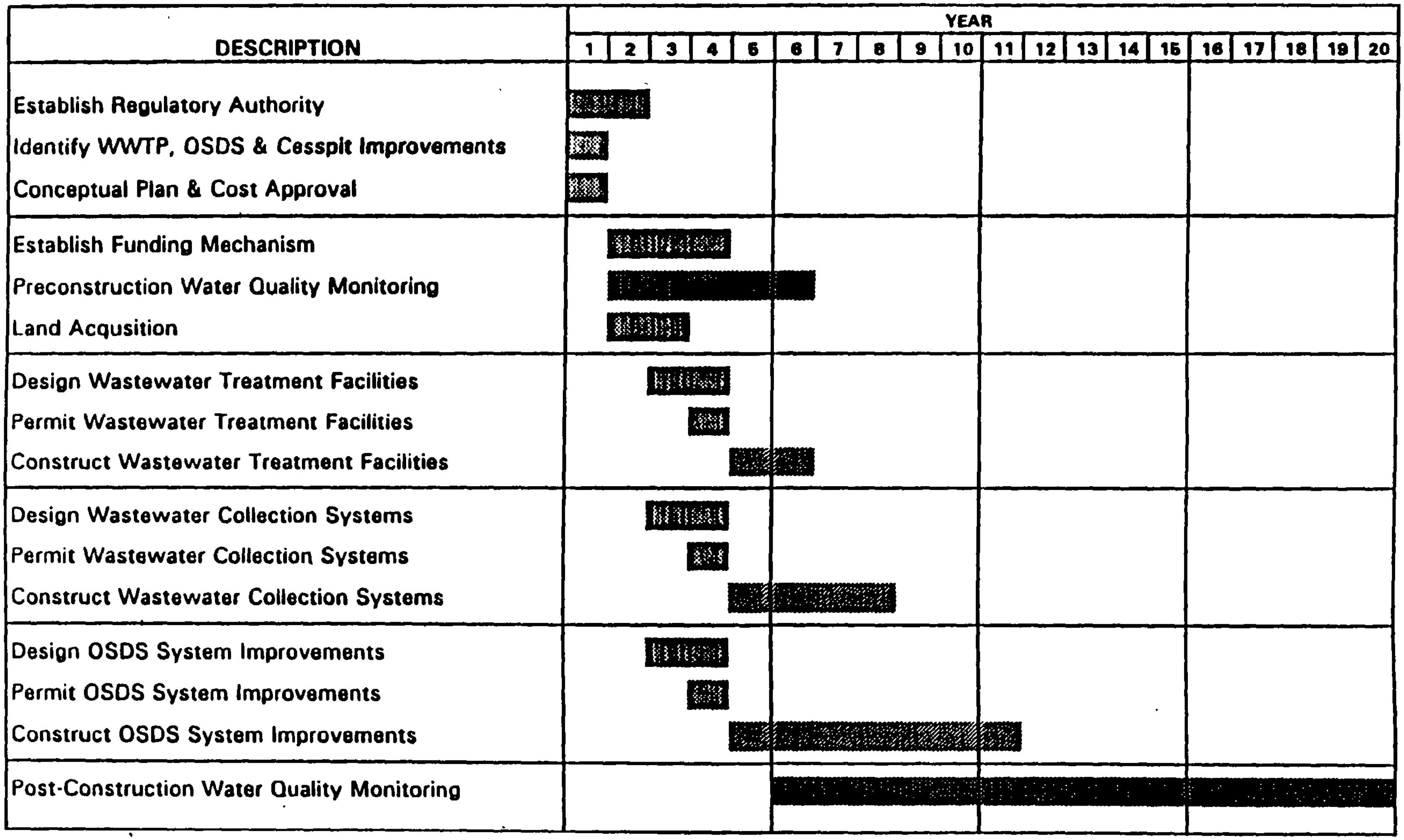


Figure C-15. Implementation schedule for Wastewater Option W3f: Construct 12 community WWTPs.

C.2.6.6 AFFECTED ENTITIES

Entities affected by Option W3f are identical to those affected by Options W3d and W3e (see Section C.2.4.6). These entities are primarily wastewater generators (cost effects) and regulatory agencies (program implementation, permitting, and compliance).

C.2.6.7 ENVIRONMENTAL EFFECTS

The environmental effects of Option W3f are similar to, but greater in extent than, those of Options W3d and W3e (see Section C.2.4.7). Overall land requirements for facility construction would be in the 48 to 72 acre range. Construction of wastewater collection systems would affect larger areas. Short-term construction effects could be minimized with prudent construction practices.

C.2.6.8 ADDITIONAL MONITORING

The monitoring needs for this option are the same as those listed for Options W3d and W3e (see Section C.2.4.8).

C.2.7 Option W3g — Construct Three Subregional Wastewater Treatment Plants

C.2.7.1 DESCRIPTION

Under this option, three subregional WWTPs and collection systems with the potential to serve all the areas of the Florida Keys outside the City of Key West would be constructed. The base option provides wastewater collection and treatment for 94% of unincorporated Monroe County wastewater flows. Wastewater flows for the Cities of Layton and Key Colony Beach are included with unincorporated Monroe County for this option analysis. Areas served are identical to those served by the base Option W3f. Additional suboptions for wastewater collection and effluent disposal are included. Service areas and WWTP locations for this option are shown in Figures C-16 through C-18. The main features of Option W3g are:

- Construct three subregional plants to serve the upper, middle, and lower Keys. These three plants would accommodate approximately 94% of wastewater flows from the Florida Keys areas excluding Key West.

- Construct STEP wastewater collection systems within service areas of each subregional plant as described for Option W3e.

- Use boreholes for effluent disposal.

- Continue OSDS/package plant use for isolated areas that are not practical to connect to a subregional system, but upgrade these systems to nutrient removal or AWT.

- Initiate an active program for the identification and elimination of all cesspits. Development using cesspits would either be served by OSDSs/package plants or subregional plants, depending on location.

- Collection System Suboptions:
  (a) Grinder pump transmission from source.
  (b) Vacuum system collection from source.

- Treatment Suboption: Use excess capacity at City of Key West WWTP to treat wastewater from PAEDs 1 and 2.

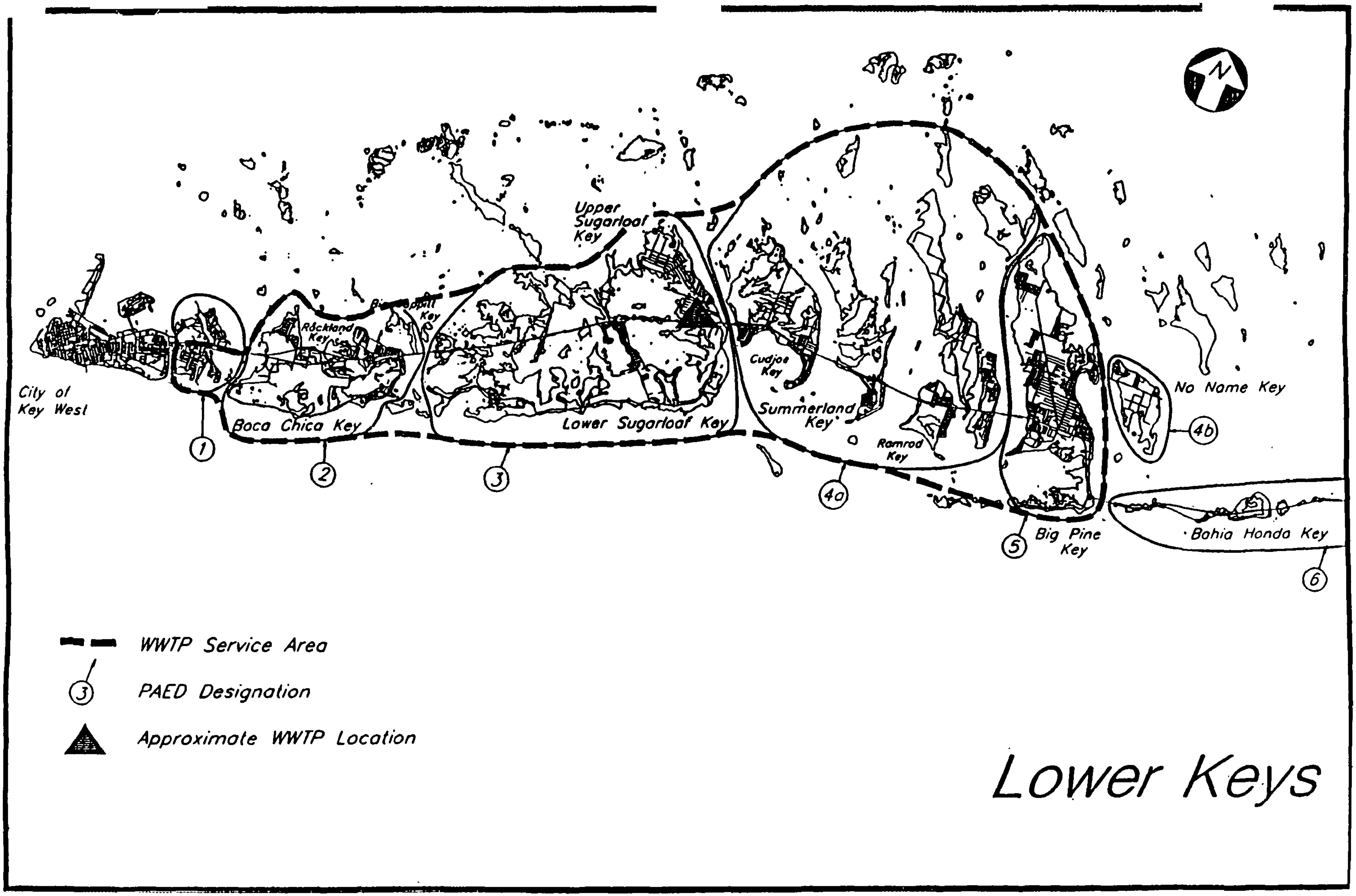


Figure C-16. Wastewater Option W3g: Construct three subregional WWTPs - Lower Keys (Scale: 1" = 6000').

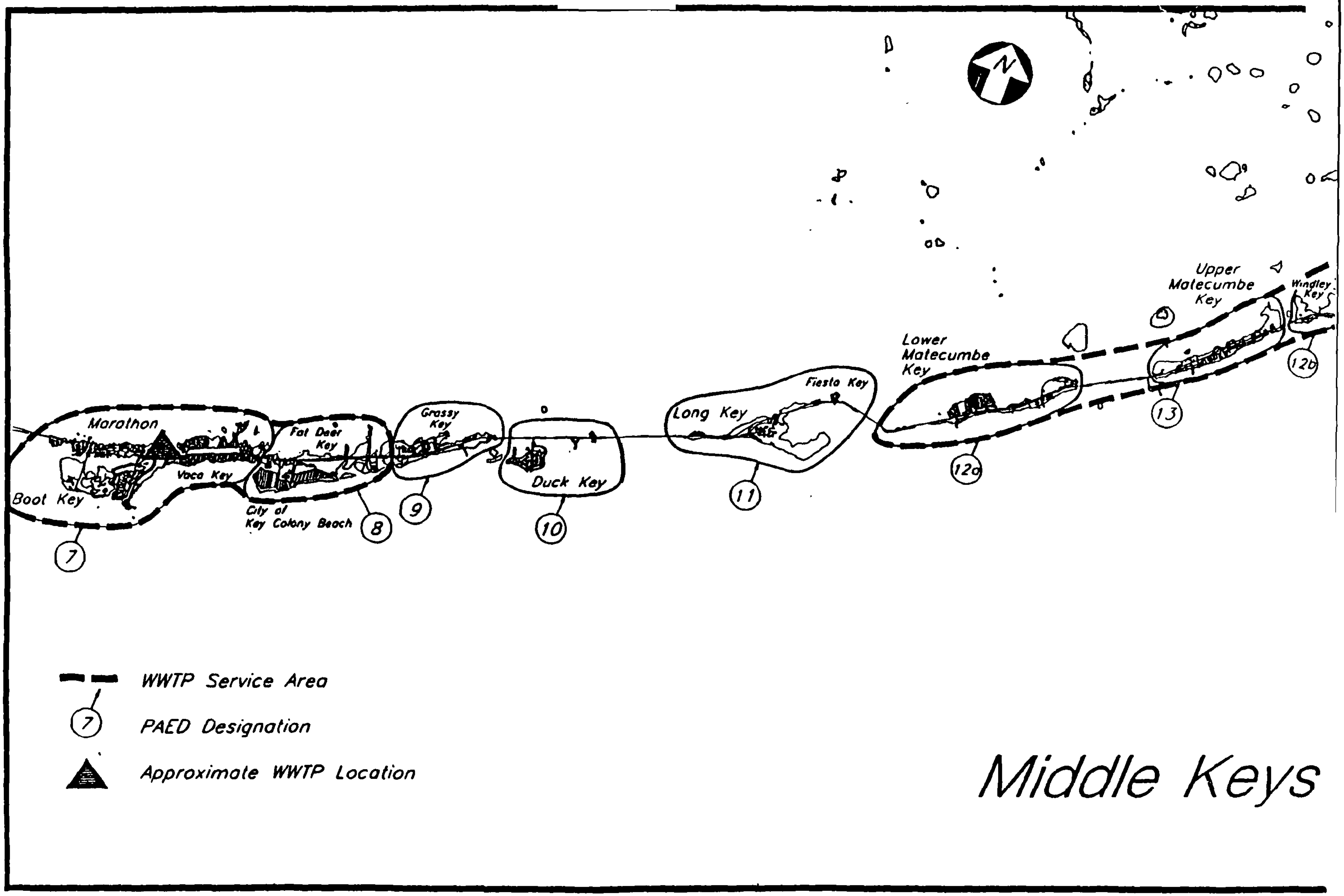


Figure C-17. Wastewater Option W3g: Construct three subregional WWTPs - Middle Keys (Scale: 1" = 6000').

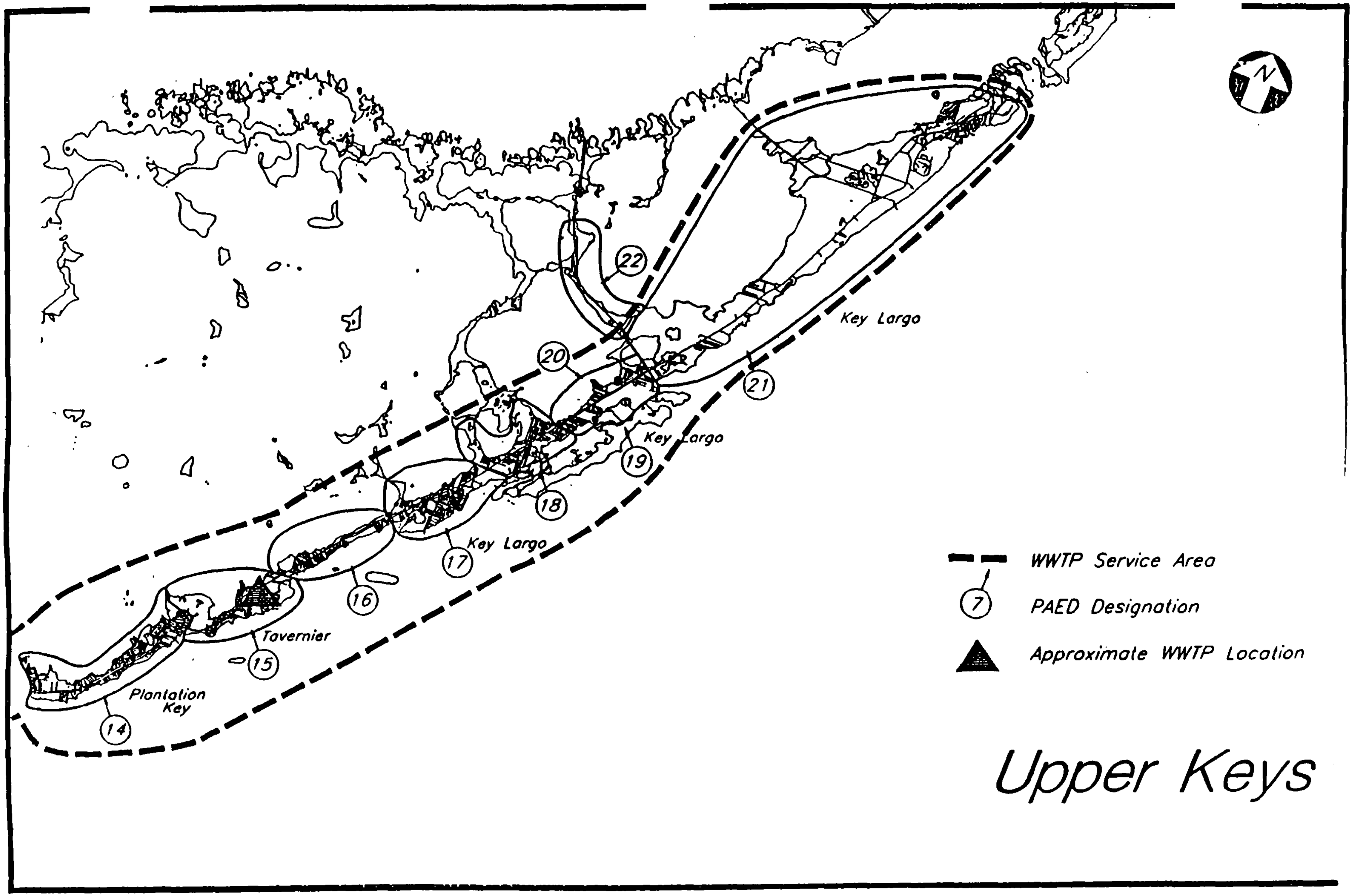


Figure C-18. Wastewater Option W3g: Construct thre   gional WWTPs - Upper Keys (Scale: 1" = 6000').

- Effluent Disposal Suboptions:
  (a) Aquifer storage
  (b) Deep well injection (reduce treatment level to secondary)
  (c) Reuse for irrigation within Keys (reduce treatment level to secondary/irrigation quality)
  (d) Reuse for irrigation in areas outside Keys (reduce treatment level to secondary/irrigation quality)
  (e) Reuse for potable water

C.2.7.2 RATIONALE

The rationale for selecting Option W3g would be similar to that for W3f, i.e. treat all Florida Keys wastewater flows to AWT level in order to achieve desired FKNMS water quality. Additionally, selection of Option W3g over Option W3f would reflect a preference for large, subregional systems over smaller, community systems. As with Option W3f, 94% of wastewater flows within unincorporated Monroe County would be collected and given a high level of treatment. Additional monitoring and studies will be required to select this option.

C.2.7.3 POLLUTION REDUCTION

The nutrient loading reduction of this option would be identical to Option W3f because wastewater service areas and treatment levels are the same. Estimated reductions in loadings of total nitrogen and total phosphorus for the base option are 72% and 43%, respectively. Estimated nutrient removal effectiveness of the various options included with Option W3g are summarized in **Table C-8**.

C.2.7.4 COST

The total estimated 20-year cost of the base option with STEP system collection from septic tanks is $690 million. This cost includes $418 million an initial cost and $272 million for 20-year operation and maintenance costs. Cost of this option is higher than Option W3d because of the larger lift station and force main sizes required to pump higher flows longer distances. Suboptions included for wastewater collection and effluent disposal affect cost and nutrient loading reduction for Option W3g. A summary of cost increases and nutrient removal effectiveness for these suboptions is given in **Table C-9**.

C.2.7.5 IMPLEMENTATION SCHEDULE

A fast-track implementation schedule for Option W3g is shown in **Figure C-19**. This schedule could be compressed or extended as priorities and funding dictate. If intensive effluent disposal suboptions such as the reuse of effluent for potable or irrigation water are selected, the schedule would be extended an estimated two years.

C.2.7.6 AFFECTED ENTITIES

Entities affected by Option W3g are identical to those affected by Options W3d, W3e, and W3f (see Section C.2.4.6). These entities are primarily wastewater generators (cost effects) and regulatory agencies (program implementation, permitting, and compliance).

Table C-8. Estimated costs and nutrient loading reductions for wastewater Option W3g: construct three subregional WWTPs

Effluent Disposal Options	N Reduction[a] (%)	P Reduction[a] (%)	Estimated Cost: Initial[b] ($ millions)	Estimated Cost: 20 Year O&M[c] ($ millions)	Estimated Cost: Total 20 Year[d] ($ millions)	Estimated Cost: 20 Year per Connection[e] ($)	Cost Effectiveness[f]: TN	Cost Effectiveness[f]: TP
BASE OPTION[g]	72	43	418	272	690	19,100	9.6	16
COLLECTION SYSTEM OPTIONS								
Grinder Pump Stations	0	0	+30	-7	+23	+640	N/A	N/A
Vacuum Systems	0	0	+17	-10	+7	+200	N/A	N/A
TREATMENT OPTION								
Utilize City of Key West WWTP Excess Capacity for PAEDs 1 & 1	0	0	-18	-13	-31	-900	N/A	N/A
EFFLUENT DISPOSAL OPTIONS								
Deep Well Injection[h]	+11	+20	-23	-17	-40	-1,100	-3.6	-2.0
Irrigation Reuse within Keys[i]	+7	+15	+120	+80	+200	+5,500	29	13
Irrigation Reuse out of Keys[i]	+11	+20	+48	+32	+80	+2,200	23	4
Potable Reuse[i j]	+11	+20	+80	+50	+130	+3,600	12	7

O&M: Operation and maintenance

[a]Reduction shown is for primarily man-induced loading, including domestic wastewater, live-aboards, and stormwater from developed areas. Stormwater load- rom undeveloped areas, atmospheric deposition, or other nonpoint sources are not included.

[b]nitial costs include land acquisition, initial WWTP construction, WWTP capacity increases to serve 20-year demands and construction of all collection syster

[c]Costs include labor, administration, repair/replacement, power and chemicals.

[d]Present worth only; no financing costs included.

[e]Cost shown is for present worth of single 250 GPD service connection share of the total cost.

[f]Cost Effectiveness = Total Cost/Percent of Nutrient Removal

[g]Base Option W3g includes STEP collection and aquifer storage effluent disposal.

[h]Costs for deep well injection option include reduction in treatment costs for reducing treatment level from AWT to secondary.

[i]Costs for reuse options assume aquifer storage and recovery will be used.

[j]Costs for potable reuse do not include revenues from sale of potable water.

Table C-9. Estimated costs and nutrient loading reductions for wastewater Option W4: upgrade effluent disposal for City of Key West.

Effluent Disposal Options	N Reduction[a] (%)	P Reduction[a] (%)	Estimated Cost				Cost Effective[f]	
			Initial[b] ($ millions)	20 Year O&M[c] ($ millions)	Total 20 Year[d] ($ millions)	20 Year per Connection[e] ($)	TN	TP
Deep Well Injection	4.7	9.3	7	4.5	12	440	2.6	1.3
Irrigation Reuse Out of Keys[h]	4.7	9.3	46	31	77	2,800	16	8.3
Potable Reuse[h,i]	4.7	9.3	80[g]	60[g]	140[g]	5,100[g]	30	15

O&M: Operation and maintenance

[a]Reduction shown is for primarily man-induced loading, including domestic wastewater, live-aboards, and stormwater from developed areas. Stormwater loads from undeveloped areas, atmospheric deposition, or other nonpoint sources are not included.

[b]Initial costs include land acquisition, initial WWTP construction, WWTP capacity increases to serve 20-year demands and construction of all collection systems.

[c]Costs include labor, administration, repair/replacement, power and chemicals.

[d]Present worth only; no financing costs included

[e]Cost shown is for present worth of single 250 GPD service connection share of the total cost.

[f]Cost Effectiveness = Total Cost/Percent of Nutrient Removal

[g]Cost for potable reuse does not include revenue from the sale of potable water.

[h]Costs for reuse options assume aquifer storage and recovery is used.

[i]Costs for potable reuse do not include revenues from sale of potable water.

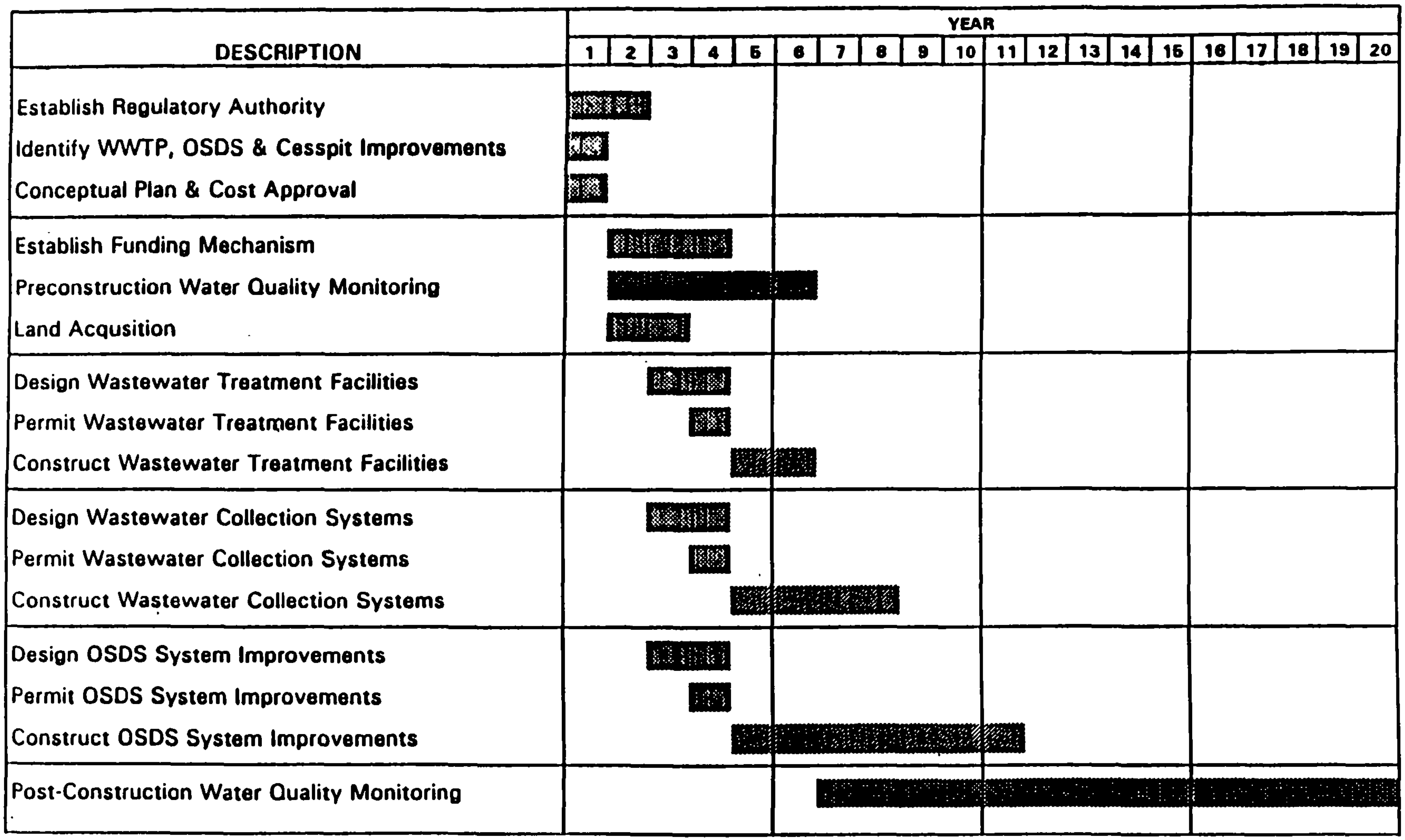


Figure C-19. Implementation schedule for Wastewater Option W3g: Construct three subregional WWTPs.

C.2.7.7 ENVIRONMENTAL EFFECTS

The environmental effects of Option W3g are similar to those of Options W3d, W3e, and W3f (see Section C.2.4.7). Overall land requirements for facility construction would be reduced to the 20 to 30 acre range. Short-term construction effects could be minimized with prudent construction practices.

C.2.7.8 ADDITIONAL MONITORING

Monitoring needs for this option are the same as those discussed for Options W3d, W3e, and W3f (see Section C.2.4.8).

C.3 OPTIONS FOR THE CITY OF KEY WEST

C.3.1 Option W4 — Upgrade Effluent Disposal for the City of Key West Wastewater Treatment Plant

C.3.1.1 DESCRIPTION

This option pertains only to the City of Key West. The City of Key West WWTP would continue providing secondary treatment of wastewater, but the ocean outfall would be replaced as the primary means of effluent disposal. The primary features of this option are:

- Continue use of the City of Key West WWTP for secondary treatment of wastewater from the service area.

- Continue programs for the extension of sewer service to areas not presently served.

- Continue infiltration/inflow reduction programs.

- Discontinue use of ocean outfall for primary effluent disposal and implement one of the following methods of effluent disposal:
  (a) Deep well injection
  (b) Reuse for irrigation within areas outside the Florida Keys (with aquifer storage and recovery).
  (c) Reuse for potable water (with aquifer storage and recovery)

Partial reuse of effluent for irrigation within Key West would be used to the extent practical under all effluent disposal options. Because of the shortage of suitable application sites, reuse of effluent for local irrigation needs will account for only a fraction of total effluent disposal needs.

Continuation of ocean outfall use with an upgrade in treatment was determined not to be a viable option. The present ocean outfall has deteriorated and does not meet current FDER requirements for ocean outfalls. A new ocean outfall would have to be constructed to meet current FDER Standards. The cost of this construction would be greater than that for deep well disposal. Also, obtaining a permit for a new ocean outfall may be very difficult, thus this option was dismissed.

The existing ocean outfall would be used as an emergency short-term disposal method for all four effluent disposal options. Reuse of effluent for irrigation in areas outside the Florida Keys would be considered only if it is proposed for unincorporated Monroe County.

C.3.1.2 RATIONALE

The rationale for selecting Option W4 would be that the existing City of Key West WWTP ocean outfall is degrading the waters of the FKNMS and upgraded effluent disposal will result in a long-term improvement in water quality. Additional monitoring and studies may be necessary to determine long-term effects.

C.3.1.3 POLLUTION REDUCTION

This option would reduce direct nutrient loading to waters of the FKNMS by the amounts present in the WWTP discharge. The City of Key West Comprehensive Plan indicates that 1990 average effluent concentrations for NH_3 + NO_3 nitrogen and orthophosphate are about 4.0 and 2.5 mg/L, respectively. Assuming these are the predominant forms of nitrogen and phosphorus in the effluent, the total nitrogen loading would be 61 lbs/day and total phosphorus would be 38 lbs/day. These estimated loads assume that all wastewater flows within the service area will be connected to the WWTP. Compared with total nutrient loadings to the FKNMS from all man-induced sources, this would amount to 5% and 9% estimated reductions in overall nutrient loadings for total nitrogen and total phosphorus, respectively.

C.3.1.4 COST

Estimated costs for suboptions under this option are summarized in Table C-9. Initial costs include design, permitting, and construction. The estimated present worth 20-year operation and maintenance costs are also included. Estimates for operation and maintenance are based upon a 6% annual inflation rate and include labor and administration, repair and replacement, and power.

C.3.1.5 IMPLEMENTATION SCHEDULE

A fast-track implementation schedule for Option W4 is shown in Figure C-20. This schedule could be compressed or extended as priorities and funding may dictate. If intensive effluent disposal suboptions such as the reuse of effluent for potable or irrigation water are selected, the schedule would be extended an estimated two years.

C.3.1.6 AFFECTED ENTITIES

Entities affected by this option include users of the wastewater systems (wastewater generators) and regulatory agencies involved in permitting and monitoring compliance of the systems. The main effect this option would have on users of the system would be sharing the costs of construction and operation. The degree to which residential and non-residential users would participate in cost sharing depends on funding mechanisms established to implement this option.

Primary areas of regulatory responsibility and authority would be:

- FDCA — reviewing wastewater master plans for consistency with comprehensive plan goals, policies, and objectives
- City of Key West — deciding whether city, FKAA, or another entity will assume the responsibility for a regional utility and the issuance of building and utility right-of-way permits required for construction
- FDER — permitting of effluent disposal systems and compliance/enforcement once system is in operation
- EPA — design review for reuse of effluent for potable water.

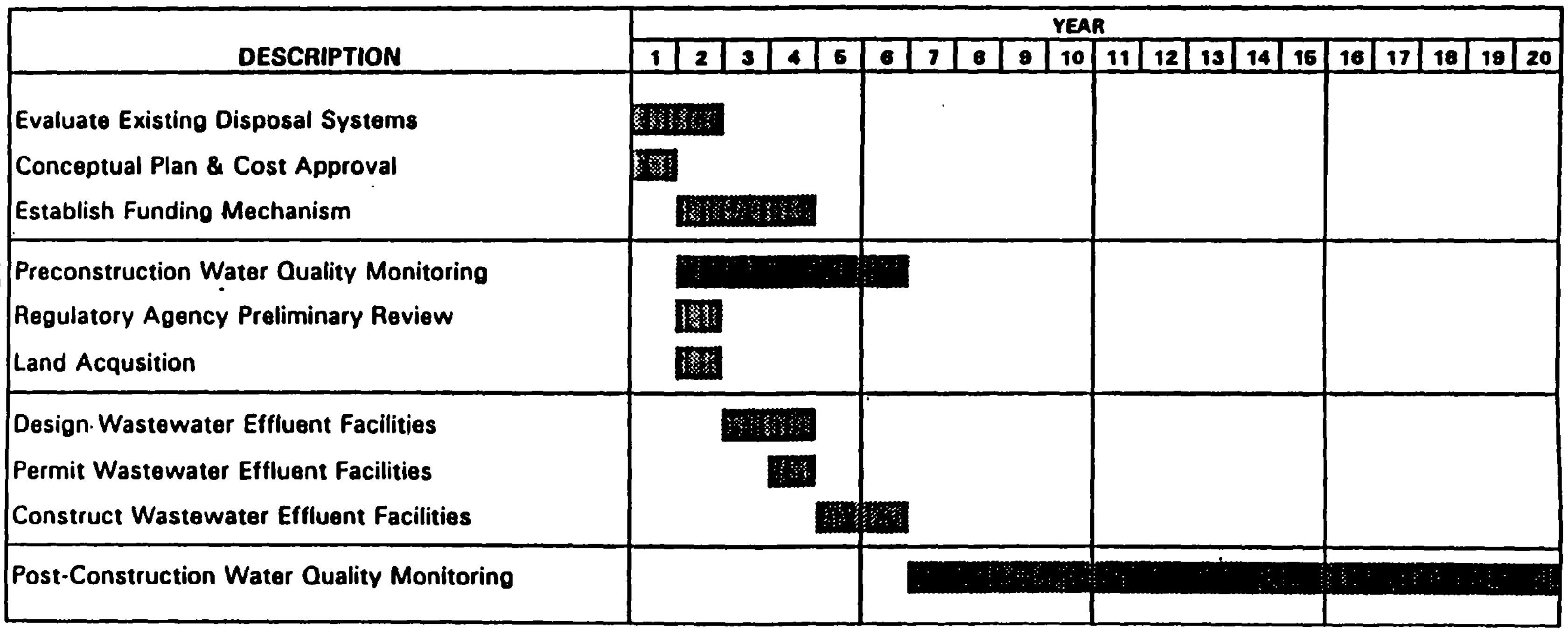


Figure C-20. Implementation schedule for Wastewater Option W4: Upgrade effluent disposal for the City of Key West WWTP.

- FDHRS — limited design review for reuse of effluent for potable water.

- FKAA — major role if delegated responsibility of wastewater utility by City of Key West or if reuse of effluent for potable water is selected; minor role in resolving utility conflicts with potable water systems if not delegated responsibility of wastewater utility.

C.3.1.7 ENVIRONMENTAL EFFECTS

The environmental effects of implementing this option would be limited to relatively short-term impacts associated with construction activities. Affected areas would be very small (for the deep well suboption) to perhaps 10 to 15 acres (for the suboption to reuse effluent for potable water). The suboption to pump treated effluent out of the Florida Keys for reuse as irrigation water would require 15 to 20 miles of pipeline construction to connect with the system for unincorporated Monroe County. The deep well injection suboption would preclude any reuse of effluent (permanent loss of resource), whereas reuse suboptions would maximize use of water resources.

C.3.1.8 ADDITIONAL MONITORING

Prior to implementing Option W4, monitoring of the Key West ocean outfall should be continued until the database is adequate to assess impacts on receiving waters and establish background conditions with the outfall in use. Following completion of an effluent disposal upgrade, monitoring of nearshore waters and systems should be continued to document the effects of removing this outfall from the Sanctuary.

APPENDIX D

Engineering Methods for Stormwater Collection, Treatment, and Disposal

ENGINEERING METHODS FOR STORMWATER COLLECTION, TREATMENT, AND DISPOSAL

As development occurs, changes in land use in the Florida Keys cause great changes in the way stormwater either runs off or is absorbed by the land. The characteristics and quality of runoff are also altered by the impervious nature of development. The natural topography's capacity to capture and buffer the effects of runoff is often exceeded. A wide range of controls is available to modify the quantity and quality of stormwater runoff. Stormwater control methods include physical measures to redirect or store stormwater and non-structural measures to affect the character of stormwater runoff. The treatment efficiencies and areas efficiently served by engineering methods for stormwater are estimated and presented in Table D-1.

D.1 GRASSED SWALES

Grassed swales are used as alternatives to curb and gutter stormwater conveyance systems. Grassed swales consist of slightly sloped grassed "valleys," often with dam-like structures made of stone and railroad ties that increase infiltration and flow attenuation.

Swales, or grassed waterways, are one of the oldest and least expensive stormwater management systems and have been used along streets and highways for years. A swale is:

- a shallow trench that has side slopes flatter than 3 ft horizontal to 1 ft vertical
- an area that contains standing or flowing water only after a rainfall
- planted with or has vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake
- designed to take into account soil erodibility, soil percolation, slope, slope length, and drainage area to prevent erosion and reduce the stormwater pollutant load.

Swales are used primarily for stormwater conveyance and are considered an on-line practice. As with other retention practices, the effectiveness of pollutant removal depends on the volume of stormwater that can be percolated through the filtering vegetation and into the soil.

Maintenance requirements for swales will not be significantly greater than those for a normal lawn. However, public education is essential, especially for residents who live in developments served by swales. Residents need to be informed about the benefits provided by their swale so that they take pride in maintaining it and do not fill it in. Residents need to know that leaves, limbs and other vegetation, along with debris and oil, should not be disposed of in the swale. If this occurs, the pollutants in these materials will be delivered to downstream waters and a benefit of the swale would be lost.

Used alone, swales must percolate 80% of the runoff from a 3-in rainfall within 72 hours to provide proper water quality benefits. However, this is often impossible because of soil type or slope, and the greatest utility of a swale is as a pretreatment conveyance system that reduces pollutants before the stormwater enters a retention and detention basin or a wetland. The use of swales should be seen as an important component of a stormwater treatment train.

D.2 SWALE/BERM SYSTEMS

In the Keys, the use of swale/berm systems may be an effective stormwater engineering method for waterfront residential properties. These systems consist of a swale near the waterfront edge of the property and a low berm between the swale and the water. The berm serves to impound stormwater runoff in the swale, allowing the stormwater to percolate into the soil or limestone before being discharged to the adjacent surface water. Swales for these systems may be grassed or may be covered with the small limerock ("pea rock") typically used for yards in the Keys.

Table D-1. Estimated removal efficiencies for stormwater engineering methods[a].

Stormwater Engineering Method	Areas Efficiently Served (acres)	Removal Efficiencies (%)				Overall Removal Capability
		Suspended Sediment	TP	TN	Trace Metals	
GRASSED SWALES	0-5					
low gradient with checkdam		20-40	20-40	20-40	0-20	Low
high gradient		0-20	0-20	0-20	0-20	Low
FILTER STRIPS	0-5					
100 ft forested strip		80-100	40-60	40-60	80-100	Moderate
20 ft turf		20-40	0-20	0-20	20-40	Low
Catch Basin	0-2	0-20	Unknown	Unknown	Unknown	Low
Porous Pavement	2-10	60-80	20-40	20-40	60-80	Moderate
Pervious Parking	0-10	40-60	20-40	20-40	40-60	Moderate
Exfiltration Trench	5-20	80-100	60-80	60-80	80-100	High
Pollution Control Structure	5-20	0-20	Unknown	Unknown	Unknown	Low
DETENTION POND	15+					
first-flush: 6-12 h detention time		60-80	20-40	20-40	40-60	Moderate
1" - 24 h detention time		80-100	40-60	20-40	60-80	Moderate
with shallow marsh		80-100	60-80	40-60	60-80	High
RETENTION POND	15+					
wet with 1/2" storage		60-80	40-60	20-40	20-40	Moderate
wet with 1" storage		60-80	40-60	20-40	60-80	Moderate
wet with 4" storage		80-100	60-80	40-60	60-80	High
dry with 1/2" infiltration		60-80	40-60	40-60	40-60	Moderate
dry with 1" infiltration		80-100	40-60	40-60	80-100	High
dry with 4" infiltration		80-100	60-80	60-80	80-100	High

[a]Source: *Water Quality - Urban Runoff Solutions* APWA Special Report #61

D.3 FILTER STRIPS

Filter strips, consisting of grass or other close-growing vegetation, are designed to accept overland flows of runoff. They are usually composed of dense vegetation (such as high grasses, ground covers, or shrubs) and are often combined with underlying stone layers to enhance infiltration. Filter strips can be effective in slowing stormwater runoff rates and velocities, reducing downstream sediment loading by settling and physical entrapment. They can also increase infiltration of stormwater and can provide some nutrient removal through uptake by plants.

D.4 CURB ELIMINATION

Curb elimination has been identified as a means to improve stormwater runoff. The absence of curbs allows runoff to disperse over a greater area rather than being channeled into collection facilities. This dispersal over adjoining land, which is usually covered by vegetation, also aids in reducing runoff velocity and the sedimentation of solids. Conversely, in urban environments, curbs function to channel vehicular traffic as effectively as they channel stormwater. Curb and gutter construction:

- Reduces pavement failure by supporting the edges of bituminous pavement
- Prevents water seepage into the road base and subbase
- Improves safety by defining the edge of streets for drivers, children and pedestrians
- Keeps litter and dirt on the roadway where it can be collected more efficiently
- Is necessary in many commercial, industrial and business districts
- Is not necessary in suburban and rural areas.

The anticipated water quality or cost benefits from eliminating curbs must be measured against the longer term operational and safety implications of their absence.

D.5 CATCH BASINS

Catch basins are part of an underground stormwater collection, treatment, and disposal system. Stormwater runoff is routed to catch basins by swales, curb and gutter, inverted crown pavement or other conveyance. The catch basin is designed to capture grit, gravel, and debris, and to protect the remainder of the storm drainage system. Combined with a swale system where the inlet of the catch basin is raised 3 inches above the surrounding swale, the catch basin acts as a pretreatment device, providing for some retention of stormwater in the swale.

Catch basins require periodic cleaning and maintenance because they can fill with debris, capture oil or other hydrocarbons, and attract mosquitoes and other insects. Catch basins have also been abused by individuals who use them as dump sites for used oil and/or radiator coolant. Organic material, such as leaves, grass clippings, and pet droppings can be trapped in the catch basin. Catch basins can contribute significant amounts of pollutants to a storm sewer system with the first flush of a storm event. For these reasons, catch basins are most effective when they are located in swales and away from areas covered with asphalt.

D.6 EXFILTRATION TRENCHES

In many areas such as the Florida Keys, where land costs are so prohibitive that the use of retention or detention basins is excluded or severely limited, the use of exfiltration trenches is common.

The most commonly used underground trench is an off-line exfiltration trench in which runoff is diverted into an oversized perforated pipe placed within an aggregate envelope above the groundwater table. The first flush of stormwater is stored in the pipe and exfiltrates out of the holes, through the gravel and into the surrounding soil. Routine maintenance consists of vacuuming debris from the catch basin inlets and, if needed, using high pressure hoses to wash clogging materials out of the pipe. Pretreatment with filter strips or swales is essential for efficient, long-term operation of exfiltration trenches.

Another trench system uses exfiltration trenches beneath swale areas. These trenches enhance the swale usage and design and increase groundwater recharge. The trench is a shallow 3 to 8 ft-deep excavated area above the groundwater table and is lined with filter fabric and filled with stone. The top of the trench is covered with three to 4 in of soil and then is covered with sod. The soil and grass layer acts as a filter for the trench. In Florida, water tables are often too high for effective use of swale exfiltration trenches.

D. 7 POLLUTION CONTROL STRUCTURES (OIL/GREASE SEPARATORS)

Pollution Control Structures (PCS) are constructed to remove sediment and hydrocarbon loadings from parking lot and street runoff. PCSs, as typically designed, have limited storage capacities, but serve to separate some of the coarse sediment, oil/grease, and debris from urban runoff. Fine-grained particulate pollutants such as silt and clay, and associated trace metals and nutrients are less likely to be removed.

PCSs are appropriate for areas with excessive oil and grease loadings, such as gas stations, roads, or loading areas. The PCSs are unobtrusive, compatible with the storm drain network, easy to access, and allow pretreatment of runoff before it enters infiltration facilities. Disadvantages associated with PCSs include limited pollutant removal capabilities, the need for annual maintenance, and difficulties in disposal of accumulated sediments, which are sometimes classified as hazardous materials.

D.8 DETENTION/RETENTION FACILITIES

Detention and retention basins are used along roadways, parking lots, and other impervious areas to control the effects of short, high-intensity storms. The basins counter the increased rate and volume of runoff from impervious surfaces by retarding storm runoff. Stormwater is temporarily held in detention basins or stored for longer periods of time in retention basins. Detention and retention basins are most effective when they are built at the same time as the surrounding developments. Although they are not substitutes for stormwater management systems, the basins have their greatest benefits immediately downstream.

Maintenance is a key consideration before building detention or retention facilities. After installation, these facilities should be maintained consistently to keep them from becoming a liability or hazard. Continuing maintenance includes routine inspection, mowing, mosquito control, clearing and repairing of outlet works, removal of sediment and debris after storm events, erosion control on the embankment, maintenance of grass covers, and keeping vehicles off embankments.

D.8.1 Retention Basins

In an undeveloped area, infiltration is a natural part of the hydrologic cycle. A certain amount of precipitation infiltrates into the ground, replenishing the groundwater and providing water for trees and other plants. A retention area retains stormwater on site, allowing it to infiltrate into the ground or to evaporate. This reduces the volume of stormwater runoff and is effective in reducing stormwater pollution by retaining the first flush of stormwater off-line. By reducing the volume of stormwater runoff, infiltration also helps reduce the effects of stormwater on estuaries that are sensitive to salinity variations.

The amount of infiltration that occurs depends primarily on soil type. Successful use of infiltration requires appropriate site conditions to assure that the stormwater will infiltrate within 24 to 72 h. Coarse-grained sandy soils have excellent infiltration capacity. As soils begin to contain higher amounts of fine-grained clays and silts, their infiltration capacity diminishes. To protect groundwater from contamination, the bottom of retention basins should be at least 3 ft above the seasonal high water table and bedrock.

D.8.2 Detention Basins

These facilities provide temporary storage of stormwater runoff. Detention basins control peak discharges and provide pollutant gravity settlement. If site conditions will not allow total infiltration of the first flush of stormwater, then parts of the first flush can be infiltrated as pretreatment before the stormwater enters a wet detention or wetland treatment system for final treatment. On a small scale, lawns, parking lot islands and small landscaped areas can all be used to store stormwater and allow it to infiltrate. Such areas are especially appropriate as elements of a stormwater treatment train where raised storm sewer inlets are placed in the retention area allowing some treatment before excess stormwater is routed to a detention facility or other ultimate destination.

D.9 CLASS V INJECTION WELLS (BOREHOLES)

The Florida Department of Environmental Regulation (FDER) allows the use of shallow (Class V) injection wells for wastewater and stormwater disposal. Shallow injection wells (or boreholes) are used widely for disposal of package wastewater treatment plant effluent. Forty-three boreholes were being used for stormwater disposal in the Florida Keys as of July, 1992. The use of boreholes for stormwater disposal should only be for stormwater pretreated by detention or other methods.

A typical borehole in the Florida Keys is an 8-in diameter hole drilled to a depth of 60 to 90 ft and cased to a depth of 30 to 60 ft. Some large-diameter boreholes (24 to 30 in) are used in the Florida Keys for stormwater disposal. Current FDER regulations require boreholes to be drilled to a depth of 90 ft and cased to 60 ft.

D.10 AQUIFER STORAGE AND RECOVERY

Aquifer storage and recovery (ASR) is a relatively new technique involving pumping treated water to a confined shallow aquifer (~ 500 ft deep) for future use. The pumped water forms a "bubble" displacing native saline water. Differences in densities between the two water masses and restrictions of the aquifer formation minimize mixing of pumped and native waters. Recovery of the pumped water, for irrigation or other uses, can take place either immediately or in the future.

D.11 DEEP INJECTION WELLS

Deep well injection historically has been used primarily for the disposal of wastewater and reverse osmosis brine. Although, there are no known deep wells used strictly for stormwater disposal in Florida, FDER may allow the use of deep wells for stormwater injection. However, because of the high costs for construction, operation, and maintenance, the decision to utilize deep well injection for stormwater disposal may be cost prohibitive.

D.12 CISTERNS

Cisterns historically were used to collect rain water for household purposes. As potable water systems have become available, their application has all but disappeared. Cisterns can be a stormwater retention device, storing the water for irrigation during dry periods. Although cisterns provide no stormwater treatment, the capture of runoff and its delayed application to surrounding vegetation provides a beneficial use of stormwater. The vegetation also provides some treatment. Cisterns can also be utilized to store water for potable use. Cisterns used to collect and hold potable water generally are associated with roof collection systems. Cisterns are the primary method of supplying potable water on many of the outer Bahama Islands.

D.13 POROUS PAVEMENT

Porous pavement is an innovative stormwater practice that is applicable to parking areas not subject to sand and mud carried on tires. Areas paved with porous concrete allow water to percolate into the underlying soil. A parking lot, if paved with porous concrete, can remain pervious and allow infiltration, thereby reducing stormwater volume, peak discharge rate, and pollutant load. In addition, porous concrete eliminates the accumulation of water pockets, providing a safer, skid-resistant parking lot surface.

However, porous concrete is only feasible and cost effective on sites with gentle slopes, permeable soils, and relatively deep water tables. When properly designed and carefully installed, porous concrete has the load-bearing strength and longevity of conventional concrete. The design and installation of porous concrete should be undertaken only by a professional team of engineers and contractors who are familiar with its properties. Routine inspection and maintenance is essential to preserve the high infiltration rate of porous concrete paving. The surface should be routinely checked after a prolonged storm for evidence of debris accumulation, ponding of water, clogging of pores, or other damage. Regular vacuum sweeping should be performed to prevent clogging of the porous parking surface. High pressure steam cleaning or vacuuming may be needed annually. During construction it is essential that sound erosion and sediment control practices be used to keep sediment off the pervious pavement and to prevent clogging of pores.

If properly designed, installed and maintained, pervious concrete provides a cost-effective, viable solution to stormwater management problems associated with parking lots.

Porous pavement is constructed in layers as:

- Top porous pavement course, 2.5 to 4.0 in thick
- Upper filter course of 0.5 in diameter gravel, 1.0 in thick
- Stone reservoir of 1.5- to 3.0-in diameter stone; storage provided by the void space between stones; depth variable depending on the storage volume needed
- Lower filter Course of gravel, 2 inches deep
- Filter fabric layer
- Undisturbed soil

Parking lots are among the largest generators of runoff and polluted stormwater. These vast paved areas generate stormwater after every storm. Many parking areas, such as those at shopping centers, are rarely completely filled with cars. Parking lots should be covered with grass or gravel as much as practical.

D.15 STORMWATER REUSE FOR IRRIGATION

The reuse of stormwater for irrigation commonly is practiced in areas where the water supply is limited. The practice involves routing stormwater to a detention basin that is adequately sized to provide irrigation water for the intended application area. Irrigation water is pumped from the detention basin to the application site, where it is applied with overhead, underground, or drip systems. Stormwater can be reused to irrigate to areas ranging from single-lot residential or commercial sites to large golf courses or agricultural areas. On large projects, detention pond area and evaporative losses may be minimized if the use of an ASR system is feasible on the site.

APPENDIX E

Engineering Options for Stormwater Collection, Treatment, and Disposal

ENGINEERING OPTIONS FOR STORMWATER COLLECTION, TREATMENT, AND DISPOSAL

Options for the improvement of stormwater runoff cover a variety of engineering methods. These methods are defined and discussed in Appendix D.

Because options typically involve a combination of several engineering methods, they are described and presented in order of increasing level of effort. The first option identifies stormwater improvements for potential hot spots. Hot spots are defined as land-based activities, such as intensive commercial, industrial, and dry dock facilities, that contribute significant quantities of pollutants to stormwater runoff. The second option involves an extensive program of retrofitting population centers, hotels, resorts, and major residential areas with stormwater treatment methods, along with the hot spots addressed in the first option. The third and ultimate option requires retrofitting all developed areas within the Florida Keys with best available technology.

Sections for each option include a description of the option, rationale for selection, estimated pollution reduction, cost, implementation schedule, affected entities, environmental effects, and additional monitoring. It should be noted that the relationship of removal efficiency to cost is only roughly understood for stormwater.

E.1 OPTION S1a — RETROFIT HOT SPOTS

E.1.1 Description

The option for retrofitting hot spot potential sources of contamination is:

- Identify hot spots or problem areas (e.g., commercial, industrial, dry docks, U.S. 1).
- Retrofit stormwater facilities in hot spots using: grass parking, swales, exfiltration trenches, PCS, and detention/retention facilities.
- Eliminate stormwater runoff in areas handling toxic and hazardous materials (e.g., commercial, industrial, dry docks).
- Install swales and detention facilities along limited sections of U.S. 1.

E.1.2 Rationale

The rationale for selecting Option S1a would be that the retrofitting of stormwater hot spots with control and treatment methods will result in a significant reduction in pollutant loadings to waters of the Florida Keys National Marine Sanctuary (FKNMS) and an improvement in long-term water quality over that provided by the "no action" option. Additional monitoring and studies may be necessary to select this option.

E.1.3 Pollution Reduction

The effectiveness of stormwater control/treatment facilities is not well known and is very site specific. Nutrient removals are highly dependent on site conditions, engineering methods, and level of facility maintenance.

- Potential reductions in total nitrogen and total phosphorous loadings are estimated to be about 0.2 to 0.5% of the total man-induced loadings (stormwater and wastewater) to the FKNMS.

- Potential reductions in sediment loadings are about 0.5 to 1.0% of the total man-induced loadings (stormwater and wastewater) to the FKNMS.

Some of the toxic constituents in stormwater runoff will be removed by this option. The toxic constituents removed generally will be those associated with sediments or floating materials. Because of the many different toxic materials, the wide range of concentrations at which specific constituents are toxic, the high variability in stormwater quality from site to site, and the lack of significant stormwater data concerned with the Keys, the degree of reduction of toxic materials attained by implementing this option cannot be reliably estimated.

E.1.3 Cost

Construction costs are estimated to be $80 million. The present worth, 20-year operation and maintenance costs are estimated to be $120 million, based on a 6% annual inflation rate. The estimated total 20-year cost of this option is $200 million.

E.1.5 Implementation Schedule

A proposed fast-track implementation schedule for Option S1a is shown in **Figure E-1**. This schedule can be compressed or extended as dictated by priorities and funding.

E.1.6 Affected Entities

Entities affected by this option are:

- Owners of hot spots
- Florida Department of Transportation (FDOT) — Responsibility for runoff from FDOT right-of-way
- Environmental Protection Agency (EPA) — Administers National Pollutant Discharge Elimination System (NPDES) program
- Monroe County — Enforces October 1992 Stormwater Management Ordinance
- South Florida Water Management District (SFWMD) — Regulates larger parcels (10 acres or more total area or 2 acres or more impervious area)
- Florida Department of Environmental Regulation (FDER) — Maintains oversight authority over SFWMD permitting
- National Oceanic and Atmospheric Administration (NOAA) — Regulates FKNMS

E.1.7 Environmental Effects

The environmental effects of the implementation of Option S1a would be limited to short-term impacts associated with stormwater facility construction in hot spot areas.

E.1.8 Additional Monitoring

Existing stormwater data are inadequate to characterize present pollutant loadings to the FKNMS. Quantifying pollutant loading reductions from implementation of this option would be even more difficult. Because of this lack of data, it is recommended that a marina stormwater-control demonstration project be conducted in the Florida Keys. This project should focus on a suspected stormwater hot spot. The recommended location is a large marina with a large, unpaved, outdoor area where bottom painting and other intensive maintenance activities are performed. Activities associated with this project should include:

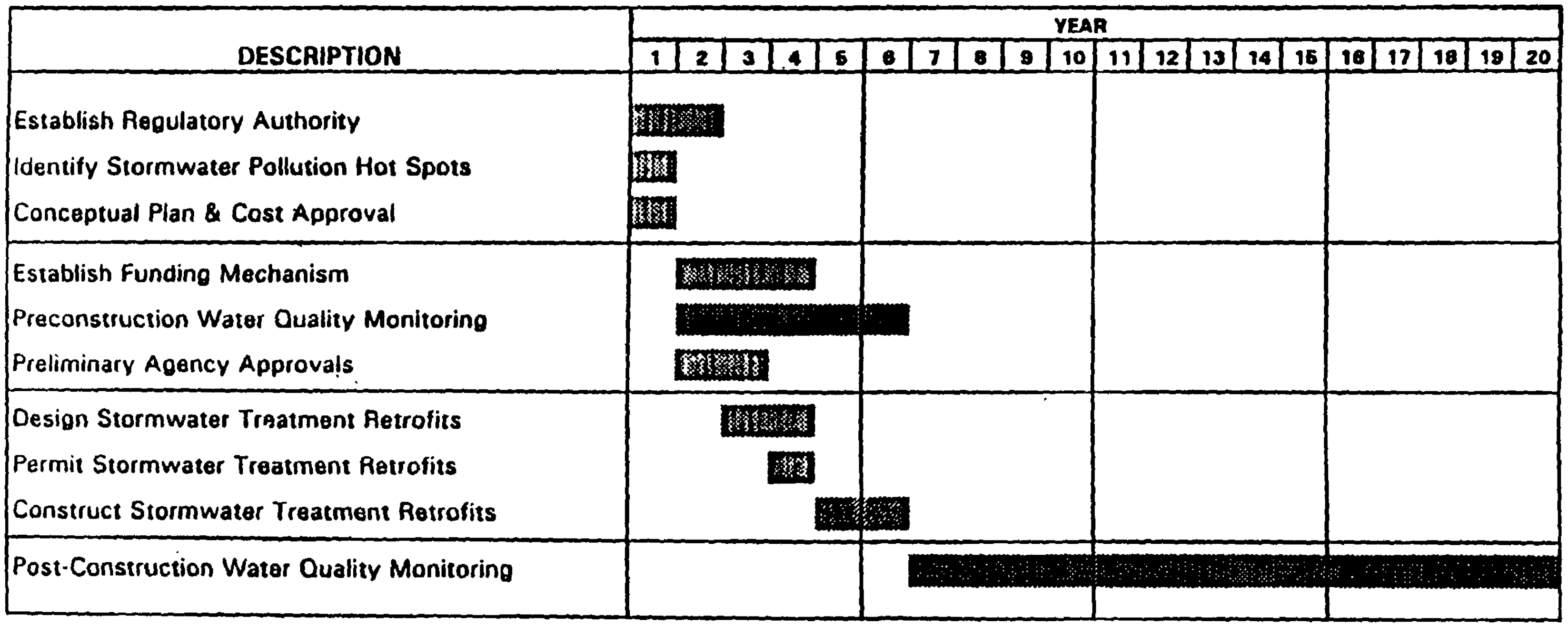


Figure E-1. Implementation schedule for Stormwater Option S1a: Retrofit hot spots.

- Paving and curbing the entire maintenance area
- Constructing pollution control device(s) and retention pond(s) as necessary to control discharge of stormwater runoff. Pollution control devices and filters should be installed ahead of all ponds
- Cleaning visible residue from waters near the existing point(s) of discharge
- Providing sweeping equipment to regularly clean the paved maintenance area

Monitoring associated with the demonstration project should include:

- Pre-implementation sediment and water quality monitoring of nearshore surface waters including background (if appropriate) and existing discharge point(s)
- Pre-implementation storm event monitoring at existing discharge point(s) (water and bed load sampling, if appropriate)
- Post-implementation sediment and water quality monitoring
- Post-implementation storm event monitoring
- Characterization of all materials removed from maintenance areas prior to disposal to determine the potential generation of pollutants by maintenance activities

Sediment and water samples should be analyzed for several parameters, including heavy metals, organics, and pesticides. Other analyses, as determined from site-specific operations and the materials used, should be performed.

In addition to the marina stormwater-control demonstration project and its associated monitoring, pre- and post-implementation monitoring of selected stormwater hot spots located away from the project should be performed in order to evaluate the pollutant reduction effectiveness of this option and the long-term effects on water quality.

E.2 OPTION S1b — RETROFIT HOT SPOTS AND POPULATION CENTERS

E.2.1 Description

The option for retrofitting population centers and hot spots is:

- Retrofit hot spots as specified in Option S1a.
- Initiate an extensive stormwater retrofitting program for population centers.
- Install swales and detention basins along a majority (i.e., developed areas) of U.S. 1.

E.2.2 Rationale

The rationale for selecting Option S1b over Option S1a would be that the higher intensity and commitment associated with Option S1b would result in a significant long-term improvement in water quality. Additional monitoring and studies may be necessary to select this option.

E.2.3 Pollution Reduction

The effectiveness of extensive stormwater engineering implementation is not well known and is very site specific. Nutrient removals are highly dependent on site conditions, engineering methods, and level of facility maintenance.

- Potential reductions in total nitrogen and total phosphorous loadings are estimated to be about 5 to 12% of the total man-induced loadings (stormwater and wastewater) to the FKNMS.

- Potential reductions in sediment loadings are estimated to be about 20 to 50% of the total man-induced loadings (stormwater and wastewater) to the FKNMS.

Some of the toxic constituents in stormwater runoff will be removed by this option. The toxic constituents removed generally will be those associated with sediments or floating materials. Because of the many different toxic materials, the wide range of concentrations at which specific constituents are toxic, the high variability in stormwater quality from site to site, and the lack of significant stormwater data concerned with the Keys, the degree of reduction of toxic materials attained by implementing this option cannot be reliably estimated.

E.2.4 Cost

Construction costs are estimated to be $370 million. The present worth, 20-year operation and maintenance costs are estimated to be $440 million, based on a 6% annual inflation rate. The estimated total 20-year cost for Option S1b is $810 million.

E.2.5 Implementation Schedule

A proposed fast-track implementation schedule for Option S1b is shown in Figure E-2. This schedule can be compressed or extended as dictated by priorities and funding.

E.2.6 Affected Entities

Entities affected by the option are identical to those affected by Option S1a (see Section E.1.6).

E.2.7 Environmental Effects

Construction of stormwater control facilities will cause short-term construction impacts. The removal of developed land for detention/retention facilities will be a long-term effect.

E.2.8 Additional Monitoring

A marina stormwater-control demonstration project is recommended (see Section E.1.8). As with Option S1a, pre- and post-implementation monitoring is recommended to assess effectiveness of the retrofit program.

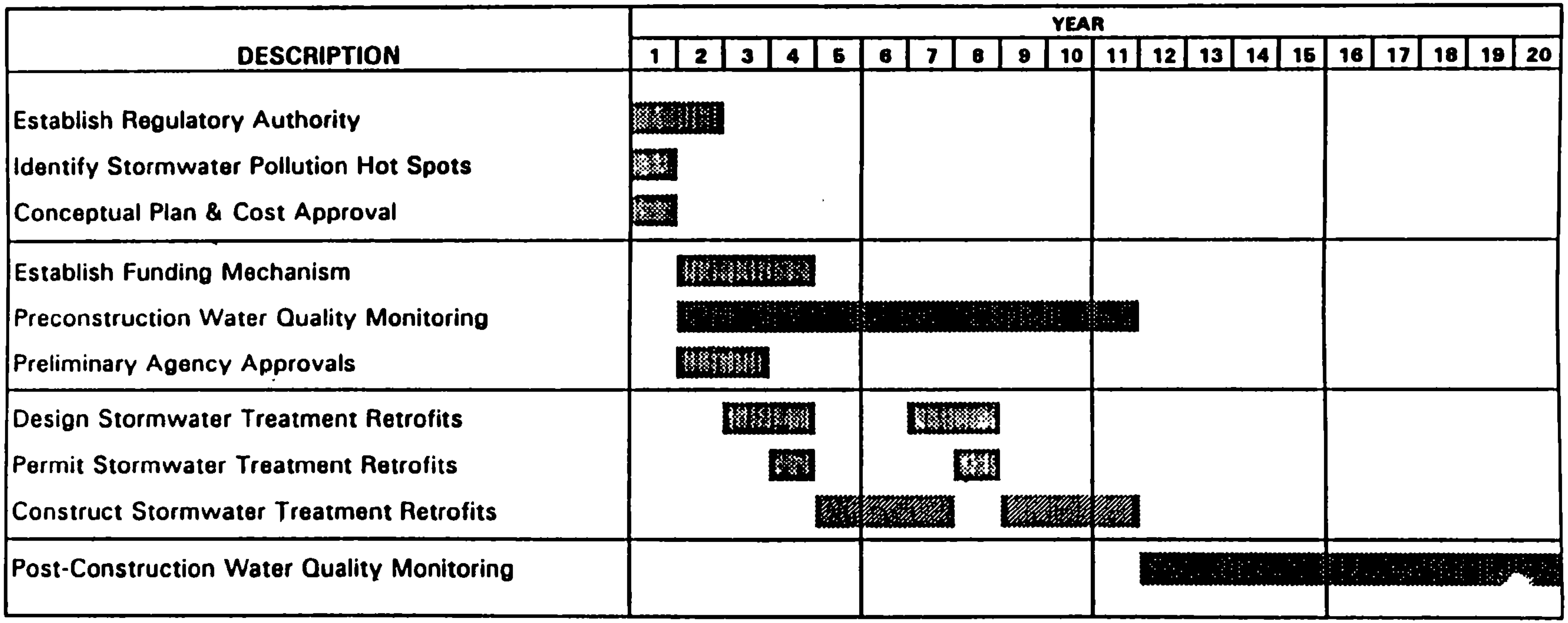


Figure E-2. Implementation schedule for Stormwater Option S1b: Retrofit hot spots and population centers.

E.3 OPTION S1c — RETROFIT STORMWATER FACILITIES THROUGHOUT SANCTUARY

E.3.1 Description

The option for retrofitting stormwater facilities throughout the Florida Keys is:

- Retrofit hot spots as specified in Option S1a.
- Initiate an extensive stormwater retrofitting program for population centers discussed in Option S1b and other developed areas.
- Install swales and detention facilities along U.S. 1.
- Include the ultimate disposal of stormwater via boreholes or deep wells.

E.3.2 Rationale

The rationale for selecting Option S1c over Option S1b would be that the higher intensity and commitment associated with Option S1c would result in a significant long-term improvement in water quality over that provided by Option S1b. Additional monitoring and studies may be necessary to select this option.

E.3.3 Pollution Reduction

The effectiveness of this option is not well known and is very site specific. Nutrient removals are highly dependent on site conditions, engineering methods, and level of facility maintenance.

- Potential reductions in total nitrogen and total phosphorous loadings are estimated to be about 20 to 50% of the total man-induced loadings (stormwater and wastewater) to the FKNMS.
- Potential reductions in sediment loadings are estimated to be about 40 to 60% of the total man-induced loadings (stormwater and wastewater) to the FKNMS.

Some of the toxic constituents in stormwater runoff will be removed by this option. The toxic constituents removed generally will be those associated with sediments or floating materials. Because of the many different toxic materials, the wide range of concentrations at which specific constituents are toxic, the high variability in stormwater quality from site to site, and the lack of significant stormwater data concerned with the Keys, the degree of reduction of toxic materials attained by implementing this option cannot be reliably estimated.

E.3.4 Cost

Construction costs, when boreholes are used for disposal, are estimated to be $530 million. The present worth, 20-year operation & maintenance costs are estimated to be $680 million based on a 6% annual inflation rate. Construction costs, when deep wells are used for disposal, are $680 million. The present worth, 20-year operation and maintenance costs are estimated to be one billion dollars, based on 6% annual rates. The estimated total 20-year costs for Option S1c are $1.2 billion with borehole disposal and $1.7 billion with deep well disposal.

E.3.5 Implementation Schedule

A proposed fast-track implementation schedule for Option S1c is shown in Figure E-3. This schedule can be compressed or extended as dictated by priorities and funding.

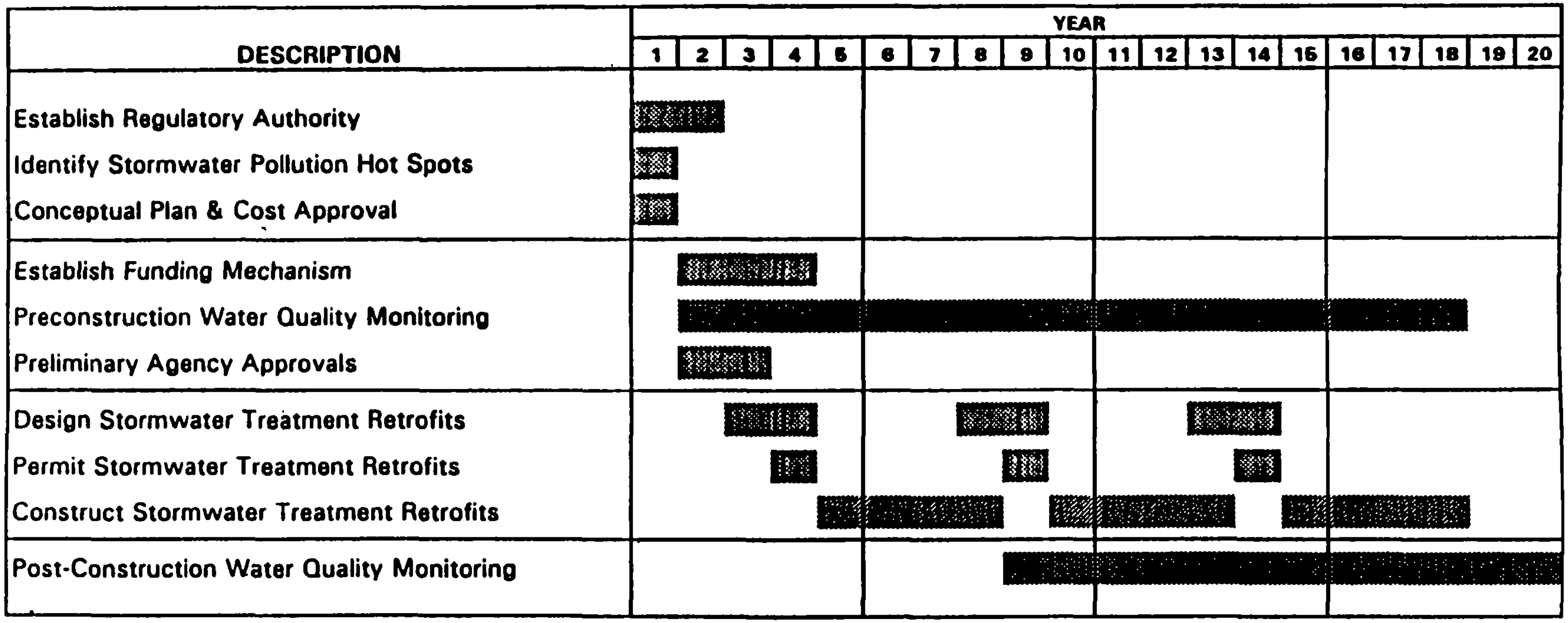


Figure E-3. Implementation schedule for Stormwater Option S1c: Retrofit stormwater facilites throughout the Sanctuary.

E.3.6 Affected Entities

Entities affected by this option are identical to those affected by Options S1a and S1b (see Section E.1.6).

E.3.7 Environmental Effects

Construction of stormwater control facilities will cause short-term construction impacts. The removal of developed land for detention/retention facilities will be a long-term effect. The creation of some artificial upland wetlands for stormwater treatment has a net beneficial result.

E.3.8 Additional Monitoring

A marina stormwater-control demonstration project is recommended (see Section E.1.8). As with Options S1a and S1b, pre- and post-implementation monitoring is recommended to assess effectiveness of the retrofit program.

TASK 5 — FUNDING SOURCES REPORT

CONTENTS

CONTENTS (continued)

TABLES

ACRONYMS

ACIR	Florida Advisory Council on Intergovernmental Relations
BEBR	Bureau of Economics, Business, and Research
BLGFA	Bureau of Local Government Wastewater Financial Assistance
BNW	Battelle-Northwest
CDBG	Community Development Block Grants/Entitlement Grants
COP	Certificates of Participation
CSO	combined sewer overflow
CWA	Clean Water Act
DOC	U.S. Department of Commerce
EPA	Environmental Protection Agency
FKNMS	Florida Keys National Marine Sanctuary
FDER	Florida Department of Environmental Regulation
FDHRS	Florida Department of Health and Rehabilitative Services
FDNR	Florida Department of Natural Resources
FDOA	Florida Department of Agriculture
FHA	USDA Farmer's Home Administration
FHFA	Florida Housing Finance Agency
FKAA	Florida Keys Aqueduct Authority
FS	Florida Statutes
FTCC	Finance, Taxation, and Claims Committee
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
HUD	U.S. Department of Housing and Urban Development
IDRB	Industrial Development Revenue Bonds
NCW	Near Coastal Waters
NEEA	National Environmental Education Act
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
OMB	U.S. Office of Management and Budget
OSDS	On-site Sewage Disposal System
PSFC	Puget Sound Finance Committee
PSWQA	Puget Sound Water Quality Authority
RCW	Revised Code of Washington
SCORE	Small Community Outreach and Education
SFWMD	South Florida Water Management District
SCS	USDA Soil Conservation Service
USDA	U.S. Department of Agriculture
WWTP	wastewater treatment plant

1.0 INTRODUCTION

As part of Phase II, Battelle-Northwest (BNW) was tasked with identifying and evaluating potential sources - funding for implementing any necessary institutional and structural corrective actions. The information used in this report has been gathered from review of Florida State regulations related to funding and analysis of funding options used in similar activities. This report should serve as an inventory of potential options that can be used to address certain aspects of the water quality issues in the Florida Keys National Marine Sanctuary (FKNMS).

A wide range of options has been identified for addressing water quality issues in the Keys. The agencies and institutions that will be involved in implementing these options are diverse in terms of capabilities and resources. Many of the funding mechanisms discussed in this report could be used to address a number of different management and engineering options, and it will be the task of the agencies and institutions involved to determine which options are more appropriate for them. At this stage in the development of management plans for the FKNMS, no single preferred option, or set of options, has been recommended for addressing water quality issues in the Keys. Because of this, it is difficult to determine the type and level of funding that will be required and the potential impacts this funding will have on the local economy. For this reason, this report does not recommend a specific suite of funding options to use nor does it contain an extensive analysis of economic impacts or potential revenue generation.

This report presents an inventory of potentially available options for financing water quality improvements in the FKNMS. Section 2 provides a description and discussion of the water quality issue areas for which funding will be required. Section 3 discusses the categories of funding mechanisms and provides examples of specific mechanisms that could be used to finance activities in the Florida Keys. In Section 4, an overview of steps for implementing the funding mechanisms, and strategies for implementing the funding mechanisms in the areas of wastewater and stormwater management, are identified and discussed. Conclusions are in Section 5.

2.0 OVERVIEW OF THE WATER QUALITY OPTIONS

The management and engineering options have been divided into several issue areas based on the priority issues identified in the Phase I report. These areas are wastewater management (including both on-site sewage disposal systems [OSDS] and wastewater treatment facilities), stormwater management, marinas and live-aboards, landfills, and spills and hazardous waste. In addition to these management and engineering options, this section also discusses potential funding for public education and outreach. Applicability of potential funding sources to water quality options is illustrated in **Table 5-1**.

2.1 WASTEWATER MANAGEMENT

2.1.1 On-site Sewage Disposal Systems

One of the major suspected sources of water quality degradation in the Keys is the extensive use of on-site septic systems, especially in the unincorporated areas of Monroe County. Although OSDSs are required to be permitted prior to installation, there is presently no requirement to upgrade older systems to bring them into compliance with current regulations. In addition, owners of these systems are not required to monitor for nutrients in their effluent.

Water quality options discussed in Tasks 3 and 4 that seek to address this problem would require that all current OSDSs comply with current regulations. This may include upgrading the septic systems to current standards or retrofitting them with nutrient removal systems. This option would allow the septic systems to remain in operation, but would increase the management and monitoring of these systems to enhance protection of the marine environment.

Table 5-1. Applicability of potential funding sources to water quality options.

	Municipal Bonds	Tax Finance	Grants and Loans	Rates	Fees	Licenses and Permits	Special Assess-ments	Privatiza-tion	Donations and Trusts
WASTEWATER									
Retrofit Package Plants	•		•	•	•	•	•	•	
Centralization of Treatment Facilities	•		•	•	•	•	•	•	
STORMWATER									
Change Agricultural Practices						•			
Enhanced Public Education		•		•	•	•			
Enhanced Curbside Trash Pickup		•		•	•				
Enhanced Public Transportation	•	•		•	•				
Eliminate Size Exemption for Stormwater Permits					•	•			
MARINAS LIVE-ABOARDS									
Construct Onshore Pumpout Facilities	•	•	•	•	•	•			
Construct Maintenance Areas	•	•	•	•	•	•			
Require Containment around Fuel Docks		•		•	•	•			
Specified Mooring Fields			•	•	•	•			
LANDFILLS									
Increased Groundwater Monitoring		•		•	•	•			
Remedial Actions	•			•	•				
MOSQUITO CONTROL									
Alter Application Techniques				•	•				
Evaluation and Study of Impacts				•	•				
PUBLIC EDUCATION AND OUTREACH		•	•	•	•				

Another approach to addressing the OSDS problem is to gradually replace the septic systems with sewers. Construction of 2 to 12 community or 3 subregional wastewater treatment plants (WWTPs) would be required over a period of 12 to 20 years (see Tasks 3 and 4). Large population areas would be the first priority of these community or subregional systems.

2.1.1.1 ACTIVITIES TO BE FUNDED

Activities requiring funding include the capital expenses of retrofitting existing OSDSs and the construction of community or subregional plants and collection systems. Should the septic systems be left in place and upgraded, additional funding will be required for providing on-site inspection and monitoring to ensure continued compliance with the regulations.

2.1.2 Package Plants

A significant portion of domestic wastewater treatment in the Keys is accomplished through the use of small "package plants" that serve individual uses such as schools, trailer parks, hospitals, restaurants, and hotels/motels. These package plants generally discharge their effluent into boreholes or injection wells permitted by the Florida Department of Environmental Regulation (FDER). Package plants are designed to meet secondary treatment standards, but do not have any requirements regarding nutrient levels. Although a direct connection between borehole disposal of effluent from package plants and nitrification of surface waters has not been made, it is suspected that these plants may be contributing to increased nitrogen levels of nearshore waters in the FKNMS.

One water quality option that would address the impacts of package plants is to retrofit the package plants for nutrient removal. This option would continue to use boreholes for effluent disposal or require the construction of deep wells (3,500 feet or deeper) for waste injection. An additional option would be to connect facilities currently using package plants to centralized wastewater treatment facilities. The latter would require the construction of 2 to 12 community or 3 subregional treatment facilities over a period of 12 to 20 years. New treatment facilities that have a potential for discharge to nearshore waters are assumed to incorporate advanced waste treatment technology. Facilities with little or no potential for discharge to nearshore waters are assumed to use secondary treatment. Treated effluent from these treatment facilities could be used for irrigation.

2.1.2.1 FUNDING REQUIREMENTS

Activities requiring funding include the capital expenses of retrofitting existing package plants and the construction of community or subregional treatment facilities. Construction of deep wells may also be classified as a capital expenditure. Noncapital funding requirements include water quality monitoring and facility inspection.

2.2 STORMWATER MANAGEMENT

A potentially major source of nonpoint pollution results from stormwater runoff from roads, industrial facilities, agricultural land, and residential areas. This water can carry several types of pollutants including petroleum products, fertilizers, and pesticides. The South Florida Water Management District (SFWMD) has been delegated authority over stormwater management by the FDER. SFWMD currently requires stormwater permits for development of sites over 10 acres in size with 2 or more acres of impervious surface. Industrial facilities and roads are required to provide some level of stormwater treatment before the water is allowed to be released to the stormwater canals. Activities that do not meet the size requirements for SFWMD permits may still be required to receive a permit from the municipality or local government. Water from the canals is not currently treated for pollutant removal prior to being released to the surface waters, nor is it required to have a discharge permit.

Because stormwater carries pollutants from a number of sources, its impact to water quality is very difficult to quantify. Two options to decrease the impact of stormwater on the FKNMS include requiring treatment of stormwater in "hot spots" and developed areas, and discharging treated water into boreholes or deep wells. Combined sewer overflows (CSOs) associated with wastewater treatment facilities often become overwhelmed during periods of heavy rain and discharge untreated sewage directly into surface waters. Managing discharges from CSOs is also an option for improving water quality. Requirements for CSO management are currently being reviewed by the Environmental Protection Agency (EPA).

Additional options include the use of natural filtration systems to retain stormwater and allow certain pollutants to settle out or be absorbed. These systems include swales, waterways, filter strips, and wetlands. In addition to changing engineering practices related to stormwater management, enhanced public education on the fate of pollutants released to storm sewers may also have some impact on water quality. Other options include enhancing the curbside trash collection program to reduce the amount of garbage carried away by stormwater, and enhancing public transportation systems to lessen the number of automobiles adding pollutants to road surfaces. An additional option would eliminate the size exemption for stormwater permits and require all activities to contribute to stormwater management.

2.2.1 Funding Requirements

Construction activities, including retrofitting wastewater treatment facilities to eliminate CSOs, the creation of boreholes or deep wells, or construction or expansion of public transportation services will require capital expenditures. Other activities that will need to be funded include enhanced stormwater monitoring, increased garbage collection, inspection of cars and trucks, and enforcement.

2.3 MARINAS AND LIVE-ABOARDS

Boating is a popular activity within the Florida Keys. The Phase I report indicates that there are approximately 1,285 slips in the lower Keys and 2,053 in the middle and upper Keys. A substantial portion of the recreational boating activity within the Keys is associated with live-aboards (defined as boats serving as a continuous residence for a period of 2 months or more). Recreational boating activities affect water quality in several ways. Fuel and oil are released to the environment from marina fuel facilities and boat bilges. Other pollutants result from boat cleaning and maintenance activities such as bottom scrubbing and painting. In addition, live-aboards contribute to water quality degradation through the release of human waste.

Of the 186 marinas in the Keys, only 8 are equipped with sewage pump-out facilities. One option for addressing the water quality impacts associated with marinas and live-aboards would be to require the construction of onshore pump-out facilities or provide mobile pump-out service. Reduction of pollutants from boat maintenance activities could be addressed by requiring maintenance areas to be constructed for collection and proper disposal of paint and other hazardous wastes. Additionally, marinas could be required to provide containment around fuel docks to prevent the spread of spills. Options for addressing boat impacts outside the marinas include designation of specific mooring fields for anchorage.

2.3.1 Funding Requirements

Because most of the marinas in the Keys are privately owned, the requirements on agencies and institutions involved in water quality management in funding marina activities are different from those associated with either wastewater or stormwater management. The marinas are located on state aquatic lands and are required to obtain permits and leases. Some public assistance to private marinas in meeting the water quality option requirements may be deemed in the interest of the state. This may include assistance in constructing pump-out facilities, purchase of mobile pump-out vessels, and construction of containment areas for boat maintenance. In addition, funding for enforcement of live-aboard sewage disposal regulations and marina fuel containment areas will be required. Public education on the issues associated with recreational boating impacts on water quality may also need to be funded.

2.4 LANDFILLS

There may be some impact on FKNMS water quality from operating or closed landfills. Of the four landfills previously operating in the FKNMS, only the Key West facility is still in operation. This facility is expected to be closed by November 1993. Although present and former landfills have operated within state and federal water quality standards, there is some question as to whether these standards are strict enough to protect the environment of the FKNMS.

Options to address the water quality issues associated with current and former landfill operations in the FKNMS include a search for abandoned landfills and increased monitoring of groundwater to determine the level of impact. Additional requirements, such as removal of the landfill or implementation of remedial actions, may also be necessary.

2.4.1 Funding Requirements

A search for abandoned landfills and increased monitoring of landfills will require additional funding. Remedial actions, such as the removal of the landfill or installation of containment devices (slurry walls), may require increased levels of funding.

2.5 MOSQUITO CONTROL

The Mosquito Control Program conducted by the Florida Department of Agriculture (FDOA) is a potential source of nonpoint pollution in the FKNMS. Pesticides are generally applied via truck spraying; however, during periods of heavy mosquito infestation, aerial spraying is employed, which increases the likelihood of airborne contaminants being dispersed into the FKNMS area. Although there have been no in-depth studies relating mosquito control activities to deteriorating ecological and environmental effects in the Keys, it is possible that adverse impacts to the nearshore environment are occurring.

Water quality options to address the impacts of mosquito control activities include changing application techniques from aerial to truck spraying, or finding alternative methods for mosquito control. Evaluation and study of the areas in which the controls are being applied have also been identified.

2.5.1 Funding Requirements

Research and monitoring of current application techniques and evaluation of alternative techniques will all require some level of funding.

2.6 PUBLIC EDUCATION/OUTREACH

Task 8, Public Education and Outreach, is identifying interested publics and existing public education and outreach programs and developing a public education and outreach program. The needs for public education and outreach identified by participants of workshops and strategy sessions hosted by the National Oceanic and Atmospheric Administration range from general information on the environment of the Keys to specific activities aimed at increasing awareness of the impacts of sewage treatment, household hazardous materials disposal, and environmentally sensitive harvesting and collecting methods for marine resources.

Some level of public education and outreach is necessary in addressing all of the water quality issues discussed above. This effort is being addressed separately to emphasize the need for coordinated activities to educate the public on the number and type of water quality issues in the Keys. In addition, specific funding revenues will need to be designated toward public education and outreach activities. These funds may come from sources specifically dedicated toward financing public education (i.e. EPA Education Grants), or may be a percentage of the revenue generated by fees and charges on specific activities.

3.0 FUNDING MECHANISMS

This section contains an inventory of categories of funding mechanisms that can be used to finance water quality improvement activities in the FKNMS. Examples of specific funding mechanisms and their applicability to water quality issues are also provided.

Most activities related to financing pollution prevention or control operate on a "polluter pays" principle that assesses the majority of the costs for an activity to the population creating the adverse impact. The public tends to view this as an equitable form of assessing costs when the polluters are corporations or industries causing a direct and noticeable impact to the environment. The perceived equitability of this type of approach is reduced when the polluter being assessed is the general public.

Since the passage of the Clean Water Act (CWA) in 1972, a significant effort has been taken to reduce the level of industrial waste and pollution being discharged into the nation's waters. These point sources are now being regulated and permitted to reduce their adverse effects on the environment. However, controlling these point sources has increased the realization that pollution resulting from automobiles, household fertilizer and pesticide use, improper disposal of household hazardous waste, and other "nonpoint" sources is also having a significant impact on the health of the environment. Because these nonpoint sources result from day-to-day activities, rather than the pollution events of industries, it is often difficult for the public to perceive the effects of their activities on the environment. In the Florida Keys, as elsewhere around the country, it needs to be recognized that these sources must also pay their fair share of the costs of a clean environment. A number of the taxes and fees discussed in this section seek to capture the costs of nonpoint source pollution.

3.1 MUNICIPAL BONDS

Municipalities, including states, counties, and "special districts," are generally authorized to issue municipal bond securities that pay interest that is exempt from federal taxation. Such "tax free" municipal bonds are most appropriately used to finance projects that involve acquisition of equipment or construction of capital facilities, such as water delivery systems, solid waste facilities, or sewage treatment plants.

For large-scale capital expenditures, the cost of development may exceed current tax revenue. Bonds offer the municipality the ability to spread the cost burden of the facility over a long period of time and distribute payment for the project to all who benefit from it. In some instances the facility created as a result of the bond issue will provide enough revenue to pay off the bond, but in other instances general tax revenue will be required for repayment. In either case the people of the municipality pay for the bond through higher taxes, user fees, or utility rate charges.

Because bonds are most appropriate for large-scale expenditures, it is often in the interest of municipalities and local governments to group their capital expenditures into large projects for which bonds could be used. Relatively small expenditures for equipment purchase, for which a bond issuance would normally be inappropriate, can be combined with activities such as the construction of wastewater treatment facilities or modification of stormwater canals and be covered by the bonds issued for those activities.

3.1.1 General Obligation Bonds

As the name implies, a General Obligation Bond is a general obligation of the municipality. This means that the bond is backed by the full faith and credit, and taxing power, of the municipality, and any form of municipal revenue may be used to repay the bond debt. General Obligation Bonds may be used for construction of facilities, infrastructure development, or municipal improvements. Some of these projects may generate revenues while others, such as roads, may not.

General Obligation Bonds could be used to finance expansion or construction of wastewater treatment facilities, and may be able to be used for financing retrofit or replacement of OSDSs if those systems are managed by an agency or authority with the ability to issue bonds. The state or local government may also issue General Obligation Bonds for construction of public infrastructure such as boat pump-out facilities, boat launches, and maintenance areas for boat repair. General Obligation Bonds may also be used for providing other types of infrastructure such as public transportation and roads.

3.1.2 Revenue Bonds

Revenue bonds are issued to finance projects that will provide revenue that can be used to repay bond debt. Sewage treatment plants, water delivery systems, and solid waste facilities are all examples of capital facilities that can be financed through issuance of Revenue Bonds. A specific type of Revenue Bond that deserves mention is a Special Assessment Bond. Special Assessment Bonds are secured by revenues generated through assessments on the properties benefiting directly from improvements. The use of special assessments as a funding mechanism is discussed in Section 3.7.

Because Revenue Bonds are used for projects that generate revenue, they are a potential option for financing the construction of wastewater and stormwater treatment facilities where those facilities charge rates or fees for their services. In addition, Revenue Bonds may also be an appropriate funding mechanism for construction of storage and reuse facilities that would sell treated effluent for agricultural/horticultural applications.

The city of Key Colony Beach used Revenue Bonds to finance construction of its sewage treatment plant, and Key West has also used Revenue Bonds for wastewater treatment facility expansion (J. Sheldon, Key Colony Beach, personal communication, 1992) (P. Cates, Key West City Government, personal communication, 1992).

3.1.3 Certificates of Participation

Certificates of Participation (COPs) are a type of municipal security similar in design to traditional municipal leases. In a traditional lease the municipality provides funding for a project and then earns income through lease of the facility. With a COP, investors purchase the COP, thereby providing funding for the project. The municipality uses those funds to finance the project, which is then leased, and the income from the lease is used to make biannual interest payments to investors and to repay the COPs at maturity. COPs have been used for financing such things as fire trucks, sewer-related equipment, and telecommunications systems (Barzel 1988). They are traditionally a small issue security but can be pooled into larger issues (Barzel 1988)

COPs are not considered a direct debt of the municipality issuing them but are considered to be a current operating expense to be paid through annual budgetary appropriation. COPs are usually short-term instruments and do not require voter approval. They provide an easy way for municipal governments to finance projects with fewer of the administrative and bureaucratic difficulties associated with standard bond issues. For this reason, COPs may be criticized as a method for governments to finance projects that provide unpopular facilities without public consent.

3.1.4 Pooled Bonds

Issuance of Municipal Bonds can be quite costly for some smaller municipalities. While large municipalities enjoy a relatively broad tax capacity and a resulting ability to issue municipal bonds easily, smaller municipalities may have difficulty obtaining a good credit rating or simply affording the cost of the bond issuance. In some instances, small municipalities, or relatively small projects, could be abandoned due to the expense of small bond issues. Several states and regions have sought to ease these difficulties by creating Municipal Bond Banks that either pool the individual bond issues into one large issue or use a large state General Obligation Bond issue to generate funds to purchase the smaller bond issues directly from small municipalities. In either case, the bonds are issued as General Obligation Bonds carrying the full faith and credit guarantee of the state. This method reduces the cost of issuance to the small municipality by spreading the costs over all participants of the pool. In addition, use of the state's higher credit rating reduces interest costs.

The funds required for some water quality improvement options at the local level may be too small for a standard bond issue. A state-operated bond bank or bond pool could provide a mechanism for issuance of bonds to finance these projects.

A similar approach to this type of financing has been used to enhance the available revenue in the State Revolving Loan Funds (see section 3.3.1.1). States issue bonds and deposit the revenue into the State Revolving Loan Fund. These monies are then loaned to local governments in the same manner as other revenues from the Fund. Federal and state contributions to the State Revolving Loan Funds are used to lower the interest rate on the loans made to the local governments, and increase the credit rating of bonds (EPA 1990b). The State of Florida uses a similar approach in its Bond/Loan Program (see section 3.3.2).

3.1.5 Private Activity Bonds

The 1986 Federal Tax Reform Act greatly altered the rules for issuance of certain classes of municipal bonds. Prior to the act, municipalities and special districts were allowed to issue tax-free Industrial Development Revenue Bonds (IDRB) to finance development (ACIR 1991d). In many cases such development was undertaken specifically to make a locality more attractive to industry. Facilities such as business incubators and manufacturing plants were constructed using IDRBs and then contracted to private companies. The proceeds of the contracting arrangement were then used to repay the bond debt.

Use of IDRBs to finance projects was severely curtailed by the 1986 Federal Tax Reform Act. The 1986 Tax Act defines such bonds as private activity bonds if more than 10% of the bond repayment revenue comes from private activities such as private operation of a WWTP. The 1986 Tax Act established a statewide private activity "unified bond cap" based on a dollar amount per capita. Subsequent to the passage of the 1986 Tax Reform Act, the Internal Revenue Service in Section 146 of the Internal Revenue Code of 1986 defined the unified bond cap as the greater of $150 million or $50 multiplied by the population (ACIR 1991d).

In 1991, Florida was allowed $633.5 million in issuance of private activity bonds statewide. The state of Florida facilitates the equitable distribution of the private activity unified bond cap through three pools; the State Pool, the Florida Housing Finance Agency (FHFA) Pool, and the Regional Pools. The State Pool receives 15% of the cap amount, which is set aside for "Priority Projects." Such projects include solid waste disposal and sewage facilities. Additionally, the State Pool may fund other eligible private activity bonds issued by the Florida government or FHFA. The FHFA pool receives 25% of the cap amount and utilizes that portion for housing-related projects. The Regional Pools receive 60% of the volume cap, which is then further allocated to each of the regions for general private activity bonds. The Executive Office of the Governor is responsible for prioritizing projects applying to the State Pool. The Regional Pools are allocated via lottery (ACIR 1991d).

Under the allocation schemes for each pool, there is no assurance that a request for a private activity bond allocation under the unified cap will be granted. Also, it is possible that only a portion of the amount needed to fund a project will be allocated to the project by the pools. In such cases, the authority to issue the private activity bonds may be carried forward for three years, during which additional applications for inclusion in future pools may be submitted (ACIR 1991d). In this way, authorization for financing a project with private activity bonds may be obtained over a three-year period.

3.1.6 Impacts

Bonds are a valuable source of revenue that allow the costs of the project to be spread over a long period of time. For this reason, they are extensively used to fund construction of public works including water and sewage works, and landfills. Depending on the type of bond issued, bonds may be paid with either rate or tax revenue. Use of rate revenue will impact the users of the project, while tax revenue spreads the costs of the project across the entire taxable public. Depending on the amount of the bond and the repayment schedule, the impacts on rates and taxes will vary.

Because they are used for long-term financing, use of bonds requires long-term debt management. In addition, bonds tend to result in either new or increased taxes or rates that can be viewed unfavorably by the public. In many cases, voter approval is required prior to issuing bonds, making the level of rate or tax increase a significant consideration. Finally, bonds can be expensive to issue and can increase administrative burdens on the issuing entity. Pooling of bonds may lower these transaction costs. In general, bonds are viewed as a relatively equitable source of finance because, whether they are repaid by taxes or rates, they spread the costs of a project providing public benefit over the population that is benefiting.

3.2 TAX FINANCE

The most prevalent form of municipal revenue generation is direct taxation of the public. Taxes can take on a wide variety of forms but usually can be grouped into one of three general categories: personal income, property, and sales and use. In addition to personal taxation, many states charge corporate income taxes or business and occupation taxes.

Taxation of personal income occurs in all but seven states (FTCC 1991b). This form of taxation is usually used to provide general revenue to be allocated in the state budget process. Some states levy income taxes on a progressive scale similar to federal income taxes, while others charge a flat percentage of income. In some cases, counties are allowed to charge "piggyback" income taxes on the state income tax to provide additional county budget revenue. Although the Florida Constitution prohibits the levying of a personal income tax, for a majority of states this type of tax represents a significant source of income.

Taxation of personal property, such as real estate, boats and automobiles, is a common form of taxation. Property taxes on real estate are usually charged via a millage rate (one mill equals $1 per $1,000 of assessed value) on the assessed value of property. Exemptions for government property and leaseholds are often granted, and some personal exemptions may be granted as well. In some states, personal property such as boats or automobiles are also taxed based on market value.

Sales and use taxes are charged by most states and include taxes on many consumer items. Such taxes can be levied on a per-unit basis or as a percentage of value. In addition to standard sales taxes, specific commodities are sometimes taxed to provide revenues for government programs related to the commodity. Such taxation often occurs on consumption of a good that has an impact on infrastructure or the environment.

3.2.1 Florida State Level Tax Revenue

The Florida State Constitution grants to the state all revenue sources not specifically provided for by law except *ad valorem* property taxes (MacManus 1991). This provision gives the state sole authority to assess and collect taxes unless the state legislature authorizes specific taxes at the local or county level. In addition, the constitution prohibits assessment of a state income tax. The inability of the state to collect *ad valorem* property taxes or state income taxes effectively limits its revenue to sales and use taxes. This limitation has resulted in numerous sales taxes and tax surcharges.

Florida tax revenue must be deposited into one of four types of funds in the custody of the state treasury, unless specifically exempted. The four fund types are: (1) the General Revenue Fund; (2) Trust Funds; (3) the Working Capital Fund; and (4) the State Infrastructure Fund (MacManus 1991). The Florida legislature is responsible for appropriation of state tax revenues in the annual budget process. Therefore, use of state level tax revenue for water quality improvement depends on legislative appropriation of funds to the agencies requesting funds for such programs.

There are numerous trust funds that are capitalized with tax receipts legislatively earmarked for a specific purpose. It is estimated that there are approximately 1,200 trust funds in the state (J. Stargel, Florida Tax and Budget Reform Commission, personal communication, 1992). The funds are established through general law, the constitution, or a trust agreement and are used for funding specific activities or programs; distributing revenues to individuals or local governments; and funding construction, repair, or replacement of facilities, as clearing accounts; and as revolving loan or capital funds (FTCC 1991a). The various trust funds received 60% of all state revenues in 1991 (R. Saunders, Florida House of Representatives, personal communication, 1992) and the trend shows an increasing share of revenue going to trust funds with less to the other treasury funds. This trend is creating revenue constraints for the state because any surpluses in the trust funds are not readily available to meet general budgetary needs. This situation, combined with recessionary decreases in sales tax revenue, has prompted a proposed constitutional amendment (vote in fall of 1992) to eliminate all trust funds and require legislative reauthorization within a four-year period and by a three-fifths majority of any funds deemed truly necessary. This amendment would return appropriations power to the legislature and would allow greater budget flexibility, but may also impact water quality funding by eliminating trust funds that receive funds with strict definitions as to disbursement for water quality improvements (J. Stargel, Florida Tax and Budget Reform Commission, personal communication, 1992). Under the proposed amendment, such a trust fund could be re-established by a three-fifths vote of the Florida Legislature.

3.2.2 Florida Local Level Tax Revenue

County and local governments in Florida are constitutionally limited to collection of *ad valorem* property taxes, "local option" taxes legislatively authorized by the state, and state revenues shared with the local and county governments.

The constitutional provision that grants *ad valorem* tax rights to cities and counties also sets property tax millage limits of 10 mills for county purposes, 10 mills for municipal purposes and 10 mills for school districts. In addition, certain Municipal Service Units and Special Utilities may be authorized to levy property taxes. The use of such taxes is developed further in Section 3.2.3.10.

In addition to state shared tax revenue, county and city governments are allowed to levy certain "Local Option Taxes." Such taxes include the Tourist Development Tax, the Infrastructure Tax, the Gas Tax, and the Convention Development Tax. The revenue from each of these taxes can be used for projects within the county or local area. The primary purposes of these taxes is to benefit tourism, develop infrastructure, enhance transportation, and provide convention facilities, respectively. Each of these taxes, with the exception of the Convention Development Tax, are discussed in relation to water quality in the subsections of 3.2.

The State of Florida shares tax revenue with counties, local governments, and school districts in order to promote equity. There are several methods used to determine the allocation of such revenues. These include considerations of where the revenue was collected, population, ability to raise revenue, as well as certain compensatory considerations. The revenue that is shared is, in some cases, limited to specific uses, and qualification to receive shared revenue may depend on state-mandated requirements. Monroe County received $1.6 million in county revenue share monies in fiscal year (FY) 1991-92, and the cities of Key Colony, Key West, and Layton received $17,000, $625,700, and $3,900, respectively. Any portion of this revenue that is not required for specified allocations goes to the General Fund and may be used by counties and cities to meet their general needs, including provision of water quality improvements. Obviously, legislative changes made to the revenue sharing programs that enhance the share distributed to the counties and cities of Florida will increase their capacity to fund local projects related to improvement of water quality.

3.2.3 Taxation Related to Water Quality Improvements

Any type of tax can be used to finance water quality activities; however, because taxes often must be approved by voters, there is generally some connection between the type of activity being taxed and the activities for which the revenue will be spent. The amount of revenue generated will depend on the type of tax being levied, the activity or property on which the tax is levied, and the goal of the tax.

Sales and use taxes provide a good mechanism for providing revenue for specific programs. These taxes can be easily earmarked for use in specific activities and, for this reason, often are received more favorably by the general public. Both personal income and personal property taxes provide money to the general state revenue. The amount allocated to specific programs for these taxes needs to be appropriated on a yearly basis, with no guarantee that funds appropriated one year will be available for ongoing project activities in the following years.

Sales and use taxes can also be used to discourage specific behaviors. An example of such a tax is North Carolina's Recycled Paper Tax Incentive, which charges a tax on virgin newsprint used by newspapers (Apogee Research, Inc. 1991). The goal of this tax is to discourage the use of virgin paper and encourage recycling. For this type of tax to work on products purchased by the general public, such as fertilizers, it is necessary for the tax to be significant, for alternatives to the taxed products to be available, and for the public to be aware of the impact that purchase of the taxed product has on water quality or the environment.

The following taxes are those that have commonly been used to finance water quality-related activities. The majority of them are taxes on items or activities that contribute to water quality degradation, such as motor fuel. Some of these taxes are currently used in Florida, while others are being used elsewhere. Personal property taxes are also used to finance water quality-related activities such as the construction of wastewater and stormwater treatment facilities.

3.2.3.1 CIGARETTE AND OTHER TOBACCO PRODUCTS TAX

Some states have used taxes on cigarettes and other tobacco products as a means of financing water quality improvements. In Washington, a percentage of the wholesale price of tobacco products and an 8-cent tax on each pack of cigarettes is dedicated to the state Centennial Clean Water Fund. This fund is used to provide grants to conservation districts and to support public education and outreach activities (Puget 1989). Both Rhode Island and Florida also have cigarette and tobacco-product taxes, but the funds are not specifically earmarked for water quality programs.

Florida charges 33.9 cents per pack of cigarettes and 25% of the wholesale sales price for noncigarette tobacco products and cigars. Collections in 1992-93 are estimated to be $455 million, with 32.4% allocated to municipal revenue sharing and 2.9% to county revenue sharing (ACIR 1991a). Increasing the cigarette tax by 1 cent per pack could generate an additional $12.8 million statewide (FTCC 1991a). Although not currently allocated to water quality programs, taxes on cigarettes and other tobacco products, if increased, could be used to finance water quality activities similar to the Centennial Clean Water Fund in Washington.

3.2.3.2 UTILITIES TAX

Florida currently charges a 2.5% tax on gross receipts from electric, gas, telecommunication services and co-generated electrical power transmission utilities. The revenue generated is allocated to the Public Education Capital Outlay and Debt Service Trust Fund. This tax will provide an estimated $4-8 million in FY 1992-93 (ACIR 1991a).

In Washington state, receipts from utility and sales taxes on water, sewer, and garbage collection go to support the Public Works Trust Fund, which provides low-interest loans for repair and construction of sanitary and storm sewers (PSWQA 1991). A tax on wastewater and stormwater utilities in Florida could provide revenue for facility expansion and improvement, water quality monitoring, and public education and outreach.

3.2.3.3 MOTOR FUELS AND PETROLEUM PRODUCTION TAXES

Several states that charge taxes on motor vehicle fuels have expanded their programs to include marine fuels. Because recreational boating has an impact on water quality, marine fuel taxes are viewed as an equitable method for financing both the capital and operating expenses of water quality improvements. This tax applies to both resident boaters and people using their boats for transportation into the state, thereby making this tax more equitable, and less easy to circumvent, than boat registration fees. Commercial carriers are currently assessed a federal marine fuels tax that is used to finance the Inland Waterways Trust Fund (Buzzards Bay Project 1991). State taxes on marine fuels can be assessed on both commercial and recreational users.

Florida charges a 4-cent-per-gallon state tax on motor fuels and special fuels. Local governments are allowed to charge a tax of 1 to 6 cents on motor fuel and special fuels sold at the retail level (ACIR 1991a). These funds are collected by the state and returned to the counties via a revenue-sharing program. In addition to this Local Option Gas Tax, a county may also impose a 1-cent-per-gallon Voted Gas Tax by referendum. Revenues from this county tax may be shared with municipalities. Monroe County does not currently have a Voted Gas Tax.

Estimated gross collections of the Motor Fuels Tax for the state for FY 1992-93 are $997 million (ACIR 1991a). Florida currently exempts fuels used for agriculture, aquaculture, and commercial fishing. The estimated value of this exemption is $2.6 million. Increasing by 1 cent the tax on motor and special fuel would provide an additional $71.6 million statewide (FTCC 1991a,b).

As with most states, the majority of the revenue generated by the motor fuels tax is allocated to road construction, maintenance, and repair (3.8% of the revenue is allocated to Aquatic Weed Control). Several states, such as Washington, Virginia, and North Carolina, are examining the potential for capturing the portion of taxes provided by purchase of marine fuels to provide funds for marine-related water quality programs. By eliminating the exemption on agriculture, aquaculture, and commercial fishing, the state of Florida would gain an additional $2.6 million that could be applied to both marine programs and activities aimed at controlling nonpoint pollution from agricultural land. Additional funds could also be diverted to water quality-related activities by estimating the amount of the Motor Fuels Tax that comes from purchase of fuel by recreational boaters and allocating those funds to water quality programs.

A Voted Gas Tax in Monroe County could also be used to provide revenue for water quality-related programs such as nonpoint pollution control from roads and highways, and providing assistance in developing facilities for controlling pollution from marinas and boat yards.

3.2.3.4 TOURIST DEVELOPMENT AND IMPACT TAXES

Some of the water quality impacts in the Florida Keys result from activities that support seasonal tourists. Use of package plants by hotels, motels, and restaurants has been suspected to contribute to increased nutrient loadings. In addition, tourists cause stress to garbage and maintenance services. Revenue generated by taxes on lodging and meals can be used to offset some of the costs of tourist-related impacts.

Sales taxes on lodging have been used in Dare County, North Carolina (Buzzards Bay Project 1991), and in Rhode Island for economic development and general revenue (EPA 1990a). In addition, both North Carolina and Virginia charge occupancy taxes on hotels, rental houses, and cottages (Apogee Research, Inc. 1991).

Under the Local Option Tourist Development Tax, Florida counties can levy taxes on living accommodations in hotels, motels, apartment houses, rooming houses, and mobile home parks. Proceeds of the tax must be used to promote tourism and finance tourist-related facilities or tourist-promotion bureaus. This includes financing "beach improvement, maintenance, renourishment, restoration, and erosion control, including shoreline protection, enhancement, (and) cleanup" (ACIR 1991a).

The Florida Keys is a major destination for scuba divers. It is unclear whether the Local Option Tourist Development Tax could be used to address water quality impacts affecting coral reefs or other coastal areas of interest to this specific group of tourists. Special authorization from the legislature may be required in order to use proceeds from the tax to offset the costs of sewer systems to which hotels and other tourists facilities would be connected. (Special authorization has been given to counties, under specific conditions, to levy Convention Development Taxes to provide revenue for development of convention centers, stadiums, and exhibition halls.)

Since 1981, Monroe County has charged a 3% tourist tax. Proceeds from this tax were approximately $5.7 million in FY 1989-1990 (ACIR 1991a). Forty percent of these proceeds were used to promote tourism and tourist activities, 29% were used to fund tourist bureaus, and the remaining 8% were used for other purposes (i.e., special events). Other counties have used a larger portion of their proceeds to finance beach and lake projects (Indian River County, 82%, Sarasota County, 50%, Walton County, 50%).

3.2.3.5 FOODFISH AND SHELLFISH TAXES

One method for financing activities aimed at protecting water quality and enhancing foodfish and shellfish resources is the use of a foodfish and shellfish tax. Washington State levies a tax on the person with first possession of foodfish and shellfish for commercial purposes after it has been caught. The state is currently investigating removing the exemption for aquaculture. The tax rate is on a variable scale by type of fish or shellfish (PSFC 1989).

In Maryland and Georgia, a shellfish tax is levied on the leasing of commercial shellfish harvesting areas. (Buzzards Bay Project 1991). In Virginia a saltwater take fee is applied to "taking" or harvesting of oysters by the commercial shellfish industry. Virginia requires both vendors and fishermen to document the amount of oysters sold (Apogee Research, Inc. 1991).

Proceeds from these taxes are generally applied to resource management and assistance to commercial fishermen. Water quality improvement activities could also be funded under the goal of resource management and enhancement. Although the burden of these taxes in Maryland and Georgia falls directly on commercial fishermen, it is envisioned that some of the burden of the tax is shifted to consumers in higher shellfish prices. Washington's tax is imposed directly on consumers.

Florida does not currently have a tax on the commercial take of either fish or shellfish. Shellfish catches in 1987 for the state were 61 million pounds, with 13 million pounds caught in Monroe County (BEBR 1991). Although monetary information is not available for 1987, data for 1984, in which Monroe County caught 18 million pounds, indicates the value of this catch to be $40.8 million (BEBR 1987). Applying a tax to this revenue could provide a significant source of funding for fisheries management and water quality improvement programs.

3.2.3.6 LITTER CONTROL TAX

Washington State imposes a litter control tax on selected products such as food, cigarettes, soft drinks, beer and wine, newspapers, household paper and paper products, and cleansing agents (EPA 1990a). Fast food restaurants are subject to the tax that is paid by manufacturers, wholesalers and retailers. Proceeds, estimated at $2 million annually, are used to fund litter control programs, public education and awareness, and recycling. Several annual campaigns are aimed at controlling litter from water-oriented activities. Another potential use of this fund is for public education on household hazardous materials and support of a households hazardous materials collection program. Rhode Island has a similar tax called the Litter Control Participation Permit. The fee varies based on the gross receipts of any business selling food for immediate consumption (EPA 1990a).

Studies indicate that a Florida Litter Tax could raise approximately $17.5 million (ACIR 1991a) during FY 1991-92. Beginning in October 1992, an advance disposal fee of 1 cent per container will be assessed on retail sales of glass, plastic, aluminum, plastic-coated paper, and other metal containers that are not currently being recycled at a sustained rate of 50% (ACIR 1991a). This tax could potentially provide $150 million for the Container Recycling Trust Fund. As with the Washington tax, a portion of these proceeds could be used to finance activities aimed at reducing litter from water-related activities, enhancing litter control on beaches and coastal areas, and providing increased litter collection during the tourist season. Another reasonable application of such a tax would be to offset the costs associated with landfill closure and transport of wastes to landfills outside the Keys.

3.2.3.7 AQUATIC LANDS LEASEHOLD TAX

In Washington, a leasehold tax on all public lands leased to private parties (including aquatic lands) is levied at both the state and local levels. Properties are charged at a rate of 12.84% on the contract or true rental value of the lands that are exempt from property taxes. Cities may levy an 4% tax, and counties a 6% tax (Apogee Research, Inc. 1991).

Florida does not currently charge a leasehold tax, and lessees of public property are currently not being assessed property tax (FTCC 1991b). (Pursuant to Florida Statutes, state and local government property is exempt if used for governmental or public purposes, although "as a matter of practice, government-owned property used by a nongovernmental lessee for private purposes was not assessed" [FTCC 1991a]). There are approximately 186 marinas in the Florida Keys. Leases for use of submerged lands are issued by the Florida Department of Natural Resources (FDNR), Bureau of Submerged Lands. Levying a tax on marinas, mooring fields, and other leases of aquatic lands could generate revenue for improving pollution control around marinas and boat yards, and financing public education on the impacts of recreational boating activities, such as sewage discharge, on the marine environment.

3.2.3.8 POLLUTANTS TAX

This category covers a range of taxes charged on specific pollutants.

The state of Florida has three pollutant taxes that are allocated to various water quality-related trust funds. A Coastal Protection Tax of 2 cents per barrel is charged for pollutants produced in, or imported into, the state. Under this tax, pollutants include petroleum products, pesticides, chlorine and ammonia (ACIR 1991a). Proceeds from this tax are allocated to the Coastal Protection Trust Fund to be used by FDER for cleanup of spills. The tax will remain in force until the balance of the trust fund reaches or exceeds $50 million. If the U.S. Department of the Interior approves offshore oil drilling in the waters off the Florida Coast, the cap on the Coastal Protection Trust Fund will be increased to $100 million. The estimated total in the fund for FY 1992-93 is $5.1 million.

The Water Quality Tax is assessed at $1.50 per new or remanufactured lead acid battery, 2.36 cents per gallon of solvent or solvent mixture, 1 cent per gallon of motor oil, and 2 cents per barrel of petroleum products, ammonia or chlorine (ACIR 1991a). Proceeds from this tax are allocated to the Water Quality Assurance Trust Fund. The estimated balance in this fund for FY 1992-93 is $24.5 million.

The amount of tax charged under the Inland Protection Tax varies depending on the balance in the Inland Protection Trust Fund to which the proceeds are allocated. The tax is 10 cents per barrel of pollutant if the balance in the fund is between $35 million and $50 million, 20 cents per barrel if the balance is above $5 million but below $35 million, and 30 cents if the balance is below $5 million (ACIR 1991a). The estimated FY 1992-93 balance in this fund is $38.7 million.

Revenues from all three of these trust funds are used to restore or replace contaminated water supplies. Products that represent a serious threat to the environment, but are not regulated under these taxes, are wood preservatives, creosote, and fertilizers. Fertilizers have been found to have caused major damage to Florida's water reserves, particularly the Everglades and Lake Okeechobee (ACIR 1991a). Commercial application of pesticides, fertilizers, and chemicals is controlled through permitting and regulation. Although guidelines are provided by manufacturers of pesticides, fertilizers, and chemicals for residential use, the actual application of these products is not well controlled. A retail tax on these products, combined with public education on the impacts that these products have on water quality and the environment, could encourage wiser chemical use and use of alternative products. Revenues generated by the tax could be used to fund public education programs on a wide variety of water quality issues, as well as providing revenue for residential hazardous waste collection programs.

Nine other states impose some type of pollutants tax. Washington state has a pesticide tax of 0.7% of the wholesale value of the product. Consideration has been given to basing the amount of the tax on toxicity, persistence and bioaccumulation of the pesticide (PSFC 1989). Water quality activities toward which the proceeds from this tax could be directed include pollution control, household hazardous waste programs, wetlands, stormwater, environmental education, and environmental enforcement.

Rhode Island levies a "Hard to Dispose Of Materials" Tax on motor oils, organic solvents, antifreeze, tires, and automobiles (Buzzards Bay Project 1991). The proceeds from this tax are given to the state Department of Environmental Management to fund household hazardous waste reduction programs, used-oil recycling, and solid waste data monitoring and research.

3.2.3.9 IMPACT TAXES

Several states currently charge taxes on goods or activities that have a perceived impact to communities and public resources. Impact fees (Section 3.5.4) are charged on specific activities impacting provision of public services such as police, fire, parks, transportation, and septage. Rather than having a number of specific fees, an impact tax could cover all public costs associated with development. Alternatives for levying impact taxes are: per unit charges for new construction (i.e., per living unit, square foot, or land unit area), excise tax on construction materials, gross receipts tax on contractors and developers, and a rezoning tax based on the category to which the land is zoned and the number of acres involved (ACIR 1991a). The amount of revenue generated by such a tax would depend on the amount of development. The funds could be used to finance water quality-related activities such as wastewater and stormwater treatment, and wetlands preservation or mitigation.

3.2.3.10 PROPERTY TAXES

Property taxes provide a general revenue source for financing improvements in services and infrastructure. In Florida, counties, municipalities, and special taxing districts are given the authority to levy taxes on personal real estate. In 1991, property taxes provided $31.3 million in revenue for Monroe County (ACIR 1991a). Under Florida law, the SFWMD has the authority to levy property taxes to cover the costs of providing and improving stormwater management systems (ACIR 1991c).

The Florida constitution currently prohibits the *ad valorem* taxation of motor vehicles, boats, airplanes, trailers, trailer coaches, and mobile homes (FTCC 1991b). However, the constitutional definition of these items is not clearly defined, and it may be possible to alter the tax status of some of these items through appropriate statutory definitions. For example, mobile homes that are permanently affixed to the property are required to be assessed as real property, and therefore subject to *ad valorem* taxation (FTCC 1991b). The CWA allows states to regulate sewage disposal from "houseboats" and allows the state to determine the amount of time a boat serves primarily as residence in order to be considered a houseboat. Similar reasoning could be applied to houseboats to make them eligible for *ad valorem* taxation. Proceeds from *ad valorem* taxes on houseboats could be used to fund education efforts aimed at explaining the impacts of sewage disposal on the marine environment, as well as increased enforcement and provision of pump-out facilities.

3.2.3.11 SALES TAX SURTAXES.

General sales taxes provide substantial revenue that is allocated via various appropriation and revenue sharing programs. These revenues do not always provide for the complete financing needs of a community, and in some cases governments may authorize additional sales taxes to meet specific needs. Such is the case in Florida, where, in addition to general sales taxes, the state of Florida allows certain "discretionary sales surtaxes" to be levied. Florida allows several tax surcharges; however, the most applicable to addressing water quality improvement needs is the Local Option Infrastructure Tax. Any county or local government may assess, for a period of up to 15 years, a 1/2% or 1% Local Option Infrastructure Tax. The tax may only be assessed on sales of value up to a $5,000 cap amount, and must be voter approved by referendum. Once adopted, the tax is added to sales tax rates, and the revenue is collected by the state and returned to the counties for use to finance, plan, construct, or improve capital infrastructure. A Monroe County referendum to levy the infrastructure tax was defeated in 1987, but voters passed a 1% tax in 1989 with a collection period of 15 years. The estimated income from this tax for 1991-92 is approximately $7.8 million (ACIR 1991a). Additionally, revenues for Key Colony, Key West, and Layton are estimated to be approximately $111,000, $2.8 million, and $20,800, respectively (ACIR 1991a). This tax provides substantial revenue that could be used by Monroe County and its cities to finance infrastructure improvements such as wastewater treatment, stormwater treatment, and other activities related to water quality.

3.2.4 Impacts

Taxes, whether assessed on income, personal property, or sales of goods and services, can provide a significant source of revenue for water quality improvement projects. Because property taxes in Florida are levied at the county and local level, a larger portion of the revenue from these taxes tends to stay in the local community for use in local projects. Unfortunately, both personal income and property taxes tend to be allocated to general revenue funds from which monies must be appropriated for specific programs. There is no guarantee that funds allocated one year will be available in subsequent years, making it difficult to finance long-term, ongoing projects with these taxes. Sales and use taxes can be more easily tied to specific programs, as has been done in Florida through the use of Trust Funds. These taxes can also be used to discourage the use of, or mitigate the impacts from, goods and services that have an adverse effect on the environment.

The major disadvantage to taxes are their unpopularity and the often unequal impact that they have on various segments of the population. Generally, taxes require voter approval in order for implementation. Florida has full disclosure laws requiring that notice and opportunity for comment be given on any proposed property tax increase. The need to gain public acceptance can often be a costly process. Property taxes have been criticized as taxing unrealized capital gains resulting from increases in property values. This has been shown to have a potentially significant impact on property owners of fixed or limited income. Sales and use taxes have been criticized as being regressive because all goods and services are taxed at the same rate regardless of the purchaser's ability to pay. In addition, while a few sales and use taxes can have a relatively small impact, in combination they can create a significant burden. Implementation of numerous taxes can also create additional administrative burdens and costs.

Whether a tax is equitable depends both on the item on which the tax is assessed (i.e., property, goods, and services) and the way the tax is implemented. Most of the sales and use taxes identified in this section have been considered equitable taxes for the purposes of water quality enhancement and environmental protection on the basis that the goods and services on which the taxes are levied contribute to water quality and environmental impacts. Thus, these taxes are merely an application of the "polluter pays" principle to individual uses.

Property taxes used to provide public services have also been defended on the basis that the services provided, such as wastewater treatment, directly benefit the population being taxed. In general, however, most observers do not consider property taxes to be equitable because of differences in the way the tax can be assessed from one area to another, and the fact that the taxes do not take into account individual taxpayer resources (ACIR 1991c).

3.3 GRANTS AND LOANS

Development of the Water Quality Protection Program for the FKNMS program is a unique cooperative arrangement between the federal government and the state of Florida. This section identifies existing sources of state and federal funds available for financing water quality protection and restoration activities. Additional funding may be made available through cooperative agreements between the state and the federal government to provide additional funds for improving the water quality in the FKNMS. Additional information on existing funding sources is available in the *Guide to Federal Domestic Assistance* published by the U.S. Office of Management and Budget (OMB 1991).

3.3.1 Federal

3.3.1.1 ENVIRONMENTAL PROTECTION AGENCY

EPA plays a lead role in identifying, evaluating, and controlling environmental pollutants. EPA has played a major role in research and monitoring activities in estuaries around the country. In FY 1989, the Chesapeake Bay program received $825,000 to fund nonpoint pollution research and monitoring activities. EPA also provided almost $10 million for development of comprehensive management plans for the ten designated national estuaries (DOC 1991). An estimated $625,000 is being provided for the development of the Water Quality Protection Plan for the FKNMS.

Until recently, the EPA was a major supplier of grants for construction of wastewater treatment works under the CWA. These grants are no longer available and have been replaced in many states by State Revolving Loan Funds that are seeded by EPA and managed by the states. Under Title VI of the CWA, EPA is authorized to make capitalization grants to the states for deposit in State Revolving Loan Funds. From these funds, states can provide loans and other financial assistance (but not grants) to communities and intermunicipal and interstate agencies for the construction of publicly-owned wastewater treatment works, for implementation of nonpoint source pollution control management programs, and for development and implementation of an estuary conservation and management plan (Mr. Steve Felerman, Bureau of Local Government Wastewater Financial Assistance, personal communication).

The state must prepare an annual plan identifying the intended use of the State Revolving Loan Fund and describing how the funds will be used alone or in combination with other state financial assistance programs. The plan must also indicate how the Fund will assist communities in attaining and maintaining compliance with the CWA and carrying out other provisions of the state clean water strategy. Both short and long-term goals must be included in the plan.

In Florida, revenues from the State Revolving Loan Fund can only be used for construction of wastewater treatment works. The Bureau of Local Government Wastewater Financial Assistance (BLGFA) of the FDER administers the fund, which is recapitalized by the repayment of the loans and interest. Allocation of loans is on a competitive basis, with priority given to projects having the greatest impact on human health. Environmental impacts that are not also presenting an impact to human health are not currently viewed as a priority (G. Swaggert, BLGFA, personal communication, 1992). The allowable uses of the fund are fairly liberal, and use of the fund for construction or retrofit of OSDSs by a septic utility (see Wastewater Treatment, Section 4.2.1) or local government may be possible.

For 1993, nine loans have been approved. Three of these are for $10 million (the maximum amount allowable) with the remainder falling in the $2 million range. Projects may be funded over several years, and some of the projects funded in 1993 are continuation segments. No one community can have more than 10% of the total Fund amount for projects within the community, and 15% of the total amount in the Fund is set aside for small community loans.

Under Section 106 of the CWA, the EPA provides grants to states for water pollution control activities. These grants may be used to finance monitoring and enforcement activities. The FDER is currently using 106 grant funds for financing the state's existing ambient water quality monitoring program, deferring the costs of compliance inspections for wastewater treatment facilities and helping to fund the state's data retrieval network.

Under Section 104 of the CWA, EPA provides project grants to the states for unique, pilot or special studies, and/or demonstrations to advance knowledge and technologies in addressing point source water pollution problems. These grants do not require state matching funds.

Grants for financing implementation of nonpoint source pollution programs, including development and implementation of groundwater protection programs, are provided under Section 319 of the CWA. EPA established initial planning targets for each state for these grants. The actual allocation of the funds is a function of the planning targets and the state's nonpoint pollution program. Approximately 50% of the target funds are for base programs and the remaining projects are funded from a regional competitive fund. These grants have specific matching requirements. Nonpoint pollution Section 319 funds cannot exceed 60% of the project cost. Other federal funds cannot be used to match Section 319 funds. States are encouraged to use at least 10% of the planning target for groundwater activities.

Section 104(b) of the CWA authorizes EPA to approve grants or cooperative agreements to state water pollution control agencies, interstate agencies, other public or non-profit private agencies, and individuals for projects related to improving the environmental conditions of Near Coastal Waters (NCW). NCWs are defined as inland waters to the head of the tide, territorial seas, and contiguous zone, and include related wetlands and the Great Lakes. Projects eligible for funding include, but are not limited to, criteria/standards development, waste load allocations, effluent guideline development, National Pollutant Discharge Elimination System (NPDES) permit development and enforcement, CWA Section 404 (dredge and fill) permitting, nonpoint source management plans, and wetlands protection. EPA Region IV funding for the NCW program was $642,500 in FY 91, and $464,686 in FY 92 (F. McManus, EPA Region IV, personal communication, 1992).

Each EPA region receives yearly funds for providing Small Community Outreach and Education (SCORE) Grants that can be used to fund public education and outreach activities related to water treatment. These grants are available to local governments, agencies, and organizations and require a 50% match. In many states these grants have been used to develop videotapes and handbooks on water conservation and other issues. In FY 1990, the Maine Department of Environmental Protection was awarded a grant to develop a handbook on planning, constructing, and financing WWTPs (Buzzards Bay Project 1991).

Under the National Environmental Education Act (NEEA), EPA also awards grants to organizations, institutions, schools and agencies for environmental education activities. NEEA grants for 1992 were nearly $4 billion nationwide. The grants provided by Region IV were for amounts of $25,000 or less.

3.3.1.2 U.S. DEPARTMENT OF AGRICULTURE

A small portion of the U.S. Department of Agriculture's (USDA) research is oriented toward examining the effects of agricultural and natural resource practices on the marine environment. The USDA supports research, monitoring, development, and education programs related to pollution causes and effects through direct federal research and through cooperative efforts and grants. These studies are directed primarily toward agriculture and the management of rural lands. A major portion of the total research effort is through state matching of federal grants (DOC 1991). The nonpoint source contaminants program conducts research on contamination of groundwater and aquifers from septic system drain fields, and soil and crop applications of chemicals, sludges, manure, and other wastes. This program received $2.7 million nationwide in 1989 (DOC 1991).

The Farmer's Home Administration (FHA) of the USDA provides grants and loans to rural communities (less than 10,000 population) for the development of point and nonpoint pollution reduction activities. Low-interest loans and grants for the installation, repair, improvement, or expansion of rural water facilities and wastewater disposal systems, including the collection and treatment of sanitary, storm, and solid wastes, may be available through the Wastewater and Disposal Systems for Rural Communities program. These facilities must primarily serve rural residents, and grants are available only when necessary to reduce the annual benefitted user charges to a reasonable level. Funds are available to communities or special improvement districts, but not to individual residences. The average size of loans is $490,000, and of grants is $357,000 (OMB 1991).

FHA also provides Industrial Development Grants to finance industrial sites in rural areas including acquisition of land, utility extensions, and necessary water supply and waste disposal facilities. Priority for these grants is given to communities that have a population of less than 25,000.

The USDA administers the Agricultural Conservation Program and the Rural Clean Water Program, which can provide up to 75% cost-sharing for measures taken on agricultural land to solve problems associated with point and nonpoint source pollution. To the extent that some water quality issues in the FKNMS are related to stormwater contaminated with upstream pollutants from agricultural areas in Dade County and other areas using SFWMD Canals, these programs might be a useful source of revenue.

Additional assistance in the form of funds or expertise is provided by the USDA Soil Conservation Service (SCS). SCS programs are aimed at protecting, developing and using land and water resources. Funds are available for the development of flood control projects, erosion control, water quality protection, and resource enhancement. Some of these funds are provided on a cost-share basis and have specific eligibility requirements.

3.3.1.3 DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

The Department of Housing and Urban Development (HUD) provides Community Development Block Grants/ Entitlement Grants (CDBG) to localities with a population of more than 50,000 for a broad range of activities including improvement or installation of public works. The grantee must certify that at least 60% of the grant received will principally benefit low- and moderate-income persons. For nonentitlement communities, grants are available through the CDBG Small Cities Grants Program. The majority of the Small Cities Grants are provided for housing rehabilitation projects, but these funds can also be used for water and sewer projects (Buzzards Bay Project 1991).

Communities eligible for Small Cities Grants are also eligible for Feasibility Study Grants that can be used to identify environmental issues. The maximum amount of the grant is $30,000, and a minimum 10% match by the local government is required (Buzzards Bay Project 1991).

3.3.1.4 NATIONAL PARK SERVICE

The National Park Service provides matching grants for planning, acquisition, and development of outdoor recreation areas and facilities for the general public. Up to 50% of the cost of park facilities or of acquiring land for protecting natural resources may be provided through this program. In the FKNMS, this program may be able to be used to enhance public facilities for boaters, including the development of pump-out facilities. This program may also be used for the purchase and protection of wetlands that may be able to be used for mitigating nonpoint source pollution from stormwater.

3.3.1.5 U.S. FISH AND WILDLIFE SERVICE

The U.S. Fish and Wildlife Service (FWS) has funds coastal activities through the National Coastal Wetlands Grants program. These grants are available to states for remediation, land acquisition, and water control. The level of state matching is determined by the nature of the project being funded. Grants have ranged from a few thousand dollars up to $1.2 million. In the Guana River, FL, a restoration project was funded to fill mosquito ditches to allow re-hydration of 382 acres of interdunal swale.

The FWS also has two other grant programs that may be applicable to the FKNMS. Through regular federal aid grants, FWS provided $351 million in 1992 for fisheries and wildlife restoration. A formula is used to allocate each state is a portion of the yearly money. The FWS reviews applications for these state grants and approves their use. FWS grants are also available under the North American Water Fowl Management Plan. These funds can be used to improve waterfowl habitat, including coastal wetlands. These grants are available to federal, state, and local agencies and private groups, such as Ducks Unlimited. Although these are single year grants, applications for additional funds can be submitted yearly. This allows of use of the grants in multi-phase projects, however, FWS will not guarantee follow-on funds for succeeding years.

3.3.1.6 U.S. DEPARTMENT OF COMMERCE

The National Oceanic and Atmospheric Administration (NOAA) is responsible for managing designated national marine sanctuaries. Significant research has been conducted at the Key Largo Marine Sanctuary on modeling environmental behavior in response to natural and pollution events. Additional research was supported in assessing the damage to coral from the grounding of the M/V *Wellwood* in August 1984, and the recovery rate of the coral since that time.

NOAA also administers two other programs of direct import to marine water quality. These are the Sea Grant Ocean Pollution Program and the Coastal Zone Management Program. The Sea Grant program awards grants to academic institutions for research oriented toward fostering wise use of the nation's estuaries and coastal and ocean resources through directed research and education (DOC 1991). Sea Grant publications are a significant source of public information on marine and estuarine water quality issues. The Coastal Zone Management program provides funds to states for coastal zone management activities.

The Public Works Division of the U.S. Department of Commerce (DOC) provides project grants for funding of public facilities, such as water and sewer systems, to support the development or retention of permanent jobs in the private sector in areas of lagging economic growth.

3.3.1.7 U.S. DEPARTMENT OF THE INTERIOR

The Clean Vessel Act of 1992 will require coastal states to ensure that adequate pumpout stations and waste reception facilities are available for use by recreational boaters. Coastal states will be required to conduct surveys of existing facilities and develop plans for ensuring that adequate facilities are available. The Secretary of the Interior will oversee the distribution of $5 million in FY93 for up to 75% of the cost to coastal states for conducting the surveys, developing and submitting plans, constructing and renovating pumpout stations, and public education on impacts of vessel waste. Priority for awarding grants will be based on the proposed construction of facilities, provisions for public/private partnerships to develop and operate the facilities, and proposed innovative methods for increasing the availability of the facilities. The Act does not apply to commercial vessels.

3.3.2 State

In addition to the State Revolving Loan Fund, the state of Florida also has a Bond/Loan Program. Under this program, the state issues bonds and turns the money over to the local government for financing improvements. The local government is responsible for paying off the debt. This program can be used for financing improvements in wastewater, stormwater, solid waste, and hazardous waste treatment. The advantage of the Bond/Loan Program is that it allows the municipality to receive a lower rate of interest by utilizing the state's credit rating. This program has not been widely used, in part because of the relatively strong credit rating of most Florida municipalities, and in part because of the planning requirements the state places on applicants. It is, however, a potential revenue source for large projects in which an incremental decrease in the interest rate can have a substantial impact in the total debt, or for a smaller community that lacks the revenue or tax base to issue debt at a favorable interest rate.

3.3.3 Impacts

Grants have a relatively limited impact on the local population, except to the extent that they require provision of local revenues in the form of matching funds. The impacts will vary depending on the source of this revenue, i.e., bonds, taxes, rates, or fees. A similar situation is true in the case of loans. The State Revolving Loan Fund requires repayment of the loan over a 30-year period. The local government has a number of options for securing funds for repayment, and the type of option chosen will determine the potential impacts.

One of the main disadvantages to using grants for financing water quality improvement programs is that there are relatively few grants available, and those that are available are strictly limited in the types of activities they will fund and the populations that qualify. There is significant competition for both the available grants and the State Revolving Loan Fund. This requires local governments to comprehensively plan their programs in a way that allows flexibility in implementation.

3.4 RATES

3.4.1 Utility Rates

Consumers of services provided by public or private utilities are charged either a flat rate or unit consumption fees. Sewage treatment, water delivery, garbage collection, gas, and electricity are all examples of utilities that charge rates. In some districts a flat rate or "Service Charge" is charged to each consumer connected to a service. In other instances, consumption is metered and rates are charged on per-unit rate scale. In situations for which the costs for the service are metered, utility rates can be used to encourage water conservation by increasing the incremental costs of successive units of consumption over a specified base level. Public and private utilities collect rate revenue to finance continuing operation (including monitoring), debt management, and profit.

In many instances, users of a specific service are charged a one-time fee for access ng the system. Both wastewater and stormwater utilities use access charges in order to recover the costs for providing services to new customers. The SFWMD charges industrial users of its stormwater canals an access fee. Access and connect charges may also be used to finance debt management or to provide revenue for future capital improvements. For wastewater, access charges could be based on the number of bathrooms in a residence or building (Apogee Research, Inc., 1991). These charges could be used to finance construction for increasing capacity of regional treatment plants, or larger more modern package plants as discussed in the management and engineering options.

In Florida, utilities are self-regulating and are able to establish their own rate schedules. The City of Key Colony Beach charges a flat rate of $15 per unit (i.e., house) per month for sewage treatment and disposal, and a $3,500 connect fee. The City of Key West charges a flat rate of $17.50 per base consumption unit (2,900 gallons) plus $3.97 per 1000 gallons. Residential connect charges are $1,000 per residence, and commercial connect charges are $1,500 plus $1,000 per each 6,000 gallons of average monthly flow. The Florida Keys Aqueduct Authority (FKAA) charges $5.18 per 1000 gallons on the first 12,000 gallons of water consumption, and $6.18 per 1,000 gallons over 12,000 gallons. These rates are for both residential and commercial water users (M. Goldent, Division of Water and Wastes Rate Section, Public Service Commission, personal communication, 1992).

There are three private sewage treatment facilities in the Keys. These are: KW Resorts Utilities, Inc., Key Haven Utilities, and Ocean Reef Utilities. These facilities are regulated by the state and charge flat rates of $29.09 per month, $33.16 per month, and $26.51 per month respectively.

3.4.1.1 CAPACITY FUTURES

One option for financing construction of wastewater treatment facilities is through the sale of capacity futures. Under this program, residential and industrial users, and developers agree to pay the charges associated with connecting to the facility in advance of the facility's construction. These connect charges, which can be discounted from the rate that would be charged to users after the facility is constructed, are used to provide some of the capital for construction. This approach was used to finance wastewater treatment facilities in Escondido, California, and Houston, Texas (EPA 1990a). This method has worked especially well in areas with high levels of development where developers can secure their rights to a specified level of treatment capacity. It is likely that this approach could also be used in constructing wastewater treatment facilities to replace on-site septic systems in portions of Monroe County.

3.4.2 On-site Sewage Disposal Systems

Once permitted in Florida, OSDSs and package plants are not required to pay any taxes or fees associated with their impacts on the environment. Routine maintenance and inspection are left to the individual landowner. These systems generally escape the oversight required of wastewater treatment utilities. In response to the impacts associated with OSDSs, some local governments are looking at ways of increasing management and oversight of these systems. In Washington state, septic tank users in two counties are required to pay a septic tank use fee. The proceeds of this fee are used to cover the costs of interceptor sewers (EPA 1990a). Development of a septic utility or special district may also provide a mechanism for monitoring the impacts of these systems (see Section 4.2.1.1). This utility would charge rates for monitoring and inspection activities similar to a wastewater utility.

3.4.3 Impacts

Rates are generally considered an equitable form of finance because they charge the population using a utility or other service for the services provided. Rates that go beyond the immediate costs of providing the service are also equitable to the point that the activities for which the revenue is spent still primarily benefit those who are paying.

3.5 FEES

Fees are a direct method of matching the costs for program activities with the population most likely to benefit from the action, or the population with the greatest responsibility for the problem the program is designed to address. To make a fee system work, it is necessary to identify, as accurately as possible, the costs of the project and the portion of that cost that should be carried by the individuals involved. If this is done, impact and user fees can be a significant source of revenue for financing improvement projects, as well as providing an impetus for pollution reduction and wise resource use.

Because fees may be assessed without requiring the consent of the community affected, they have been criticized as a way around the constraints imposed on taxes. In addition, it is possible to assess a fee on so many activities that, even though the incremental effect of the fee is slight, the cumulative effect of all of the fees becomes a burden to the public. Care must be taken to ensure that the cumulative effect of impact and user fees is not excessive.

3.5.1 User Fees

As the name implies, a user fee is charged to those members of the population that partake in an activity or will gain the most benefit from the proposed project. Such fees may be charged on a myriad of items ranging from use of parks and public facilities to monitoring and maintenance fees for utilities. Because they are generally collected for ongoing activities, user fees can provide a long-term source of financing for developing and maintaining projects.

3.5.1.1 MOORAGE FEES AND PRIVILEGE FEES

Moorage Fees and Privilege Fees are two types of user fees that may be applicable in the FKNMS. Moorage fees have been used in other parts of the country to cover the costs associated with public provision of services related to recreational boating. This has included sanitary waste and garbage service, as well as docks, boat launches, and other types of public access to harbors. Moorage fees are currently charged by individual marinas. An additional flat-rate surcharge could be assessed on these fees to provide revenue to the local government for boat-related activities.

Privilege Fees have been used in several communities in Massachusetts (EPA 1990a) to offset the costs of providing specific privileges such as access to beaches or shellfish beds. Revenue from access fees can be used to provide beach maintenance and protection, as well as increased litter collection. The town of Narragansett places its fees in an enterprise fund that is used to finance beach maintenance and operation, repay a bond issue, and provide additional revenue for the town (EPA 1990a). Rhode Island and Delaware charge access fees to both residents and nonresidents, but the rates for nonresidents are often twice as high. This type of fee is limited in its application because of the requirement for a close connection between the costs associated with providing these activities and the amount of the fee. In addition, while this type of fee is often popular with local communities, it is generally unpopular with the tourists who make up a large portion of the Florida Keys revenue base.

A way to increase the popularity of privilege fees is to charge a single rate for access to an area or activity, but to provide the option of purchasing seasonal passes. Both residents and long-term tourists will benefit by paying lower prices over time, and short-term visitors will tend to feel less discriminated against.

One of the options for reducing the impact to coral communities is the designation of specific mooring fields. Requiring boaters to purchase a sticker giving them permission to use these fields could provide revenue for maintenance and enforcement. This is more comprehensive than the aquatic lands lease tax, which only charges marinas and other lessees of public submerged lands. Rhode Island is currently investigating the use of a similar fee for the use of submerged lands including, long-term storage of boats and other vessels and discharge of pollutants (EPA 1990a).

3.5.1.2 DISCHARGE AND RUN-OFF FEES

Many local governments use a system of discharge fees and permits to partially finance wastewater and stormwater management activities. In addition to being required to obtain a permit for discharge, users of wastewater and stormwater systems are also charged a discharge fee, based either on the amount of impervious land surface or on a per-unit basis.

In Florida, requirements to obtain a SFWMD permit for activities that will impact stormwater runoff are limited to properties ten acres or larger with two or more acres of impervious surface. One of the water quality improvement management options recommends removing this limitation and requiring all activities to receive a permit. An additional option is to charge a monthly stormwater discharge or runoff fee. Collections of the fees could be managed either by the SFWMD or through the development of a stormwater utility (see Section 4.2.2). If they are charged to both residential and commercial landowners, runoff fees can be an equitable method for paying for stormwater collection, treatment, or disposal.

In other parts of the country, residential areas have not escaped the imposition of discharge fees. These fees are charged on a unit basis and are designed to offset the impacts of structures, such as roads and driveways, that contribute to nonpoint pollution in stormwater runoff. Because residential infrastructure is publicly owned, it has been difficult to assess costs associated with nonpoint pollution from road runoff and residential storm drains. Dividing this cost across all residential property owners can provide funds to be used for stormwater treatment and nonpoint pollution abatement, as well as public education and outreach activities designed to heighten awareness of water quality issues associated with residential activities.

For both residential and commercial users served by a wastewater utility, wastewater discharge fees are generally incorporated into utility rates. In situations for which there is no utility, as with the on-site septic systems and package plants in the Keys, a wastewater discharge fee could be assessed to pay for impacts associated with these activities. Essentially, the fee pays for the privilege of discharging to surface or groundwaters. (Discharge to boreholes or deep wells could also be assessed a fee based on the eventual impact to groundwater from the discharge.) The fee could be based on either a flat rate per residence or tied to water consumption.

When discharge fees are tied to overall water consumption on a graduated scale, where an incrementally higher rate is charged on consumption over a certain base amount, discharge fees can serve as an incentive for water conservation. This type of fee system has encouraged industries to pursue "zero discharge" systems (EPA 1990a). Certain types of industries can realize significant cost savings in both water use and discharge fees by using low- or no-discharge technologies. Funds generated by discharge fees may be used to provide guidance to industry on the types of zero discharge technologies available.

3.5.1.3 INSPECTION FEES

At present, the SFWMD requires industries to treat their stormwater prior to discharging it into the canals. Many wastewater treatment facilities also require on-site pretreatment of wastewater prior to discharge by the industry into the system. In situations for which the regulatory agency lacks sufficient staff with expertise to perform on-site inspection of pretreatment activities, local governments have contracted with private engineering firms to provide on-site inspections and testing. A combination of permit and inspection fees are used to fund this type of program (EPA 1990a).

This type of inspection fee could also be used for requiring routine inspections of OSDSs and package plants to ensure that they are being properly maintained. The Stinson Beach, California, septic utility requires homeowners to have their systems inspected semiannually and charges residents for this service (PSWQA 1991).

3.5.2 Tolls

Tolls are a type of user fee in that they are charged for the use of a bridge or road. They have frequently been used to collect revenue for road improvements and bridge construction. In the area of water quality, tolls are somewhat different from user fees in that the revenue collected can be used to pay for projects, such as stormwater treatment and control, that do not directly benefit the road users but do seek to mitigate the impacts of the road's existence.

3.5.3 Impact Fees

Impact fees are similar to user fees; however, they are oriented toward requiring a section of the population to pay for the impacts associated with their activities. Development and other activities often create direct impacts to the local infrastructure and environment. An impact fee is charged to a developer or other party to offset these impacts. Impact fees can be one-time charges for an activity or can be charged on an on-going basis. One-time impact fees are generally not a reliable source of revenue because the amount of revenue generated is dependent upon several economic factors including the level of growth and development in an area. Impact fees charged for mitigating the effects of a continuing activity, such as automobile use, could be charged on a yearly basis and therefore become a much more reliable source of income. Impact fees may also be used as a means to discourage specific activities that have an impact on water quality or the environment, or to provide some level of mitigation for the impacts.

3.5.3.1 DEVELOPMENT FEES

Impact fees on development are generally designed to offset the impacts of that development on utilities, police and fire protection forces, transportation, and recreation. A number of impact fees are charged by various counties and municipalities in Florida. Both Dade and Monroe counties charge impact fees for police, transportation, and parks. They do not currently require impact fees for water and sewer systems. Impact fees have been criticized by developers on the basis that developers are being required to pay for services that were provided to the original residents for free.

Impact fees associated with increased stormwater runoff have been assessed in other areas of the country (EPA 1990a). The SFWMD requires developers to obtain a one-time permit for construction on sites larger than ten acres and containing two or more acres of impervious surface. The cost of these permits generally covers only the administrative costs of permit issuance. In addition to the permitting requirements, developers could also be required to pay a one-time impact fee based on the effects that their development would have on current water management systems. Funds generated by this fee could be used to upgrade stormwater management systems or help finance stormwater treatment.

Not all development impact fees are necessarily monetary, because one of the goals of an impact fee can be to discourage specific activities. In East Greenwich, Rhode Island, a recreational impact fee is charged on new development to provide public lands for recreation. This fee is generally a land set-aside of one acre for every 20 housing units (EPA 1990a). Monetary payment may be accepted in some circumstances.

3.5.3.2 USE IMPACT FEES

Impact fees do not have to be associated with a new activity, such as development. Impact fees have also been charged to users of equipment, such as cars, that create a impact to the environment. This type of fee is similar to a motor vehicle licensing tax. One advantage of the fee over the tax is that a fee charged for the incremental contribution of personal autos to increased pollution in stormwater runoff would be tied directly to a specific water quality improvement activity (such as treating the stormwater), while a portion of the tax would need to be allocated to the general fund. Florida currently charges new residents a New Cars on the Road fee for the first time a vehicle is registered in the state. Several states have car impact fees associated with automotive contributions to air pollution. For example, under Washington State's Clean Air Act, a clean air excise tax is imposed for the privilege of using a motor vehicle. The annual amount of the tax is $2.25. [RCW (70.94.011) 1990].

Boats are another category of good that has an impact on water quality in the Keys. An impact fee on boats could be established as a yearly charge on the sale of a moorage or boat activity sticker allowing boats to use Florida waters. It would be charged to both resident and transient boaters. Boats designated as live-aboards would pay a higher fee than non-live-aboards. The proceeds from this fee could be used to fund public education on the impacts of boat-related marine pollution on water quality, monitoring and study of water quality in marinas, and water quality improvement programs.

Impact fees can also be assessed for ongoing activities that affect surface and groundwater. Thus, an impact fee could be assessed against an OSDS user, or package plants, that discharge their effluent to boreholes for the impacts that their activities have on the FKNMS. The revenue generated from these fees could be allocated to phasing out underground injection and connecting these systems to a subregional treatment facility.

3.5.4 Fines and Penalties

Fines and penalties are assessed for violations of regulations, or late payment of outstanding debt. While the assessment of fines and penalties may result in a significant amount of revenue, it cannot be counted upon to generate a specific level of revenue that can be directed toward a specific project or water quality option. Fines and penalties should not be considered viable mechanisms for "funding" water quality activities; they should instead be viewed as a type of windfall profit that can be used to enhance proceeds from traditional funding sources. For this reason, they are not further discussed as potential revenue generating mechanisms in this report.

3.5.5 Impacts

Fees are a direct method for tying the costs of an activity or impact to either the population receiving the benefits of the program, or the population creating the impact. Several courts have determined that impact fees must be established in such a way that creates a nexus between the activity causing the impact and the fee. Because of this, the revenue generated by the fees should be spent on activities or programs related to the impact. Depending on the type of fee, this funding mechanism can provide a source of continuing revenue for financing water quality improvement activities. In addition, fees have been used to encourage resource conservation and behavioral changes. This is especially true for situations in which the fees are tied to some type of public education that informs the public of the impacts that a specific activity or product has on the environment.

As with taxes, fees can become burdensome in a number of ways. In many cases, activities on which a specific tax could be levied may also be a good candidate for use of a fee. Because fees generally do not require public approval, and taxes generally do, fees have been criticized as a way of getting around the requirements imposed by taxes to provide an unwelcome or unpopular additional cost. Developers have criticized development impact fees as being an unfair burden on new development, and charging development for services that were provided to the original residents or tenants for free (ACIR 1991b). Whether to charge a fee or a tax, or both, will depend on the goals of the program and the sensitivities of the local population.

The equitability of fees depends on the activities for which the fee is charged. Unlike a tax, fees do not necessarily have to charge all users of a good or service the same rate. Certain fees may charge different rates for residents and nonresidents, but may still be equitable to the extent that the nonresidents increase the need for specific services that would otherwise not be required or would be required in smaller quantities. An example of this is garbage collection because the amount of garbage tends to increase during seasonal tourist periods when there is a larger population. To the extent that fees are attached to activities or products that have a measurable impact on water quality and the environment, they have been viewed as an equitable application of the "polluter pays" principle.

Budget: The amount of revenue currently being generated by all relevant sources of funding should be identified and calculated. This will include state revenue, local revenue, and special program monies, such as sales and use taxes, rates, and fees already allocated to water quality programs. Available sources may also include funding mechanisms that are not currently being used but that are specifically available for the types of projects being implemented. An example of this type of revenue is the State Revolving Loan Fund, which provides funds for specific projects in wastewater management. As part of the budget assessment, a review of the current level of taxation in the state or area where the project is to be implemented, and an assessment of the state of the economy should also be performed in order to develop a comprehensive picture of areas where additional revenue may be obtained.

Budget Shortfall: This is essentially a calculation to determine the difference between the available budget and the costs of the project or program. This information, and an estimation of the requirements for short-term financing, will be used to determine the funding needs.

Funding Mechanisms: With the above information in place, it should be possible to select the suite of funding options most appropriate for the project or program being implemented. Knowledge of the fiscal health of the local economy and the ability to use specific funding sources will be helpful in choosing between similar funding mechanisms. Once the funding mechanisms are selected, changes may need to be made to the estimation of the project costs and the overall funding needs.

4.2 APPROACHES TO FINANCE

Florida has a number of agencies responsible for water quality and environmental management in the Florida Keys. Task 3 identified a wide range of options for addressing water quality issues in the Keys. The agencies and institutions that will be involved in implementing these options are diverse in terms of capabilities and resources. Many of the funding mechanisms discussed in this report could be used to address a number of different management and engineering options, and it will be the task of the agencies and institutions involved to determine which options are more appropriate for them. This section presents some examples of implementation strategies for wastewater and stormwater management that have been used in estuary programs across the country to address similar issues. These examples are provided for illustration purposes only and are not meant to represent the only combination of funding options available for addressing wastewater and stormwater management. When applicable, a discussion of how these strategies could be used in Florida is provided.

4.2.1 Wastewater Treatment

As discussed in Task 3, Monroe County has a large number of OSDSs and "package plants" that are impacting on water quality in the FKNMS. Although permits are required for their installation, these OSDSs are relatively free from regulation once they are installed. In addition, many OSDS owners have not been required to upgrade their systems to bring them into compliance with current regulations. In effect, this gives OSDS users an advantage over households connected to sewage treatment systems because the OSDS users are not required to pay rates reflecting the impacts of their OSDS on the environment. Because the majority of these OSDSs are found in the unincorporated areas of Monroe County, they do not readily fit into existing management structures for wastewater management.

Several options for converting OSDSs and package plants to larger wastewater treatment facilities have been identified in Task 4. Construction of these systems is likely to be costly both in terms of construction and rates to finance the debt incurred. A primary source of funding for construction of wastewater facilities is the use of bonds that are paid off through tax or rate revenue. Another option is use of the State Revolving Loan Fund. In addition to these primary sources of revenue, a utility approach to OSDS management could be used both for building the capital required for construction of wastewater management facilities and to finance monitoring and regulation of OSDSs until such time as the wastewater facilities can be built, or in lieu of building larger facilities.

4.2.1.1 COMPREHENSIVE ON-SITE SEWAGE DISPOSAL SYSTEM MANAGEMENT PROGRAM

Use of OSDSs has certain legal constraints that differ from state to state. This section presents some of these issues, but specific information on the area in which such a program would be implemented would be necessary prior to implementation.

In Florida, FDHRS is responsible for overseeing construction, installation, and operation of domestic sewage systems of less than 5,000 gallons per day. Current law limits FDHRS to restricting use of OSDSs only for public health reasons. There is currently no system for continuing management of these OSDSs once they have been installed. In addition to lacking jurisdiction for requiring repair or replacement of OSDSs that do not pose a threat to public health but are having adverse environmental impacts, FDHRS also lacks the resources for inspection and enforcement of the estimated 25,000 septic systems (EPA 1992) in the Florida Keys.

Stinson Beach, California: One option for providing funding for OSDS management is through a comprehensive management program. An example of such a program is the Stinson Beach County Water District administration of an OSDS maintenance program. Start-up costs for this program were funded through the use of EPA Construction Grants using money originally targeted for construction of a wastewater treatment facility. Operation and maintenance is financed through fees and property taxes. A comprehensive OSDS management program was developed because a number of OSDSs were failing and county residents defeated a proposal to construct a wastewater treatment facility.

The major functions of the utility are conducting mandatory inspections of all OSDSs every 2 years, issuing of discharge permits for all OSDSs, ordering remediation of failing OSDSs, monitoring surface and ground waters (surface waters are tested bimonthly for nitrates, nitrites, ammonia, and fecal coliform bacteria; groundwater is tested quarterly for bacteria), and permitting of new construction including review of plan designs. The District has the authority to require that failing OSDSs be replaced, and has the authority to turn off the customer's water if remedial actions are not taken within a specified time period.

Operation and maintenance costs are covered through a combination of fees and property taxes. All households are required to purchase a yearly discharge permit at a rate of $155 per year. The proceeds from the permit make up approximately 60% of the operation and maintenance budget. The District also receives funds from county property taxes. Additional revenue sources include monitoring and inspection fees, new connection fees, and variance application fees. Fees are also collected for design review and permitting of new construction to ensure that development does not reverse progress made in septic system management. The District has the right to deny water service to proposed development that does not meet standards for on-site disposal (PSWQA 1991).

Potential Application in Monroe County, Florida: Under Florida Statute 153, counties are given the authority to establish water and sewage districts in unincorporated areas of the county (Florida Statutes 153). The FKAA currently provides water to the Florida Keys and has authority to provide wastewater treatment to all areas within its defined service area. Whether through creation of a new utility, or by using the existing structure provided by the FKAA, OSDSs in the Florida Keys could be managed under a program similar to the one being used in Stinson Beach. The use of a utility or management program can decrease the administrative costs associated with funding and provide a structure for the administration of funds and collection of fees.

One of the major tasks of a utility or management program would be the repair and replacement of failing or noncomplying OSDSs. Individual homeowners are generally responsible for maintaining and upgrading their OSDSs. If a utility or management program is authorized to enforce compliance with required modification or replacement via some mechanism such as suspension of water service or eviction (for health-related problems), this may place a significant burden on the individual property owner for the costs of repair. The utility or management program may be able to take on some of this cost through issuance of bonds or provision of low-interest loans.

According to information from the BLGFA, the State Revolving Loan Fund (Section 3.3.1.1) could possibly be used to finance capital costs of upgrading these OSDSs. In addition, the county could issue bonds (Section 3.1) that could serve as the basis for low-interest loans to homeowners to pay for upgrades, or the county could undertake the repairs and pay back the bonds through special assessments (Section 3.7) on the homeowners. There are some legal limitations on making repairs on private property. One way to get around these constraints may be through some sort of contractual arrangement between the county, utility, or management program and the property owner to deed the OSDS to the management agency until the costs of the repair or replacement has been paid off through special assessments or direct payment (PSWQA 1991). Similarly, repairs could be financed through rates, discharge permits, connect fees, and other charges. The BLGFA has suggested the creation of a septic utility that would use revenue from such charges to accrue the necessary capital for construction of a wastewater treatment facility. One of the drawbacks to using rates and charges for financing repairs and upgrades is that the number of repairs would be limited by available funds, thereby limiting the number of OSDSs that could be repaired in any one year.

The other major function of a septic utility or management program would be environmental monitoring and OSDS inspection. These could be made up through the use of rates, charges, and fees. The types of rates and fees discussed in this report that may be applicable include utility rates (Section 3.4.1), discharge fees (Section 3.5.1.2), inspection fees (Section 3.5.1.3), development fees (Section 3.5.3.1), and use impact fees (Section 3.5.3.2).

Additional funding available for both OSDS repair, wastewater treatment facility construction, or operations and maintenance of the utility or management program could be provided through impact taxes (Section 3.2.3.9) and property taxes (Section 3.2.3.10). Depending on the size of the area that is contained in the utility or management program, the community may be able to qualify for USDA grants or loans for rural community pollution programs (Section 3.3.1.2). Potential combination of funding sources for a comprehensive OSDS is illustrated in **Table 5-2**.

4.2.2 Stormwater Treatment

Stormwater management in the Keys is under the purview of the SFWMD, which issues permits for construction that may affect stormwater and charges access fees for industry use of its canals. Development on properties under 10 acres in size or with less than 2 acres of impervious surface are exempt from SFWMD permit requirements, although they may still be required to obtain a permit from the local government. In addition, existing surface water management systems in the Keys are not required to be retrofitted to meet current water quality standards. Industrial users are required to treat their stormwater prior to its release into the canals. In the primarily residential areas of the Keys, the majority of development projects received either a general permit or are exempt from the permitting process. The stormwater runoff from these areas is not required to be treated.

4.2.2.1 STORMWATER UTILITY

A funding alternative for management of stormwater is the creation of a stormwater utility. The SFWMD has the authority to create and manage stormwater utilities in the Florida Keys. In addition to construction and maintenance of canals and ditches, the activities of the stormwater utility will depend on the local stormwater management plans. At a minimum, they should include monitoring, treatment, discharge, and public education. Potentially applicable funding options for a stormwater utility are illustrated in **Table 5-3**.

Capital construction of new canals, ditches, or stormwater collection and treatment facilities could be financed through bonds (Section 3.1) or special assessments (Section 3.7). The SFWMD has the authority to levy special assessments on property owners and to create stormwater management benefit areas. The properties within these benefit areas may be assessed per acre fees (F.S. 403.0893). Additional funding may be available from federal grants for the prevention or limitation of nonpoint pollution (Section 3.3). Additional capital could be derived from impact taxes (Section 3.2.3.9) or development impact fees (Section 3.5.3.1).

Table 5-2. Potential combination of funding sources for a comprehensive on-site sewage disposal system.

	State Revolving Loan Fund	Bonds	Special Assessments	Utility Rates	Discharge Fees	Inspection Fees	Development Fees	Use Impact Fees	Impact Taxes	Property Taxes	Other Grants and Loans
Repair and Replacement of OSDS	•	•	•						•	•	•
Operations and Maintenance									•	•	
Environmental Monitoring										•	
On-site Inspection				•	•	•	•	•			
Building Capital for Construction of Wastewater Treatment Facility				•		•	•	•	•	•	•

Table 5-3. Potential combination of funding sources for a stormwater utility.

	Bonds	Special Assessments	Utility Rates	Discharge Fees	Access Fees	Development Fees	Inspection Fees	Impact Fees	Impact Taxes	Sales and Use Taxes	Property Taxes	Other Grants and Loans
New Canals and Ditches	•	•				•			•			•
Construction of Collection and Treatment Facilities	•	•				•			•			•
Operations and Maintenance			•	•	•						•	
On-site Inspection (Industrial Facilities)			•	•	•	•	•					
Public Education/Outreach								•		•		•
Household Hazardous Waste Programs								•		•		
Environmental Monitoring			•		•	•		•	•	•	•	•

Operations and maintenance funds could be provided through a combination of rates and fees. For residential and agricultural areas, most stormwater utilities charge a flat rate based on the surface area of the lot. Commercial areas are generally handled in a manner similar to SFWMD permit regulations: by examining the amount of impervious surface area. In Snohomish County, Washington, single-family residential property pays a flat rate of $22 per year; farms pay a flat rate of $88 per year, and commercial properties are charged on a sliding scale from $7 to $66 per quarter acre per year (PSWQA 1991). New developments, both residential and commercial, could be charged a one-time access rate for use of the stormwater system (Section 3.4.1).

Monitoring, public education, and a portion of activities such as household hazardous waste collection programs (to prevent household chemicals such as paints and solvents from being disposed of in storm drains) could be financed through various fees. These would include inspection fees (Section 3.5.1.3) for industrial facilities required to treat their own stormwater prior to discharging it into SFWMD canals and development fees (Section 3.5.3.1). A portion of the funding for stormwater management could also be derived from impact fees or taxes on automobiles, pesticides, fertilizers, and other activities or products that have the potential to increase stormwater pollutant loads.

5.0 CONCLUSIONS

This paper has presented a wide range of funding options that could be used for financing any necessary institutional or structural corrective actions in the FKNMS. Because there is significant overlap between different funding mechanisms, it is not envisioned that all of these options will be implemented. The agencies and institutions tasked with implementing the corrective actions will need to determine which options best fit their requirements, capabilities, and the financial climate of the economy in which they will be used.

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TASK 6 — WATER-QUALITY MONITORING PROGRAM

CONTENTS

CONTENTS (contini ed)

3.6 LICENSES AND PERMITS

3.6.1 Licenses

Licenses are commonly issued to give people the right to participate in an activity that is controlled by the state or local government. Fishing, hunting, and operating a motor vehicle are good examples of licensed activities. Business licenses and many professional certifications are also in the category. Usually a nominal license fee is charged to offset the cost of issuance and processing. In some instances, additional fees may be charged to fund activities related to the licensed activity. Such is the case for fishing and hunting for which fees are often charged to help pay for fisheries and game habitat and stock enhancement programs.

3.6.1.1 FISHING AND HUNTING

Florida currently requires licenses for the taking of fish and shellfish. The proceeds from the sale of saltwater fishing licenses helps pay for research activities conducted by the FDNR. In many states, the sale of a license is augmented by requiring users to purchase an additional stamp allowing the taking of specific species. Washington state has a Duck Stamp program in which they contract with a well-known local artist each year to create a special stamp for duck hunting licenses. Revenue is generated by the sales of the stamp to hunters and stamp collectors, as well as sales of limited number of prints made from the stamp to collectors (PSFC 1989). The potential revenue generation from the program depends on several factors including the extent to which people connect the sale of the stamp and prints to a preservation or mitigation function, the number of fishermen or hunters purchasing the stamps, and the name recognition of the artist who creates the stamp. Combining the sale of the stamps with a public education and outreach program that emphasizes the uses of the revenue from the stamp can increase the stamps' revenue generating potential (PSFC 1989).

3.6.1.2 BOAT LICENSES AND REGISTRATION

Several states require purchase of a license and registration for recreational boats. Depending on how they are implemented, registration fees can be either one-time or yearly charges on specific goods. In Rhode Island, a one-time charge of $5 is required to register outboard motors (EPA 1990a). A one-time fee is also charged to secure an owner's title to a boat. This latter fee is imposed on both motorized and nonmotorized watercraft. North Carolina, Washington, and Rhode Island also charge annual boat registration fees. North Carolina charges a flat yearly fee, while Rhode Island uses a graduated scale based on the size of the boat. In Washington, the fee is an excise tax of 0.5% of the fair market value of the registered watercraft, or a minimum of $5.00.

Proceeds from this fee could be allocated to boating safety activities and other boating related services such as maintenance of mooring fields, parks, and boat launches. Because boats and automobiles contribute to water quality degradation, registration fees could be charged at a rate that reflects these impacts. The proceeds could be allocated to mitigating boat- and automobile-related water quality impacts.

3.6.2 Permits

State and local governments require permitting for many construction and development activities. In addition, ongoing activities such as discharges to surface waters or operation of private waste treatment facilities are often allowed only by permit. A permit fee is often charged for processing of the permit application. In addition, permit fees could be levied to fund ongoing inspection and monitoring activities, or as a disincentive for specific activities such as discharges. Permit fees could be assessed as a per-application flat fee, or may be based on the size of the project or amount of impact the permitted activity will have on the environment.

The SFWMD requires permits for certain activities that may affect stormwater runoff. FDER and Florida Department of Health and Rehabilitative Services (FDHRS) permit wastewater treatment facilities and OSDSs. In addition, permits are required for dredging and filling of wetlands, discharges to surface waters National Pollutant Discharge Elimination System (NPDES), and underground injection. In general, permits fees are established at a level that covers the costs of processing the permit. The potential for additional revenue generation from permits, to cover the costs of enforcement and monitoring, depends on the number of permits being issued and any limitations placed on permit fees by law. Revenues collected by FDHRS are given to the state for allocation. Nothing in the legislation establishing these permit fees requires the revenue to be used for enhancing or protecting water quality. Changes in legislation to allocate present revenues for water quality improvement and enforcement could provide additional funds for these activities.

3.6.3 Impacts

Both licenses and permits are generally considered equitable because they assign the costs of an activity to the population using the resource or impacting an area. Hunting and fishing licenses charge users for the taking of public goods and a portion of the costs for the management of those resources. Licenses for using a boat or car are also viewed a means for offsetting the costs of providing services, such as roads and navigational aids, related to those activities. Permits charge for ensuring that activities comply with specific regulations.

Both licenses and permits tend to be relatively small sources of revenue. Licenses rarely cover all of the costs of monitoring, enforcement, and resource enhancement activities. Likewise, permits are often set at a rate that does not reflect the actual costs associated with the activity for which they are granted. In addition, permits for development or alteration, such as wetlands filling, rarely reflect the social costs of the activities being undertaken.

3.7 SPECIAL ASSESSMENTS

In some instances certain improvements to infrastructure benefit a small sector of the population. Examples include new road construction, extension of water delivery systems to new areas, and extension of sewer connections to a specific district. In such cases, special assessments may be levied to each property owner in the district to pay for the improvements. A form of Revenue Bond, called a Special Assessment Bond, may be issued to finance the improvements. In some instances general tax revenue may be used to supplement the assessments.

Several sections of the Florida Statutes currently allow counties to levy special assessments (ACIR 1992). Section 125.01 F.S. allows counties to establish a municipal service benefit unit that may levy taxes and special assessments. Section 125.01 is quite liberal in defining allowable purposes for use of special assessments. Among the many purposes allowed are beach erosion control, recreation service and facilities, water, streets, garbage and trash collection and disposal, waste and sewage collection and disposal, drainage, and other essential facilities and municipal services (F.S. 125.01). This statute effectively allows the use of special assessments for most of the proposed water quality improvement options presented in Task 3.

An additional authorization of special assessments is contained in Chapter 170, Florida Statutes *Supplemental and Alternative Method of Making Local Municipal Improvements*. It provides municipalities the following authorization for the use of special assessments:

- Order the construction, reconstruction, repair, renovation, excavation, grading stabilization, and upgrading of greenbelts, swales, culverts, sanitary sewers, storm sewers, outfalls, canals, primary, secondary, and tertiary drains, water bodies, marshlands, and natural areas, all or part of a comprehensive stormwater management system, including the necessary appurtenances and structures thereto and including, but not limited to, dams, weirs, and pumps;
- Order the construction or reconstruction of water mains, water laterals, and other water distribution facilities, including the necessary appurtenances thereto; .....

- Provide for the drainage and reclamation of wet, low, or overflowed lands;
- Provide for mass transportation systems; and
- Provide for the payment of all or any part of the costs of any such improvements by levying and collecting special assessments on the abutting adjoining contiguous, or other specially benefitted property (FS 170).

In addition to these municipal authorizations, certain special districts are given authority to levy special assessments. Of particular interest to financing water quality improvements are such authorizations for Water Control Districts, Water Managements Districts (SFWMD), and Water and Sewer Districts. FS 403.0893 further authorizes the use of stormwater utilities and stormwater utility fees "sufficient to plan, construct, operate, and maintain stormwater management systems." The creation of "stormwater management system benefit areas" is allowed by the statute, and property within the area may be assessed per acre fees (F.S. 403.0893).

It is clear from the Florida Statutes discussed above that municipal use of special assessments is authorized for many activities related to the water quality improvement options. There are, however, significant legal considerations in the levying of a special assessment. Generally, special assessments must be levied only when a special benefit to the property to be assessed will occur as a result of the assessment (ACIR 1992). In addition, apportionment of the assessment among property owners must be fair and reasonable (ACIR 1992).

Despite the apparent widespread authorization, special assessments do not make up a large share of municipal or special district revenue in Florida. In 1986-87 only 0.5% of county revenues, 0.7% of municipal revenues, and 0.9% of special district revenues were generated via special assessments (ACIR 1992). In localities where special assessments are used, the most prevalent purposes for their use have been to fund solid waste facilities, street lighting, road paving, and fire protection. In addition, at least three counties were levying special assessments for sewer projects in 1991.

3.7.1 Impacts

Special assessments are similar to taxes in that they are an enforceable contribution from property owners (ACIR 1992). However, special assessments are limited to the property directly benefiting from an activity, whereas taxes are levied over a local-government-wide tax base. Because the base of the special assessment is smaller than the overall tax base, they generally do not provide as large a source of revenue. The advantage is in the defined benefit principle: apportioning the costs for improvements according to the benefit the property receives from them.

An additional benefit to using special assessments as a finance tool is that they are enforceable levies. Unlike rates and charges, special assessments are generally limited to facility construction. Operation and maintenance will still need to be funded through other forms of revenue, such as rate revenue. Special assessments also protect general borrowing capacity by minimizing the requirement of the municipality to incur debt through other mechanisms, such as bonds.

Special assessments have a definite, sometimes substantial, impact to the property owners being assessed. Property owners are not able to deduct the amount of the special assessment from their taxes, as they would be able to do with *ad valorem* property taxes (ACIR 1992). In addition, the start-up and administration of special assessments is complex and can be costly.

3.8 DONATIONS/CHARITABLE TRUSTS

3.8.1 General Description

Donations provide an attractive mechanism for financing environmental programs. Five percent of the available grant dollars in 1991 was directed toward environmental and animal programs, with two-thirds of that money being spent in programs for protecting natural resources (Olson 1992). Several foundations and trusts provide funding for specific programs in their areas of interest. The size of grants can range from $20,000 for the One Thousand Friends of Florida to assist communities in implementing the state's growth management plan, to $100,000 for Collier City, Florida, to develop a new landfill recycling program (Olson 1992). Grants are available to local governments, organizations, and interest groups, and specific application requirements usually apply. For the purposes of the FKNMS, these grants are likely to be most useful in funding public education and outreach activities to raise the awareness of Keys resource impacts and issues. A primary source for information on available grants is the *Foundation Grants Index for 1992* published by the Foundation Center. (Olson 1992)

3.9 PRIVATIZATION

3.9.1 Operations Contracting

During the past several years, budgetary difficulties combined with the increasing complexity of providing services has prompted the privatization of many public services traditionally provided by municipal governments (Roehm *et al.* 1989). The most common form of privatization, known as Public/Private Partnerships, involves the contracting of a private firm to operate and maintain public facilities. There are several types of Public/Private Partnerships ranging from contract services (least private) to merchant owned and operated facilities (most private). One example of such an arrangement is the contracting of a waste management firm to operate a municipal wastewater treatment facility. Often, the operation of such facilities is quite complex and costly. Large and small municipalities alike may suffer from lack of expertise in establishing management and operations of wastewater facilities and may choose to contract the operation of the plant to a private firm. The private firm is contracted to operate the plant for a negotiated fee designed to cover operating expenses and negotiated profit margins. While contracting specifications vary, and can be quite complex, a usual component is a provision for sharing excess profits realized through operating cost minimization between the private firm and the municipality (Holcombe 1991). Such an arrangement provides operational efficiency incentives for the private firm and may result in a return of profits to the municipality. In most cases the municipality owns the plant and retains responsibility for monitoring and enforcement of contract provisions including regulatory compliance. It is important to note that the municipality must be cognizant of the possibility of excessive cost cutting by the private firm to enhance profits. Unfortunately, this is a built-in difficulty of a profit incentive based on operating cost minimization and must be prevented through stringent monitoring of operations. A current example of this mechanism in the Florida Keys is the contracting of operations of the Key Colony Beach WWTP to Anti-Pollution Associates. The City of Key West currently contracts the operation of wastewater treatment to OMI, Inc.

3.9.2 Construction and Operations Contracting

The construction of a municipal WWTP is both a costly and lengthy proposition. Construction costs can be in the tens of millions of dollars and in some cases municipal construction of a plant has taken more than ten years (Holcombe 1991). Costs of construction will increase with the length of time required for completion. In addition, if plant construction is funded through the use of bonds, the delay in establishing a stream of rate revenue from the plant will require that other revenues such as tax revenues be raised to provide for debt maintenance during the construction phase. Such problems have prompted the use of a more extensive form of privatization than the common operations contracting method mentioned previously.

In general, the construction of a wastewater treatment facility must proceed through a series of stages including authorization, design, and construction. During this process, certain permits must be obtained, and construction code inspections must be conducted. These processes are generally the same for a municipality that is contracting with a construction company to build a public plant or for a private company constructing a private plant that it will then own and operate privately or on contract to a municipality. Thus, it would seem that the overall cost of construction and the time required would be the same for both the public plant and the private plant. In fact, however, this is simply not the case (Holcombe 1991).

A private firm operates with the primary purpose of earning a profit by providing goods and services. The municipality, on the other hand, has no such "profit incentive" and is simply providing the services that it has deemed necessary for orderly operation of the municipal government. Providing for such orderly operations has resulted, over the years, in extensive layers of bureaucracy that may severely hamper the ability of a municipal government to efficiently manage the construction of facilities. The result is that some municipal plants can take as much as ten or more years for completion while similar private plants have been constructed in approximately two years (Holcombe 1991). The total savings in administrative cost earned by elimination of the unnecessary construction time, combined with the potential income from eight years of plant operation, foregone in the public ownership case, may be quite an incentive for privatization of both the construction and operation of WWTPs or other municipal facilities. In addition to the profit incentive, private firms may also have greater technical and design expertise that enables them to assess opportunities for using more advanced technologies and make knowledgeable predictions of cost and performance benefits (EPA 1990c). Private partners are often more free to make cost-benefit decisions than public officials who are more directly influenced by political pressures.

In this more extensive privatization, the facility is constructed, owned, and operated by the private firm under contract to the municipality. The municipality has traditionally issued a Revenue Bond to provide funds for construction of the facility. These funds are then made available to the private firm to finance construction of the plant, and the private firm repays the debt with rate revenue during the operation contract. Under this scenario, the private partner has significant incentive to construct the plant quickly and at the least possible cost. In addition, if the contract is wisely composed, incentive to operate the plant efficiently is built in as a profit motive via profit sharing agreements as in the case of operations contracting. In practice, this type of arrangement has resulted in planning and construction of a treatment plant in two years as compared to as much as eleven years for a municipal plant (Holcombe 1991).

Public/Private partnerships are by no means the answer to all of the problems of providing municipal service needs. There are significant contracting complexities to overcome, and, in some instances, inefficiencies in contracting may create costs that exceed any benefit to be gained by privatization (Holcombe 1991). In addition, use of IDRBs to finance such projects was severely curtailed by the 1986 Federal Tax Reform Act. Such bonds are issued by the municipality as tax free revenue bonds and are repaid with revenue from private contracting of the facility constructed with the bond financing. The 1986 Federal Tax Reform Act defines such bonds as private activity bonds if any more than 10% of the bond repayment revenues come from private activities such as private operation of a WWTP. The Act established a statewide private activity bond cap based on a dollar amount per capita.

Florida is currently allowed $633.5 million in issuance of private activity bonds statewide (see Section 3.1.5) (ACIR 1991d). As Section 3.5.1 discussed, the state facilitates the distribution of available private allocation bonds through three pools and projects must compete for inclusion in the cap amount. If a private activity bond project is not included in the cap allocation, the project cannot be financed with private activity IDRBs and must be funded through alternate means or delayed for possible inclusion in future pools.

3.9.3 Impacts

One advantage of privatization is the greater expertise that is brought to management of facilities by private contractors. This tends to decrease the level of bureaucracy by relieving the local government of the need to operate a facility. In addition, private contractors have a profit incentive that tends to encourage more efficient management of activities than public agencies provide. Privatization has demonstrated an ability to significantly reduce the time required to construct facilities, and the overall costs of construction.

A disadvantage to privatization is the potential for profit maximization to encourage lower levels of service and product quality in order to achieve a higher level of profit. This requires a rigorous amount of oversight and monitoring on the part of the public agency, which can increase costs. In addition, privatization requires a sophisticated level of contracting ability, usually including extensive legal services.

Because privatization tends to decrease the costs of construction, it can significantly reduce rates, thereby having a beneficial impact on the rate paying public. In certain circumstances, privatization can displace public workers in favor of private ones.

4.0 IMPLEMENTATION

The preceding section outlines some potential funding mechanisms that could be used to finance water quality improvement activities. The next step in the process will be selecting and implementing the most appropriate funding mechanisms. This step will necessarily take place after a preferred set of water quality improvement options has been identified, and with in-depth analysis of the local economy in which the options will be implemented. This section outlines the issues that need to be addressed in selecting specific funding mechanisms and identifies some strategies for combining the mechanisms discussed in Section 3.0 into a funding approach for wastewater and stormwater management activities.

4.1 SELECTING FUNDING MECHANISMS — CONSIDERATIONS

Several factors will affect the choice of funding mechanisms. Foremost among these is a determination of the amount of additional revenue needed in order to implement the preferred management and engineering options. In addition, an understanding of the constraints imposed on collection of specific revenues, such as taxes, is also required. This section identifies the major factors that should be considered in selecting the appropriate funding mechanisms and outlines an approach to making that selection.

Authorization: Once specific water quality implementation options have been selected, the agency or institution tasked with implementation will need to be identified. Task 3 suggests potential agency and institutional actions for each of the major management and institutional options. The funding mechanisms available to these agencies and institutions will depend on the legislative and constitutional authorization they have been granted. In Florida, as with other states, there are specific limitations on implementing some of the funding mechanisms identified in this report. An example is the Florida tax system, which limits municipalities and local governments to collection of *ad valorem* property taxes and local option taxes. Determining which agency or institution is best suited to implementing the water quality improvement options should be partly based on their ability to generate needed revenue.

Project Costs: In determining the amount of revenue required, an assessment of the overall project costs is required. This includes construction, management, and operational costs, as well as costs associated with managing any debt incurred in financing the project. At the early stage of selecting funding mechanisms, the amount of debt management required may not be known. The overall project costs are likely to change as funding mechanisms are identified, and as the project is implemented. Early estimation of the level of funding required will allow the implementing entities to more easily identify the most appropriate funding mechanisms. Once these mechanisms have been identified, their impact to the debt management portion of the project cost assessment will need to be calculated.

CONTENTS (continued)

TABLES

FIGURES

ACRONYMS

AA	autoanalyzer
AAS	atomic absorption spectrophotometry
AIW	Advanced Inventory of Wetlands
APA	alkaline phosphatase activity
AVHRR	advanced very high resolution radiometer
BCD	Biological Conservation Database
BNP	Biscayne National Park
CARICOMP	Caribbean Marine Productivity Program
CAMRA	Coastal and Marine Resource Assessment
CMAN	Coastal Marine Automated Network
CMC	Center for Marine Conservation
C:N:P	carbon:nitrogen:phosphorus
DERM	[Dade County] Department of Environmental Management
DFAA	dissolved free amino acids
DIN	dissolved inorganic nitrogen
DIP	dissolved inorganic phosphate
DO	dissolved oxygen
DON	dissolved organic nitrogen
DQO	Data Quality Objectives
ECD	electron capture detector
EDF	Environmental Defense Fund
EMAP	Environmental Monitoring and Assessment Program
ENP	Everglades National Park
EPA	Environmental Protection Agency
FAAS	flame atomic absorption spectrophotometry
FDCA	Florida Department of Community Affairs
FDER	Florida Department of Environmental Regulation
FDNR	Florida Department of Natural Resources
FID	flame ionization detector
FIO	Florida Institute of Oceanography
FIU	Florida International University
FKLST	Florida Keys Land & Sea Trust
FKNMS	Florida Keys National Marine Sanctuary
FMRI	Florida Marine Research Institute
FWS	U.S. Fish and Wildlife Service
GC/MS	gas chromatography/mass spectrometry
GIS	Geographic Information System
GPS	Global Positioning System
HBOI	Harbor Branch Oceanographic Institution
HDPE	high density polyethylene
IC	inorganic carbon
IR	infra-red
KLNMS	Key Largo National Marine Sanctuary
LAI	leaf area index
LKNMS	Looe Key National Marine Sanctuary
MFP	methyl fluorescein phosphate
MOA	Memorandum of Agreement
NAS	National Audubon Society
NBS	National Bureau of Standards
NNED	N-(1-naphthyl)-ethylenediamine dihydrochloride
NOAA	National Oceanic and Atmospheric Administration

ACRONYMS (continued)

NPOC	non-purgeable organic carbon
NPS	National Park Service
NRC	National Research Council
NTU	nephelometric turbidity unit
NURC	[NOAA] National Undersea Research Council
OPA	*o*-phthaldialdehyde
OSDS	on-site sewage disposal system
PAR	photosynthetically active radiation
PCB	polychlorinated biphenyl
PTFE	polytetrafluoroethylene - (Teflon)
PVC	polyvinylchloride
QA	Quality Assurance
QAO	Quality Assurance Officer
QAPjP	Quality Assurance Project Plan
QC	Quality Control
RFA	Rapid Flow Analyzer
SEAWIFS	Sea-Viewing Wide Field of View Sensor
SFRL	South Florida Regional Laboratory
SFWMD	South Florida Water Management District
TDN	total dissolved nitrogen
TDP	total dissolved phosphorus
TN	total nitrogen
TNC	The Nature Conservancy
TOC	total organic carbon
TP	total phosphorus
TSS	total suspended solids
μM	micromoles per liter
μmhos	micromhos
USGS	United States Geological Survey
WWTP	wastewater treatment plant

1.0 INTRODUCTION

The goal of Task 6 is to develop a comprehensive water quality monitoring program for the Florida Keys National Marine Sanctuary (FKNMS). For the Water Quality Protection Program, monitoring is defined as the continued observation of FKNMS waters to determine the spatial and temporal variability in water quality and the status of the biological resources to determine whether these conditions are improving or degrading. Theoretically, some form of monitoring will continue as long as the FKNMS exists. Sanctuary managers will use the monitoring program and the research results in conjunction with the institutional and engineering options (Tasks 3 and 4) to accomplish the objectives of the Water Quality Protection Program.

The monitoring program is closely related to the research program discussed under Task 7. The monitoring program will focus on documenting status and trends and measuring the success of remedial actions, whereas the research program will focus on processes and cause/effect relationships. One way in which the research program will interact with the monitoring program is through the development of new monitoring tools (e.g., indicators). In addition, the monitoring program will provide data for the validation and refinement of predictive models developed through research.

The monitoring program described here is developing through an iterative process. A preliminary draft monitoring program was circulated to scientists for review prior to the Monitoring/Research Workshops held July 14-16, 1992 in Marathon, Florida. The monitoring program was then revised based on numerous comments and suggestions provided by the workshop participants. A draft monitoring program (Task 6 report) was reviewed by the Environmental Protection Agency (EPA) and the state of Florida.

Although an overall monitoring design has been developed, some aspects of design (e.g., coral reef sampling locations and methodologies, seagrass sampling locations) and other details of implementation remain to be worked out. In addition, the monitoring program was designed with no cost constraints, Therefore, before the monitoring program can be implemented, it will be necessary to develop an implementation plan that will (1) revise the monitoring program design based on anticipated funding and (2) describe specific steps to be taken in implementing the program.

2.0 OBJECTIVES

According to the Florida Keys National Marine Sanctuary and Protection Act, the goals of the water-quality monitoring program are to

- Determine the sources of pollution causing or contributing to existing or anticipated pollution problems in the FKNMS
- Evaluate the effectiveness of efforts to reduce or eliminate those sources of pollution
- Evaluate the progress toward achieving and maintaining water quality standards and toward protecting and restoring the coral reefs and other living marine resources of the FKNMS

The EPA Statement of Work for Phase II of the Water Quality Protection Program provides an expanded set of goals for the monitoring program based on the Florida Keys National Marine Sanctuary and Protection Act. These goals are to

- Provide a baseline for comparison with future conditions
- Determine significant water quality trends
- Evaluate the progress toward achieving and maintaining water quality standards
- Provide a framework for testing hypothesized pollutant fate/effects relationships
- Determine the sources of pollution causing or contributing to existing or anticipated pollution problems in the FKNMS, including far-field pollution sources that may be affecting the FKNMS

- Evaluate the effectiveness of efforts to reduce or eliminate sources
- Evaluate compliance with regulations (water-quality effluent limitations and other enforceable pollution control measures)

3.0 BACKGROUND

The monitoring program was developed on the basis of the objectives listed in **Section 2.0**, the Phase I literature review and workshops, and guidance from scientists familiar with the water quality and biological resource problems in the Keys. In addition, guidance was provided by the following relevant documents:

- National Oceanic and Atmospheric Administration (NOAA) Research Planning Workshop (Harwell 1991)
- FKNMS Strategy Identification Sessions
- National Estuary Program: Monitoring Guidance Document (EPA 1991)
- Managing Troubled Waters: The Role of Marine Environmental Monitoring (National Research Council [NRC] 1990)
- Proceedings, International Symposium on the Design of Water Quality Information Systems (Ward *et al.* 1989)
- Biological Criteria: National Program Guidance for Surface Waters (EPA 1990)
- Environmental Monitoring and Assessment Program (EMAP) Guidelines for Preparing Logistics Plans (Baker and Merritt 1991)
- 1990 Demonstration Project: Quality Assurance Project Plan (QAPjP) for EMAP Near Coastal (Valente *et al.* 1990)

These documents were used to define the primary characteristics and constraints of the monitoring program. In particular, they provided information regarding monitoring objectives, stratification of the Sanctuary, sampling design, allocation of the sampling effort, and the selection of parameters of interest. The documents were also useful for determining the characteristics of successful monitoring programs and identifying common pitfalls.

Based on these general sources of guidance, the following broad characteristics of the monitoring program were determined:

- The program should monitor the status and trends of water quality parameters throughout the Sanctuary, including areas near the known pollution sources.
- The program should monitor the status and trends of biological resources potentially affected by water quality problems.
- In addition to status and trends, the program should monitor remedial actions (e.g., engineering and/or institutional actions to reduce or eliminate pollutant sources) with a program design appropriate to the specific action.

During the initial phases of the monitoring program development, a preliminary monitoring framework that described the approach being taken to develop the monitoring program was prepared and circulated to the natural resource managers and scientists. These individuals were interviewed to determine their opinions on the monitoring framework, information needs (resource managers), and opinions on specific parameters/methods (scientists). Participants at the Monitoring/Research Workshops (July 14-16, 1992) provided further guidance for monitoring program development, including suggestions for sampling locations. The following points were emphasized.

- **Everglades/Florida Bay system**
  The monitoring program design should take into account the close relationship between the Sanctuary and adjacent areas, especially the Everglades/Florida Bay system. To the extent possible, proposed monitoring methodologies and those methodologies currently used in the adjacent areas should be consistent. For complete geographic coverage, monitoring stations should be established outside the FKNMS boundaries.

- **Monitoring of "hot spots"**
  There is ample evidence of pollution problems at known or suspected "hot spots." The monitoring program should include a representative sampling of such areas, but its main focus should be detecting degraded water quality in nearshore and offshore waters.

- **Remote sensing**
  Remote sensing can be used to monitor biological resources (hard-bottom communities, seagrass communities, and mangrove communities) on a broad scale. This approach can be used to augment field sampling efforts and to help generalize findings obtained from a limited number of fixed stations.

4.0 COMPONENTS

4.1 STATUS AND TRENDS MONITORING

The purpose of the status and trends monitoring is to provide a base of information concerning the condition of water quality and biological resources in the FKNMS. The status and trends monitoring will be geographically comprehensive, providing a baseline of information and documenting trends in water quality and biological resources. The status and trends monitoring effort is expected to continue as long as the FKNMS exists.

4.1.1 Water Quality

Nearshore and offshore waters will be sampled as part of the water-quality monitoring program. This sampling will be conducted to gather representative data for determining the status and trends in water quality and to examine gradients associated with distance from the land mass. This sampling will be conducted during periodic surveys when water quality measurements are made and water samples are collected and analyzed. In addition, water quality measurements will be made by using continuously recording *in situ* instrumentation.

Water quality in confined waters that are known or suspected to be severely degraded will also be monitored by periodically collecting water quality measurements and collecting and analyzing water samples. These data will be used to determine the status and trends of pollution sources and will be useful in designing remedial action monitoring efforts (Section 4.2).

4.1.2 Biological Resources

The status and trends of biological resources in the FKNMS will also be monitored. Of the biological resources in the FKNMS, those to be monitored include coral reef, hard-bottom, seagrass, and mangrove areas. Hard-bottom communities, which include nearshore hard-bottom and offshore coral reef communities, will be monitored by *in situ* sampling and remote sensing. Data pertaining to the seagrass communities will also be collected by *in situ* sampling and remote sensing. Changes in mangrove communities will be monitored using remote sensing.

4.2 REMEDIAL ACTION MONITORING

Remedial actions will be taken to control pollution sources in the Keys, probably on both policy and engineering levels. This remediation monitoring should document the success or failure of engineering and/or institutional alternatives to reduce or eliminate pollution sources. The scope of the monitoring will be determined on a case-by-case basis; this monitoring could be broad or site-specific (e.g., a pilot project).

5.0 GENERAL DESIGN CONSIDERATIONS

Several general aspects of the monitoring program design are considered in this section.

- **Hypotheses**
  What questions will the data collected during the monitoring program be used to answer?

- **Program structure and evaluation**
  Is there enough data concerning the spatial and temporal variation in water quality to design a long-term monitoring program? If not, a phased approach may be appropriate, with the program design being reevaluated and refined after the completion of an initial baseline monitoring period.

- **Stratification**
  What stratification will be incorporated into the monitoring program design to control different sources of variability?

- **Sampling designs**
  How will transect-oriented and stratified random-sampling designs be incorporated into the monitoring program?

- **Existing study locations**
  To what extent will existing study sites be incorporated into the monitoring program?

- **Remote sensing**
  How will the remote sensing of biological resources be incorporated into the program?

- **Selection of parameters**
  What parameters will be measured in the water quality and biological resources monitoring program?

- **Analytical methods**
  What analytical methods will be used in the monitoring program?

5.1 HYPOTHESES

The hypotheses for the water-quality monitoring program will determine what data are collected and how they will be analyzed and interpreted. The hypotheses must be related to the overall objectives of the Water Quality Protection Program so that the Sanctuary managers can use the information from the monitoring program to determine appropriate management actions.

Because a primary objective of the Water Quality Protection Program is to improve water quality in the Sanctuary, a basic question for the status and trends monitoring efforts for water quality and biological resources is whether water quality in the Sanctuary is remaining relatively constant, deteriorating, or improving. Therefore, hypotheses for the status and trends monitoring are related to temporal changes. The null hypothesis for water quality and biological community parameters is that there is no long-term change with respect to present conditions. The alternative to this hypothesis is that there is a trend (i.e., the parameters are changing in one direction or the other [improving or deteriorating]). If trends are identified in the biological communities during the course of the status and trends monitoring, then additional hypotheses relating changes in the biological communities to changes in water quality parameters can be investigated.

Engineering and institutional alternatives will be considered to reduce or eliminate pollutant sources (see Tasks 3 and 4). An appropriate null hypothesis to evaluate such actions is that a particular remedial action has no effect on water quality in areas where the effects of the pollution source have been observed. The alternative hypothesis is that a particular remedial action improves water quality in areas where the effects of the pollution source have been observed. This null hypothesis can be applied in site-specific monitoring programs for wastewater treatment plants (WWTP), on-site sewage disposal system (OSDS) foci, injection wells, marinas and live-aboard mooring sites, commercial and industrial facilities, stormwater runoff, and mosquito spraying. The remedial-action monitoring program would be designed to test the null hypothesis, and if the action proves effective, regulatory agencies would have a justification for implementing changes over a larger area.

5.2 PROGRAM STRUCTURE AND EVALUATION

One aspect of the program design that had to be considered was whether there were sufficient available data to design a long-term monitoring program that would require minimal refinement during its execution. Based on the results of Phase I of this project, it is clear that sufficient data concerning spatial and temporal variations in water quality are not available to design a final long-term monitoring program. The monitoring program will therefore be conducted in phases, with the design of each phase dependent upon the results of the preceding phases.

Because a comprehensive, temporally continuous baseline does not exist for the FKNMS, the first phase of the status and trends monitoring program will begin with a baseline monitoring effort. This baseline effort will continue for 5 years because this is thought to be sufficient to (1) evaluate the sources of variability in water quality; (2) determine what parameters are most effective to measure and what methodologies are most effective to use; and (3) evaluate what sampling frequency and sampling design are effective in terms of the density and distribution of the sampling locations. This baseline monitoring effort is described in this document. After the completion of the baseline monitoring, the data will be evaluated and a long-term monitoring effort will begin. The scope of this long-term monitoring effort will be evaluated every year and refined as needed.

During the baseline monitoring period, status and trends data will be collected for water quality and biological resources. During the initial survey, sediment and tissue samples will also be collected to evaluate the distributions of sewage tracers such as coprostanol and toxic compounds such as heavy metals, pesticides, polychlorinated biphenyls (PCBs), and petroleum hydrocarbons. These sediment and tissue data will be evaluated to determine if the scope of the baseline monitoring should be expanded with respect to these compounds routinely.

The most important use of the data collected during the baseline monitoring will be to develop and calibrate the water quality/hydrodynamic and ecological models that will provide the central framework for the long-term monitoring design, as discussed in Task 7. These models are not presently available, and adequate data are not available for their development. Baseline monitoring data will be used to identify important spatial and temporal scales of water quality variability. In addition, these data will be used to evaluate the ability to detect changes. Data collected during the baseline monitoring program will also be used to identify sources of redundant information. Examples of such sources are (1) stations that are strongly correlated with respect to water quality and, therefore, provide essentially the same information, and (2) parameters that are strongly correlated and, therefore, data for one parameter is sufficient to compute the other. Correlations among parameters may be useful for the interpolation between measurements made at discrete times from data collected continuously.

5.3 STRATIFICATION

The purpose of stratification in a monitoring program design is to control the different sources of variability (i.e., quantify the variability that may be associated with different sources so that real trends are not masked by variability from these sources). Because regions of the FKNMS differ with respect to the sources of variability, such as different oceanic regimes, distance from the mainland, physiography, and biological resource habitats, stratification is incorporated into the status and trends monitoring program design.

Considering the Sanctuary as a whole, a geographic stratification (segmentation) framework will be incorporated in the monitoring program design (see Section 6.0). These strata were determined based on the distance from the South Florida mainland and oceanic regime (Atlantic Ocean, Gulf of Mexico, and Florida Bay). Geographic regions are generally related to distance from the South Florida mainland and differences between the Upper Keys, Middle Keys, Lower Keys, and Western Extension. Oceanic regimes are separated because proximity to the Loop Current/Florida Current system affects water quality. Physiography was incorporated to use a separate sampling design for the segment surrounding the Lower Keys. Boundaries between segments were refined based on a spatial framework developed by Klein (1993), which divides the FKNMS into segments based on dominant hydrodynamic scales. Congruence between the water quality sampling design and hydrodynamic spatial framework will facilitate modeling of hydrodynamic processes important to water quality in the Sanctuary.

A second level of stratification was established within segments where large passes between Florida Bay and the Atlantic Ocean occur (e.g., in the Middle Keys). Water quality may vary among the transects depending on an association with the land mass and movement of water through the passes. Therefore, water quality transects will also be stratified according to whether their shoreward end is adjacent to land or a pass.

In the biological resource status and trends monitoring, stratification will also be established to account for different habitat types. Within the coral reef study sites, the stations will be stratified as back reef, reef flat, shallow and deep spur-and-groove, fore reef, and deep reef. Nearshore hard-bottom areas will be stratified into different distributional patterns — sparse, moderately dense, and patchy — based on the preliminary list of benthic communities to be mapped in the Florida Department of Natural Resources (FDNR)/NOAA mapping study (F. Sargent, FDNR, personal communication, 1992). Seagrass communities will also be stratified based on the benthic communities to be mapped by the FDNR/NOAA. These strata will be contiguous (moderate and dense), sparse, and patchy areas of seagrass distribution.

5.4 SAMPLING DESIGNS

Different aspects of the status and trends monitoring program require different sampling designs, such as transects and stratified random sampling. Transects are applicable in situations where a gradient in the parameters of interest exists. This is certainly the case for water quality in relation to the Florida Keys land mass. In addition to a natural land mass effect, there are also sources of pollution associated with the land mass. Random sampling or stratified random-sampling designs are means of obtaining representative data when there is not evidence of an underlying trend. Because there are natural strata associated with the FKNMS system, randomized sampling within these strata is applicable to these situations.

Transect-oriented and stratified random-sampling designs are incorporated into the monitoring program, depending on the component. For water quality, transects are used in all but one particular geographic stratum to provide spatial information concerning gradients related to distance from shore. The physiography of this one geographic stratum, which encompasses much of the Lower Keys, is not conducive to using a transect-oriented sampling design. In this stratum, a randomized sampling design is used. Within each geographic stratum, there are natural biological strata. To obtain representative data within these biological strata, a randomized design was used in the biological resource status and trends monitoring.

5.5 EXISTING STUDY LOCATIONS

Ongoing research programs [e.g., the cooperative SEAKEYS/National Undersea Research Center (NURC)/Harbor Branch Oceanographic Institution (HBOI) program (see Appendix D)], address specific questions concerning water quality, such as the high-frequency variability of water quality. These data are important because they provide information on aspects of water quality that will not be addressed in the status and trends monitoring program. The sampling sites in such studies are generally selected to investigate specific scientific questions; therefore, incorporating these sites into the status and trends monitoring program is not appropriate because the sites were not selected based on the overall objective of the status and trends monitoring program. Water-quality sampling is routinely conducted in the Everglades National Park ([ENP] Florida Bay) and in Biscayne National Park ([BNP] Biscayne Bay). Coordination (in terms of sampling methodology and analysis) and exchange of data between these programs and the FKNMS status and trends monitoring program is needed because they are part of the South Florida system.

Seagrass monitoring stations do not currently exist in the Sanctuary, therefore, it was necessary to develop a sampling design that incorporates the selection of seagrass monitoring stations into the monitoring program. However, there is a series of monitoring stations in Florida Bay (investigators from ENP, University of Virginia, and FDNR). Because this region is part of the same system and is adjacent to the Sanctuary, monitoring methods used in this program will be comparable to those used in Florida Bay.

There are a number of existing coral reef study sites in the Sanctuary (Appendix D). Because much of the information concerning the status of coral reefs at these sites within the Sanctuary is valuable baseline data, sampling at these sites is recommended for incorporation into the monitoring program.

5.6 REMOTE SENSING

Remote sensing and mapping are valuable tools for gaining perspective of the overall distributions of benthic habitats in large areas such as the FKNMS. Comparison of the results between mapping efforts allows the evaluation of changes in the distributions of the habitats. FDNR/NOAA are currently conducting a mapping effort of FKNMS benthic habitats, including seagrass and hard-bottom communities; results are anticipated to be released in December 1993 (K. Haddad, FDNR Marine Research Institute, personal communication, 1992). In addition, a separate remote sensing effort, the Advanced Inventory of Wetlands (AIW), is being conducted to map mangroves. The monitoring program design includes repetition of these mapping efforts every few years to assess any broad-scale changes in habitat distribution.

5.7 SELECTION OF PARAMETERS AND METHODS

The selection of parameters to be measured in the monitoring program was based on a number of considerations. The Florida Keys National Marine Sanctuary and Protection Act specified that a water-quality monitoring program be designed to monitor the status and trends in water quality and biological resources, particularly coral reefs, seagrass communities, and mangroves, within the Sanctuary. Specific guidance on program priorities was taken from the Phase I document and workshop problem statements. The Core Working Group of the FKNMS also provided a prioritized (though subjective) ranking of the sources of pollutants in the Sanctuary based on known, suspected, or potential effects on natural resources. Nearfield sources of nutrients and both nearfield and farfield sources of toxics were judged to be the pollutants of most concern. In addition, recommendations from the FKNMS Research Planning Workshop (Harwell 1991) were examined to develop a more complete list of parameters. Literature was reviewed and technical experts were consulted to determine the appropriate methodologies to employ to measure the parameters. The preliminary list of parameters and recommended methods were then presented for discussion during the Monitoring and Research Workshops.

The selection of sediment quality and biological body burden parameters was based on postulated nearfield and farfield pollution sources. The specific compounds were identified through available literature and by consultation with the Monroe County Mosquito Control District, the Florida Cooperative Extension Office, and the NOAA National Status and Trends Program.

In the Monitoring and Research Workshops, experts discussed the preliminary parameter and methods list. The experts recommended that a number of standard water quality measurements not be measured because of their lack of utility in the Keys environment or redundancy. These parameters included silicate, total suspended solids (TSS), Secchi disk depth, chlorophyll *b* and *c*, sediment porosity, and particulate nitrogen and phosphorus. Based on the recommendations, a final parameter and methods list was developed and is presented in **Sections 6.0 and 7.0**.

5.8 ANALYTICAL METHODS

The choice of analytical methods is an important concern in the monitoring program. In particular, there has been some debate about the appropriateness of using "oceanographic" rather than "regulatory" (i.e., EPA) methods to measure nutrient concentrations in the oligotrophic waters of the Florida Keys.

Standard EPA methods for nutrients that were developed for use in freshwater and wastewater, have levels of detection or applicable ranges that are higher than what is found naturally in the Florida Keys (**Table 6-1**). The monitoring program incorporates the use of "oceanographic" methods that have detection limits lower than natural concentrations found in FKNMS waters. Generally, the proposed methods are analytically similar to EPA methods but are optimized to improve the detection limits (**Appendix B**). To ensure that the methods used in the monitoring program will allow the detection of changes in conditions, performance criteria for each parameter are specified in **Appendix B**. The specified performance criteria will ensure that the methods used are sensitive enough to detect anthropogenically-induced changes above the background levels of natural variability. A quality assurance (QA) program (**Section 9.0**) will be instituted to specify and document the quality control (QC) procedures required to ensure the scientific soundness and success of the monitoring effort.

Much of the discussion during the workshops centered on nutrients and their measurement; less attention was paid to the measurement of toxics. However, there was general agreement that, as with the nutrient analyses, analytical methods for toxics, including heavy metals and pesticides, employ methods appropriate for the environmental conditions. As appropriate, NOAA National Status and Trends Program methods or other suitable methods were selected for incorporation, rather than using EPA-approved methods that are based on requirements for analysis of solid wastes. The NOAA National Status and Trends Program takes a performance-based rather than a protocol/methods-based approach in the analytical program. The satisfaction of performance standards is monitored and documented in QA plans and in an annual program-wide intercalibration exercise among participating researchers and laboratories. All participating contract laboratories analyze sets of "unknowns" of sediment and tissue samples prepared by expert laboratories (U.S. National Institute of Science and Technology and National Research Center of Canada) (A. Cantillo, NOAA, personal communication, 1992).

6.0 WATER QUALITY STATUS AND TRENDS MONITORING

6.1 OVERVIEW

Table 6-2 summarizes sampling types, locations, frequency, and parameters for the water quality status and trends monitoring program. The program includes

- Collection and analysis of water samples from nearshore/offshore waters and confined waters near pollution sources (hot spots)
- Continuous monitoring of water-quality parameters at selected locations

Table 6-1. Comparison of detection limits of EPA-approved and routine oceanographic analytical methods for nutrients.

Parameter	Detection Limit, EPA Methods (EPA 1979a)	Detection Limit, Oceanographic Methods	Natural Range (R. Jones, FIU pers. comm., 1992)	Natural Range (Ogden 1991)	Natural Range (Lapointe and Clark 1990)	Proposed Method
Ammonium	1.6 μM	0.1 μM	0.020-10000 μM	0.15-1.0 μM	UD-5.75 μM	Indophenol
Nitrate + nitrite	1.6 μM	0.01 μM	0.01-33 μM	0.25-2.5 μM	UD-5.77 μM	Diazo (after Cd reduction)
Nitrite	0.32 μM	0.01 μM	0.01-1.5 μM	NAV	NAV	Diazo
Phosphate	2 μM	0.02 μM	0.01-1 μM	0.08-0.2 μM	0.05-0.6 μM	Ascorbic acid
Total nitrogen	14 μM	1.4 μM	2-75 μM Total N	12.5-35 μM	2-18.2 μM	High temperature combustion
Total phosphorus	1.4 μM	0.03 μM	0.1-3 μM Total P	0.5-2.5 μM	0.1-2.85 μM	Ignition w/ $MgSO_4$
Chlorophyll *a*	NA	NA	0.1-3 $\mu g/L$	0.15-1.0 $\mu g/L$	0.1-4.53 $\mu g/L$	Fluoromet

UD: Undetected.
Total N: Total nitrogen.
Total P: Total phosphorus.
NA: Not applicable.
NAV: Not available.

Table 6-2. Water quality status and trends monitoring.

Sample Type	Sampling Locations	Sampling Frequency	Parameters	Notes
WATER (discrete sampling times)	Minimum 4 transects/segment; distances of 10 m, 50 m, 100 m, 250 m, 500 m, 1 km, 5 km, 10 km (plus 15 km, 20 km, 30 km in certain cases) from shore or U.S. 1; samples at mid-depth for stations <3 m deep; samples at 0.5 m below the surface and 1 m above bottom for stations 3-5m deep; 0.5 m below the surface, mid-depth, and 1 m above bottom for stations >5 m deep; plus sampling near known/suspected pollution sources (hot spots)	Every 6 weeks for nearshore/offshore waters; quarterly on a rotating schedule for hot spots	Profiles: Temperature, salinity, DO, pH, and PAR. Discrete water samples: Nutrients, chlorophyll *a*, alkaline phosphatase, and turbidity.	
WATER (continuous observations)	Most central transect in each segment; distances of 50 m, 1 km, 10 km	Continuous (by using *in situ* instrumentation)	Temperature, salinity, DO, and PAR	Continuous observations will be considered for seagrass monitoring stations
SEDIMENT	Same as for water samples	Single survey only (unless data warrant more sampling)	Grain size, mineralogy, organic matter content, heavy metals, tributyltin, pesticides, PCBs, petroleum hydrocarbons, and coprostanol	Coprostanol and tributyltin analyzed at selected stations only
ORGANISMS (tissue samples)	Selected hard-bottom and seagrass monitoring stations	Single survey only (unless data warrant more sampling)	Body burdens of heavy metals, tributyltin, pesticides, and PCBs	Organisms include corals, seagrasses, macroalgae, sponges, bivalves, crustaceans, and fish

- Collection and analysis of sediments to obtain integrated measures of toxics
- Collection and analysis of representative organisms to estimate body burdens of toxics

Different sampling schemes will be used for status and trends monitoring in (1) nearshore/offshore waters and (2) confined waters near pollution sources (hot spots). For nearshore/offshore waters, the Sanctuary will be stratified based on the segmentation scheme presented in **Figure 6-1**. Within each segment (except for Segment 4), stations will be located on transects that extend from nearshore to at least the offshore boundary of the Sanctuary. Transect positions will be randomized to insure that representative water quality samples are obtained. In segments where passes occur (e.g., Segment 7), transect placement will also be stratified relative to the passes and land masses.

Nearshore and offshore waters will be sampled during the 5-year baseline monitoring period to gather representative data to determine the status and trends in water quality, and to examine gradients associated with distance from the land mass. Water-quality measurements will be made and water samples will be collected at monitoring stations at six-week intervals. In addition, water-quality measurements will be collected at selected stations using continuously recording *in situ* instrumentation. This instrumentation will be maintained through the 5-year baseline period to gain information concerning phenomena that have periods shorter than six weeks and infrequent or unpredictable phenomena, such as storms and hurricanes.

Confined waters near pollution sources (hot spots) will be sampled quarterly on a rotating schedule. After 4 years, each hot spot will have been sampled four times, each during a different quarter of the year (see Section 6.2.2). This effort is less intensive than the nearshore and offshore sampling, based on the consensus of the expert panel assembled for the July 1992 Monitoring/Research Workshop. It was the panel's opinion that degradation near known pollution sources was well known and that extensive sampling was not necessary.

A suite of water-column parameters will be measured at each station. These water column parameters include physico-chemical parameters (temperature, salinity, dissolved oxygen (DO), pH, turbidity, and photosynthetically active radiation [PAR]), nutrients (dissolved ammonia, nitrate, nitrite, and phosphate; total nitrogen (TN) and total dissolved nitrogen (TDN); total phosphorus (TP) and total dissolved phosphorus (TDP); and organic/inorganic carbon), and biological parameters (chlorophyll *a* and alkaline phosphatase activity [APA]).

Some toxic compounds tend to be present in water samples in extremely low or undetectable quantities. However, these compounds are detectable in sediment and tissue samples because they are associated with particulate material or are bioconcentrated. Sediment and tissue concentrations can serve as time-integrated measures of the exposure of the water to these compounds. To address the status of these compounds, during the initial baseline survey sediment samples will be collected and analyzed for heavy metals, tributyltin, pesticides, PCBs, petroleum hydrocarbons, and a sewage tracer (coprostanol). In addition, tissue samples will be collected and analyzed for heavy metals, tributyltin, pesticides, and PCBs. If the results from these analyses indicate that more sampling is needed, then the sampling program will be modified accordingly.

6.2 SAMPLING LOCATIONS

6.2.1 Nearshore/Offshore Waters

Water quality sampling stations for determining the status and trends in nearshore and offshore waters will be located on onshore-offshore transects (with the exception of Segment 4 as discussed below). The location of transects in the segments are presented in **Figure 6-2**. To provide comprehensive coverage of the Sanctuary, a minimum of four transects will be located within each segment. Transects will vary in length depending on the distance to the Sanctuary boundary, but each will be at least 10 km long. The exception to this length are three transects in Segment 8, where portions of the transects occur over the Florida mainland (**Figure 6-2**). To ensure a broader coverage of the transects within segments, each segment will be divided into approximately equal subsegments, with one transect randomly located within each subsegment. This method of randomization ensures

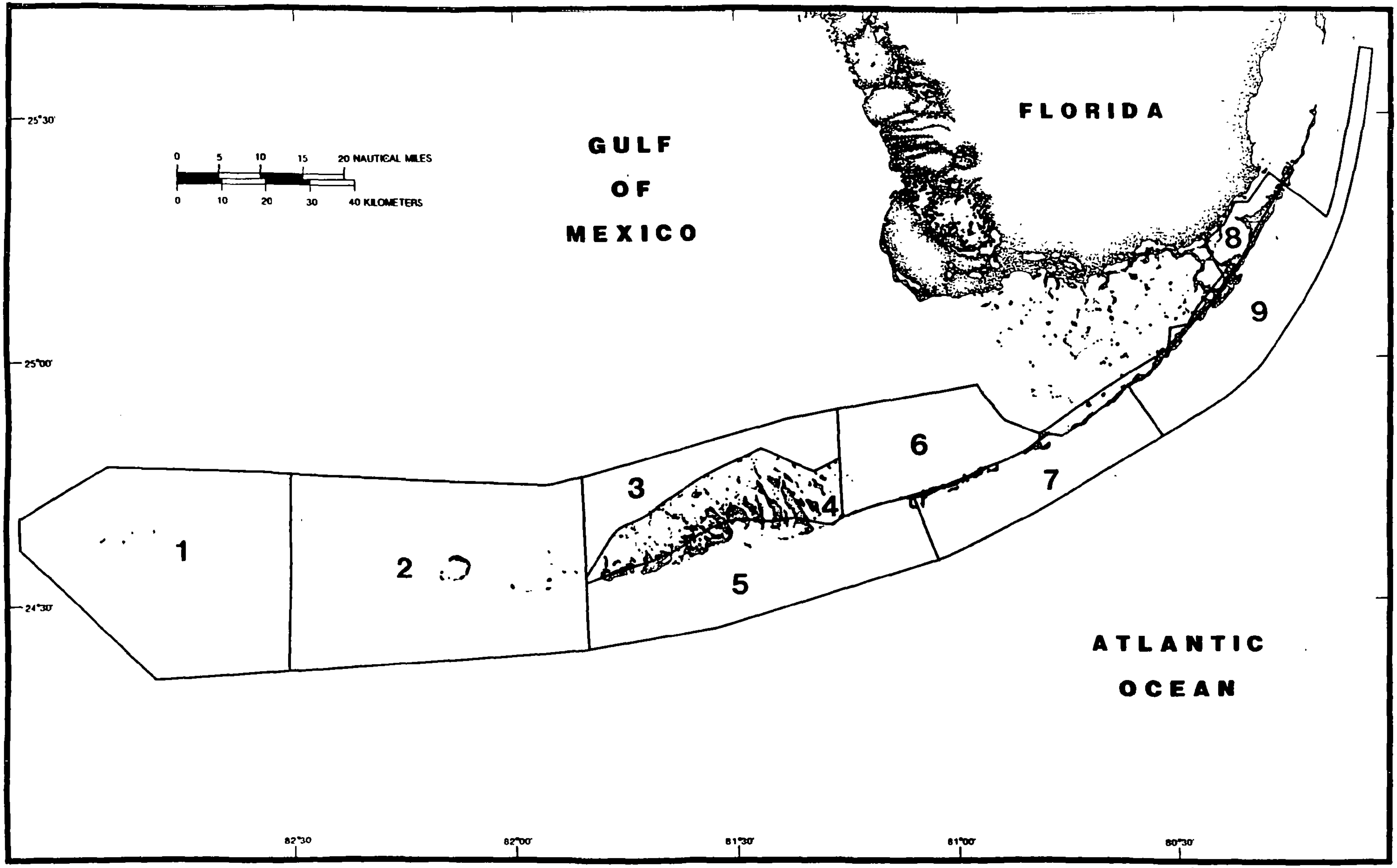

Figure 6-1. Geographic stratification scheme (Segments).

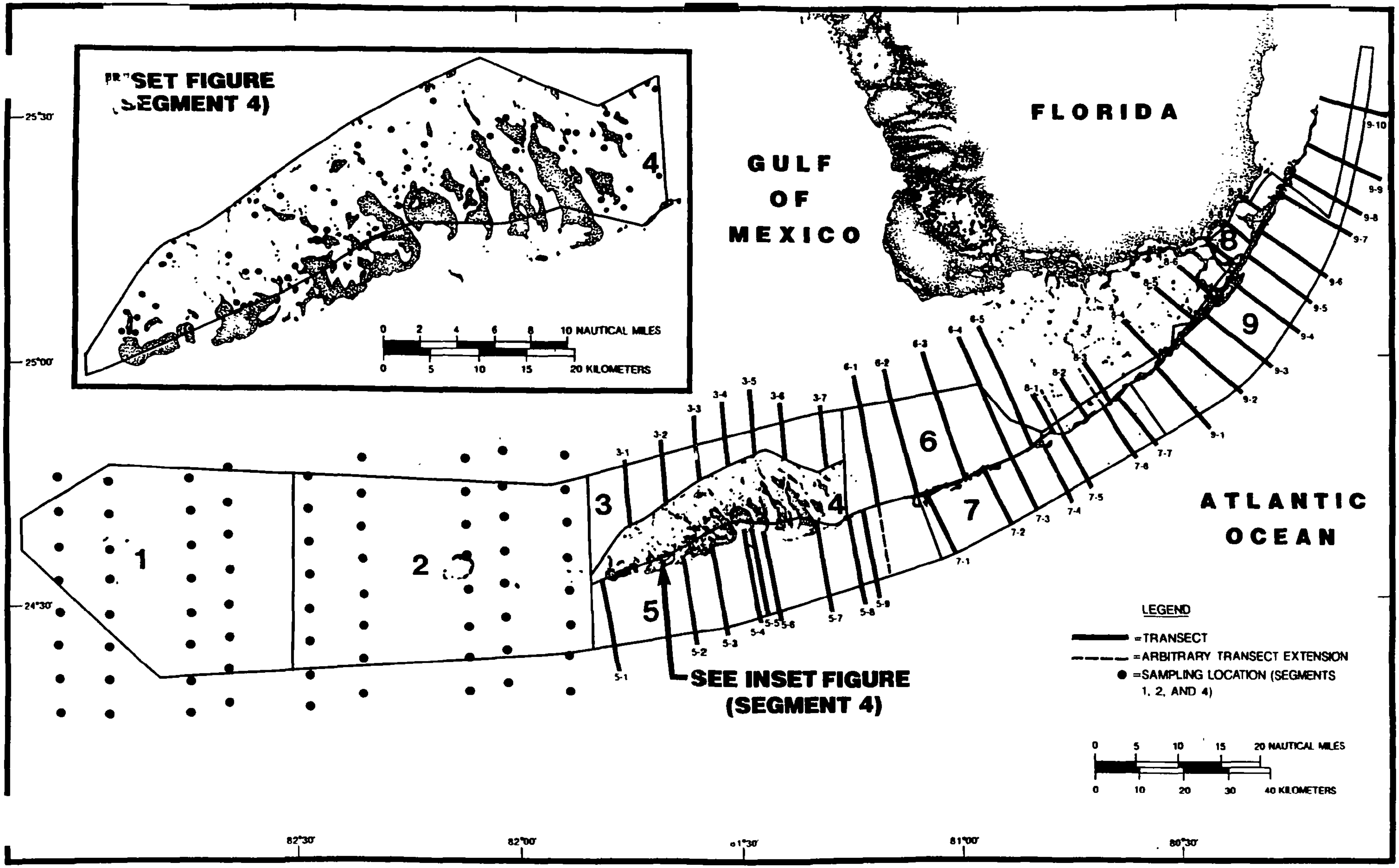

Figure 6-2. Locations of water quality sampling sites in Segments 1, 2, and 4 and water quality transects in Segments 3, 5, 6, 7, 8, and 9. Sampling site locations on water quality transects are presented in Table 6-3.

that transects will be more uniformly spread over each segment than if a purely random method had been used. The design is robust relative to periodic phenomena that could potentially occur along the segment. Where appropriate, transect locations will be stratified based on land mass and passes. The number of transects allocated between land mass and pass areas will be based on the percent contribution to these two strata in a particular segment.

A minimum of eight stations will be located on each transect. Stations will be located on the transects in a manner to insure that representative results are obtained and that the gradient of water quality from the land mass to offshore areas can be observed. Stations will be equally spaced along each transect for the two oceanic segments (Segments 1 and 2 in **Figure 6-1**). For the segments associated with the Florida Keys land mass (except Segment 4 in **Figure 6-1**), one station will be located at 10 m from the mean low water line. Seven stations will be located nominally at the following distances from shore (or U.S. 1, in the case of passes): 50 m, 100 m, 250 m, 500 m, 1 km, 5 km, and 10 km. To overcome bias inherent in arbitrarily selecting stations, locations were randomized following Cochran (1963) for systematic sampling. Distances between these seven stations will be fixed on individual transects. The 50-m station will be randomly located between 25 and 100 m from shore, based on a random draw from a uniform distribution. This randomization makes the design robust relative to potential phenomena that are periodic relative to the shore. Additional stations were added to the offshore end of transects (15 km, 20 km, and 30 km), if necessary, to reach the boundary of the Sanctuary. Station locations on the transects are presented in **Table 6-3**. For Segment 4, stations are randomly located within the marine areas (**Figure 6-2**).

If the depth at a station is less than 3 m, water samples will be collected at mid-depth between the sea surface and seafloor. At stations 3-5 m in depth, samples will be collected from 0.5 m below the surface and 1 m above the bottom. At stations deeper than 5 m, an additional sample will be collected at mid-depth. Profiles of temperature, salinity, DO, pH, and PAR will be performed at each station. Stations will be revisited at six-week intervals for water quality sampling. Additional sampling efforts can be mobilized to respond to episodic phenomena such as storms and hurricanes.

Continuously recording instrumentation will be deployed at the 50 m, 1 km, and 10 km stations along the most central transect in each segment. Information from these continuously recording instruments will serve to fill in gaps between sampling visits. These data will be used to examine phenomena with periods shorter than six weeks and episodic phenomena, such as storms.

6.2.2 Pollution Sources (Hot Spots)

Water quality will be monitored in confined waters that are suspected or known to be severely degraded (hot spots) to determine the status and trends of pollution sources. These hot spots include outfalls from sewage treatment plants, canals, landfills, marinas, and live-aboard areas. Each of these 103 hot spots have been assigned randomly to one of four groups (**Table 6-4**). Sampling of each group will occur at quarterly intervals over the first 4 years of the baseline study. The sampling period (quarter) for each group will be rotated so that each group will be sampled during each of the four quarters. This sampling strategy is as follows:

Quarter of Sampling for the Four Groups of Hot Spots				
Hot Spot Group	Year of Baseline Period			
	Year 1	Year 2	Year 3	Year 4
1	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.
2	2nd Qtr.	3rd Qtr.	4th Qtr.	1st Qtr.
3	3rd Qtr.	4th Qtr.	1st Qtr.	2nd Qtr.
4	4th Qtr.	1st Qtr.	2nd Qtr.	3rd Qtr.

Table 6-3. Locations of stations on transects in Segments 3, 5, 6, 7, 8, and 9 (Transect locations are presented in Figure 6-2).

Transect	Station Location on Transect from the following nominal distances (m from starting point)										
	10	50	100	250	500	1,000	5,000	10,000	15,000	20,000	30,000
3-1	10	28	78	228	478	978	4,978	9,978	14,978	—	—
3-2	10	55	105	255	505	1,005	5,005	10,005	15,005	—	—
3-3	10	52	102	252	502	1,002	5,002	10,002	15,002	—	—
3-4	10	53	103	253	503	1,003	5,003	10,003	15,003	—	—
3-5	10	29	79	229	479	979	4,979	9,979	14,979	—	—
3-6	10	45	95	245	495	995	4,995	9,995	14,995	—	—
3-7	10	51	101	251	501	1,001	5,001	10,001	15,001	—	—
5-1	10	65	115	265	515	1,015	5,015	10,015	15,015	20,015	—
5-2	10	60	110	260	510	1,010	5,010	10,010	15,010	20,010	—
5-3	10	31	81	231	481	981	4,981	9,981	14,981	19,981	—
5-4	10	55	105	255	505	1,005	5,005	10,005	15,005	20,005	—
5-5	10	65	115	265	515	1,015	5,015	10,015	15,015	20,015	—
5-6	10	58	108	258	508	1,008	5,008	10,008	15,008	20,008	—
5-7	10	40	90	240	490	990	4,990	9,990	14,990	19,990	—
5-8	10	74	124	274	524	1,024	5,024	10,024	15,024	20,024	—
5-9	10	34	84	234	484	984	4,984	9,984	14,984	19,984	—
6-1	10	58	108	258	508	1,008	5,008	10,008	15,008	20,008	30,008
6-2	10	51	101	251	501	1,001	5,001	10,001	15,001	20,001	30,001
6-3	10	54	104	254	504	1,004	5,004	10,004	15,004	20,004	30,004
6-4	10	25	75	225	475	975	4,975	9,975	14,975	19,975	29,975
6-5	10	72	122	272	522	1,022	5,022	10,022	15,022	20,022	30,022
7-1	10	41	91	241	491	991	4,991	9,991	14,991	—	—
7-2	10	74	124	274	524	1,024	5,024	10,024	15,024	—	—
7-3	10	41	91	241	491	991	4,991	9,991	14,991	—	—
7-4	10	26	76	226	476	976	4,976	9,976	14,976	—	—
7-5	10	34	84	234	484	984	4,984	9,984	14,984	—	—
7-6	10	29	79	229	479	979	4,979	9,979	14,979	—	—
7-7	10	28	78	228	478	978	4,978	9,978	14,978	—	—
8-1	10	52	102	252	502	1,002	5,002	10,002	—	—	—
8-2	10	26	76	226	476	976	4,976	9,976	—	—	—
8-3	10	74	124	274	524	1,024	5,024	10,024	—	—	—
8-4	10	73	123	273	523	1,023	5,023	10,023	—	—	—
8-5	10	73	123	273	523	1,023	5,023	10,023	—	—	—
8-6	10	72	122	272	522	1,022	5,022	10,022	—	—	—
8-7	10	29	79	229	479	979	4,979	9,979	—	—	—
8-8	10	29	79	229	479	979	4,979	9,979	—	—	—
8-9	10	52	102	252	502	1,002	5,002	10,002	—	—	—
9-1	10	68	118	268	518	1,018	5,018	10,018	15,018	20,018	—
9-2	10	28	78	228	478	978	4,978	9,978	14,978	19,978	—
9-3	10	54	104	254	504	1,004	5,004	10,004	15,004	20,004	—
9-4	10	52	102	252	502	1,002	5,002	10,002	15,002	20,002	—
9-5	10	53	103	253	503	1,003	5,003	10,003	15,003	20,003	—
9-6	10	51	101	251	501	1,001	5,001	10,001	15,001	20,001	—
9-7	10	44	94	244	494	994	4,994	9,994	14,994	19,994	—
9-8	10	49	99	249	499	999	4,999	9,999	14,999	19,999	—
9-9	10	26	76	226	476	976	4,976	9,976	14,976	19,976	—
9-10	10	41	91	241	491	991	4,991	9,991	14,991	19,991	—

Table 6-4. Group designations of confined water sites with known or suspected severely degraded water quality.

Location	Pollution Source	Group
Cow Key Channel	Boat live-aboards	1
Islamorada	Boat live-aboards	1
Matecumbe Harbor	Boat live-aboards	1
Pine Channel	Boat live-aboards	1
Kampgrounds of America Marina	Boat-related activities	1
Ocean Reef Marina	Boat-related activities	1
Campbell's Marina	Boat-related activities; live-aboards	1
Marathon Seafood	Boat-related activities; live-aboards	1
Winken, Blynken, and Nod	Boat-related activities; live-aboards	1
Dispatch Creek	Canal configuration; H_2S groundwater intrusion	1
Alex's Junkyard	Hazardous waste site	1
Key West Landfill	Landfill	1
Doctor's Arm	OSDS	1
Gulfrest Park	OSDS	1
Hammer Point	OSDS	1
Key Colony Subdivision	OSDS	1
Marian Park	OSDS	1
Orchid Park Subdivision	OSDS	1
Port Pine Heights	OSDS	1
Rock Harbor Estates	OSDS	1
Tamarac Park	OSDS	1
Treasure Harbor	OSDS	1
Venetian Shores	OSDS	1
Coco Plum Beach	OSDS; Boat-related activities	1

Table 6-4. Group designations of confined water sites with known or suspected severely degraded water quality. (continued)

Location	Pollution Source	Group
Safe Harbor	Seafood processing; commercial and industrial development; Stock Island Power Plant	1
Outdoor Resorts of America	Trailer park with RV camping	1
Boot Key Harbor	Boat live-aboards	2
Carsound Bridge	Boat live-aboards	2
Garrison Bight	Boat live-aboards	2
Mile Marker 84.5, Bayside	Boat live-aboards	2
Plantation Yacht Harbor	Boat-related activities	2
Sea Camp	Boat-related activities	2
Key Largo Fishery Marina	Boat-related activities; live-aboards; seafood processing	2
Faro Blanco Marina	Boat-related activities; live-aboards	2
Key Colony Beach STP Outfall	Discharge to surface waters	2
U.S. Navy Base WWTP	Discharge to surface waters	2
Key Largo Landfill	Landfill	2
Bay Point Subdivision	OSDS	2
Blue Water Trailer Park	OSDS	2
Conch Key	OSDS	2
Cross Key Waterways Subdivision	OSDS	2
Cudjoe Ocean Shore	OSDS	2
Pirate Cove Subdivision	OSDS	2
Porpoise Point	OSDS	2
Port Antigua	OSDS	2
Port Largo	OSDS	2
Sands Subdivision	OSDS	2
Sea-Air Estates	OSDS	2
Seaside Resort	OSDS	2

Table 6-4. Group designations of confined water sites with known or suspected severely degraded water quality. (continued)

Location	Pollution Source	Group
Sugar Loaf Shore Subdivision	OSDS	2
Ming Seafood	Seafood processing	2
Venture Out Trailer Park	Surface discharge from STP	2
Cross Key	Boat live-aboards	3
House Boat Row	Boat live-aboards	3
Key Colony Beach	Boat live-aboards	3
Worlds Beyond (Carysfort Marina)	Boat-related activities and OSDS	3
Sunshine Key Marina	Boat-related activities	3
Bonefish Towers Marina	Boat-related activities; live-aboards	3
Caloosa Cove Marina	Boat-related activities; live-aboards	3
Winner Docks	Boat-related activities; live-aboards	3
C-111 Canal	Canal discharge	3
Navy/Coast Guard Marina and Trumbo Point Fuel Storage Facility	Fueling related operations	3
Truman Annex Marina	Fueling related operations	3
Long Key Landfill	Landfill	3
90th Street Canal	OSDS	3
Breezeswept Beach Estates	OSDS	3
Cudjoe Gardens Subdivision	OSDS	3
Eden Pines Colony	OSDS	3
Indian Waterways	OSDS	3
Knight Key Campground	OSDS	3
Long Key Estates and City of Layton	OSDS	3
Riviera Canal	OSDS	3
Sexton Cove Subdivision	OSDS	3

Table 6-4. Group designations of confined wate[illegible]s with known or suspected severely degraded water quality [illegible]ontinued)

Location	Pollution Source	Group
Tropical Atlantic Shores Subdivision	OSDS	3
Tropical Bay	OSDS	3
Whispering Pines Subdivision	OSDS	3
White Marlin Beach	OSDS	3
City Fish Market	Seafood Processing	3
Boca Chica Channel	Boat live-aboards	4
Christmas Tree Island	Boat live-aboards	4
Community Harbor	Boat live-aboards	4
Largo Sound	Boat live-aboards	4
Holiday Isle Resort	Boat-related activities	4
Sugar Loaf Lodge Marina	Boat-related activities	4
Oceanside Marina	Boat-related activities; live-aboards	4
Faro Blanco Oceanside Marina	Boat-related activities; live-aboards	4
Phase I	Canal configuration; H_2S groundwater intrusion	4
Key West Sewage Treatment Plant Outfall	Discharge to surface waters	4
Cudjoe Key Landfill	Landfill	4
Submarine Pens	Naval base related activities	4
Bahia Shores	OSDS	4
Boca Chica Ocean Shores	OSDS	4
Cahill Pines and Palms	OSDS	4
Coral Shores Estates	OSDS	4
Cutthroat Harbor Estates	OSDS	4
Jolly Roger Estates	OSDS	4
Key Haven Subdivision	OSDS	4
Lake Surprise Subdivision	OSDS	4
Lower Matecumbe Beach	OSDS	4

Table 6-4. Group designations of confined water s tes with known or suspected severely degraded water quality. (continued)

Location	Pollution Source	Group
Pine Channel Estates	OSDS	4
Plantation Key Colony	OSDS	4
Summerland Key Cove	OSDS	4
Summerland Key Fisheries	Seafood processing	4

OSDS: On-site sewage disposal system.
RV: Recreational vehicle.
STP: Sewage treatment plant.

Water quality samples will be collected as near to sewage treatment plant outfalls as practical. In marinas, a station will be established in the center of the marina. Similarly, a station will be established in the center of live-aboard areas not associated with marinas. In canal systems surrounded by subdivisions, mid-length and dead-end locations in a representative canal in each canal system will be sampled. Sites near landfills will be located in marine waters as near to the landfill as possible.

6.3 PARAMETERS AND METHODS

6.3.1 Water Quality — Periodic Monitoring

To characterize the spatial patterns and temporal trends in water quality conditions within the Sanctuary, the following parameters will be measured.

Physico-chemical parameters
- Temperature
- Salinity
- DO
- pH
- PAR
- Turbidity
- Depth

Nutrients
- Dissolved ammonia
- Dissolved nitrate, nitrite, and phosphate
- TN and TDN
- TP and TDP
- Organic/inorganic carbon

Biological parameters
- Chlorophyll *a*
- APA

This suite of physico-chemical parameters was selected to characterize the environmental regime. Additionally, the parameters can potentially affect the growth and survival of biological resources. The nutrient parameters are measured because their levels can be affected by anthropogenic sources of nutrients. The nutrient parameters are related to the biological parameters (e.g., chlorophyll *a*). The biological parameters (chlorophyll *a* and APA) are measured as indicators of nutrient status in the system.

Except for nutrient forms in the particulate fraction (which is usually estimated by difference), the suite of nutrient parameters to be measured in this program is comprehensive. These measurements are intended to provide the nutrient status of nearshore and offshore waters and to track the surface transport of nearshore waters to offshore areas.

Nitrite is generally found in low concentrations in the open ocean environment and may not be of immediate value. However, this measurement is readily available because it is routinely performed whenever analyses of dissolved inorganic nutrients are made using automated continuous flow methods. The nitrite concentration may be important in areas where leachate from landfills or sewage discharge is suspected. Similarly, chlorophyll measurements in open ocean environments are generally low. They are being measured in this program primarily as a "tracer" of more eutrophic nearshore waters that may be transported to offshore reef areas. Chlorophyll *a*, along with turbidity and temperature measurements, also are important to provide calibration for remote sensing data.

Only a general description of the parameters and methods is presented here. Detailed protocols for those analytical methods that are not EPA-approved are included in **Appendix B**. In particular, detailed analytical protocols are presented for nutrient determinations because routine oceanographic, rather than EPA-approved, analytical methods are recommended.

A multi-sensor, water-quality monitoring instrument, the Hydrolab H20, will be used to measure basic physico-chemical parameters in the field. This particular instrument is recommended for the following reasons.

- Hydrolab also manufactures the Datasonde III (an H20 with datalogging capabilities and an internal battery pack) — a cost-effective environmental monitoring instrument package.
- The current Coastal Marine Automated Network (CMAN) system uses Hydrolab units.
- The current ENP, BNP, and Dade County Department of Environmental Management (DERM) monitoring programs use Hydrolab instruments.
- EPA's EMAP has adopted the Hydrolab as its primary water-quality monitoring instrument.

Although other instruments may provide better performance, the workshop panel agreed that the Hydrolab equipment would be adequate for the monitoring program. Field measurements to be made with the Hydrolab H20 include temperature, salinity, DO, pH, and depth.

A light extinction coefficient will be determined by measuring the attenuation of PAR at depth using underwater quantum sensors (see **Appendix A**). The physico-chemical parameters will be measured at the surface and at depth as described in **Appendix A**. At depths greater than 3 m, continuous profiles will be made. Water samples will be collected using a Niskin sampler and analyzed for turbidity, nutrient content, and biological parameters. Nutrient parameters to be analyzed primarily by autoanalyzer include dissolved ammonium, dissolved nitrate, dissolved nitrite, TDN, TN, soluble reactive phosphorus, TDP, TP, and organic/inorganic carbon.

Dissolved nutrients will be defined using Whatman GF/F filters with a nominal pore size of 0.8 μm. Ammonium will be analyzed by the indophenol method (Koroleff 1983). Nitrite will be analyzed using the diazo method and nitrate will be measured as nitrite after cadmium reduction (Grassoff 1983a,b). The ascorbic acid/molybdate method will be used to determine dissolved phosphorus (Murphy and Riley 1962). High-temperature combustion or persulfate digestion will be used to measure total and TDN and phosphorus (Solórzano and Sharp 1980a,b; Walsh 1989). Organic/inorganic carbon will be determined using the high-temperature combustion method of Sugimura and Suzuki (1988). Detailed protocols are presented in **Appendix B**.

Samples will be analyzed for chlorophyll *a* content by fluorometry of acetone extracts (Yentsch and Menzel 1963). The degree of phosphate limitation in the water column will be estimated using an assay of APA (R. Jones, Florida International University, personal communication, 1992). Protocols are presented in **Appendix B** for chlorophyll *a* and APA.

6.3.2 Water Quality — Continuous Monitoring

The periodic monitoring conducted every six weeks will provide information on a certain level of variability in water quality parameters. An important and crucial source of variability in water quality conditions are periodic and episodic phenomena that have time scales of hours to days or weeks. These phenomena are related to diurnal cycles, tides, storm events, wind events, and regional and local current patterns that greatly affect water quality and biological resources. A continuous, water-quality monitoring network will be set up to account for the variability associated with periodic phenomena and to ensure that the variability caused by episodic and stochastic events can be captured. This network will supplement data from the CMAN system developed by the SEAKEYS program (Ogden 1991).

The CMAN system currently includes four monitoring stations located at Fowey Rocks, Molasses Reef, Sombrero Reef, and Sand Key (**Figure D-3, Appendix D**). The CMAN stations are associated with the National Data Buoy

Center towers and provide near real-time meteorological and water quality information. Two additional CMAN sites are scheduled to be installed in 1992 (one in Florida Bay near Long Key and one at Iowa Rock, Dry Tortugas). In addition, Hydrolab units are deployed in several areas around the Keys (**Figure D-3, Appendix D**) to measure temperature, salinity, depth, and DO.

Continuous instrumentation will be deployed at the 50 m, 1 km, and 10 km stations along the most central transect in each segment of the FKNMS. The instrumentation will consist of the following:

- A water-quality sensor package (Hydrolab Datasonde III/H20) with probes for temperature, conductivity/salinity, depth, and DO
- Two PAR sensors (Licor quantum sensors), one mounted at 1 m above the bottom and another 0.5 m higher
- A datalogger (Campbell Scientific CR10 or Licor) and power supply

In addition, similar continuous monitoring equipment will be considered for deployment at selected seagrass monitoring sites. Continuous water quality data is expected to be available from coral reef locations through the existing CMAN system.

6.3.3 Water Quality — Remote Sensing

Advanced very high resolution radiometer (AVHRR) and Sea-Viewing Wide Field of View Sensor (SEAWIFS) imagery will be used to provide synoptic and temporal coverage of temperature, turbidity, and chlorophyll *a* distributions in the Sanctuary that are unattainable by field sampling. Regional satellite coverage capable of providing synoptic water color to assess regional trends in turbidity and chlorophyll will be collected on a near realtime basis. AVHRR sensors can provide daily images in the visible spectrum; temperature ranges and turbidity distributions also can be generated. After SEAWIFS is launched in the summer of 1993, data from the satellite can be used to generate turbidity and chlorophyll *a* distributions. In addition to the collection of this satellite imagery, a calibration station for the satellite sensors will be established at the Florida Keys Marine Laboratory (Long Key) in conjunction with the C-MAN station (K. Haddad, FDNR Marine Research Institute, personal communication, 1992). Data collected during the periodic water-quality monitoring also will be used for image calibration.

6.3.4 Sediment Quality

Because of the discharge of wastewater and stormwater, presence of boat yards, and marinas (petroleum spills and boat bottom painting) and landfills near marine waters, and the use of pesticides (mosquito spraying) and herbicides (road right-of-ways), certain parameters were selected for analysis in sediments. Sediment samples will be collected only once during the initial baseline period (**Table 6-2**) to provide an overall evaluation of the status of the sediment quality in the Sanctuary. This evaluation includes basic sediment parameters and toxic constituents. The basic sediment parameters are measured to provide a means of normalizing the concentrations of toxic constituents so they can be interpreted properly.

These parameters are

Basic sediment parameters

- Organic matter
- Grain size
- Mineralogy

Heavy metals

- Copper
- Lead
- Zinc
- Cadmium

- Aluminum
- Mercury
- Chromium
- Arsenic

Tributyltin

Pesticides
- Insecticides from mosquito spraying
    - Fenthion (Baytex)
    - Cythion (Malathion)
    - Permethrin (Biomist)
    - Methoprene (Altosid)
    - Naled (Dibrom)
- Right-of-way control and agricultural herbicides
    - Triclopyr
    - Hexazinone
    - Sulfometuron-methyl
    - Glyphosate
    - 2,4-D
    - Paraquat
    - Atrazine
- Persistent pesticides
    - DDT and breakdown products

PCBs
Petroleum hydrocarbons
Sewage tracers
- Coprostanol

A brief description of methods is provided below while more detailed methods for the determination of heavy metals, tributyltin, pesticides, PCBs, petroleum hydrocarbons, and coprostanol are presented in **Appendix B**. The methods are primarily based on the NOAA National Status and Trends Program.

If possible, sediments will be collected by scuba divers using hand cores. In water depths precluding diver collection, a Smith-McIntyre grab sampler will be used. Sediments collected by grab sampler will be subsampled by using hand cores in the field. The top 2 cm of each sediment core sample will be retained for analysis. Acetyl butyrate cores will be used for the basic sediment parameters, tributyltin, and heavy metal samples. Teflon cores will be used for pesticide, petroleum hydrocarbon, PCBs, and coprostanol samples. Basic sediment parameters such as organic matter content, grain size distribution, and mineralogy will be determined in the subsamples. Organic content will be measured gravimetrically, grain size distribution by the hydrometer method, and mineralogy by X-ray diffraction. Heavy metals will be analyzed by flame atomic absorption spectrophotometry (FAAS) of acid digests. Petroleum hydrocarbons will be determined by gas chromatography (GC) with a flame ionization detector (FID) of methylene chloride extracts. Tributyltin concentrations in sediments will be determined by GC with flame photometric detection of methylene chloride/toluene with 0.05% tropolone extracts. Pesticides will be analyzed primarily by GC with electron capture detectors (ECD) of methylene chloride/hexane extracts. Coprostanol concentrations in sediments will be determined by GC/FID of methylene chloride/hexane extracts.

6.3.5 Biological Body Burdens

To estimate the presence and concentrations of xenobiotic substances in living organisms, samples from representative producers and consumers (including corals, seagrasses, macroalgae, sponges, zooanthids, bivalves, crustaceans, and fish) will be collected by scuba divers or traps. The samples will be obtained at biological resource monitoring stations. Tissue sample collections will be made at each biological resource site and should include three to five species. These species should be representative of different phylogenetic categories and consistent for each biological resource type (s grass, nearshore hard bottom and coral reef). Actual species for tissue collection will be selected at a workshop convened by EPA among participating researchers and laboratories. Each sample will be analyzed for heavy metals, tributyltin, pesticides, and PCBs. Samples will be processed for analysis as described in **Appendix B**.

6.4 DATA ANALYSIS AND INTERPRETATION

Hypotheses for nearshore and offshore water quality address temporal and spatial trends. Data collected during the water quality status and trends monitoring will be evaluated to determine if there are changes in the water quality parameters. This will necessitate separating natural variability (e.g., seasonal) from long-term trends. Spatial variability, such as distance from shore, will also be assessed. Long-term trends in water quality will be related to long-term trends in the biological resources. Relationships among water quality parameters measured during the *in situ* sampling should be examined. If meaningful correlations among parameters are observed, then the possibility of extrapolating to the continuously recorded data should be examined.

The power associated with detecting various levels of change in water quality parameters was estimated. The procedures of Dixon and Massey (1969) for paired data were used because stations will be reoccupied on successive surveys. Data for this analysis were provided by Dr. Alina Szmant from the Key Largo study site for Phase I of the SEAKEYS project (Szmant 1991). At the Key Largo study site, Szmant sampled canal stations, inshore stations, Hawk Channel stations, White Banks stations, and offshore stations. Canal stations were not considered in the power analysis. An among-station variance estimate was computed for each of the remaining four groups of stations, and a pooled variance estimate was computed by using the four station group variance estimates. This pooled variance estimate was used in the power analysis. The results of the power analysis are presented in **Figure 6-3**. Data collected during the baseline period should be evaluated to determine the power of the appropriate analytical procedures and analyses used to detect trends.

7.0 BIOLOGICAL RESOURCE STATUS AND TRENDS MONITORING

The status and trends of biological parameters in hard-bottom, seagrass, and mangrove communities will be monitored. Monitoring will include both *in situ* sampling (hard-bottom and seagrass communities) and remote sensing (hard-bottom, seagrass, and mangrove communities). **Table 6-5** provides an overview of sampling types, locations, frequency, and parameters for each community type.

7.1 HARD-BOTTOM COMMUNITIES

7.1.1 Overview

During the 5-year baseline monitoring period, both offshore coral reefs and nearshore hard-bottom areas will be sampled annually. Parameters to be measured include coral cover, diversity, growth, and recruitment; incidence of bleaching and disease; octocoral abundance; sponge and macroalgal cover; and the abundance of *Diadema*, reef fishes (sampled quarterly), and coralivores (e.g., bristleworms).

Monitoring locations for coral reefs will include existing study sites, additional sites suggested by panelists at the Monitoring/Research Workshop, and randomly selected sites within the mapped strata from the FDNR/NOAA remote sensing/mapping project. Monitoring locations for nearshore, hard-bottom areas will consist of randomly selected sites within mapped strata and within each segment where hard-bottom communities exist.

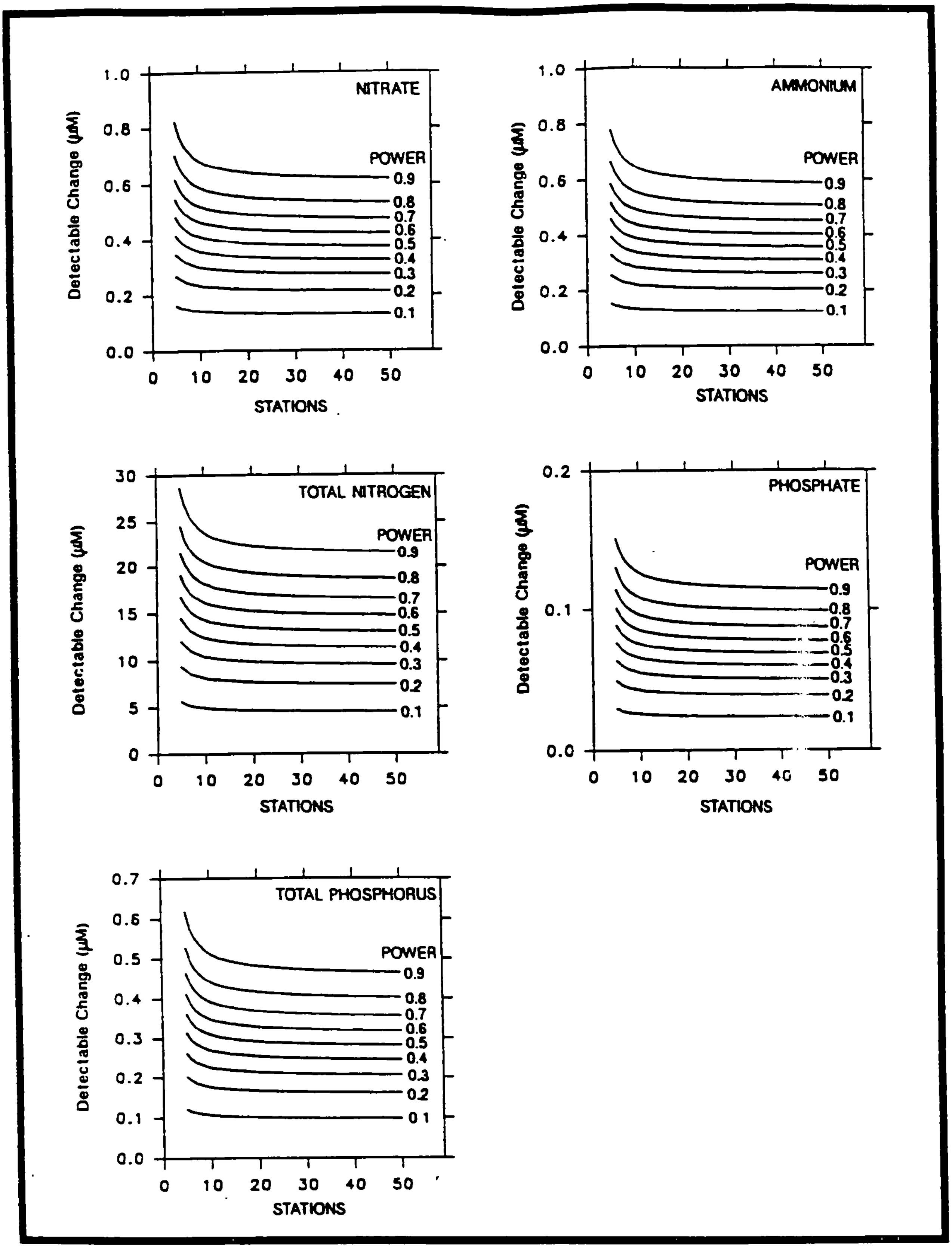

Figure 6-3. Results of the power analysis for nitrate, ammonium, total nitrogen, phosphate, and total phosphorus.

Table 6-5. *Biological resource status and trends monitoring.*

Type of Sampling	Sampling Locations	Sampling Frequency	Parameters	Notes
HARD-BOTTOM COMMUNITIES				
Remote sensing	Sanctuary-wide	Every 5-7 years	Geographic extent of hard-bottom communities (mapping categories)	This is a repetition of the ongoing FDNR/NOAA remote sensing/mapping project
In situ - offshore coral reefs	Segments 1, 2, 5, 7, 9 (see Figure 6-1); includes existing study sites, sites suggested by workshop panelists, and randomly selected sites in segments 5, 7, 9	Annual	Coral species composition, coral cover, growth, bleaching, disease incidence; octocoral abundance; sponge cover; macroalgal cover; *Diadema* abundance; fish abundance; corallivore abundance	FDNR/NOAA remote sensing maps will be used to generate the random site locations
In situ - nearshore hard bottom	Randomly selected sites in each segment containing nearshore hard bottom; stratified using FDNR/NOAA mapping categories	Annual	Same parameters as for coral reefs (if applicable)	FDNR/NOAA remote sensing maps will be used to generate the random site locations
SEAGRASS COMMUNITIES				
Remote sensing	Sanctuary-wide	Every 5-7 years	Geographic extent of seagrass communities (mapping categories)	This is a repetition of the ongoing FDNR/NOAA remote sensing/mapping project
Remote sensing	1 km photo-corridors in each segment	Every 2 years	Geographic extent of seagrass communities (mapping categories)	
Qualitative swim-over surveys	Permanent study sites in each segment; selected randomly from FDNR/NOAA remote sensing maps	Bimonthly	Extent of bottom covered by seagrasses and macroalgae; species composition; die-off conditions; recolonization by *Halodule*; degree of epiphytism	FDNR/NOAA remote sensing maps will be used to generate the random site locations
Photo/count stations	Permanent study sites in each segment, as above	Bimonthly	Number of short shoots; number of blades per short shoot; number of new shoots, fruits, and flowers; canopy height; numbers of individuals of calcareous algae; presence of fleshy algae	
Productivity plots	Permanent study sites in each segment, as above	Quarterly	Above-ground standing crop and productivity; leaf-area index; below-ground standing crop	
Faunal plots	Permanent study sites in each segment, as above	Quarterly	Abundance, biomass, diversity, etc. of seagrass-associated epifauna	
MANGROVE COMMUNITIES	Remote sensing	Every 5-7 years	Geographic extent of mangrove communities	This is a repetition of the ongoing Advanced Inventory of Wetlands remote sensing/mapping project

7.1.2 Sampling Locations

7.1.2.1 NEARSHORE HARD-BOTTOM COMMUNITIES

Because nearshore hard-bottom communities have not been well studied and there is little previous information, a stratified random design will be used to locate permanent sampling sites. Remote sensing maps being prepared by the FDNR/NOAA will be used to define the strata, and three permanent sampling sites will be selected at random within each stratum and within each segment of the Sanctuary. Based on the potential benthic communities to be mapped by FDNR/NOAA (F. Sargent, FDNR, personal communication, 1992), monitoring should include areas of sparse, moderately dense, and patchy distributions of nearshore hard bottom. The FDNR/NOAA mapping effort is expected to be completed in December 1993 (K. Haddad, FDNR Marine Research Institute, personal communication, 1992). If the maps are not complete by the time the biological monitoring is ready to begin, it will be necessary to discuss alternative methods for site location. By using the remote sensing maps as a framework for stratified random sampling, it should be possible to generalize findings from the sampling sites to the broad areas of the Sanctuary.

7.1.2.2 CORAL REEFS

Coral reef monitoring locations will include existing study sites, sites suggested by panelists at the Monitoring/Research Workshop, and randomly selected sites in segments 5, 7, and 9 (see **Figure 6-1**). The continuation of existing sites will ensure that previous monitoring data are incorporated into the long-term database; randomly selected sites will help to ensure that results can be generalized to the rest of the reef tract in each segment.

Several existing sites for coral reef monitoring have been identified as being potentially appropriate. These include sites at the Dry Tortugas (Bird Key Reef, Pulaski Shoal, Loggerhead Key, White Shoal, and Texas Rock), Western Sambo, Looe Key, John Pennekamp Coral Reef State Park (Mosquito Banks and Basin Hill Shoals), Carysfort Reef, Pacific Reef, and Triumph Reef. Final sites will be selected at a workshop convened by EPA among potential participating researchers and laboratories. Sampling at these selected study sites will continue, but sampling methods may need to be altered so that all sites are monitored to yield comparable data.

During the Monitoring/Research Workshops in July 1992, panelists discussed several other general areas of interest for coral reef monitoring. Some of the areas discussed are already represented by existing monitoring sites and are not considered further. Three additional study sites will be established at the Marquesas, Tennessee Reef, and Molasses Reef .

In addition to the locations listed above, three study sites will be located randomly along the reef tract in each of segments 5, 7, and 9. The purpose of these additional stations is to ensure that results can be generalized to the reef tract in each segment. Coral reef stations will be located in all habitats represented at a particular study site (e.g., back reef, reef flat, shallow and deep spur-and-groove, fore reef, and deep reef).

7.1.3 Parameters and Methods

Hard-bottom community monitoring will involve both remote sensing and *in situ* measurements. These methods are described in general in this section. By agreement during the July 1992 Monitoring/Research Workshops, specific methods and protocols will be developed and recommended by potential participating researchers and laboratories in a workshop to be convened by EPA.

7.1.3.1 REMOTE SENSING

Remote sensing techniques will be used to provide a broad areal coverage for monitoring the hard-bottom community status and trends at the landscape level within the Sanctuary. After completion of the FDNR/NOAA benthic mapping project, aerial photography of the FKNMS will be repeated every 5-7 years. Aerial photography will be interpreted, ground-truthed, and digitized for entry into Geographic Information System (GIS) data layers. GIS techniques will be used to determine the changes in hard-bottom community distribution and cover. The information derived from remote sensing will be integrated with information from *in situ* monitoring to determine significant patterns and trends.

7.1.3.2 *IN SITU* SAMPLING

In general, *in situ* sampling refers to data collected by diving. Parameters to be measured include coral species composition, coral cover, growth, and recruitment; incidence of bleaching and disease; octocoral abundance; sponge and macroalgal cover; and abundances of *Diadema*, reef fishes, and coralivores (e.g., bristleworms). Although the objective is straightforward, there are many different approaches that can be taken. Methodological issues will need to be resolved among the participating researchers and laboratories.

7.1.3.2.1 Benthos

Because of the difficulties in the comparability of data derived from different survey methods, a consensus among the researchers and laboratories participating in the monitoring program will have to be reached during the workshop as to the specific methods to use. If more than one survey method is to be used, an effort will need to be made to calibrate existing data with future measurements. Some methods that could be used for conducting surveys of hard-bottom communities (nearshore hard bottom and coral reefs) are listed in **Table 6-6**.

In general, *in situ* monitoring of hard-bottom communities will be conducted annually in selected study sites, using primarily non-destructive sampling methods. Each study site will consist of an area of defined size wherein monitoring will be conducted. Within each study site, a system of randomly located permanent quadrats and transects will be demarcated. An initial survey of each selected study site will be conducted. These data will be evaluated to determine community structure and sampling adequacy (e.g., species area curve). The length and number of the permanent transects and the size and number of the permanent quadrats will be determined by agreement among the participating researchers and laboratories.

Permanent plots and quadrats will be sampled to provide data on year-to-year variation in community level parameters while minimizing or accounting for spatial variability associated with strict random sampling. In coral reef sites, permanent plots will be measured by scuba divers for the following parameters:

- Coral cover
- Coral species composition
- Coral growth/mortality
- Incidence of diseases/morbidity
    - Black-band disease
    - White-band disease
- Incidence of bleaching/loss of zooxanthellae
- Octocoral abundance and species composition
- Sponge cover and species composition
- Macroalgal cover
- *Diadema* and other echinoderm abundance
- Coralivore (e.g., bristleworm) abundance

Table 6-6. Techniques that have been used for coral reef surveys.

NON-PHOTOGRAPHIC METHODS

Line Transect Methods

Line transect methods include Continuous Recording Line Transect, Chain Transect, Linear Percentage Transect, Line Intercept Transect Method, or Intersected-length Transect. Identify corals (or other taxa) falling directly below a taut transect deployed across the reef and measure length of the line crossing each of the corals. May also run secondary transects parallel to depth contours off a main traverse at regular or random intervals to more thoroughly characterize community. Beginning and endpoints of transects can be permanently marked allowing indefinite collection of data along specific transects for yearly comparisons (Dustan and Halas 1987, Loya 1972, 1978; Dodge *et al.* 1982; Jaap *et al.* 1989).

Transect/Quadrat Method

Quadrats are deployed at regular or random intervals along transects across or along the reef. All attached epifauna or specific groups (e.g., hard and soft corals) are identified and counted within the quadrat. Quadrat may be subdivided into smaller quadrats to facilitate identification/counting (Wheaton and Jaap 1988).

Point Centered Quadrant Method

Also known as Quarter Point and Point-quarter Methods. Method assumes the average abundance of corals and other attached epifauna can be determined by measuring the average distances from random points along a line or from a randomly selected point to the centers of the nearest colony or individual organism in each of four quadrats around the point (Dodge *et al.* 1982). Also measured are the length (longest dimension of the organism) and the width (perpendicular to the length) of the organism.

PHOTOGRAPHIC METHODS

Belt Quadrat Method

Also known as Photographic Transect Method. A continuous set of photographs is taken along a transect line. Photographs are taken with a camera and strobe system mounted to a camera mount/framer placing camera at a specific distance from the seafloor. Photographs are analyzed at a later date for species identification, number of colonies or individuals, and percent cover. If transect beginning and endpoints are permanently marked, data can be collected indefinitely and year-to-year comparisons can be made (Goldberg 1973).

Photostation Quadrats

Quadrats are set up in specific locations and permanently marked with stainless steel stakes. The size of the quadrats should be optimized relative to the habitat being sampled. A grid framework is placed over the quadrat to allow repetitive photography of smaller subunits within the quadrat. A camera/strobe system similar to that used for Belt Quadrat Method is then used to take photographs at a specific distance from the seafloor. Photographs are analyzed at a later date for species identification, number, and percent cover. Comparisons can be made of data collected from year to year (White and Porter 1985; Porter and Meier, in press).

Videocamera Data

Underwater videocamera data can be collected along all previously mentioned transects. Video data are valuable in providing a permanent record of the transect when photographic data are not collected. Where photographs are taken as the primary data set, the video can provide a different perspective when videocamera data are collected with the camera in a nearly horizontal to 45 degree orientation to the bottom. Data may also be collected for future analyses with yet-to-be-developed video image analysis techniques (Porter and Meier, in press).

Methods for the measurement of the parameters listed above will use direct counts by scuba divers, measurements using photostation quadrats, and video recordings of bottom cover along transects. In addition, a permanent record of the bottom characteristics at each study site will be made with photographs taken from oblique angles. Each of these methods will be standardized and adopted by participating researchers and laboratories prior to their use.

Randomly located quadrats and transects will also be measured annually for the parameters listed above to provide better data on spatial variability. Quadrats and transects of standardized size and length will be used.

Collections of macroalgae from randomly located quadrats within each study site will also be made to determine standing crop and carbon:nitrogen:phosphorus (C:N:P) ratios. Standing crop will be measured by gravimetric techniques. Carbon and nitrogen content will be measured in the subsamples by flash-combustion in a carbon/nitrogen analyzer using National Bureau of Standards (NBS) standards. Phosphorus content will be determined as TP by combustion in a muffle furnace with magnesium sulfate, and analysis of the residue for orthophosphate will be determined by using the ascorbic acid method.

In nearshore hard-bottom sites, the increased dominance of soft corals and sponges will require modification of the sampling effort. similar sampling techniques will be utilized to obtain the following parameters:

- Octocoral cover and species composition
- Sponge cover, size, and species composition
- Scleractinian coral cover and species composition
- Macroalgal cover and species composition
- Vagile macroinvertebrate abundance and species composition.

7.1.3.2.2 Nearshore Hard Bottom and Coral Reef Fishes

Scuba divers will conduct a census of fish populations within each study site. Randomly selected nodes within a grid established in each study site will be used for performing visual censuses. These censuses will be conducted quarterly. Various, non-destructive visual census techniques, as listed in **Table 6-7**, will be considered by participating researchers and laboratories at the inception of the monitoring program. A standardized method and detailed protocol will then be developed.

7.2 SEAGRASS COMMUNITIES

7.2.1 Overview

Seagrass communities will be monitored using both remote sensing and *in situ* sampling. Remote sensing surveys of the entire Sanctuary will be conducted every 5-7 years, and surveys of 1 km "photo-corridors" in each segment will be conducted every 2 years. For *in situ* sampling, a stratified random design will be used to locate permanent study sites in each segment of the Sanctuary. Remote sensing maps currently in preparation by FDNR/NOAA will provide the basis for stratification. The *in situ* monitoring will provide measures of population- and community-level characteristics in the seagrass community, including seagrass cover, density, growth rate, standing crop, and productivity. In addition, macroalgal cover and epiphytic and macroalgal standing crop will be estimated. Epifauna associated with the seagrass community will also be sampled. *In situ* sampling of the seagrass communities will be performed bimonthly and quarterly (depending on the type of sampling).

Although there are no existing monitoring stations in the Sanctuary, stations do exist in Florida Bay (see **Appendix D**). To allow comparison of data from the two areas, similar methodologies will be used (**Section 7.2.3**).

Table 6-7. Non-destructive visual census techniques for coral reef fishes.

Traditional Transect Method (Brock 1954)

A line of appropriate length (e.g., 75 m) is laid underwater and a scuba diver counts all the individuals of each reef species that occur within 2 m of the line on either side of the line and any fish above the line. Data are recorded on a prepared species list compiled from previous experience. The length of time for traversing the transect is standardized (e.g., 50 min)

Rapid Visual Technique (Jones and Thompson 1978)

A scuba diver conducts a census of fishes for a period of 50 min while swimming in an irregular or random pattern. The period is broken up into 5, 10-min intervals and species that are present are noted on prepared lists according to the intervals in which they are sighted. Abundance scores are compiled for each species.

Visual Fast Count (Kimmel 1985)

This method is similar to the Rapid Visual Technique except that the actual number of individuals are counted during the initial 10-min period during which a species is sighted.

Stationary Visual Census Technique (Bohnsack and Bannerot 1986)

Fish occurring within an imaginary cylinder extending from the surface to the bottom within a radius of 7.5 m from the scuba diver and over a 5-min period are recorded by species and number of individuals on prepared lists. The scuba diver selects random points within a study site in which to conduct a census. While facing seaward and rotating in a clockwise direction, the scuba diver notes new species as they occur. Over the next 5-min period, statistical data are collected for the species that occurred during the initial 5-minute period; all other species are ignored. The number of individuals and the minimum, maximum, and mean length for each observed species are recorded.

7.2.2 Sampling Locations

Based on the currently available information (which will be revised in the FDNR/NOAA mapping study), seagrasses occur in all segments. Because the results of the FDNR/NOAA mapping study will not be available until December 1993, the actual locations of seagrass community monitoring stations cannot be determined at this time. If biological monitoring is scheduled to begin before the results are available, it will be necessary to discuss alternative methods for site location selection. Based on the potential benthic communities to be mapped by FDNR/NOAA (F. Sargent, FDNR, personal communication, 1992), monitoring should include areas of contiguous (moderate and dense), sparse, and patchy areas of seagrass distribution. Within each geographic segment, three stations will be randomly located in each of these seagrass habitat (i.e., seagrass density) strata.

7.2.3 Parameters and Methods

The overall approach for monitoring seagrass communities will involve both remote sensing and *in situ* measurements. The methods are described in general in this section; more detailed methods are presented in Appendix C.

7.2.3.1 REMOTE SENSING

Remote sensing techniques will be used to provide broad areal coverage for monitoring seagrass community status and trends at the landscape level within the Sanctuary. After completion of the FDNR/NOAA benthic mapping project, biannual overflights will be conducted along three "photo-corridors" measuring 1-km wide for each segment. Aerial photography, using aerocolor film, a digital camera, or a multispectral scanner, will be centered on seagrass monitoring transects. Surveys of the entire FKNMS will be conducted every 5-7 years. The aerial photographs will be interpreted, ground-truthed, and digitized for entry into GIS data layers. GIS techniques will be used to determine the changes in the seagrass distribution and cover within these "photo-corridors", and comparisons will be made with other monitoring areas. The information derived from remote sensing will be compared with information from *in situ* monitoring to determine significant patterns and trends.

7.2.3.2 *IN SITU* SAMPLING

The sampling techniques to be used in this monitoring program are based on the methodology currently used by Robblee and Zieman in the ENP in Florida Bay, primarily related to the seagrass die-off (J. Zieman, University of Virginia, personal communication, 1992). The techniques include both rapid, qualitative visual assessments and more tedious quantitative methods.

A range of *in situ* techniques will be used to monitor seagrass communities at randomly selected, permanent study sites in each segment of the FKNMS:

- **Swimover surveys (bimonthly)**
  Qualitative visual swimover surveys will be conducted by scuba divers at permanent seagrass study sites to detect gross changes. The following parameters will be estimated:
  - Percent of bottom covered by seagrasses and algae
  - Percent composition by species for species with coverage greater than 10%
  - Species present with coverage less than 10%
  - Die-off status and conditions
  - Recolonization by *Halodule*
  - Degree of epiphytism: fleshy or calcareous

- **Photo and count stations (bimonthly)**
  Photo and count stations will be established at each of the permanent study sites. Within each count station, the following parameters will be measured:
  - Number of short-shoots for each seagrass species
  - Number of blades per short shoot
  - Number of new shoots, fruits and flowers
  - Canopy height
  - Number of individuals of calcareous algae and presence of fleshy algae

  After the counts are made, 0.25 m^2 quadrats centered within the count stations will be photographed to provide a permanent visual record that can be used to calibrate rapid visual methods against quantitative methods.

- **Productivity plots (quarterly)**
  Productivity plots will be established at each of the permanent study sites to obtain quantitative measurements of seagrass standing crop, growth rate, and productivity, as well as epiphytic and macroalgal standing crop. Above-ground productivity will be monitored in randomly selected 0.02 m^2 plots using a modification of the leaf-marking method. Cores will be taken to estimate below-ground standing crop.

- **Faunal plots (quarterly)**
  Randomly selected faunal quadrats at each permanent study site will be sampled quarterly using a suction dredge to estimate the abundance, biomass, and community parameters of seagrass-associated epifauna. Three to six quadrats measuring 0.2 m^2 will be sampled for fauna in each study site. Samples will be collected in a 3-mm mesh bag and sorted. All organisms collected will be identified to the lowest taxonomic level possible and counted. Subsamples will be collected, dried, and weighed to estimate biomass.

At selected study sites, water-quality parameters, including PAR attenuation, may be monitored using continuously recording instrumentation. The deployment of continuous monitoring instrumentation will be considered after examination of the water quality and seagrass community data for significant patterns. These methods may be used when phenomena of interest occur at study sites.

7.3 MANGROVE COMMUNITIES

Distributions of mangrove communities in the FKNMS will be determined by remote sensing. Changes in mangrove coverage will be determined by comparison of remote sensing surveys from different time periods. The initial coverages will be determined from the results of the AIW project (K. Haddad, FDNR Marine Research Institute, personal communication, 1992). Remote sensing surveys encompassing the FKNMS and adjacent areas will be repeated every 5-7 years.

8.0 REMEDIAL ACTION MONITORING

Engineering and management/institutional alternatives will be considered to abate pollution in the FKNMS (Tasks 3 and 4). The effectiveness of these actions will be evaluated by remedial action monitoring. Examples are the evaluation of alternative OSDS designs for nutrient removal and the installation of small, expandable WWTPs utilizing advanced wastewater treatment in Marathon to serve an area of dense septic tank use where nearshore water quality problems have been identified. Such remedial actions may have a relatively high priority because members of the Core Working Group ranked nutrients as the most important water quality parameter for the Water Quality Protection Plan. A pilot project may be undertaken to demonstrate the effectiveness of such actions on a limited scale before widespread adoption throughout the Florida Keys. A site-specific monitoring program would be instituted as part of the pilot project to evaluate the effectiveness of the action in improving water quality.

Because specific actions have not been identified, details of a remedial action monitoring program cannot be specified. The project should include sampling of the source, pathways of introduction into marine waters (e.g., groundwater), and FKNMS waters, including reference sites if possible. Sampling sites should be located in a pattern sufficient to ascertain the pollution gradient with respect to the source. The program should begin prior to implementation of the remedial action and continue until sufficient data are available to judge the effectiveness of the action. Biological resources affected by effluents from the pollution source should be monitored to ascertain the effectiveness of the remedial action.

9.0 QUALITY ASSURANCE/QUALITY CONTROL

QA refers to "those operations and procedures which are undertaken to provide measurement data of stated quality with a stated probability of being right" (Taylor 1985). Simply stated, QA is the total integrated program for assuring reliability of monitoring and measurement data. The requirement for establishing a QA program for the water quality monitoring and research program is based on the EPA's policy and authority stipulated by the Administrator of EPA in memoranda of 30 May and 14 June 1979. This policy and requirement not only covers EPA organizations, but also monitoring activities supported or specified through contracts, grants, regulations or other formal agreements. The policy also extends to states with cooperative programs implemented through EPA regional offices.

In accordance with EPA policy, the FKNMS water-quality monitoring program will adhere to existing rules and regulations governing QA and QC procedures as described in EPA guidance documents. Because the implementation of the monitoring program will be a collaborative (cooperative) effort among several federal and state agencies, academic and research institutions, and non-governmental organizations, a single QA plan will not be developed at this time. It will be the responsibility of all participating entities to develop and submit for approval a QA Project Plan (QAPjP) for their component of the program.

9.1 QUALITY ASSURANCE PROGRAM GOAL

The FKNMS QA program will be implemented to ensure that all data and information produced and used for decision-making and resource management will be of known quality, scientifically valid and defensible, and thoroughly documented. To achieve this goal, the program will use standardized and fully characterized methods and procedures that will be validated for their intended use and rigorously followed. All data will be reported with measures of quality (accuracy and precision). All non-standard or modified methods will be documented.

9.2 QUALITY ASSURANCE PROJECT PLANS

All federal and state agencies, academic institutions, and other non-governmental organizations that are funding recipients or participants in the monitoring program will be required to submit a QAPjP prior to any work. For any data to be accepted and utilized, a QAPjP must have been submitted and approved. Through the QAPjP, participants will explicitly commit to incorporating procedures that will reduce and maintain random and systematic errors within specified tolerable limits (QC). In addition, they will document their QC procedures and evaluate the quality of the data being produced. Plans should include or refer to a description of safety, training, and equipment maintenance.

QAPjPs will be prepared according to the format prescribed in *Guidance for the Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring* (EPA 1984) and *Guide for Preparation of*

Quality Assurance Project Plans for the National Estuary Program (EPA 1988). Participating laboratories should develop their QAPjP in close coordination with the EPA Region IV QA section and the Florida Department of Environmental Regulation (FDER) QA section to minimize delays in the process. The *Handbook for Analytical Quality Control in Water and Wastewater Laboratories* (EPA 1979b) should be consulted for guidance on QC procedures for participating laboratories.

Through the QAPjPs, participating entities will provide a description of

- The project that explicitly defines the sampling strategy and design to be used, and the scientific and statistical basis for selection of specific sampling sites
- The sampling, analytical methodology, calibration procedures, and standard operating procedures to be used, along with detailed information on probes, collection devices, storage containers, and preservatives to be used
- Any special operating conditions related to sample storage and preservation
- The reference, equivalent, or alternate test procedures, along with the appropriate instrument selection and use (in addition to the primary methodology)
- The preventative and remedial maintenance that will be required for each instrument
- Specific procedures for estimating and documenting accuracy and precision of analytical procedures, such as replicate samples, blind and spiked samples, and field and analytical blanks
- Any inter- and intra-laboratory QC procedures (e.g., internal QC checks, split samples, etc.) associated with analytical methods
- Methods for documenting the QC procedures, including acceptance criteria
- Procedures for corrective action
- Performance and system audits
- A mechanism for maintaining sample chain-of-custody
- Procedures for data reduction, validation, and reporting

A QAPjP will also describe the project organization and responsibilities. When appropriate, the use of the data generated during the project will be described.

The QAPjPs to be submitted for review and approval should address the following aspects of QA.

- Identification and establishment of specific data quality goals to be achieved during the monitoring project
- Description of the procedures that will be used to measure or assess the quality of the environmental measurements obtained during the project
- Description of the nature of the report that will be prepared to document the quality of the measurements

In general, the development of a QAPjP will involve the following activities:

- Establishment of data quality objectives
- Compilation of method performance data
- Specification of measures of data quality

All participants in the water-quality monitoring program will be required to establish clear Data Quality Objectives (DQO). In establishing DQOs, tradeoffs between data quality and incremental costs associated with increasing quality in terms of time, personnel, and expense should be closely examined. DQOs should satisfy project objectives, but these goals must be reasonably attainable within the available time, resources, and methodology.

All methods to be used within the program should be well established and have performance data available. In addition, all monitoring activities will specify and document the measures of data quality that will be achieved. To ensure data accuracy and comparability, the monitoring program should participate in the Quality Assurance Project of the National Status and Trends Program. Participation in the yearly comparison exercises may reduce interlaboratory and intralaboratory analytical variation.

9.3 RESPONSIBILITIES

The QA Program will be implemented by a Quality Assurance Officer (QAO), who is appointed by the Management Committee of the FKNMS.

The QA functions of the QAO will be to
- Develop a mechanism to provide participating entities with the technical and material guidance and assistance necessary to produce reliable and comparable data
- Develop and implement a system for continually evaluating the performance of participating researchers, laboratories, and personnel, as well as the adequacy of the methods and instruments being used
- Enhance the overall capability and performance of monitoring activities through corrective action
- Develop mechanisms to identify and correct methodological discrepancies between participating laboratories
- Continually review and improve the QA program while ensuring that the requirements placed on participants achieve the goals of the program without becoming an undue burden

The QAO will be responsible for transmitting QAPjPs to the EPA Region IV QAO for review and approval. A copy of the draft QAPjP will also be submitted to the designated FDER QAO for comment. The acceptance or rejection of QAPjPs will be communicated to the submitting party through the QAO. Approved QAPjPs, which will be subject to periodic review, will be filed with the QAO.

The EPA Region IV QAO will coordinate with the QAO in the requirements for performance and systems audits which may be required of all participating entities. The performance and systems audits will be based on guidance and procedures provided by EPA (1985) in *Standard Operating Procedures for Conducting Surplus and Sample Bank Audits*. Unannounced audits may be performed by EPA/FDER to determine compliance with the approved QAPjP. The QAO will also coordinate inter-laboratory calibration exercises to improve data reliability and comparability.

10.0 DATA MANAGEMENT

Data management will play an important role in the performance of the monitoring program because it will serve as the central node for the flow of data. As this central node, data management will participate in and oversee the data flow among the participants and to Sanctuary management. The objective of data management is to monitor, control, and facilitate data flow, ensuring the integrity of the data through each phase of the project.

The entity conducting data management should develop the data management plan. The data management plan should meet certain requirements but should reflect the facilities available at the designated entity. In this document, an entity to conduct data management is recommended, Sanctuary management support is outlined, and requirements for the data management plan are discussed. The data management entity will prepare a draft version of the plan that meets the requirements, and the NOAA Core Group will review the draft plan to ensure that it meets the needs of the Sanctuary program and approve the final plan.

The recommended entity to conduct data management for the FKNMS Water Quality Protection Program is the Florida Marine Research Institute (FMRI). This agency is a logical choice because its representatives have been involved in the development of the Water Quality Protection Program since its beginning. FMRI also has experience in and facilities for providing data management services, and regularly coordinates with state and federal agencies.

Data management should be overseen by the Water Quality Protection Program Management Committee, in consultation with the Technical Advisory Committee, to ensure that data management meets the needs of the

Sanctuary managers and the participating scientific community. In addition, a committee to coordinate information exchange should be established to facilitate the flow of information among government agencies. This will ensure that data exchanges between the Sanctuary database and the agencies will be coordinated. This committee should be chaired by the Sanctuary data manager and be comprised of data managers from the state and federal agencies that will exchange data with the Sanctuary database. Primary participants in the coordination committee should be the EPA, FDER, FDNR, Florida Department of Community Affairs (FDCA), Florida Office of Planning and Budget, Monroe County, NOAA, South Florida Water Management District (SFWMD), and the U.S. Fish and Wildlife Service (FWS).

To accomplish the data management objective, four interrelated elements need to be incorporated into the data management plan: (1) data management, (2) data control, (3) data utilization, and (4) archiving. Data management is the element of the data management plan that ensures the continuous tracking and custody of samples and data with evidence of data possession, comparison, and security with signatures, dates, times, and location of data. It will also ensure proper formatting, reporting, and dissemination of data. The purpose of data control is to monitor the progress of the data flow, identify gaps in the information supplied, and signal further processing requirements. Data control procedures enable documentation of data availability, data reduction, and data analysis. Data control also includes a routine backup of computer files. This should be addressed in the data management plan to ensure efficient data recovery if a catastrophic event occurs, such as hardware failure. Data utilization ensures that all data are processed, validated, and made available (as needed) to program participants and that these data are retrievable (as needed) for analysis. QC via data entry and validation procedures ensures that only validated data are entered into the project database. All necessary data are therefore available for analysis and interpretation. Data archival is a method for the safe storage and easy retrieval of all accumulated data. An archival routine assures the permanency of the data archives and is a necessary part of the data management plan.

The data management plan should include descriptions of the following items:

- Data security including backup procedures
- Data entry and validation protocols
- Data processing protocols
- Database documentation procedures
- Data reduction and reporting requirements
- Information exchange protocols (among agencies)
- Data archival procedures
- Data access and utilization protocols
- Sample/data tracking and custody protocols
- QA/QC requirements and procedures for data management activities
- Structure of the data base
- Tools for accessing data and developing data products for the Sanctuary management
- Personnel training
- Hardware specifications
- Staffing requirements
- Budgetary requirements

In addition, a strategy for evaluating and incorporating existing data from sources such as FDER and FDNR into the database should be developed.

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APPENDIX A

Field Protocols for Water Column, Sediment, and Tissue Monitoring

FIELD PROTOCOLS FOR WATER COLUMN, SEDIMENT, AND TISSUE MONITORING

A.1 SAMPLING SCHEDULE

Sampling for water column, sediment, and tissue monitoring will be conducted as described in detail in **Section 6.0** of this document. In general, water column monitoring within the first five years of the program will be conducted every six weeks. Sediment sampling will be conducted on an initial survey during the first year of the program. Tissue samples will be collected during a single survey to the biological resource study sites.

A.2 SAMPLING SITES AND STATIONS

The activities described below will be conducted at sites and stations specified in **Section 6.0** of this document. After a station is selected, the site's coordinates will be determined, the site will be located by using a Global Positioning System (GPS) unit, and the site will be examined for appropriateness. The selected station will be marked or reliable references points will be identified and noted. A station description form will be completed and entered into the Registry of Sites and Stations maintained in the Florida Keys National Marine Sanctuary (FKNMS) Data Management System. Each site and station will be assigned a unique code that will be used as an identifier for all data collected at that station.

A.3 FIELD METHODS

Because field collections will likely be made by different teams based in three or more areas of the Keys, for quality control (QC) purposes, the number of laboratories where the analyses are to be conducted will be minimized.

At each water column sampling station, the physico-chemical parameters to be measured in the field are

- Water temperature
- Conductivity/salinity
- Dissolved oxygen (DO)
- pH
- Photosynthetically active radiation (PAR)

These parameters (except PAR) will be measured at 0.5 m below the surface at stations less than 3 m in depth. At stations 3-5 m in depth, measurements will be made at 0.5 m and 1 m above the bottom. At depths greater than 5 m, an additional measurement will be made at mid-depth. PAR will be measured at several depths (as described in the attached protocol) to calculate a light extinction coefficient. In addition, ancillary information such as air temperature, wind speed and direction, tidal stage, sea state, and cloud cover will be noted. Precision, accuracy, and reporting requirements for each parameter will be specified in the Quality Assurance (QA) Plan. A multi-sensor environmental package such as the Hydrolab Datasonde III or H2O Sensor with a Surveyor 3 display unit/datalogger are recommended for use as the primary instrumentation. The recommended instrumentation for PAR measurement includes the Licor 4 *pi* underwater quantum sensors with an LI-1000 datalogger. All field data with clear station identification codes and times (as Eastern Standard Time) will be entered on appropriate data sheets.

Water samples will be collected at each water column sampling station by using a 5 L Niskin sampler deployed at depths as described above. Water samples of adequate volume will be collected, stored in appropriate containers, packed in ice, and transported to the laboratory within 4 h of collection. In the field, subsamples will be filtered through a Whatman GF/F glass fiber filter for dissolved nutrient determinations. The used filter will then be placed in a microcentrifuge tube and kept under ice until it can be stored in a freezer. All bottles will be appropriately labeled and, if necessary (e.g. when the field sampling and analytical work is performed by separate laboratories, particularly for sediment), a protocol for sample chain-of-custody will be observed following the procedures in the approved QA Plan for the program. Appropriate field blanks and control samples will be prepared as required by QA/QC procedures.

Sediment samples of adequate volume will be collected with a Smith-McIntyre grab or by scuba divers, then placed in wide-mouth Teflon-lined glass jars or polyethylene tubes/bottles, sealed, packed in ice, and transported to the laboratory.

A.4 FIELD SAMPLING PROTOCOL

This protocol describes the activities to be conducted at the designated sampling stations. Basic station descriptions are presumed to have been conducted prior to the actual sampling effort. This protocol may be employed for all phases of the monitoring program. Sediment quality measurements are likely to be conducted during the initial survey.

Although the sampling activities described in the following sections are relatively straightforward, training and review of protocols and the appropriate QA/QC plans by all personnel involved should be conducted prior to conducting the field work.

A.4.1 Mobilization and Preparations

1. Review appropriate protocols and QA/QC plan.
2. Clean sampling equipment and materials.
3. Check battery power, calibration, and function in all electronic equipment. Record results in a Maintenance and Calibration Log Book.
4. Check data sheets and checklists.
5. Check labels on sample bottles.
6. Assemble all field sampling equipment and materials including backup equipment, field blanks, and standards. Use and initial the appropriate checklist.
7. Check vehicle and boat for fuel, safety, and communications equipment.
8. Check station locations for current sampling session.
9. Prepare a Float Plan.

A.4.2 Field Work

Because of the minimal tidal range and the greater influence of wind-driven "tides," sampling will be conducted without regard for tidal stage. However, sampling will be suspended or delayed if weather conditions render field work hazardous or if wind conditions generate unusual turbidity. This protocol assumes that samples will be collected from docks (with at least 1 m depth) or from a boat. Only personnel with proper training and knowledge of the procedures may conduct the sampling.

Assuming that station locations are appropriately marked or adequate reference points are located, personnel should proceed to the designated sampling site according to the sampling schedule.

A.4.3 Parameter Measurements and Sample Collections

Sampling includes the following activities:

I. Physico-chemical measurements and ancillary notes (water-column stations):
   (a) Water temperature
   (b) Conductivity/salinity
   (c) pH
   (d) DO
   (e) PAR by depth (light extinction coefficient)
   (f) Water depth
   (g) Air temperature
   (h) Wind speed and direction
   (i) Cloud cover
   (j) Tide stage
   (k) Sea state

II. Water sample collections (water-column stations):
   (a) Nutrients
   (b) Chlorophyll *a*
   (c) Alkaline phosphatase activity (APA)
   (d) Nephelometer turbidity

III. Sediment sample collections (water-column stations):
   (a) Basic sediment parameters
   (b) Toxic constituents

IV. Tissue sample collections (biological resource study sites):
   (a) Organic matter content
   (b) Toxic constituents

A.4.3.1 PHYSICO-CHEMICAL MEASUREMENTS

Measurements and sample collections will be conducted in the order listed above to minimize contamination of the water samples. The boat operator should approach each sampling station slowly to prevent stirring up the bottom and resuspending sediments that will cloud up the water column and "contaminate" the water samples. If an anchor must be dropped, any sediment that has been resuspended should be allowed to clear before starting the sampling procedures.

The recommended instrument for measuring physico-chemical measurements in the water column is the Hydrolab H20 with a sensor package for temperature, conductivity/salinity, pH, and DO connected to a Hydrolab Surveyor 2. A second, properly calibrated Hydrolab H20 should be brought along as a back-up. If a second Hydrolab H20 is not available as a back-up, then the following instruments should be available:

- YSI Model 33 Salinity-Conductivity and Temperature meter with 3-m long cable
- YSI Model 57 dissolved oxygen meter with 3-m long cable
- Beckman or Orion field pH meter

These instruments should be calibrated daily and brought to the field whenever a backup Hydrolab H20 is not available. Upon arriving at each sampling station and after the boat has been secured, turn on all instruments and allow the electronics to warm up and stabilize, determine the depth at the sampling station, and set the Surveyor 3 to log the sensor readings every minute. When the Hydrolab H20 is ready, lower the instrument so that the sensors are at 0.5 m depth. Allow the instrument to equilibrate for 1 min and then record the time, depth, water temperature, conductivity/salinity, pH, and DO on a data sheet. Continue lowering the Hydrolab H2O slowly to the next measurement depth. Allow the instrument to equilibrate for 1 min and record the time, depth, water temperature, conductivity/salinity, pH, and DO on a data sheet. Although the data will be recorded on the Surveyor 3 datalogger, handwritten records should be kept for greater security.

Measurement depths will depend on the water depth at a station and are as follows:

- <3 m - mid-depth
- 3-5 m - 0.5 m below the water surface and 1 m above the seafloor
- 5-50 m - 0.5 m below the water surface and at 2-m depth increments to 1 m above the seafloor
- >50 m - 0.5 m below the water surface and at 5-m depth increments to 1 m above the seafloor

If a pycnocline or other abrupt change of measurements is observed during the downcast, the depths of change should be profiled with greater resolution (e.g., 1-m depth increments) during the upcast.

When the primary instrument fails and a backup Hydrolab H20 is not available, the following procedure can be employed using the backup instruments, a 5-gallon bucket and a Niskin sampler:

(1) Empty the water sample from the Niskin sampler via the tubing to fill up the 5 gallon bucket.

(2) Submerge the probes for the Salinity-Conductivity-Temperature (S-C-T) meter and DO meter into the bucket to start equilibrating with the sample. After 2 min, the oxygen probe should be gently agitated to prevent building up gradients across the membrane. The S-C-T meter probe does not need agitation.

(3) Measure the pH of the sample.

After recording the data obtained by using the above instrument(s), proceed as follows.

1. Deploy the reference sensor. Using a calibrated line, lower the PAR sensor on a weighted lowering frame over the unshaded side of the boat. Take measurements at the following depths: 0.15, 0.20, 0.40, 0.60, 0.80, 1, 2, 3 m, etc. (see PAR attenuation coefficient protocol). Ensure that the sensor remains at each depth for a period longer than the averaging time set on the datalogger. Record all measurements on an appropriate data sheet. After taking the PAR measurements, measure the depth to bottom using the same calibrated line.

2. Enter the following information on the data sheet: sampling station (code), date (MM/DD/YY), time (HHMM) as Eastern Standard Time, station depth (m), tidal stage, weather conditions, etc.

3. Estimate the wind direction and speed.

4. Record, on the appropriate data sheet, water temperature (degrees Celsius [°C]), salinity (parts per thousand [ppt or o/oo]), conductivity, DO content (mg O_2 per liter [mg/L or parts per million (ppm)]), and wind direction (e.g. northwest [NW]) and speed (miles per hour [mph]).

A.4.3.2 WATER SAMPLE COLLECTION

After completing the measurements of physico-chemical and ancillary parameters, proceed with water sample collection as follows:

1. After cocking open the Niskin sampler, lower it over the side of the boat to the appropriate depth (see above) and collect a sample.

2. Rinse the 125 mL high-density polyethylene (HDPE) sample bottle for nutrients with the sample three times before filling it to capacity. Fill and tightly cap one sample bottle for each depth. Make sure the bottle is properly labeled.

3. Filter all samples immediately after collection. Rinse the 60 mL syringe and the 25 mm filter holder with the remaining water from the Niskin sampler.

4. Load the filter holder with a Whatman GF/F 25-mm glass fiber filter.

5. Fill the 60 mL syringe by withdrawing the water from the 125 mL sample bottle. Filter the sample by hand. Discard the first 10 mL of the sample. Rinse the 60 mL bottles three times with the filtered sample before filling the bottle to capacity. Fill the syringe with another 60 mL of sample and filter it through the same filter.

6. Store the filtered water samples under ice while being transported to the lab.

7. Open the filter holder and place one drop of saturated magnesium carbonate ($MgCO_4$) on the filter. Remove the used filter, carefully fold it in half, place it in a labeled microcentrifuge tube, and transport it under ice until it can be frozen in the laboratory. These filters will be used for chlorophyll measurements.

8. Store each sample bottle in a cooler at ambient temperatures while being transported to the laboratory after a subsample has been filtered.

9. Note on an appropriate checklist that the above samples were collected.

10. Rinse the used syringe and filter holder with deionized water and reload the filter holder after shaking out any excess water. Complete this procedure prior to collecting sediment samples or proceeding to the next site to avoid any possibility of contamination.

A.4.3.3 SEDIMENT SAMPLE COLLECTION

The preferred method of sediment sample collection is by divers using hand cores. If diver sampling is not possible, then proceed with sediment grab sampling as follows:

1. Assemble the following equipment and materials in the appropriate area of the boat.
   (a) Smith-McIntyre grab
   (b) Wash basin and scoop
   (c) Labeled and clean sample containers
   (d) Hand-cores

2. Cock the grab open, bring it to the proper position over the side, and deploy. Retrieve the grab, carefully raising it to the surface and on deck.

3. Carefully examine the contents to ensure that an acceptable sample was collected.
   (a) The jaws of the grab should be completely shut.
   (b) The sediment-water interface should be undisturbed, as indicated by the presence of water between the sediment surface at the top of the grab. There should be about 1 in. of space between the sediment surface and the top of the grab.

(c) There should not be any evidence that some portion of the sample was washed out.
(d) The surface of the sample should not be canted more than 5 degrees.

4. Using a hand-core, collect small subsamples of the sediment and put them in the appropriate labeled containers.

5. Store all sediment samples under ice while being transported to the laboratory.

6. Clean and thoroughly rinse all sediment sampling equipment and the work area of sediment prior to proceeding to the next site.

A.4.3.4 TISSUE SAMPLING

Tissue samples will be obtained at the biological resource monitoring stations. Species to be collected will depend on the habitat and will be selected during a workshop convened by EPA among potential participating researchers and laboratories. Representative producers and consumers will be collected by scuba divers, traps, or other appropriate means. All specimens will be wrapped in aluminum foil, placed in plastic bags, and transported to the laboratory on ice.

A.4.3.5 TRANSIT BETWEEN STATIONS

After checking that all the needed samples have been collected, discard all extra and unneeded samples. Rinse the sampling equipment and store all the materials so that they are protected against spray and sun. Move to the next station after ensuring all station information has been properly recorded, labels are properly logged, and equipment and materials are stowed. Return all the water samples to the lab within 4 h of sampling.

A.4.4 Demobilization

1. Upon returning to the laboratory, store the chlorophyll filters, filtered water, and sediment samples in designated refrigerators and freezers.

2. Remove aliquots of the unfiltered water samples for determination of APA as described in a separate protocol.

3. Filter any water samples soon after returning to the lab (if this has not been done in the field). See filtering procedure (Section A.4.3).

4. Rinse and dry all meters and sampling equipment to minimize corrosion. Soiled/used sampling and filtering materials should be cleaned and washed.

5. Transfer the data from the Surveyor 3 into a desktop or laptop computer; immediately copy the file and store in a separate location.

6. All data sheets should be collated, checked for clarity and completeness, and placed in appropriate binders after each field session. A copy of the completed field data sheet should be made and stored in a separate location.

A.5 MINIMUM PERFORMANCE CRITERIA FOR THE PHYSICO-CHEMICAL PARAMETERS

PARAMETER	METHOD/ RANGE	REPORTING UNITS	PRECISION (%)	ACCURACY (%)	COMPLETENESS (%)	CALIBRATION
Temperature	Thermistor -5.0 to 45.0	°C	5	99	99	NBS certified thermometer
Salinity	By conductivity 0 to 45	ppt	5	99	99	Potassium chloride standards
pH	Electrometric 0 to 14	pH units	5	99	95	NBS traceable buffers, 2 point calibration
DO	Polarographic sensor 0 to 20	mg/L	5	95	95	Water saturated air or Winkler titration
Light attenuation coefficient, k	PAR attenuation 0 to – (negative number)	– /m	NA	NA	95	Factory calibration of quantum sensor

NA: Not applicable

A.6 PHOTOSYNTHETICALLY ACTIVE RADIATION DIFFUSE ATTENUATION COEFFICIENT METHODOLOGY

The following format follows EPA (1979).

1. **Scope and Application**

   1.1 This method provides a more ecologically important measure of light availability than Secchi disk transparency. Measurement of PAR at multiple depths is the recommended method of assessing transparency (Kenworthy and Haunert 1991). The method is also more flexible in that it can be used in turbid or clear shallow water by adjustment of the depths at which PAR measurements are made. The only limitation to the method will be in very turbid, shallow waters where there may not be enough water below the lowering frame to immerse the submarine sensor. A thorough discussion on the physics and measurement of underwater irradiance is found in Kirk (1983). This protocol was developed at a workshop of seagrass researchers (L. Morris, St. John's River Water Management District, pers. comm., 1993).

2. **Summary of Method**

   2.1 Measurements of diffuse incident and reflected PAR (400-700 nm) are made at successive depths from the surface to the bottom of the water column while simultaneous measurements are made in the air on a deck sensor and on a reference sensor near the surface. A diffuse attenuation (extinction) coefficient is calculated from the change in PAR intensity with depth after the readings are corrected for changes in cloud cover.

3. **Sample Handling and Preservation**

   3.1 Not applicable

4. **Interferences**

   4.1 Not applicable

5. **Apparatus and Materials**

   5.1 The recommended instrumentation are the LICOR 4 *pi* underwater quantum (PAR) sensors for PAR measurements in the air (deck cell) and underwater with a LI-1000 datalogger (J. Kenworthy, National Marine Fisheries Service, personal communication, 1992). The spherical 4 *pi* sensor is recommended over the 2 *pi* which only measures downwelling radiation. The 4 *pi* sensors measures both downwelling and reflected light which are both important for photosynthesis. There are also major leveling problems associated with using 2 *pi* sensors particularly at depths with significant currents. A datalogger with averaging algorithms is also recommended since these will provide a more accurate measure of light levels than single measurements. Underwater cable lengths of 25 m will be required. Three sensors will be required: A fixed deck sensor mounted on a black plate, a fixed subsurface sensor mounted on a floating frame, and a movable sensor mounted on a lowering frame. The lowering frame should be weighted with lead as required. A separate line should be used to carry the weight of the lowering frame and lead weights. The fixed submarine sensor is mounted on a floating frame painted black which suspends it 15 cm below the surface.

6. **Reagents**

   6.1 None

7. **Procedure**

   7.1 Adjust the instrument package by entering the calibration factor on the datalogger for the attached PAR sensors. The reporting units will be in μeinsteins cm^{-2} sec^{-1}. Adjust the averaging period to no less than 20 sec. The calibration factor (in the air or underwater) is provided by the factory. Mount the sensors on the deck mount, floating frame, and lowering frame and check all the connections for water-tightness. It is recommended that measurements be taken between 10 a.m. and 2 p.m.

7.2 Lower the underwater sensor on the unshaded side of the boat/dock and record the PAR intensity from the deck sensor and submarine sensor while the sensor on the lowering frame is at 0.1 m depth. [*NOTE:* Keep the submarine sensor in position longer than the averaging time set on the datalogger].

7.3 Continue lowering the submarine sensor into the water and record the PAR intensity from the deck and submarine sensors at each depth according to the following depth ranges.

> Station depth less than 3 m — Depths: 0.15, 0.20, 0.40, 0.60, 0.80, 1.00, 1.50, 2.00, and at canopy height.
>
> Station depth 3-5 m — Depths: 0.15, 0.20, 0.40, 0.60, 0.80, 1.00, 1.50, 2.00, 3.00, and 4.00.
>
> Station depth greater than 5 m — Depths: 0.15, 0.20, 0.40, 0.60, 0.80, 1.00, 1.50, 2.00, 3.00, 4.00, and a depth of 1 m above the bottom.

Repeat measurements three times at each site.

8. Calculation

8.1 Light or irradiance is attenuated underwater in an exponential manner. The relationship between underwater irradiance at a particular depth and irradiance at the water surface can be expressed as

$$\ln E_d(z) = -K_d z + \ln E_d(0)$$

where $E_d(z)$ and $E_d(0)$ are the values of irradiance at z m depth and at the surface, respectively. K_d is the light attenuation coefficient.

The deck sensor readings are recorded for future use to make further corrections for sun angle and immersion effects. They are not needed for the calculations described below.

Each reading made with the sensor on the lowering frame at depth $E_d(z)$ is corrected for changes in cloud cover during the period of measurements by multiplying by a correction factor $f(z)$ based on the reference sensor readings $E_r(z)$ (e.g., the correction factor for the reading at 0.20 depth, $f(0.20)$ is equal to $E_r(0.15)/E_r(0.40)$, where $E_r(0.15)$ is the reference sensor reading at the beginning of the measurements (when the moveable sensor was at 0.15 m depth) and $E_r(0.40)$ the reference sensor reading when the moveable sensor was at 0.40 m depth.

The PAR attenuation coefficient K_d is calculated by fitting a regression to the natural log of the corrected PAR values $E_c(z)$ against depth z. The slope of the regression line is equal to the light attenuation coefficient. The average of the K_d values calculated for each site is calculated and reported.

A light attenuation coefficient for each depth interval $K_d(z)$ may also be calculated if there is significant evidence for stratification in the water column which may be of interest. This may be calculated by taking the difference between the natural loganthims of the corrected PAR values at each depth z [$\ln E_c(z)$] and dividing it by the difference in depth (z_2-z_1).

$$K_d(z) = \frac{1}{(z_2-z_1)} \ln \frac{E_c(z_1)}{E_c(z_2)}$$

9. Precision and Accuracy

9.1 Since this specific methodology is relatively new, estimates of its precision and accuracy are not available.

References

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A.7 HYDROLAB CALIBRATION PROCEDURES

A.7.1 Temperature

Note: Temperature is calibrated at the factory and is not adjustable.

- Select T from variable menu.
- Select (C)entigrade or (F)arenheit.
- Return to screen 1.
- Compare Hydrolab reading with calibration thermometer in water bucket.
- Record values on calibration form.

A.7.2 Dissolved Oxygen

- Select DO from variable menu.
- Select (S)tandard membrane.
- Select (S)alinity compensation.
- Select % from calibrate menu.
- Enter local barometric pressure in millimeters of mercury (local newspaper or weather radio: in × 25.4 = mm).
- Remove calibration cup from sensors.
- Orient unit so sensors are facing up.
- Screw on bottomLess cup and fill with freshwater to a level even with the o-ring used to secure the membrane.
- Carefully remove any water droplets from the membrane using the corner of a paper towel.
- Set the calibration cup lid upside down on top of the cup (air flow blocked but not sealed).
- Return to screen 1 and allow readings to stabilize for 2 min.
- The DO percent saturation value should read 100.0.
- Record values on calibration form.
- Select o (not zero) instead of % to get DO in mg/L.

A.7.3 Depth

- Select D from variable menu.
- Select (F)eet or (M)eters.
- Select (D)epth for depth transducer.
- Select DEPTH from calibrate menu.
- Enter 0.0 if sensor is in calibration bucket or enter correct value if sensor is at known depth.
- Record values on calibration form.

A.7.4 Conductivity

[*Note*: Conductivity and salinity are measured with the same sensor; therefore by calibrating one, the other is automatically calibrated. The unit is equipped with the saltwater cell block and can only be used in water with specific conductance greater than 10 μS/cm.]

- Select Sp Cond from variables menu.
- Select (M) milli or (U) micro units.
- Select (S)alt water cell block.
- Select (A)uto range.
- Select (S)alinity for other display.

- Select (U)ncompensated Cond/Sal readings.
- Pour conductivity calibration solution into clean calibration cup and install over sensors.
- Select SpC/S from calibrate menu.
- Select (C)onductance and enter the correct value for the solution (be sure units are correct).
- Record values on calibration form.

A.7.5 pH

- Select pH from calibrate menu.
- Pour pH 7.0 solution into clean calibration cup and install over sensors.
- Enter correct pH value.
- Pour pH 11 solution into clean calibration cup and install over sensors.
- Enter correct pH value.
- Record values on calibration form.

A.8 HYDROLAB CALIBRATION FORM

Asset #: __________ Hydrolab Serial #: _____________

TEMPERATURE

calibration thermometer: ___________(°C)

hydrolab temperature: ______________(°C)

DO

salinity compensation: yes _____ no _____

local barometric pressure: __________(mmHg)

% saturation: _____________________(%)

DEPTH

actual depth of sensor: ____________(ft or m)

hydrolab depth reading: ____________(ft or m)

CONDUCTIVITY

range: auto____ hi____ med____ low____

uncompensated setting: yes____ no____

calibration solution concentration: ________(μS/cm)

hydrolab conductivity of cal. solution: ______(μS/cm)

pH

hydrolab value for pH 7.0 solution: ______

hydrolab value for pH ____ solution: ______

Comments:

____

____

____

Battery Voltage: ________ Maintenance and Calibration By: ________
Date: ___________

A.9 CHECKLIST OF MATERIALS AND EQUIPMENT

Physico-chemical Measurements

Primary equipment: Hydrolab H20 and Surveyor 3 datalogger 0
Backup equipment: Hydrolab H20; or, ... 0
YSI Model 33 S-C-T meter and probe 0
YSI Model 57 Oxygen meter and probe 0
Meter stick 0
Licor 193 underwater quantum sensor 0
and LI-1000 data logger 0
5 gallon bucket 0
Watch 0
Tide tables 0
GPS Pathfinder 0

Water Sampling

5 L Niskin Sampler 0
125 mL clear HDPE bottle, d.i. water rinsed . . . . Number Available: ___
60 mL clear HDPE bottle, d.i. water rinsed . . . . Number Available: ___

Filtration

60 mL syringe 0
25 mm filter holder 0
Whatman GF/F 25 mm glass fiber filters 0
Filter forceps 0
1.8 mL microcentrifuge tube . . . . Number Available: ___
Saturated magnesium carbonate solution 0

Sediment Sampling

Smith-McIntyre grab 0
Wash basin and spatula 0
Hand cores 0
Sample jars/centrifuge tubes . . . . Number Available: ___

Miscellaneous Supplies

Kimwipes 0
HCl wash bottle 0
Labeling tape 0
Labeling markers 0
Coolers 0
Station location maps 0
Data sheets 0

Date: __________
Initials: ________

A.10 FIELD DATA SHEET

Site Name: __________ Site Code: _________ Station Code: ________ Coordinates: _________
Date: __________ Time: ________ Data Recorder (Initials): ________
Water Depth (m): ______ Tidal Stage: _________ Sea State: ___________
Air Temp: _________ Wind Speed: _________ Wind Direction: _________
Cloud Cover: Clear-0 Partly Cloudy-1 Overcast- 2 Precipitation: none-0 drizzling-1 heavy-2

Sampling Depth (m)	Temp (°C)	Dissolved O_2 (mg/L)	Conductivity μmhos/cm	Salinity (ppt)	Turbidity (ntu)	Remarks

Site Name: __________ Site Code: _________ Station Code: ________ Coordinates: _________
Date: __________ Time: ________ Data Recorder (Initials): ________
Water Depth (m):______ Tidal Stage: __________ Sea State: ___________
Air Temp: _________ Wind Speed: _________ Wind Direction: _________
Cloud Cover: Clear-0 Partly Cloudy-1 Overcast- 2 Precipitation: none-0 drizzling-1 heavy-2

Sampling Depth (m)	Temp (°C)	Dissolved O_2 (mg/L)	Conductivity μmhos/cm	Salinity (ppt)	Turbidity (ntu)	Remarks

Site Name: __________ Site Code: _________ Station Code: ________ Coordinates: _________
Date: __________ Time: ________ Data Recorder (Initials): ________
Water Depth (m): ______ Tidal Stage: _________ Sea State: ___________
Air Temp: _________ Wind Speed: _________ Wind Direction: _________
Cloud Cover: Clear-0 Partly Cloudy-1 Overcast- 2 Precipitation: none-0 drizzling-1 heavy-2

Sampling Depth (m)	Temp (°C)	Dissolved O_2 (mg/L)	Conductivity μmhos/cm	Salinity (ppt)	Turbidity (ntu)	Remarks

A.11 SITE AND STATION DESCRIPTION FORM

Date Established: ____________

Station Type: Water Quality Sediment Quality Seagrass Community Coral Community

Latitude: _______ Longitude: __________

Coordinates Determined by: Reckoning Loran GPS

Description of Station Marker, if any:

____
____

Average depth at low water: __________ m

Description of bottom type and cover:

____
____
____
____
____

Description of nearby navigational markers:

____
____
____
____

Description of current patterns:

____
____

Other comments (e.g., proximity to developed islands, proximity to natural features, relative visitation frequency, proximity to major traffic areas):

____
____
____
____
____

By: __________ Date: __________

A.12 CHAIN-OF-CUSTODY FORM

SAMPLE I.D.	DATE SAMPLED	TIME SAMPLED	COLLECTION METHOD	CONTAINER TYPE AND NUMBER	SAMPLE TYPE/ REMARKS/PRESERVATIVE	ANALYSIS

RELINQUISHED BY:__________ DATE_____ TIME_____ RECEIVED BY:__________ DATE_____ TIME_____

RELINQUISHED BY:__________ DATE_____ TIME_____ RECEIVED BY:__________ DATE_____ TIME_____

RELINQUISHED BY:__________ DATE_____ TIME_____ RECEIVED BY:__________ DATE_____ TIME_____

CONTACT NAME & TELEPHONE NUMBER:____________________

APPENDIX B

Laboratory Methods and Analytical Protocols

LABORATORY METHODS AND ANALYTICAL PROTOCOLS

B.1 INTRODUCTION

Laboratory methods and analytical protocols for measuring water quality and sediment quality parameters are described in this appendix. Where appropriate, alternate manual methods are described for automated wet chemistry procedures to cover contingencies (e.g., when instruments fail or are unavailable).

Generalized descriptions of laboratory methods for water and sediment samples are presented in Section B.2. Sample preservation and holding times are discussed in Section B.3. As appropriate, standard or published methodologies are presented for water and sediment analyses. Because Environmental Protection Agency (EPA) methods for the water quality parameters of interest were developed for freshwater and wastewater, the detection limits of some of the EPA methods may be inappropriate for the unique nature of the Florida Keys. Therefore, alternative methods, which are analytically similar to EPA methods but are optimized to improve detection limits, are described for these water quality parameters in Section B.4 because they are not available in the open literature. State-of-the-art methods are also described in Section B.4 for low levels of nutrients. These state-of-the-art methods may not be used routinely, but they are appropriate for special monitoring efforts and research studies where very low detection limits are required.

Because of differences between laboratories in terms of instrumentation and capabilities, exact precision and accuracy values are not presented for protocols; rather, the data quality achievable with a particular setup is presented. Laboratories using these methods should develop quality control (QC) procedures to validate and document precision and accuracy standards.

B.2 LABORATORY METHODS

B.2.1 Water Samples

Upon arrival in the laboratory, water samples will be processed as follows:

(a) Alkaline phosphatase activity (APA)
Duplicate 3 mL volumes of unfiltered water samples will be placed in a disposable cuvette and spiked with 30 μl of methylfluorescein phosphate (MFP). The relative fluorescence will then be measured on a fluorometer (e.g., Gilford Fluorometer IV or Turner Instruments Model 112) to determine a T_0 value. After 2 h of incubation at ambient temperatures, the relative fluorescence will be determined for a T_2 value. APA determinations will be performed within 12 h of collection.

(b) Nephelometer turbidity
Subsamples from the unfiltered samples will be removed for the measurement of nephelometer turbidity with a nephelomenter/turbidimeter. Measurements will be read directly from the instrument and reported as nephelometric turbidity units (NTU) as described by EPA protocol (Method 180.1). The instrument will be calibrated with AMCO-AEPA-1 standards (AMCO Standards International).

(c) Dissolved ammonia, nitrate, nitrite, and phosphate
Filtered water samples will be analyzed for dissolved nutrients by automated high sensitivity wet chemical techniques according to the protocols specified by the manufacturer (Alpkem, Inc. or Technicon, Inc.). Sensitivity, precision, accuracy, and reporting requirements are listed in Table B-1. Ammonia will be analyzed by the indophenol method, nitrite by the diazo method, nitrate (as nitrite after cadmium reduction), and phosphate by the ascorbic acid/molybdate method. Dissolved nutrient determinations will be performed

Table B-1. Performance criteria for analytical methods.

Parameter	Method/Range	Units	Limit of Detection	Precision (%)	Accuracy (%)	Completeness	Calibration
Dissolved ammonium	Autoanalyzer 0.1-15 μM	μM	0.1	0.2	97	95	$(NH_4)_2SO_4$
Dissolved nitrate	Autoanalyzer 0.01-20 μM	μM	0.01	0.5	99	95	KNO_3
Dissolved nitrite	Autoanalyzer 0.01-1 μM	μM	0.01	0.5	99	95	KNO_2
Soluble reactive phosphate	Autoanalyzer 0.02-2 μM	μM	0.02	1	97	95	KH_2PO_4
Total N	Hi-temp. oxid. 1-100 μM	μM	1	5	90	90	Urea
Total P	Ignition with $MgSO_4$ 0.1-10 μM	μM	0.1	5	85	90	KH_2PO_4
Alkaline phosphatase activity	Enzyme assay	μM/h	TBA	TBA	TBA	90	Methylfluorescein
Nephelometer turbidity	Nephelometer	ntu	NA	NA	NA	90	AMCO-AEPA-1
Chlorophyll *a*	Fluorometry 0.1-10 μg/L	μg/L	NA	10	95	95	*Anacystis* chl *a* standards

NA: Not applicable
TBA: To be announced

within 24 h of sample collection. Alternatively, samples may be analyzed by manual wet chemistry methods as described below.

(d) Total nitrogen (TN) and total dissolved nitrogen (TDN)
Unfiltered and filtered aliquots will be analyzed for TN and TDN content, respectively. A 1.5 mL sample will be placed in a sample vial and sealed with a Teflon/silicon lined crimp cap and stored at 2 °C until analyzed. Analysis will be performed by oxidation of the sample at high temperature to nitric oxide (NO) and reaction with ozone to form nitrogen dioxide (NO_2). Alternatively, samples may be analyzed by the persulfate digestion method described below. These analyses will be performed within 30 days of sample collection.

(e) Total phosphorus (TP) and total dissolved phosphorus (TDP)
Unfiltered and filtered aliquots will be analyzed for TP and TDP, respectively. A 5 mL sample will be completely mixed with 100 μl of $MgSO_4$ in a scintillation vial and evaporated to dryness at 80 °C in an oven. The evaporated sample will then be ashed at 550 °C for 3.5 h, hydrolyzed with 5 mL of HCl, and incubated overnight at 80 °C. The orthophosphate content of the hydrolyzed sample will then be determined in an autoanalyzer. These analyses will be performed within 30 days of sample collection.

(f) Non-purgeable organic carbon (NPOC)/inorganic carbon
Unfiltered aliquots will be analyzed for NPOC/inorganic carbon by high-temperature combustion and analysis of CO_2 by infra-red gas analysis (e.g., Shimadzu TOC-5000). Samples will be acidified and purged for 8 min with nitrogen prior to analysis for NPOC content, while unacidified and unpurged samples will be analyzed for inorganic carbon content. This analysis will be performed within 7 days of sample collection.

(g) Chlorophyll *a*
The used GF/F glass fiber filters will be stored frozen at -15 °C until analyzed within seven days of sample collection. Each filter will be thawed out and steeped overnight in 1.5 mL of acetone solution at 4 °C. The fluorescence in a 750 μL aliquot of the extract, diluted with 2.25 mL of acetone will be determined in a cuvette using a fluorometer equipped with the appropriate filters.

Performance criteria for the required analytical methods are listed in **Table B-1**.

B.2.2 Sediment Samples

Sediment samples will be stored at about 4°C until analyzed for basic sediment parameters or extracted for heavy metals and organics such as pesticides (known mosquito control agents and right-of-way control herbicides), heavy metals, tributyltin, polychlorinated biphenyls (PCBs), and coprostanol. Basic sediment parameters such as organic matter content, grain-size distribution, and mineralogy will be measured.

B.2.2.1 BASIC SEDIMENT PARAMETERS

Subsamples will be taken to determine grain-size distribution using the Buoyoucos hydrometer method. Prior to analysis, samples will be oxidized to remove organic matter by slowly adding 3% hydrogen peroxide until no visible reaction occurs. A subsample of the cleaned sediment will be set aside for analysis of mineralogy by x-ray diffraction (Royse 1970). Enough sediment for each sample will be cleaned and dried to collect 50 g of dry sediment. Each sample will be placed in a 1000-mL volumetric cylinder and filled to the mark with a 5% sodium hexametaphosphate (Calgon®) solution. The mixture will be stirred thoroughly with a plexiglass plunger and the hydrometer and thermometer placed within the cylinder. The hydrometer and thermometer will be read at 1, 5, 15, 60, and 210 min after stirring. The readings will be used to determine sand, silt, and clay fractions according to the Bouyoucos formula (Royse 1970). Organic matter content will be measured by determining the ash-free dry weight of 50 g aliquots that are oven-dried at 100°C on a tared aluminum cup to constant weight. The pellet will be ignited at 500°C for 6 h in a muffle furnace (Baker and Wolff 1987).

B.2.2.2 HEAVY METALS AND TRIBUTYLTIN

Sediment subsamples will be analyzed for selected heavy metals and tributyltin. Heavy metals will include the following:

- Copper
- Lead
- Zinc
- Cadmium
- Chromium
- Arsenic
- Mercury
- Aluminum

After acid digestion, samples will be analyzed for the trace metals (with the exception of mercury and aluminum) by graphite furnace atomic absorption spectrophotometry. Aluminum will be analyzed by flame atomic absorption spectrophotometry. Mercury will be analyzed in the extracts by cold-vapor atomic absorption (Battelle 1989). Samples will be oven dried at 100°C and 250 mg aliquots will be placed into 100 mL Teflon flasks and 10 mL of HNO_3 and 5 mL of HF added. Additional HNO_3 or HF may be added to complete digestion. After a 2-hour digestion at room temperature, 3 mL of $HClO_4$ will be added and the sample dried on a hot plate set at about 120°C. The residue will be dissolved in 1.0 mL of concentrated HNO_3 and diluted to 10.0 mL with deionized water (Windom et al. 1989). Accuracy and precision of the analytical methods will be checked by analysis of NBS Estuarine Sediment Reference Standards and by intercalibration with other laboratories. Specific procedures will be described by participating laboratories in a QA/QC plan. Recommended performance criteria are presented in **Table B-2.** Heavy metal concentrations will be expressed as μg metal g^{-1} dry sediment.

Sediment subsamples also will be collected for analysis of bis(tri-n-butyltin)oxide (TBT). TBT samples will be air-dried, ground to a fine powder with a mortar and pestle, extracted with methylene chloride, toluene, HBr and tropolone and derivitized. The extracts will be analyzed as total solvent extractable organotin by GC/FPD. Concentrations will be expressed as ng g^{-1} (Uhler *et al.* 1991).

B.2.2.3 EXTRACTABLE ORGANIC COMPOUNDS

Sediment samples will be stored at about 4°C until extracted and analyzed as described below. A general description of the analytical procedures are provided below. Specific field and analytical protocols are described in these documents. Recommended performance criteria are specified in **Table B-2.** Samples will be thawed if necessary and sample splits removed using solvent-cleaned equipment. Surplus samples will be stored under refrigeration for reanalysis if necessary. After 30 days, surplus or archival samples will be stored below -20°C.

Petroleum Hydrocarbons

A first aliquot will be removed and placed in solvent cleaned flasks, extracted with methylene chloride, cleaned up using silica gel, and analyzed by GC-FID for total petroleum hydrocarbons. Results will be reported as concentrations in $\mu g/g$ (National Research Council 1985). The results of analysis for total petroleum hydrocarbons will be used to determine areas of significant contamination. Where high values are found, the fractions of the samples extracted by HPLC as described below can be analyzed for more detailed measurements of aliphatic and aromatic hydrocarbons by GC-MS.

Table B-2. Recommended performance criteria for analysis of heavy metal and extractable organics in sediments and tissues.

			METHOD LIMITS OF DETECTION					
PARAMETER	UNITS	METHOD	SEDIMENT	TISSUE	PRECISION (%)	ACCURACY (%)	COMPLETENESS (%)	CALIBRATION/STANDARD
Al	µg/g dry wt	FAA/GFAA	400	5.0	1	95	95	1000 ppm Al Fisher SA-442
As	µg/g dry wt	GFAA	1.0	1.0	5	95	95	1000 ppm As Fisher SA-449
Cd	µg/g dry wt	GFAA	0.01	1.0	5	95	95	1000 ppm Cd Fisher SC-118
Cr	µg/g dry wt	GFAA	1.0	0.1	5	95	95	1000 ppm Cr Fisher SC-192
Cu	µg/g dry wt	GFAA	1.0	0.5	5	95	95	1000 ppm Cu Fisher SC-194
Hg	µg/g dry wt	CVAA	0.01	0.05	5	95	95	1000 ppm Hg Fisher SA-114
Pb	µg/g dry wt	GFAA	1.0	0.1	5	95	95	1000 ppm Pb Fisher SC-21
Zn	µg/g dry wt	FAA	5.0	5.0	5	95	95	1000 ppm Zn Fisher SC-13
tributyltin	ng/g dry wt	GC-FPD	10.0	10	10	85	95	TBT Series (Alfa, Inc.)
Cythion, Permethrin	ng/g dry wt	GC-ECD	0.5	0.5	10	85	95	NIST Pesticides Standard Sol.
PCB congeners	ng/g dry wt	GC-ECD	2.0	1.0	10	85	95	NIST PCB Congeners Standard Sol.
DDT metabolites	ng/g dry wt	GC-ECD	0.5	5.0	10	85	95	NIST Pesticides Standard Sol.
Atrazine, Triclopyr, 2,4-D	ng/g dry wt	GC-ECD	0.5		10	85	95	NIST Pesticides Standard Sol.
Fenthion, Naled, Temephos	ng/g dry wt	GC-NPD	0.5		10	85	95	NIST Pesticides Standard Sol.
Methoprene	ng/g dry wt	GC-FID	0.5		10	85	95	NIST Pesticides Standard Sol.
Hexazinone, Sulfometuron Glyphosate	ng/g dry wt	GC-Hall	0.5		10	85	95	NIST Pesticides Standard Sol.
Paraquat	ng/g dry wt	HPLC	0.5		10	85	95	NIST Pesticides Standard Sol.
Coprostanol	µg/g dry wt	GC-FID/MS	0.1		10	85	95	coprostanol, 5α-androstan-17β-ol

FAA: Flame Atomic Absorption Spectrophotometry
CVAA: Cold Vapor Atomic Absorption Spectrophotometry
GC-FID: Gas Chromatography-Flame Ionization Detector
GC-Hall: Gas Chromatography-Electrolyitc Conductivity Detector
GC/MS: Gas Chromatography Mass Spectrometry
GFAA: Graphite Furnace Atomic Absorption Spectrophotometry
GC-ECD: Gas Chromatography-Electron Capture Detector
GC-NPD: Gas Chromatography-Nitrogen/Phosphorus Detector
GC-FPD: Gas Chromatography Flame Photometer Detector
HPLC: High Performance Liquid Chromatography

Pesticides and PCBs

The methods for extractable organic compounds such as pesticides, PCBs, and coprostanol will observe the guidance provided in the Phase 4 Work/Quality Assurance Project Plan for the National Status and Trends Program (Battelle 1989) and Standard Analytical Procedures of the NOAA National Analytical Facility 1985-1988, New HPLC Cleanup and Revised Extraction Procedures for Organic Contaminants (Krahn *et al.* 1988) which describes the extraction procedure summarized below.

A second aliquot (10 g) of wet sediment will be placed in a solvent-cleaned and tared bottle, and dewatered by centrifugation and decanting. A similar weight of wet sediment will be processed for dry-weight determination.

Pesticide-grade methylene chloride, appropriate internal standards, and sodium sulfate will be added to each sample bottle. The bottle will then be capped securely, shaken to loosen the contents and rolled overnight. After extraction, the sample will be centrifuged and then decanted into a flask. Then, 100 mL of methylene chloride will be added to the sediment and the bottle will be rolled for another 6 h. The sample will be centrifuged and decanted, and then extracted further with another 100 mL of methylene chloride and rolled overnight. All three extracts will be combined. The combined extract will be concentrated by boiling in a 60°C water bath to a volume of 10-15 mL. The extract is further reduced to about 1 mL volume in a concentrator tube. Then, 3 mL of pesticide-grade hexane will be added and the extract reduced to 2 mL. Field blanks, spiked blanks, reagent blanks, and analyte-calibration solutions will be prepared as appropriate.

Prior to the HPLC procedure, pre-cleanup will be performed by concentrating the extract on a steam table and then filtering by gravity through a glass wool column. The extract will be placed in a centrifuge tube and concentrated to 1.0 mL using a tube heater. HPLC internal standards will be added to the concentrate and aliquots are transferred to labelled GC vials for storage until analyzed. A portion of each extract will be chromatographed with methylene chloride on a calibrated 100-angstrom size exclusion HPLC column. The chromatographed fraction will be collected in a concentrator tube and reduced to a 1.0 mL volume using a tube heater. The procedure will be repeated after adding 2 mL of hexane. GC internal standards (hexamethylbenzene and tetrachloro-m-xylene) will be added and the fraction transferred to a GC vial.

The fraction will be analyzed by GC-ECD for the organophosphorus insecticide Cythion, for the pyrethroid insecticide Permethrin, for Total PCBs, Total DDTs, and for ROW control herbicides such as Atrazine, 2,4-D, and Triclopyr. Fenthion, Naled, and Temephos in the extracts will be analyzed by GC-FPD or NPD. Extracts will be analyzed by GC-FID for Methoprene, an insect growth inhibitor and by GC-Hall for Hexazinone, Sulfometuron-methyl, and Glyphosate. Concentrations of pesticides will be expressed as nanograms per gram dry weight of sediment (ng g^{-1}). Any pesticides identified in samples will be confirmed by gas chromatography/mass spectrometry (GC/MS) analysis.

Coprostanol

The fraction also will be analyzed for coprostanol by capillary gas chromatography with flame ionization detection (FID). An aliquot will also be reacted with acetic anhydride to convert the alcohols to acetate to confirm the analysis. The concentration of coprostanol will be expressed as microgram of coprostanol per gram dry weight of sediment ($\mu g\ g^{-1}$).

B.2.3 Biological Body Burdens

All specimens will be stored frozen at about −20°C until processed. Plant samples will be cleaned with freshwater to remove sediments and epiphytes. All samples will be freeze-dried and homogenized. Each sample will be split for analysis of pesticides, PCBs, heavy metals, and for archival purposes.

Samples will be processed for organic matter content as described above for sediments. Guidance for sampling and analytical methodology will also be taken from the Phase 4 Work/Quality Assurance Project Plan for the National Status and Trends Program (Battelle 1989) and new HPLC procedures of the National Analytical Facility (Krahn et al. 1988). Copper, lead, cadmium, chromium, arsenic, and zinc will be analyzed in samples digested with nitric acid. These digests will be analyzed by GFAA whereas CVAA will be employed for mercury analysis. Pesticides, PCBs, and butyltins will be analyzed in methyl chloride/hexane extracts of subsamples with a modification of the methods described above for sediment. Tissue samples will be analyzed by GC-ECD for toxic organics that have known bioconcentration potential. These include the organophosphorus insecticide Fenthion, PCBs, DDT metabolites, and the herbicide 2,4-D.

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B.3 SAMPLE PRESERVATION AND HOLDING TIMES

The objective of sampling in a monitoring program is generally to determine the value of a chosen parameter in the natural environment at a particular point in space and time. In order to accomplish this, the analytical (physical, chemical, or electrometric) method must be applied before any changes occur in the sample that is taken. While some parameters can be reliably measured *in situ* or in the field, a number of parameters can only be determined by analyzing samples in the laboratory, thereby requiring standardized methods for sampling and preservation to maintain accuracy and repeatability. In practice, a bias or lack of accuracy in the analytical result is almost always introduced that reflects the influence of sample collection, bottle effects, analytical error, operator error, etc. The reported values also have associated with them a level of precision that is affected by these errors.

A number of different factors can affect the concentration of an analyte within a sample that has been removed from its natural environment. Some constituents may be readily taken up by living organisms present in the sample, adsorbed or absorbed by compounds naturally present in the sample or by the surfaces of the sample container, or undergo chemical reactions or changes in valence states. Treatment or processing of the sample can also induce changes such as cytolysis (breakdown of cells), releasing soluble and chemically active components.

No method of preservation is complete. Most recommended preservation methods attempt to do the following:

- Minimize biological activity
- Prevent exposure of the analyte to factors that cause the breakdown or a change in the analyte
- Avoid volatilization
- Minimize absorption and adsorption

There are a number of different methods for sample preservation according to the type of sample and the analyte of interest. These methods generally involve

- pH control
- Addition of preservatives
- Refrigeration
- Freezing

One objective of an analytical chemist is to develop a sampling and analytical protocol that will determine the concentration of an analyte in a sample that closely matches that which occurs in the natural environment. To achieve this, good sampling and analytical protocols minimize the time between removal of the sample from the natural environment and the actual analysis for a particular parameter. Reduction of biological activity can be accomplished by filtration and cooling to freezing temperatures. Cooling also reduces the rate of chemical reactions. Good protocols also involve collecting a sufficient quantity of sample such that any changes in the concentration of an analyte that occur are minimized or are small relative to the total quantity of the analyte within the sample. It is also important to choose the right type and size of sample container for holding the sample so that binding with the container walls is minimized; proper container size also reduces the surface area of sites for chemical reactions and microbial growth that are common sources of biologically mediated changes in analyte concentrations. For some parameters, proper pH control is critical to minimize volatilization, precipitation in high ionic strength solutions, degradation, and changes in valences of the analyte.

Finally, the chosen method of preservation should not adversely affect the subsequent analytical method to be performed on the sample. Some preservation methods (e.g., addition of acid for ammonia samples) would affect the indophenol method, which occurs under basic conditions. As another example, mercuric chloride can precipitate in autoanalyzer columns.

The recommended sample containers, preservation, and maximum holding times for parameters to be measured are listed in **Table B-3**.

Table B-3. Florida Keys National Marine Sanctuary Water Quality Monitoring Program — sample containers, preservation, and maximum holding times

ANALYSIS	SAMPLE CONTAINER AND PRESERVATION	MAXIMUM HOLDING TIME	
		This Program	EPA/FDER REQUIREMENTS
Temperature	NA	Field	Analyze immediately
Salinity	NA	Field	28 d for specific conditions
Dissolved oxygen, membrane	NA	Field	Analyze immediately
pH	NA	Field	Analyze immediately
Light attenuation coefficient	NA	Field	None
Nephelometer turbidity	HDPE or glass	12 h	48 h
Dissolved ammonia (NH_4^+)	HDPE or glass, filter immediately and cool to 4°C	48 h	28 d at < pH 2
Dissolved nitrite/nitrate (NO_2^-, NO_3^-)	HDPE or glass, filter immediately and cool to 4°C	48 h	48 h 28 d at < pH 2
Dissolved phosphate (PO_4^{-3})	HDPE or glass, filter immediately and cool to 4°C	48 h	48 h
Total dissolved nitrogen	HDPE or glass, filter immediately and cool to 4°C	28 d	28 d
Total dissolved phosphorus	HDPE or glass, filter immediately and cool to 4°C	28 d	28 d
Total phosphorus	HDPE or glass, and cool to 4°C	28 d	28 d
Total nitrogen	HDPE or glass, and cool to 4°C	28 d	28 d
Non-purgeable organic carbon/inorganic carbon	HDPE or glass, Cool to 4°C and refrigerate at 2°C	7 d	None
Chlorophyll *a*	HDPE or glass, filter immediately, freeze at -15°C	48 h	None
Alkaline phosphatase activity	HDPE or glass, Hold at ambient temp. in the dark	12 h	None
Basic sediment parameters	Acid-washed glass or HDPE, cool to 4°C, store at 0°C until analyzed	Analyze within 28 d	Not specified

Table B-3. Florida Keys National Marine Sanctuary Water Quality Monitoring Program — sample containers, preservation, and maximum holding times (continued)

ANALYSIS	SAMPLE CONTAINER AND PRESERVATION	MAXIMUM HOLDING TIME	
		This Program	EPA/FDER REQUIREMENTS
Sediment heavy metals except Hg	Nitric acid and solvent washed glass, Teflon-lined cap, cool to 4°C, store at 0°C until analyzed	Analyze within 28 d	Analyze within 6 mos (soils)
Sediment Hg	Nitric acid and solvent washed glass, Teflon-lined cap, cool to 4°C, store at 0°C until analyzed	Analyze within 28 d	Analyze within 28 d
Sediment tributyltin	Nitric acid and solvent washed glass, Teflon-lined cap, cool to 4°C, store at 0°C until analyzed	Extract within 7 d, analyze within 28 d	Extract within 14 d, analyze within 40 d
Sediment pesticides	Solvent washed glass, Teflon-lined cap, cool to 4°C, store at 0°C until analyzed	Extract within 7 d, analyze within 28 d	Extract within 14 d, analyze within 40 d
Sediment PCBs	Solvent washed glass, Teflon-lined cap, cool to 4°C, store at 0°C until analyzed	Extract within 7 d, analyze within 28 d	Extract within 14 d, analyze within 40 d
Sediment petroleum hydrocarbons	Solvent washed glass, Teflon-lined cap, cool to 4°C, store at 0°C until analyzed	Extract within 7 d, analyze within 28 d	Extract within 14 d, analyze within 40 d
Sediment coprostanol	Solvent washed glass, Teflon-lined cap, cool to 4°C, store at 0°C until analyzed	Extract within 7 d, analyze within 28 d	Extract within 14 d, analyze within 40 d
Tissue heavy metals and tributyltin	Polyethylene bags, cool to 4°C, store at 0°C until analyzed.	Extract within 7 d, analyze within 28 d	Not specified
Tissue pesticides, PCBs	Polyethylene bags, cool to 4°C, store at 0°C until analyzed	Extract within 7 d, analyze within 28 d	Not specified

B.4 ANALYTICAL METHODS

Analytical methods are provided below for the parameters included in the water quality monitoring program. Where appropriate, alternate manual methods are provided for automated wet chemistry procedures to cover contingencies. The methods follow the format of EPA (1984).

- Ammonium NH_4^+ (colorimetric, automated, small volume, low to high range).
- Ammonium NH_4^+ (spectrophotometric, manual, small volume, low to mid range).
- Ammonium NH_4^+ (fluorometric, automated, small volume, ultralow range).
- Nitrite NO_2^- (colorimetric, automated, small volume, low to mid range).
- Nitrate NO_3^- (cadmium reduction, colorimetric, automated, small volume, low to medium range).
- Nitrite NO_2^- (spectrophotometric, manual, small volume, low to medium range).
- Nitrate NO_3^- (cadmium reduction, colorimetric, automated, small volume, low to medium range).
- Total nitrogen and total dissolved nitrogen (high temperature combustion, gas chromatography).
- Total nitrogen and total dissolved nitrogen (persulfate digestion, spectrophotometric, manual, large volume).
- Soluble reactive phosphorus/orthophosphate PO_4^{-3} (colorimetric, automated, small volume, low to mid range).
- Soluble reactive phosphorus (spectrophotometric, manual, medium volume, low range).
- Soluble reactive phosphate and total dissolved phosphate (co-precipitation/spectrophotometry/colorimetry, manual/automated, high volume, ultralow range).
- Total phosphorus and total dissolved phosphorus (high temperature digestion, manual, small volume, low range).
- Non-purgeable organic carbon and inorganic carbon (high temperature combustion with infra-red detection, automated, small volume, low to high range).
- Chlorophyll *a* and phaeophytin concentrations (fluorometric, manual).
- Alkaline phosphatase activity (fluorometric, manual).

AMMONIUM NH_4^+

(Colorimetric, automated, small volume, low to high range)

1. Scope and Application

1.1 This method is applicable for the determination of ammonium in terrestrial groundwater, submarine groundwater, marine, and estuarine water containing ammonium in the 0.1-30.00 μM range. Higher concentrations may be analyzed after dilution. The method is recommended for large numbers of samples when logistical considerations require small volumes of samples.

2. Summary of Method

2.1 Alkaline phenol and hypochlorite react to form indophenol blue. The blue color formed is intensified with sodium nitroprusside. The color is proportional to the concentration of ammonium in the sample.

3. Sample Handling and Preservation

3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h.

3.2 Submarine or terrestrial groundwater containing a significant amount of sulfides are acidified with 1N HCl and purged prior to analysis.

3.3 HDPE or glass containers may be used after acid-washing with ammonia-free dilute HCl solution.

4. Interferences

4.1 Calcium and magnesium can precipitate during analysis. A sodium potassium tartrate solution is used to prevent precipitate formation.

4.2 High concentrations (millimolar) of sulfide or the low redox potential associated with the sample can cause interference in the indophenol method during color development.

4.3 Metal-sulfide salts can also precipitate in the flow cells of an autoanalyzer and degrade them.

4.4 Sample color or turbidity that absorbs in the photometric range may also interfere.

4.5 At low ranges, sample contamination from atmospheric sources is common. Ammonia analysis should be conducted in a very clean environment. Strong ammonia solutions should not be used in the laboratory during the analysis.

4.6 At low ranges, scrupulously clean labware is required. If the acid-wash can be kept free from ammonia, labware should be acid-washed and thoroughly rinsed with copious deionized water immediately before use. Unless labware is rinsed free of acid, the residual acid may act as a scavenger of ammonia from the atmosphere.

5. Apparatus and Materials

5.1 The Technicon Autoanalyzer Unit or Alpkem Rapid Flow Analyzer (RFA) Unit consist of a

- Sampler
- Manifold or analytical cartridge
- Proportioning pump
- Temperature control
- Colorimeter
- Recorder or integrator

6. Reagents

6.1 Ammonia-free Deionized Water: Only fresh deionized water should be used in this analysis. Deionized water that has been stored is subject to contamination from the air. Distilled water may be used after passing it through a deionizing column with strong acidic cation and strongly basic anion resins. [*NOTE:* All solutions must be made up with ammonia-free deionized water.]

6.2 Synthetic Seawater or Gulfstream Water: Standard solutions and cuvette blanks should be made up with ammonia-free solutions of the same ionic strength as the samples. The recommended matrix is Sargasso Sea or Gulfstream axis water that has been filtered through pre-combusted glass fiber filters. If this is not available, synthetic seawater may be made up with low-nitrogen analytical grade chemicals as follows:

- NaCl — 31 g/L
- $MgSO_4 \cdot 7H_2O$ — 10 g/L
- $NaHCO_3$ — 0.05 g/L

6.3 Formulations of the following reagents according to the instrument manufacturer's specifications:

- Hypochlorite solution
- Sodium hydroxide solution
- Sodium citrate solution
- Phenol/nitroprusside solution

6.4 Ammonia Standard Stock Solution: Dissolve 100 mg ammonium sulfate $(NH_4)_2SO_4$ in deionized water and make up to 1 L. Preserve with 1 mL chloroform. Store in glass at 4 °C. This solution is stable for several months if well stoppered.

1 mL of the stock solution contains 1.5 μg atoms NH_4^+.

Prepare dilutions for high range standards with Gulfstream water as follows:

mL of stock	dilute to	μM concentration
2.0	100 mL	30.00
1.0	100 mL	15.00
0.5	100 mL	7.50
0.2	100 mL	3.00

Prepare dilutions for low range standards with Gulfstream water as follows:

mL of stock	dilute to	μM concentration
0.10	100 mL	1.50
0.05	100 mL	0.75
0.02	100 mL	0.30
0.01	100 mL	0.15

7. Procedure

7.1 Allow electronics to warm up and stabilize.

7.2 Set up the manifolds or cartridges according to the manufacturer's instructions for the appropriate range.

7.3 Run the proportioning pump at the recommended speed while feeding deionized water through the sample line and obtain a stable baseline with reagents.

7.4 Place the appropriate ammonium standards in the sampler in order of decreasing concentration and complete loading of the sample tray with unknown samples.

7.5 Switch sample line to sampler and start analysis.

8. Calculation

8.1 Prepare appropriate standard curves derived from passing NH_4^+ standards through the autoanalyzer manifold. Compute sample concentrations by comparing sample peak heights against standard curve. While sample concentrations may be automatically computed, a record of absorbancies of the blanks and standards should be kept.

9. Precision and Accuracy

9.1 At the 1 μM range with a 10-cm path length, the precision should be better than $\pm$ 0.05 μM.

References

EPA. 1984. Methods for chemical analysis of water and wastes. EPA-600/4-79-020. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring and Support Laboratory, Cincinnati, OH.

Koroleff, F. 1983. Determination of ammonia. In K. Grassoff, M. Erhardt, and K. Kremeling, *Methods of seawater analysis*. Verlag Chemie, Weinheim, Germany.

AMMONIUM NH_4^+

(Spectrophotometric, manual, small volume, low to mid-range)

1. Scope and Application

1.1 This method is applicable for the determination of ammonium in terrestrial groundwater, submarine groundwater, marine, and estuarine water containing ammonium in the 0.1-30.00 μM range. Higher concentrations may be analyzed after dilution. The method is recommended as an alternative to automated procedures when at least 10 mL of sample is available. The method is modified from the procedures described by Koroleff (1983).

2. Summary of Method

2.1 This method is based on the formation of the blue color of indophenol by phenol and hypochlorite in the presence of ammonia.

3. Sample Handling and Preservation

3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h.

3.2 Submarine or terrestrial groundwater containing a significant amount of sulfides are acidified with 1N HCl and purged prior to analysis.

3.3 HDPE or glass containers may be used after acid-washing with ammonia-free dilute HCl solution.

4. Interferences

4.1 Calcium and magnesium can precipitate during analysis. A sodium potassium tartrate solution is used to prevent precipitate formation.

4.2 High concentrations (millimolar) of sulfide or the low redox potential associated with the sample can cause interference in the indophenol method during color development.

4.3 Sample color or turbidity that absorbs in the photometric range may also interfere.

4.4 At low ranges, sample contamination from atmospheric sources is common. Ammonia analysis should be conducted in a very clean environment. Strong ammonia solutions should not be used in the laboratory during the analysis.

4.5 At low ranges, scrupulously clean labware is required. If the acid-wash can be kept free of ammonia, labware should be acid-washed and thoroughly rinsed with copious deionized water immediately before use. Unless labware is rinsed free of acid, the residual acid may act as a scavenger of ammonia from the atmosphere.

5. Apparatus and Materials

5.1 10 mL automatic pipettes
5.2 0.3 mL automatic pipettes
5.3 100 mL volumetric flasks
5.4 Spectrophotometer
5.5 Cuvettes

6. Reagents

6.1 0.5 N Sodium Hydroxide: Dissolve 20 g NaOH in deionized water and dilute to 1 L.

6.2 REAGENT A. Trisodium Citrate Reagent: Dissolve 30 g trisodium citrate dihydrate ($C_6H_5Na_3O_7 \cdot 2H_2O$) in ca. 60 mL deionized water. Add 2.5 mL of 0.5 N NaOH. Store in refrigerator in glass with plastic or glass stopper.

6.3 REAGENT B. Phenol Reagent: Dissolve 9.5 g C_6H_5OH (phenol) or 10.8 mL of 88% phenol stock solution and 100 mg of disodium nitroprusside dihydrate ($Na_2Fe(CN)_5NO \cdot 2H_2O$) in deionized water and dilute to 250 mL. Store in refrigerator in amber glassware; it will be stable for months.

6.4 REAGENT C. Hypochlorite Reagent: Dissolve 0.05 g of Trione (dichloroisocyanuric acid) in 20 mL of 0.5 NaOH. [*NOTE:* Prepare a fresh solution each day.]

6.5 Ammonia Standard Stock Solution: Dissolve 100 mg ammonium sulfate, $(NH_4)_2SO_4$, in deionized water and dilute to 1 L. Preserve with 1 mL chloroform. Store in glass at 4 °C. This solution is stable for several months if well stoppered.

1 mL of the stock solution contains 1.5 μg atoms N-NH_4^+.

Prepare dilutions with deionized water as follows:

mL stock	dilute to	μM concentration
1.00	100	15.0
0.50	100	7.5
0.20	100	3.0
0.10	100	1.5
0.05	100	0.75

7. Procedure

7.1 Rinse test tubes and caps once with 15% HCl and four times with deionized water immediately before starting the procedure. Shake out excess drops of water and keep tubes inverted and capped until used.

7.2 To avoid contamination of samples and reagents, all containers should be tightly capped until needed for use.

7.3 Pipette 10 mL of sample into a test tube. To each test tube:

a) Add 0.3 mL of Reagent A and shake/vortex.

b) Immediately add 0.3 mL of Reagent B and shake/vortex.

c) Immediately add 0.3 mL of Reagent C and shake/vortex.

7.4 Cap the tubes tightly with parafilm. Let the reaction proceed in the dark for at least 6 h, preferably overnight.

7.5 Prepare blanks and standards by adding reagents as above to 10 mL volumes of seawater water blanks and standards. Allow color development to proceed for at least 6 h.

7.6 When samples and standards are ready for the reading of absorbance, prepare reagent blanks using 10 mL of seawater. Add reagents as above. Measure absorbance immediately.

7.7 Set the spectrophotometer to 630 nm wavelength and adjust to read zero with Gulfstream water or synthetic seawater in a 1 cm pathlength cuvette. Longer pathlengths will increase sensitivity proportionately.

8. Calculation

8.1 Compute sample concentrations by comparing sample peak heights against standard curve. While sample concentrations may be automatically computed, a record should be kept of the absorbances of the blanks and standards.

9. Precision and Accuracy

9.1 At the 1 μM level, precision should be better than 0.1 μM with a 1-cm path length.

References

Koroleff, F. 1983. Determination of ammonia. In K. Grassoff, M. Erhardt, and K. Kremeling. *Methods of seawater analysis*. Verlag Chemie, Weinheim, Germany.

AMMONIUM NH_4^+
(Fluorometric, automated, small volume, ultralow range)

1. Scope and Application

1.1 This method is recommended for use in natural (fresh or seawater) waters containing nanomolar ranges of ammonium (NH_4^+). The method is an improvement over the method of Aoki et al. (1983) and Willason and Johnson (1986). Up to 30 samples in the nanomolar range may be analyzed with this method.

2. Summary of Method

2.1 Ammonium in nanomolar concentrations are analyzed by diffusion of ammonia gas (NH_3) through a Teflon membrane into a *o*-phthaldialdehyde solution where a fluorescent complex is formed. Ammonium in solution is converted to ammonia gas under basic conditions. The concentration of fluorescent material is measured in a fluorometer. The carrier solution is acidified to < pH 3 which maintains any contaminating ammonia in the carrier in solution. The NaOH-citrate solution is stripped of ammonia contaminants by passing the solution through a microporous Teflon column immersed in 10% sulfuric acid.

3. Sample Handling and Preservation

3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h. Do not preserve samples with mercuric chloride or by addition of H_2SO_4.

4. Interferences

4.1 Dissolved free amino acids (DFAA) were reported not to cause significant interferences. The low concentrations of volatile amines in the natural environment will cause only minimal interferences.

4.2 At these very low ranges, sample contamination from atmospheric sources is common. Ammonia analysis should be conducted in a very clean environment. Strong ammonia solutions should not be used in the laboratory during the analysis.

4.3 Scrupulously clean labware is required. If the acid-wash can be kept free of ammonia, labware should be acid-washed and thoroughly rinsed with copious deionized water immediately before use. Unless labware is rinsed free of acid, the residual acid may act as a scavenger of ammonia from the atmosphere.

5. Apparatus and Materials

5.1 The apparatus consists of the following components:

Autoanalysis tubing:

	Tube ratings	Effective flow at 25% of pump rate
Carrier solution:	0.60 mL min^{-1}	1.00 mL min^{-1}
NaOH-citrate:	0.05 mL min^{-1}	0.09 mL min−1
OPA solution	0.32 mL min^{-1}	0.61 mL min^{-1}
Samples:	1.20 mL min^{-1}	2.03 mL min^{-1}

Ammonia stripping block (1 m 2.0 mm i.d., 2.0 μm poresize, W.L. Gore Co.)
Proportioning pump (Ismatec 16-channel, Coleman Instrument Co.)
Injection loop (1.0 mL)
Injection valve (Teflon rotary, Rheodyne Inc.)
Diffusion cell (30.1 cm Technicon AAII block diffuser, A-87-03 Technicon)
Teflon diffusion membrane (nonlaminated hydrophobic Goretex, 0.45 μm poresize, W.L. Gore Co.)
PTFE mixing coil (25 cm)
Constant temperature cabinet (35 ± 0.2 °C)
Fluorescence Detector (Hitachi F-1050, excitation 335 nm; emission 470 nm; time constant, 3 secs; sensitivity, 100, Hitachi, Ltd.)
Computer control system (E-Lab Lab integration package, OMS Tech)

6. Reagents

6.1 0.25 M Borate Buffer: Dissolve 15.46 g of reagent grade H_3BO_4 in 1000 mL of deionized water adjusted to pH 9.50 with 10N NaOH.

6.2 OPA Reagent: Dissolve 100 mg of *o*-phthaldialdehyde (Sigma Chem. Co) in 2 mL of methanol and 500 µl of 2-mercaptoethanol (Sigma) and add to 1000 mL of 0.25 M borate buffer in a clean amber glass bottle. Deoxygenate the solution for 20 min by bubbling 200 mL O_2-free N_2 per minute. Allow to stand for 24 h prior to use to let background fluorescence decay. Store capped at room temperature. Use reagents within 72 h after preparation.

6.3 NaOH-sodium citrate: Dissolve 200 g of reagent grade sodium citrate and 18.0 g NaOH in 950 mL of deionized water. Store in tightly capped HDPE or glass bottle with silicone stopper with the headspace purged with N_2.

6.4 Carrier Solution: Add 8 mL concentrated H_2SO_4 to 4,000 mL of deionized water. Store in tightly capped HDPE or glass bottle with silicone stopper with the headspace purged with N_2.

6.5 10% H_2SO_4: Store in tightly capped HDPE or glass bottle with silicone stopper with the headspace purged with N_2.

6.6 Ammonium Standard Stock Solution: Dissolve 100 mg ammonium sulfate, $(NH_4)_2SO_4$, in deionized water and dilute to 1 L. Preserve with 1 mL chloroform. Store in glass at 4 °C. This solution is stable for several months if well stoppered.

1 mL of the stock solution contains 1.5 µg atoms N-NH_4^+.

6.7 Ammonium Standard Working Solution: Dilute 1 mL of the ammonium standard to 1000 mL.

1 mL of the working solution contains 1.5 ng atoms N-NH_4^+.

Prepare selected dilutions with filtered Gulfstream water as follows:

mL of stock	dilute to	nM concentration
100.0	use as is	150.0
50.0	100 mL	75.0
20.0	100 mL	30.0
10.0	100 mL	15.0
5.0	100 mL	7.5
2.0	100 mL	3.0
1.0	100 mL	1.5

7. Procedure

7.1 Allow the electronics and temperature cabinet to warm up to stable temperature.

7.2 Run the proportioning pump at 25% of full speed and obtain a stable baseline by running deionized water and all reagents through the sample line.

7.3 Place the appropriate ammonium standards in the sampler in order of decreasing concentration and complete loading of the sample tray with unknown samples.

7.4 Switch sample line to sampler and start analysis.

8. Calculation

8.1 Prepare appropriate standard curves derived from passing NH_4^+ standards through the autoanalyzer manifold. Compute sample concentrations by comparing sample peak heights against standard curve.

9. Precision and Accuracy

9.1 Jones (1991) reported a limit of detection of 1.1 nM using Sargasso Sea seawater and 1.2 nM using deionized water. He reported a standard deviation of 0.25 nM for an analysis of 5 replicate Gulfstream samples with a mean concentration of 18.1 nM.

References

Aoki, T., S. Uemura, and M. Munemari. 1983. "Continuous flow fluorometric determination of ammonia in seawater." Mar. Chem. 55:1620-1622.

Jones, R.D. 1991. "An improved fluorescence method for the determination of nanomolar concentrations of ammonium in natural waters." Limnol. Oceanogr. 36:814-819.

Willason, S.W., and K.S. Johnson. 1986. "A rapid highly sensitive technique for determinations of ammonia in seawater." Mar. Biol. 91:285-290.

NITRITE NO_2^-
(Colorimetric, automated, small volume, low to mid range)

1. **Scope and Application**
   1.1 This method is applicable for the determination of nitrite in terrestrial groundwater, submarine groundwater, marine, and estuarine water. Nitrite is typically found in low concentrations (below 0.5 μM) in natural seawater. The applicable range of this procedure is 0.01 to 5 μM.

2. **Summary of Method**
   2.1 The analysis is based on the method of Bendschneider and Robinson (1952). The nitrite in a filtered sample is diazotized with sulfanilamide and coupled with N-(1-naphthyl)-ethylenediamine dihydrochloride (NNED) to form a highly colored azo dye that is measured colorimetrically.

3. **Sample Handling and Preservation**
   3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h.
   3.2 HDPE or glass containers are used for sample collection.
   [*CAUTION:* Samples must not be preserved with mercuric chloride.]

4. **Interferences**
   4.1 High concentrations of iron, copper or other metals can result in low values.
   4.2 The high solubility of nitrite in water precludes binding to sediments or container walls. There are minimal sources of contamination for this compound.
   4.3 A small salt-effect is corrected by preparing standards and blanks with synthetic or Gulfstream water.

5. **Apparatus and Materials**
   5.1 The Technicon Autoanalyzer Unit or Alpkem RFA Unit consist of a
   - Sampler
   - Nitrite manifold or analytical cartridge
   - Proportioning pump
   - Temperature control
   - Colorimeter
   - Recorder or integrator

6. **Reagents**
   6.1 Synthetic Seawater or Gulfstream Water: Using deionized water, prepare the following solution:
   - $NaCl$ — 31 g/L
   - $MgSO_4 \cdot 7H_2O$ — 10 g/L
   - $NaHCO_3$ — 0.05 g/L

   6.2 Formulations of the following solution according to the instrument manufacturer's specifications:
   Sulfanilamide solution
   NNED solution

   6.3 Nitrite Standard Stock Solution: Dissolve 8.511 g of oven-dried (100 °C for 1 h) anhydrous potassium nitrite (KNO_2) in 1000 mL of deionized water. Add 1 mL of chloroform as preservative and store in a brown glass bottle at 4 °C. Discard if brown coloration develops.

   1 mL of the stock solution contains 100 μg atoms N-NO_2.

   6.4 Nitrite Standard Working Solution: Prepare a working standard solution by diluting 5.0 mL of the standard stock solution to 500 mL with deionized water in a volumetric flask.

   1 mL of the working solution contains 1 μg atoms NO_2^-.

Prepare a medium range set of standards by dilutions of the working standard solution with synthetic seawater or Gulfstream water:

mL of stock	dilute to	μM concentration
0.500	100 mL	5.0
0.100	100 mL	1.0
0.050	100 mL	0.5

Prepare a low range of standards by dilutions of the 1.0 μM standard with synthetic seawater or Gulfstream water.

mL of 1.0 μM	dilute to	μM concentration
100	use as is	1.00
0.50	100 mL	0.50
0.20	100 mL	0.20
0.10	100 mL	0.10
0.01	100 mL	0.01

7. Procedure

7.1 Allow electronics to warm up and stabilize.
7.2 Set up the manifolds or cartridges according to the manufacturers instructions for the appropriate range.
7.3 Run the proportioning pump at the recommended speed while feeding deionized water through the sample line, and obtain a stable baseline with reagents.
7.4 Place the appropriate standards in the sampler in order of decreasing concentration and complete loading of the sample tray with unknown samples.
7.5 Switch sample line to sampler and start analysis.

8. Calculation

8.1 Prepare appropriate standard curves derived from passing NO_2^- standards through the autoanalyzer manifold. Compute sample concentrations by comparing sample peak heights against the standard curve.

9. Precision and Accuracy

9.1 Using a 10-cm path length, the precision of the method should be better than ± 0.01 μM.

References

Bendschneider, K., and R.J. Robinson. 1952. "A new spectrophotometric method for the determination of nitrite in seawater." J. Mar. Res. 11:87-96.

EPA. 1984. Methods for chemical analysis of water and wastes. EPA-600/4-79-020. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring and Support Laboratory, Cincinnati, OH.

Grassoff, F. 1983. Determination of nitrite. In K. Grassoff, M. Erhardt, and K. Kremeling, *Methods of seawater analysis*. Verlag Chemie, Weinheim, Germany.

Strickland, J.D.H., and T.R. Parsons. 1972. *A practical handbook of seawater analysis*. Fisheries Research Board of Canada, Ottawa, Canada.

NITRATE NO_3^-

(Cadmium reduction, colorimetric, automated, small volume, low to medium range)

1. **Scope and Application**
   1.1 This method is applicable for the determination of nitrate in terrestrial groundwater, submarine groundwater, marine, and estuarine water. The applicable range for this procedure is 0.01 to 5 μM.

2. **Summary of Method**
   2.1 Nitrate is reduced to nitrite under buffered conditions through a copperized cadmium column. The nitrite is diazotized with sulfanilamide and coupled with NNED to form a highly colored azo dye which is measured colorimetrically.

3. **Sample Handling and Preservation**
   3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h.
   3.2 HDPE or glass containers are used for sample collection.
   [*CAUTION:* Samples must not be preserved with mercuric chloride.]

4. **Interferences**
   4.1 High concentrations of iron, copper or other metals can result in low values.
   4.2 The high solubility of nitrate in water precludes binding to sediments or container walls. There are minimal sources of contamination for this compound.
   4.3 A small salt-effect is corrected by preparing standards and blanks with synthetic or Gulfstream water.

5. **Apparatus and Materials**
   5.1 The Technicon Autoanalyzer Unit or Alpkem RFA Unit consist of:
   - Sampler
   - Nitrate manifold or analytical cartridge
   - Proportioning pump
   - Temperature control
   - Colorimeter
   - Recorder or integrator

6. **Reagents**
   6.1 Synthetic Seawater: using deionized water, prepare the following solution:
   - $NaCl$ — 31 g/L
   - $MgSO_4 \cdot 7H_2O$ — 10 g/L
   - $NaHCO_3$ — 0.05 g/L

   6.2 Formulations of the following solution according to the instrument manufacturer's specifications:
   Sulfanilamide solution
   NNED solution
   Ammonium chloride/imidiazole buffer
   HCl acid solution
   Copper sulfate solution

   6.3 Nitrate Standard Stock Solution: Dissolve 10.106 g of anhydrous KNO_3 in approximately 500 mL deionized water and diluted to 1 L. The solution is preserved with 1 mL chloroform and should be kept refrigerated. This solution is stable for 6 months.

   1 mL of the stock solution contains 100 μg atoms N-NO_3.

   6.4 Nitrate Standard Working Solution: Dilute 5.0 mL of the standard stock solution to 500 mL of deionized water in a volumetric flask.

1 mL of the working solution contains 1 μg atoms NO_3^-.

Prepare a medium range set of standards by dilutions of the working standard solution with synthetic seawater or Gulfstream water:

mL of stock	dilute to	μM concentration
0.500	100 mL	5.0
0.100	100 mL	1.0
0.050	100 mL	0.5

Prepare a low range set of standards by dilutions of the 1.0 μM standard with synthetic seawater or Gulfstream water.

mL of 1.0 μM	dilute to	μM concentration
0.50	100 mL	0.50
0.20	100 mL	0.20
0.10	100 mL	0.10
0.01	100 mL	0.01

7. **Procedure**
    - 7.1 Allow electronics to warm up and stabilize.
    - 7.2 Set up the manifolds or cartridges according to the manufacturer's instructions for the appropriate range.
    - 7.3 Run the proportioning pump at recommended speed while feeding deionized water through the sample line and obtain a stable baseline with reagents.
    - 7.4 Place the appropriate standards in the sampler in order of decreasing concentration and complete loading of the sample tray with unknown samples.
    - 7.5 Switch sample line to sampler and start analysis.

8. **Calculation**
    - 8.1 Prepare appropriate standard curves derived from passing NO_3^- standards through the autoanalyzer manifold. Compute sample concentrations by comparing sample peak heights against standard curve. This value is the concentration of nitrite and nitrate in the sample. To determine nitrate concentrations, deduct nitrite concentrations from the value determined.

9. **Precision and Accuracy**
    - 9.1 Using a 10-cm pathlength, the precision of the method should be better than $\pm$ 0.01 μM.

References

EPA. 1984. Methods for chemical analysis of water and wastes. EPA-600/4-79-020. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring and Support Laboratory, Cincinnati, OH.

Grassoff, K. 1983. Determination of nitrate. In K. Grassoff, M. Erhardt, and K. Kremeling, *Methods of seawater analysis*. Verlag Chemie, Weinheim, Germany.

Strickland, J.D.H., and T.R. Parsons. 1972. *A practical handbook of seawater analysis*. Fisheries Research Board of Canada, Ottawa, Canada.

NITRITE NO_2^-
(Spectrophotometric, manual, small volume, low to medium range)

1. Scope and Application

1.1 This method is applicable for the determination of nitrite in terrestrial groundwater, submarine groundwater, marine, and estuarine water. Nitrite is typically found in low concentrations (below 0.5 μM) in natural seawater. The applicable range of this procedure is 0.1 to 5 μM.

2. Summary of Method

2.1 The nitrite in a filtered sample is diazotized with sulfanilamide and coupled with NNED to form a highly colored azo dye which is measured on a spectrophotometer.

3. Sample Handling and Preservation

3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h.

3.2 HDPE or glass containers are used for sample collection.
[*CAUTION:* Samples must not be preserved with mercuric chloride]

4. Interferences

4.1 High concentrations of iron, copper, or other metals can result in low values.

4.2 The high solubility of nitrite in water precludes binding to sediments or container walls. There are minimal sources of contamination for this compound.

4.3 A small salt-effect is corrected by preparing standards and blanks with synthetic or Gulfstream water.

5. Apparatus and Materials

- Test tubes
- 10 mL automatic pipettes
- 100 μL automatic pipettes
- Spectrophotometer
- 1 cm cuvettes

6. Reagents

6.1 REAGENT A. Sulfanilamide Solution: Dissolve 10 g sulfanilamide in 200 mL concentrated HCl and dilute to 1 L. Solution is stable for several months.

6.2 REAGENT B. NNED Solution: Dissolve 1 g NNED, dilute with deionized water to 1 L. Renew solution once a month or a strong brown coloration will develop.

6.3 Nitrite Standard Stock Solution: Dissolve 8.511 g of oven-dried (100 °C for 1 h) anhydrous potassium nitrite (KNO_2) in 1000 mL of deionized water. Add 1 mL of chloroform as preservative and store in a brown glass bottle at 4 °C. Discard if brown coloration develops.

1 mL of the stock solution contains 100 μg atoms N-NO_2.

6.4 Nitrate Standard Working Solution: Dilute 5 mL of standard stock solution to 500 mL with deionized water.

1 mL of the working solution contains 1 μg atoms N-NO_2.

Prepare dilutions with Gulfstream water or synthetic seawater as follows:

mL of stock	dilute to	μM concentration
0.20	100	2.00
0.10	100	1.00
0.05	100	0.50
0.10	100	0.01

7. Procedure

7.1 Pipette 10 mL of sample into a test tube.

7.2 Add 0.2 mL of sulfanilamide reagent. Vortex and allow reagent to react for 2-8 min.

7.3 Add 0.2 mL of NNED reagent and vortex. Allow a minimum of 10 min for color development.

7.4 Prepare a reagent blank using Gulfstream water or synthetic seawater and add reagents as above.

7.5 Set spectrophotometer to 543 nm wavelength and adjust to zero using Gulfstream water or synthetic seawater in a 1-cm pathlength cuvette. Take all absorbance readings within 2 h of adding color reagents.

8. Calculation

8.1 Prepare appropriate standard curves derived from passing NO_2^- standards through the autoanalyzer manifold. Compute sample concentrations by comparing sample peak heights against standard curve.

9. Precision and Accuracy

9.1 Using a 1-cm path length, the precision of the method should be better than ± 0.1 μM.

References

Grassoff, K. 1983. Determination of nitrite. In K. Grassoff, M. Erhardt, and K. Kremeling, *Methods of seawater analysis*. Verlag Chemie, Weinheim, Germany.

Parsons, T.R., Y. Maita, and C.M. Lalli. 1984. *A manual of chemical and biological methods for seawater analysis*. Pergamon Press, Oxford, England.

NITRATE NO_3^-
(Cadmium reduction, spectrophotometric, manual, small volume, low to medium range)

1. Scope and Application

1.1 This method is applicable for the determination of nitrate in terrestrial groundwater, submarine groundwater, marine, and estuarine water. The applicable range for this procedure is 0.1 to 5 μM. The method requires 50 mL of sample for analysis.

2. Summary of Method

2.1 Nitrate is reduced to nitrite under buffered conditions through a copperized cadmium column. The nitrite is diazotized with sulfanilamide and coupled with NNED to form a highly colored azo dye which is measured colorimetrically.

3. Sample Handling and Preservation

3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h.

3.2 HDPE or glass containers are used for sample collection.
[*CAUTION:* Samples must not be preserved with mercuric chloride.]

4. Interferences

4.1 High concentrations of iron, copper or other metals can result in low values.

4.2 The high solubility of nitrate in water precludes binding to sediments or container walls. There are minimal sources of contamination for this compound.

4.3 A small salt-effect is corrected by preparing standards and blanks with synthetic or Gulfstream water.

5. Apparatus and Materials

5.1 Nitrate reduction apparatus
5.2 10 mL automatic pipettes
5.3 0.2 mL automatic pipettes
5.4 100 mL volumetric flasks
5.5 Spectrophotometer
5.6 1 cm cuvettes

6. Reagents

6.1 Concentrated Ammonium Chloride: Dissolve 125 g ammonium chloride (NH_4Cl) in 500 mL deionized water. Store in plastic or glass bottle.

6.2 Dilute Ammonium Chloride: Dilute 50 mL of concentrated ammonium chloride to 2000 mL deionized water. Store in plastic or glass bottle.

6.3 1 N HCl: Dilute concentrated HCl.

6.4 2% Copper Sulfate: Dissolve 20 g $CuSO_4$ in 250 mL of deionized water and dilute to 1000 mL.

6.5 REAGENT A. Sulfanilamide reagent — as above.

6.6 REAGENT B. NNED reagent — as above.

6.7 Nitrate Standard Stock Solution: Dissolve 10.106 g of anhydrous KNO_3 in about 500 mL deionized water and diluted to 1 L. The solution is preserved with 1 mL chloroform and should be kept refrigerated. This solution is stable for 6 months.

1 mL of the stock solution contains 100 μg atoms N-NO_3.

6.8 Nitrate Standard Working Solution: Dilute 5 mL of standard stock solution to 500 mL with deionized water.

1 mL of the working stock solution contains 1 μg atoms N-NO_3.

Prepare standards with Gulfstream water or synthetic seawater as follows:

mL of stock	dilute to	μM concentration
5.0	100	50.0
2.5	100	25.0
1.0	100	10.0
0.5	100	5.0
0.1	100	1.0

7. Procedure

7.1 The Cu-Cd reduction column is prepared by treating enough cadmium granules for the number of columns needed with the following solutions:

a) 1 N HCl — new cadmium granules will appear silvery whereas used cadmium will show a dull gray color.

b) Deionized water — wash the cadmium granules in several changes of ionized water until the wash is no longer acidic.

c) 2% copper sulfate — add enough solution to the cadmium slurry until there is just a suggestion of blue color, indicating an excess of copper sulfate. At this point the granules should appear black.

d) Deionized water — wash the slurry with deionized water until all colloidal material has been removed. Gently swirl the mixture while washing.

e) Dilute ammonium chloride — wash the slurry with three changes of dilute ammonium chloride. After this point, the cadmium slurry should always be kept under a solution and away from air. Exposure to air will ruin the copper-cadmium slurry.

7.2 Set up the columns on their stands and insert copper shavings into the bottom of each column. Fill the columns with dilute ammonium chloride. Carefully fill the column with the copperized cadmium granules. Continuously tap the sides of the column to avoid dead spaces. Leave about 1 in. of clearance from the top of the cadmium to the base of the upper vessel. Fill the top with a glass wool plug. Care must be taken to avoid exposing the reduction column to air. Keep the tip of the drip tub above the top of the cadmium column to prevent accidentally exposing the column to air.

7.3 The column is conditioned for use by passing 100 mL of dilute ammonium chloride solution and activated by passing 500 mL of 50 μg atoms N-NO_3 standard solution buffered with 10 mL of concentrated NH_4Cl solution.

7.4 Pipette 50 mL of sample in acid-washed centrifuge tubes and 1 mL of concentrated ammonium chloride solution. Mix thoroughly.

7.5 Immediately introduce the sample into the cadmium column. Let 25 mL of the treated sample pass through the reduction column with the flow speed adjusted to 1 mL per minute.

7.6 Discard the first 25 mL of reduced sample. Pass the remaining sample through the reduction column at the same speed and collect the last 25 mLs in a centrifuge tube. Pipette 10 mL for nitrite analysis.

7.7 To each 10 mL sample,

a) Add 0.2 mL of sulfanilamide reagent. Vortex and allow the reaction to proceed for 2-8 min.

b) Add 0.2 mL of NNED reagent and vortex. Allow 20 min for color development.

7.8 Prepare a blank using 50 mL of synthetic seawater or dilute ammonium chloride. Pass the blank through the reduction column as above. Add reagents as above.

7.9 Set spectrophotometer to 543 nm wavelength and adjust to read zero using deionized water or synthetic seawater.

7.10 Read samples, standards, and blanks in 1 cm cells with the spectrophotometer set at 543 nm wavelength. Take all readings within 2 h of adding color reagents.

7.11 After using the reduction column, it is prepared for storage by passing 500 mL of 50 μM nitrate standard and then 100 mL of dilute ammonium chloride solution through the column. Cap the top of the column with parafilm and make sure the tip of the drip tube is completely sealed.

8. Calculation

8.1 Prepare appropriate standard curves derived from passing NO_2^- standards through the autoanalyzer manifold. Compute sample concentrations by comparing sample peak heights against standard curve. This value is the concentration of nitrite and nitrate in the sample. To determine nitrate concentrations, deduct nitrite concentrations from the value determined.

9. Precision and Accuracy

9.1 Using a 1-cm path length, the precision of the method should be better than $\pm$ 0.1 μM.

References

Grassoff, K. 1983. Determination of nitrate. In K. Grassoff, M. Erhardt, and K. Kremeling, *Methods of seawater analysis*. Verlag Chemie, Weinheim, Germany.

Parsons, T.R., Y. Maita, and C.M. Lalli. 1984. *A manual of chemical and biological methods for seawater analysis*. Pergamon Press, Oxford, England.

TOTAL NITROGEN AND TOTAL DISSOLVED NITROGEN
(High temperature combustion, gas chromatography)

1. Scope and Application

1.1 This method is applicable for natural waters (freshwater and seawater). TN determinations are made on raw, unfiltered samples. TDN is determined in filtered samples. Dissolved organic nitrogen (DON) is estimated from the difference between TDN and dissolved inorganic nitrogen (DIN) (NH_4 + NO_2 + NO_3) concentrations.

2. Summary of Method

2.1 The nitrogen compounds in an unfiltered sample are oxidized at high temperature to nitric oxide (NO) and further oxidized with ozone to form nitrogen dioxide (NO_2). The nitrogen dioxide concentration is determined by gas chromatography.

3. Sample Handling and Preservation

3.1 Collect 10-25 mL of unfiltered samples for TN analysis in HDPE bottles. Refrigerate at 4 °C until analyzed within 48 h.

3.1 TDN samples are filtered through Whatman GF/F glass fiber filters immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h.
[*NOTE:* Do not preserve samples with mercuric chloride or by addition of H_2SO_4.]

4. Interferences

Due to the complete oxidation of nitrogen compounds, no interferences are expected.

5. Apparatus and Materials

5.1 TN analyzer (ANTEK Model 7000N) consists of:
- Pyroreactor
- Nitric oxide chemoluminescent detector
- Sample boat drive
- Sample injection valve set to 10 μl sample volume

5.2 Integrator

6. Reagents

6.1 Nitrate Standard Stock Solution: Dissolve 10.106 g of oven-dried (100 °C for 1 h) anhydrous potassium nitrate (KNO_3) and make up to 1000 mL in a volumetric flask. Add 1 mL chloroform as a preservative. Store the solution in a well-stoppered glass bottle at 4 °C.

1 mL of the stock solution contains 100 μg atoms NO_3^-

6.2 Nitrate Standard Working Solution: Dilute 5.0 mL of the standard stock solution to 500 mL with deionized water in a volumetric flask.

1 mL of the working solution contains 1 μg atoms NO_3^-

Prepare dilutions of the working standard solution with synthetic seawater or Gulfstream water:

mL of stock	dilute to	μM concentration
5.0	100 mL	50.0
2.5	100 mL	25.0
1.0	100 mL	10.0
0.5	100 mL	5.0
0.1	100 mL	1.0

Urea Standard Stock Solution: Dissolve 2.1437 g of urea in 1 L of deionized water.

1 mL of the stock solution contains 1 mg of N.

Urea Standard Working Solution: Dilute 5 mL of urea stock solution to [illegible] with deionized water.

1 mL of the working solution contains 0.01 mg of N.

Using the working standard stock solution, prepare the following standard solutions with deionized water in volumetric flasks.

mL of stock	dilute to	μM concentration
1	100	7.14
2	100	14.28
5	100	35.69
10	100	71.38
15	100	107.07

7. Procedure

7.1 Allow the electronics and furnace temperature to stabilize as directed in the instrument operations manual.

7.2 Run the unit with the sample injection valve connected to a deionized water tap and obtain a stable baseline.

7.3 Place the appropriate nitrate and urea standards in the sampler in order of decreasing concentration and complete loading of the sample tray with unknown samples.

7.4 Switch sample line to sampler and start analysis.

8. Calculation

8.1 Prepare appropriate standard curves derived from passing NO_3^- standards through the analyzer. Compute sample concentrations by comparing sample peak heights against standard curve.

9. Precision and Accuracy

9.1 Walsh (1989) reports an average 101% recovery with a standard deviation of 1.8% for samples containing common DON compounds. Samples containing recalcitrant DON have a mean 98.3% recovery with a standard deviation of 3.7%.

References

Walsh, T.W. 1989. "Total dissolved nitrogen in seawater: A new high-temperature combustion method and a comparison with photo-oxidation." Mar. Chem. 26:295-311.

TOTAL NITROGEN AND TOTAL DISSOLVED NITROGEN
(Persulfate digestion, spectrophotometric, manual, large volume)

1. Scope and Application

1.1 This method is applicable for natural waters (freshwater and seawater). TN determinations are made on raw, unfiltered samples. TDN is determined in filtered samples. DON is estimated from the difference between TDN and DIN (NH_4 + NO_2 + NO_3) concentrations. The method is applicable for concentrations of 2 to 40 μM.

2. Summary of Method

2.1 TN (inorganic and organic fixed nitrogen) is determined by subjecting a sample to a potassium persulfate digestion. After digestion, an HCl and borate buffer solution are added; the sample is analyzed as described in the nitrate procedure.

3. Sample Handling and Preservation

3.1 Samples should be collected in acid-washed and deionized water rinsed bottles. TN is determined in unfiltered samples. TDN is determined in samples filtered through Whatman GF/C filters.

4. Interferences

4.1 Digestion of samples in borosilicate glass can cause formation of fine precipitates which may clog a cadmium column. Use of Teflon vessels will correct the problem.

5. Apparatus and Materials

5.1 125 mL Teflon screw-cap bottles
5.2 10 mL automatic pipettes
5.3 Autoclave

6. Reagents

6.1 1.5 M Sodium Hydroxide Solution: Dissolve 120 g of low N (<0.001%) NaOH in 1 L of distilled water.

6.2 Oxidizing Reagent: 6.0 g of twice-recrystallized low N (<0.001%) potassium persulfate ($K_2S_2O_8$) are dissolved in 100 mL of 1.5 M NaOH. Aid solution using a Teflon-coated stir bar. The solution is stable for up to 8 days if stored in the dark in a Teflon bottle.

6.3 1.4 M HCl: Dilute 200 mL of concentrated HCl with 1.7 L of deionized water to make a 1.4 M HCl solution. Determine the proper volume of this solution to add to a sample by titration. Add 6 mL of oxidizing solution to 40 mL volumes of deionized water and add the volume of 1.4 M acid necessary to lower the pH to 2.6-3.2. This solution is stable for months.

6.4 Buffer Solution: 75 g of NH_4Cl is dissolved in 400 mL deionized water. After adjusting the pH to 8.5 with concentrated NH_4OH, dilute to 500 mL. This solution is stable for months.

6.5 Urea Standard Stock Solution: Dissolve 2.1437 g of urea in 1 L of deionized water.

1 mL of the stock solution contains 1 mg of N.

Urea Standard Working Solution: Dilute 5 mL of urea stock solution to 500 mL with deionized water.

1 mL of the working solution contains 0.01 mg of N.

Using working standard stock solution, prepare the following standard solutions with deionized water in volumetric flasks.

mL of stock	dilute to	μM concentration
1	100 mL	7.14
2	100 mL	14.28
5	100 mL	35.69
10	100 mL	71.38
15	100 mL	107.07

7. Procedure

7.1 Add 6.0 mL of oxidizing reagent to 40.0 mL of filtered sample in a 125 mL screw-cap Teflon bottle. Prepare the range of standards similarly.

7.2 Autoclave (cap loosely) the standards and samples at 120 °C at 15 pounds of pressure for 30 min and allow to slowly return to atmospheric pressure.

7.3 After test tubes cool to room temperature, add the volume of 1.4 N HCl as determined in Section 6.3 and mix to dissolve the precipitate.

7.4 Transfer the acidified digest to a 125 mL flask, add 3.0 mL of buffer solution, and dilute with deionized water to a mark on the tube indicating 50 mL and mix.
[*NOTE:* The pH of the buffered digest should be approximately 8 to 8.4.]

7.5 Analyze an aliquot of the digest for nitrate.

7.6 Prepare a reagent blank by digesting 6.0 mL of oxidizing reagent in a 125 mL screw-cap Teflon bottle and adding 40 mL of deionized water.

8. Calculation

8.1 Prepare appropriate standard curves derived from standards as described above and analyze each with autoanalyzer or manual wet chemistry methods. Compute sample concentrations by comparing sample peak heights against standard curve.

9. Precision and Accuracy

9.1 Using 20 μM urea standards, Solórzano and Sharp (1980) reported relative standard error of ± 2% and 100% recovery of urea.

References

Parsons, T.R., Y. Maita, and C.M. Lalli. 1984. *A manual of chemical and biological methods for seawater analysis*. Pergamon Press, Oxford, England.

Solórzano, L., and J. Sharp. 1980. "Determination of total dissolved nitrogen in natural waters." Limnol. Oceanogr. 25:751-754.

SOLUBLE REACTIVE PHOSPHORUS/ORTHOPHOSPHATE PO_4^{-3}
(Colorimetric, automated, small volume, low to mid range)

1. Scope and Application

1.1 This method is applicable for the determination of orthophosphate (PO_4^{-3}) in terrestrial groundwater, submarine groundwater, marine, and estuarine water containing phosphate in the 0.02-5 μM range.

2. Summary of Method

2.1 A reagent containing ammonium molybdate and antinomy potassium tartrate react in an acid medium with dilute solutions of phosphorus to form an antimonyl-phospho-molybdate complex which is reduced by ascorbic acid to an intensely blue-colored compound.

3. Sample Handling and Preservation

3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h. HDPE or glass bottles may be used for sample collection.

3.2 Groundwater samples are acidified with HCl upon collection to prevent the formation of iron oxyhydroxide colloids.

3.3 For groundwater samples, plastic containers should only be used once because of the difficulty in thoroughly removing all traces of phosphate from the bottle.

4. Interferences

4.1 High iron concentrations and low pH can cause the formation of iron oxyhydroxide colloids that bind free phosphates.

4.2 Carbonate sediments or precipitates will strongly absorb free phosphates.

4.3 Salt error is minimal.

4.4 Sample color that absorbs in the photometric range may also interfere.

5. Apparatus and Materials

5.1 The Technicon Autoanalyzer Unit or Alpkem RFA Unit consist of:

- Sampler
- Phosphate manifold or analytical cartridge
- Proportioning pump
- Temperature control
- Colorimeter
- Recorder or integrator

6. Reagents

6.1 Formulations of the following reagent solutions according to the instrument manufacturer's specifications:

- Ascorbic acid solution
- Ammonium molybdate solution
- Sulfuric acid solution
- Potassium antimony tartrate solution

6.2 Phosphate Standard Stock Solution: Dissolve 136.1 mg anhydrous potassium dihydrogen phosphate (KH_2PO_4) in deionized water and make up to 1 L after adding 0.2 mL of 1N H_2SO_4. Store in glass at 4 °C. This solution is stable for several months if well stoppered.

1 mL of the stock solution contains 1 μg atoms PO_4^{-3}.

Prepare dilutions with deionized water as follows:

mL of stock	dilute to	μM concentration
0.50	100 mL	5.00
0.20	100 mL	2.00
0.10	100 mL	1.00
0.05	100 mL	0.50
0.01	100 mL	0.01

7. Procedure

7.1 Allow electronics to warm up and stabilize.

7.2 Set up the manifolds or cartridges according to the manufacturer's instructions for the appropriate range.

7.3 Run the proportioning pump at the recommended speed while feeding deionized water through the sample line, and obtain a stable baseline with reagents.

7.4 Place the appropriate standards in the sampler in order of decreasing concentration and complete loading of the sample tray with unknown samples.

7.5 Switch sample line to sampler and start analysis.

8. Calculation

8.1 Prepare appropriate standard curves derived from passing PO_4^{-3} standards through the autoanalyzer manifold. Compute sample concentrations by comparing sample peak heights against standard curve.

9. Precision and Accuracy

9.1 Using a 10-cm pathlength, the precision of the method should be better than ± 0.01 μM.

References

EPA. 1984. Methods for chemical analysis of water and wastes. EPA-600/4-79-020. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring and Support Laboratory, Cincinnati, OH.

Murphy, J., and J.P. Riley. 1962. "A modified single solution method for the determination of phosphate in natural water." Anal. Chim. Acta. 27:31-36.

Strickland, J.D.H., and T.R. Parsons. 1972. *A practical handbook of seawater analysis.* Fisheries Research Board of Canada, Ottawa, Canada.

SOLUBLE REACTIVE PHOSPHORUS
(Spectrophotometric, manual, medium volume, low range)

1. Scope and Application

1.1 This method is applicable for the determination of orthophosphate (PO_4^{-3}) in terrestrial groundwater, submarine groundwater, marine, and estuarine water containing phosphate in the 0.1-5 μM range.

2. Summary of Method

2.1 Samples are allowed to react with a combined reagent containing molybdic acid, ascorbic acid, and trivalent antimony resulting in a blue-colored solution that can be measured at 885 nm. Although a pH adjustment procedure is described below, it is usually not required for seawater analysis.

3. Sample Handling and Preservation

3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h. HDPE or glass containers are used for sample collection.

3.2 Groundwater samples are acidified with HCl upon collection to prevent formation of iron oxyhydroxide colloids.

3.3 For groundwater samples, plastic containers should only be used once because of the difficulty in thoroughly removing all traces of phosphate from the bottle.

4. Interferences

4.1 There is no salt effect, therefore, dilutions and blanks may be made with deionized water. Care should be taken to avoid contamination from glassware washed with phosphate-containing detergents. Acid-washed glassware should be used at all times in this procedure.

5. Apparatus and Materials

5.1 10 mL automatic pipettes
5.2 1 mL automatic pipettes
5.3 100 mL volumetric flasks
5.4 Spectrophotometer
5.5 1 cm or 5 cm cuvettes

6. Reagents

6.1 Ammonium Molybdate Solution: Dissolve 15 g ammonium molybdate ($(NH_4)_6Mo_7O_{24} \cdot 4H_2O$) in 500 mL deionized water. Store in plastic in the dark. This solution is stable indefinitely.

6.2 5 N Sulfuric Acid Solution: Add 140 mL of concentrated sulfuric acid (H_2SO_4) to 900 mL of deionized water, cool, and store in glass bottle; stable indefinitely when sealed.

6.3 Ascorbic Acid Solution: Dissolve 27 g of ascorbic acid in 500 mL of deionized water and store in plastic. Stable for months if frozen, or for weeks if cold, or for days at room temperature.

6.4 Potassium Antimonyl Tartrate: Dissolve 0.34 g of potassium antimonyl tartrate ($K(SbO)C_4H_4O_6 \cdot ½\ H_2O$) in 250 mL of deionized water and warm if necessary. Store in glass or plastic. Stable for months.

6.5 Combined reagent:

Mix the following solutions in an acid-washed container with a cap:

25 mL	ammonium molybdate solution
62.5 mL	sulfuric acid solution
25 mL	ascorbic acid solution
12.5 mL	potassium antimonyl tartrate solution

This solution is stable for 6 h or less. The solution should be a light straw-color. A shade of green will suggest the presence of phosphate in the deionized water or reagents, or contamination from the environment.

6.6 Phenolphthalein Indicator Solution: Dissolve 0.5 g phenolphthalein in a solution of 50 mL ethyl alcohol and 50 mL deionized water.

6.7 6 N NaOH Solution: Dissolve 240 g sodium hydroxide in approximately 500 mL and dilute to 1 L with deionized water.

6.8 1 N H_2SO_4 Solution: Mix 28 mL of concentrated H_2SO_4 with 900 mL of distilled water and dilute to 1 L.

6.9 Phosphate Standard Stock Solution: Dissolve 136.1 mg of anhydrous potassium dihydrogen phosphate (KH_2PO_4) in deionized water, and make up to 1000 mL after adding 0.2 mL of the sulfuric acid solution. Store in glass at 4 °C. Stable for months.

1 mL of the stock solution contains 1 μM P-PO_4.

Prepare standard dilutions as follows:

mL of stock	dilute to	μM concentration
0.50	100	5.0
0.20	100	2.0
0.10	100	1.0
0.05	100	0.5

7. Procedure

7.1 Adjust the pH of each sample as follows:
- a) Add one drop of phenolphthalein indicator to each sample.
- b) Add 6 N NaOH dropwise until a pink color develops.
- c) Add 1 N H_2SO_4 until the pink color disappears.

7.2 Pipette 10 mL of filtered sample into a test tube.

7.3 Add 1 mL of combined reagent and shake immediately.

7.4 Allow color development to proceed for 20 min.

7.5 Prepare phosphate standards by adding the combined reagent as above to 10 mL volumes of standards.

7.6 Prepare a reagent blank using 10 mL of acidified (with 0.1 mL 1N HCl) deionized water. Add reagents as above.

7.7 Set spectrophotometer to 885 nm wavelength and adjust to read zero absorbance with deionized water in a 1-cm or 5-cm pathlength cuvette. Take readings within 1 h of adding reagents.

8. Calculation

8.1 Prepare appropriate standard curves derived from processing PO_4^{-3} standards as described above. Compute sample concentrations by comparing sample peak heights against standard curve.

9. Precision and Accuracy

9.1 With a 1-cm pathlength, the precision of this method should be better than 0.1 μM.

References

Murphy, J., and J.P. Riley. 1962. "A modified single solution method for the determination of phosphate in natural water." Anal. Chim. Acta. 27:31-36.

SOLUBLE REACTIVE PHOSPHATE AND TOTAL DISSOLVED PHOSPHATE
(Co-precipitation/spectrophotometry/colorimetry, manual/automated, high volume, ultralow range)

1. Scope and Application

1.1 This method is applicable for measuring phosphate concentrations below 2 μM in natural waters (freshwater and seawater).

2. Summary of Method

2.1 This method increases the usual sensitivity of the ascorbic acid method by co-precipitating all the phosphate in solution with brucite $Mg(OH)_2$ with the addition of NaOH. The concentrated sample is then analyzed using the ascorbic acid/molybdate method.

3. Sample Handling and Preservation

3.1 Samples should be collected in HDPE bottles cleaned with phosphate-free detergent, rinsed in tap water, acid-washed, and thoroughly rinsed with deionized water. During collection, three changes of the filtered sample should be used to rinse the bottle before filling it to capacity. Plastic bottles have a large capacity for adsorbing phosphorous (especially during prolonged storage) leading to lowered results. At ultralow PO_4^{-3} concentrations, holding times should be minimized as much as possible and samples should be filtered in the field. Freezing can also result in matrix effects causing further loss of phosphate to precipitation.

3.2 For soluble reactive phosphate determinations, samples should be filtered through Whatman GF/F glass fiber filters, and iced/refrigerated at 4 °C until analyzed within 24 h of collection.

3.3 In the event that samples are held for more than 24 h, enough of the sample should be drained to allow for expansion and then frozen. Frozen samples should be allowed to thaw and then be shaken vigorously to redissolve all salts.

4. Interferences

4.1 High iron concentrations and low pH can cause formation of iron oxyhydroxide colloids that bind free phosphates.

4.2 Carbonate sediments or precipitates will strongly absorb free phosphates.

4.3 Salt error is minimal.

4.4 Sample color that absorbs in the photometric range may also interfere.

5. Apparatus and Materials

5.1 Centrifuge

5.2 Autopipettor

5.3 Vacuum pump

5.4 Phosphate determination apparatus and materials (ascorbic acid method)

6. Reagents

6.1 1 M NaOH Solution: Dissolve 39.998 g of low phosphate NaOH (Fluka BioChemika No. 716789) in deionized water.

6.2 0.1 M HCl: Dilute 8.3 mL of low phosphate HCl (Baker No. 9530-33) to 1000 mL with deionized water.

7. Procedure

7.1 Set up the apparatus and materials required.

7.2 Bring 50 mL samples to room temperature in clean disposable polypropylene centrifuge tubes.

7.3 Add 1.25 mL of 1 M NaOH solution to each sample. Cap each tube, thoroughly mix (Vortex), and incubate for 5 min at room temperature. Vortex the sample again and incubate for another 5 min.

7.4 Centrifuge the sample at 1000 × g for 60 min at room temperature.

7.5 Draw off and discard the supernatant by aspirating with a Pasteur pipette connected to a vacuum source/water trap.

7.6 Add 8.5 mL of 0.1 M HCl and vortex until the pellet is completely dissolved.

7.7 Dilute the solution with 0.1 M HCl to a 10.0 mL volume. This results in a five-fold concentration.
7.8 Continue analysis of the sample according to methods for orthophosphate analysis.

8. Calculation

8.1 Prepare appropriate standard curves derived from processing PO_4^{-3} standards as described above and analyzing each with autoanalyzer/manual wet chemistry methods. Compute sample concentrations by comparing sample peak heights against standard curve.

9. Precision and Accuracy

9.1 Karl and Tien (1992) report 99.5 to 99.8% recovery of phosphate in the sample (spiked to a concentration of 10 μM PO_4^{-3}) in seawater ranging in volume from 10 to 500 mL. Accuracy and precision of the actual analysis would depend on the analytical method employed.

References

Karl, D.M., and G. Tien. 1992. "MAGIC: A sensitive and precise method for measuring dissolved phosphorus in aquatic environments." Limnol. Oceanogr. 37:105-116.

Murphy, J., and J.P. Riley. 1962. "A modified single solution method for the determination of phosphate in natural water." Anal. Chim. Acta. 27:31-36.

TOTAL PHOSPHORUS AND TOTAL DISSOLVED PHOSPHORUS
(High temperature digestion, manual, small volume, low range)

1. Scope and Application

1.1 This method is applicable for the determination of TP and TDP in terrestrial groundwater, submarine groundwater, marine, and estuarine water containing phosphorus in the 0.05-18 μM range. TP determinations are made on raw, unfiltered samples. TDP is determined in filtered samples. Dissolved organic phosphorus (DOP) is estimated from the difference between TDP and DIP concentrations.

2. Summary of Method

2.1 Filtered or unfiltered samples are evaporated and baked at high temperature with magnesium sulfate. Digested samples are allowed to react with a combined reagent containing molybdic acid, ascorbic acid, and trivalent antimony resulting in a blue-colored solution that can be measured at 885 nm. The method described is a manual procedure although this may readily be adapted to automated analysis.

3. Sample Handling and Preservation

3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h. HDPE or glass containers are used for sample collection.

4. Interferences

4.1 There is no salt effect, so dilutions and blanks may be made with deionized water. Care should be taken to avoid contamination from glassware washed with phosphate-containing detergents. Acid-washed glassware should be used at all times in this procedure.

5. Apparatus and Materials

5.1 10 mL automatic pipettes
5.2 1 mL automatic pipettes
5.3 100 mL volumetric flasks
5.4 Spectrophotometer
5.5 1 cm or 5 cm cuvettes
5.6 Drying oven
5.7 Muffle furnace

6. Reagents

6.1 0.17 M Magnesium Sulfate Solution: Dissolve 10 g of $MgSO_4$ in 500 mL of deionized water and add 1 mL of concentrated H_2SO_4. This solution is stable for months in a glass bottle.

6.2 0.75 M Hydrochloric Acid Solution: Dilute 65 mL of concentrated HCl with deionized water in a 1000 mL volumetric flask to the mark. This solution is stable for months.

6.3 Mixed Reagent — as described above.

7. Procedure

7.1 Pipette 10 mL of sample into a small Pyrex container and evaporate to dryness in a clean oven at 95 °C.

7.2 Transfer the container to a muffle furnace and bake at 450 to 500 °C for 2 h.

7.3 Allow the container to cool to room temperature and add 3 mL of 0.75 HCl and heat the sample in an oven at 80 °C for 20 min. The container should be covered tightly with a lid during the hydrolysis.

7.4 Add 7 mL of deionized water to the sample and continue heating for another 10 min with the lid tightly closed.

7.5 Transfer the sample to a test tube and add 1 mL of mixed reagent and shake.

7.6 Allow color development to proceed for 20 min.

7.7 Prepare phosphate standards by adding the combined reagent as above to 10 mL volumes of standards.

7.8 Prepare a reagent blank using 10 mL of acidified (with 0.1 mL 1N HCl) deionized water. Add reagents as above.

7.9 Set to spectrophotometer 885 nm wavelength and adjusted to read zero absorbance with deionized water in a 1 or 5 cm pathlength cuvette. Take readings within 1 h of adding reagents.

8. Calculation

8.1 Prepare appropriate standard curves derived from passing PO_4^{-3} standards through the autoanalyzer manifold. Compute sample concentrations by comparing sample peak heights against standard curve.

9. Precision and Accuracy

9.1 A test of recovery with various DOP compounds yielded 95-103%. At 6 μM, precision is better than 1% relative standard error.

References

Murphy, J., and J.P. Riley. 1962. "A modified single solution method for the determination of phosphate in natural water." Anal. Chim. Acta. 27:31-36.

Solórzano, L., and J. Sharp. 1980. "Determination of total dissolved phosphorus and particulate phosphorous in natural waters." Limnol. Oceanogr. 25:754-758.

NON-PURGEABLE ORGANIC CARBON AND INORGANIC CARBON
(High temperature combustion with infra-red detection, automated, small volume, low to high range)

1. Scope and Application

1.1 This method is applicable for the determination of NPOC and inorganic carbon in terrestrial groundwater, submarine groundwater, marine, and estuarine water.

2. Summary of Method

2.1 The carbon compounds contained in a sample are oxidized by high-temperature into CO_2 and analyzed by infra-red gas chromatography. Carbonates and free carbon dioxide is removed by purging with nitrogen prior to analysis.

3. Sample Handling and Preservation

3.1 Water samples are filtered through Whatman GF/F glass fiber filter immediately after collection. Filtered samples are refrigerated at 4 °C until analyzed within 48 h.

4. Interferences

4.1 There are no interferences reported for this method.

5. Apparatus and Materials

5.1 Purging manifold

5.2 Total organic carbon analyzer (e.g., Shimadzu TOC-5000)

6. Reagents

6.1 3N HCl

6.2 Glucose Standard Stock Solution: Dissolve 3.000 g of reference standard grade glucose in 1 L of hot 3% super-pure NaCl solution. Dispense the solution in quartz ampoules and store in a cold and dark place until used. The solution is good for one week.

This stock solution has a concentration of 100 mM C.

6.3 Glucose Standard Working Solution: Prepare daily by diluting from 1 to 100 mL with hot 3% NaCl.

This working solution has a concentration of 1000 μM C.

Prepare standard dilutions as follows:

mL of stock	dilute to	μM C concentration
50	100	500
25	100	250
10	100	100
5	100	50
1	100	10
0.5	100	5

7. Procedure

7.1 Acidify the sample with 50 μl of 3N HCl and purge it with CO_2-free air for 8 min.

7.2 Inject the sample into the analyzer.

7.3 For total carbon content, directly inject unacidified and unpurged samples. This analysis should be done within 7 days of sample collection.

8. Calculation

8.1 Prepare appropriate standard curves derived from processing standards as described above. Compute sample concentrations by comparing sample peak heights against standard curve.

9. Precision and Accuracy

9.1 Sugimura and Suzuki (1988) reported 99% recovery using a 50 μM C solution of glucose with a precision of $\pm$ 0.4 μM.

References

Sugimura, Y., and Y. Suzuki. 1988. "A high temperature catalytic oxidation method for determination of non-volatile dissolved organic carbon in seawater by direct injection of liquid samples." Mar. Chem. 24:105-131.

CHLOROPHYLL *a* AND PHAEOPHYTIN CONCENTRATIONS
(Fluorometric, manual)

1. Scope and Application

1.1 This method is applicable to the analysis of estuarine and marine waters. A very wide range of natural concentrations can be analyzed by appropriate adjustment of the volume of sample that is filtered. The applicable range of concentrations depends on the volume of the sample filtered. There is no lower limit of detection since this is dependent on the volume of water that is filtered. The fluorometric method sacrifices accuracy for speed and a smaller sample volume.

2. Summary of Method

2.1 A measured volume of sample is filtered through a glass fiber filter and placed in a microcentrifuge tube with a drop of saturated magnesium carbonate. An aqueous solution of acetone is used to extract the photosynthetic pigments which are then analyzed using a spectrofluorometer or a fluorometer equipped with appropriate emission and excitation filters. Phaeophytin is estimated from the difference in fluorescence before and after acidification of the sample. Chlorophyll concentrations are calculated relative to prepared standards of purified chlorophyll extracts.

3. Sample Handling and Preservation

3.1 Water samples should be filtered as soon as possible. Samples which cannot be filtered soon after collection should be collected in amber HDPE bottles and stored under ice until filtered. Filters that are not analyzed within 24 h should be frozen at −15 °C and analyzed within 7 days. Extracts should be kept in the dark and refrigerated at 4 °C and analyzed.

4. Interferences

4.1 Large amounts of detrital material or fine suspended sediments may prevent the filtration of adequate volumes of sample.

4.2 Extended exposure of the extracts to light can cause photolytic degradation of the chlorophyll molecule.

4.3 Acidic conditions can promote degradation of the chlorophyll molecule, decreasing the measured concentration. The breakdown products are phaeophytin molecules. Acidic conditions are avoided by adding one drop of saturated magnesium carbonate solution on the filter and by using an acetone solution buffered with magnesium carbonate or ammonium hydroxide.

5. Apparatus and Materials

5.1 60 mL syringe
5.2 25 mm filter holders
5.3 Whatman GF/F glass fiber filters
5.4 Filter forceps
5.5 250 mL squeeze bottle
5.6 1 L dispenser bottles with delivery volume set at 1.5 and 2.25 mL
5.7 Autopipettor with delivery volume set at 750 μL
5.8 1.8 mL microcentrifuge tubes
5.9 Cooler for transporting used filters under ice
5.10 Freezer set at −15 °C
5.11 Refrigerator set at 4 °C

6. Reagents

6.1 Saturated magnesium carbonate solution ($MgSO_4$)

6.2 90% Aqueous Acetone Solution: To prepare 1 L, measure 100 mL of deionized water in a volumetric pipette, transfer into a 1 L volumetric flask, and make up to volume with deionized water. Add 1 drop of concentrated ammonium hydroxide or 0.5 g of $MgSO_4$ to buffer the solution.

6.3 Chlorophyll *a* Standard Stock Solution: Sigma chlorophyll *a* standard purified from *Anacystis* culture. Dissolve 0.1 g in 100 mL of 90% aqueous acetone solution.

This stock solution contains 1000 μg/L chlorophyll *a*.

Prepare working standards by diluting with aqueous acetone as follows:

mL of stock	dilute to	concentration
0.01	100 mL	0.01 μg/L
0.05	100 mL	0.05 μg/L
0.10	100 mL	1.00 μg/L
0.50	100 mL	5.00 μg/L
1.00	100 mL	10.00 μg/L

6.4 5% v/v HCl Acid Solution: Dilute 5 mL of concentrated HCl to 100 mL with deionized water.

7. Procedure

7.1 Filter at least 120 mL of the sample through the Whatman GF/F glass fiber filter. Open the filter holder and add one drop of saturated magnesium carbonate solution to the residue-side of the filter. Fold the filter in half and insert it into the microcentrifuge tube.
7.2 Store the used GF/F filters frozen at −15 °C until analyzed within 7 days of sample collection.
7.3 Thaw out the filter and steep it overnight in 1.5 mL of acetone solution at 4 °C.
7.4 Shake the microcentrifuge tube and then remove 750 μl of the extract with an autopipettor.
7.5 Dilute the aliquot with 2.25 mL of the acetone solution in a cuvette.
7.6 Zero the fluorometer using a cuvette blank with 3 mL of acetone solution.
7.7 Determine the relative fluorescence of calibration standards and samples using a fluorometer with a 435 nm emission filter and a 667 nm excitation filter.
7.8 Acidify the sample by adding one drop of 5% v/v HCl and mix the sample by inverting the cuvette twice. Read the fluorescence within 30 seconds of adding the acid.

8. Calculation

8.1 Obtain a standard curve by plotting the relative fluorescence of standards run by the above procedure against μg/L of chlorophyll *a* or calculate a conversion factor from a single calibration standard.
8.2 Calculate the chlorophyll *a* concentration by multiplying the conversion factor by the fluorometer reading and the volume of the extract (in mL) and dividing the sum by the volume of the sample filtered (in L).
8.3 Calculate the phaeophytin concentration as the difference in chlorophyll *a* concentrations before and after acidification.

9. Precision and Accuracy

9.1 The limit of detection of this method depends on the volume of water filtered and the sensitivity of the fluorometer. At the 0.5 μg/L chlorophyll *a* level, the precision should be better than 10%.

References

Holm-Hansen, O., C.J. Lorenzen, R.W. Holmes, and J.D.H. Strickland. 1965. "Fluorometric determination of chlorophyll." J. Cons. Perm. int. Explor. Mer 30:3-15.

Yentsch, C.S., and D.W. Menzel. 1963. "A method for determination of phytoplankton chlorophyll and phaeophytin by fluorescence." Deep-Sea Res. 10:221-231.

ALKALINE PHOSPHATASE ACTIVITY
(Fluorometric, manual)

1. Scope and Application

1.1 APA is an assay for an enzyme responsible for hydrolysis of organic phosphate to inorganic phosphate. This method is applicable to freshwater and seawater.

2. Summary of Method

2.1 Unfiltered water samples are spiked with a *o*-methylflourescein-phosphate complex and incubated for 2 h. The activity of the enzyme and the degree of phosphorus availability/limitation is proportional to the change in relative fluorescence measured after at the start and end of incubation. *o*-methylfluorescein-phosphate is a non-fluorescent complex. In the presence of alkaline phosphatase, the phosphate is removed producing the fluorescent *o*-methylfluorescein compound.

3. Sample Handling and Preservation

3.1 Samples are collected in HDPE containers and held in the dark at ambient temperature until analyzed within 12 h.

4. Interferences

4.1 There are no interferences reported for this method.

5. Apparatus and Materials

5.1 60 mL HDPE bottles
5.2 Cooler, no ice
5.3 3 mL autopipettor
5.4 Disposable cuvette
5.5 Fluorometer (Gilford Model IV) with the following settings: excitation: 430 nm; emission: 507 nm

6. Reagents

6.1 100 mM Tris Buffer: Dissolve 3.0 g of Trizma HCl (Sigma Chemical T 3253, trishydroxymethylaminomethane hydrochloride FW 157.6) and 9.8 g of Trizma Base (Sigma Chemical T 1503, trishydroxymethylaminomethane FW 121.1) in 1 L of deionized water. The pH of this solution at 25 °C is 8.7. Store the solution in a well-stoppered glass bottle at 4 °C.

6.2 1 mM 3-*o*-methylfluorescein-phosphate Solution: Dissolve 5.25 mg of 3-*o*-methylfluorescein- phosphate (Sigma Chemical M 2629, $C_{21}H_{15}O_8P \cdot C_6H_{13}N$, FW 525.5) in 10 mL of 100 mM of tris buffer adjusted to pH 8.7. This solution is good for over 300 determinations.

6.3. Methylfluorescein Standard Stock Solution: Dissolve 0.03460 g of 3-*o*-methylfluorescein (Sigma Chemical M 7004, $C_{21}H_{14}O_5$, FW 346.3) in 100 mL of spectrophotometer grade methanol (Sigma Chemical M 3641, CH_3OH, FW 32.04).

This stock solution contains 1 µg atoms/L methylfluorescein.

Prepare the following standards by adding the following volumes to 3 mL deionized water in duplicate disposable cuvettes as follows:

µL of stock	add to	concentration
0	3 mL	0.0 µM
3	3 mL	3.0 µM
7.5	3 mL	7.5 µM
15	3 mL	15.0 µM
30	3 mL	30.0 µM

7. **Procedure**

7.1 Measure 3 mL volumes of unfiltered water samples in duplicate in disposable cuvettes.

7.2 Spike each cuvette with 30 μl of methylfluorescein phosphate.

7.3 Zero the fluorometer with distilled water. Thoroughly clean all the surfaces of all standard and sample cuvettes before each measurement.

7.4 Measure the relative fluorescence of each sample immediately on a fluorometer (e.g., Gilford Fluorometer IV or Turner Instruments Model 112) to determine a T_0 value.

7.5 Incubate the sample for 2 h at ambient temperatures.

7.6 Measure the relative fluorescence again to determine a T_2 value. APA determinations should be made within 12 h of collection.

8. **Calculation**

8.1 Prepare appropriate standard curves derived from measuring the fluorescence in standards as described above. Compute sample concentrations by comparing sample peak heights against standard curve.

9. **Precision and accuracy** (to be added).

9.1 The limit of detection of this method is 0.0005 μM/h with a precision of $\pm 1\%$ (R. Jones, FIU, personal communication, 1992).

References

Franko, D. 1984. Phytoplankton metabolism and cyclic nucleotides. II. Nucleotide-induced perturbations of alkaline phosphatase activity. Archiv für Hydrobiologie 100:409-421.

Hill, H.D., G.K. Summer, and M.D. Waters. 1968. An automated fluorometric assay for alkaline phosphatase using 3-*o*-methylfluorescein phosphate. Analytical Biochemistry 24:9-17.

SEAGRASS MONITORING PROTOCOLS

C.1 INTRODUCTION

In contrast to coral reef community monitoring, seagrass community parameters and methods are more standardized. Therefore, a more detailed set of protocols has been developed for the seagrass component of the water quality monitoring program. These protocols are based on methods that are currently being used by the Everglades National Park and collaborating scientists (J. Fourqurean, San Francisco State University; M. Robblee, Everglades National Park; and J. Zieman, University of Virginia; personal communication, 1992).

A range of techniques will be used to monitor seagrass communities:

- Remote sensing surveys (with ground-truthing as needed) will be conducted biannually (selected "photocorridors" in each segment) and every 5 to 7 years (entire Florida Keys National Marine Sanctuary [FKNMS]) to detect gross changes in the areal coverage of the seagrass communities. These surveys will repeat the benthic mapping effort currently being conducted by the National Oceanic and Atmospheric Administration (NOAA) and the Florida Department of Natural Resources (FDNR).

- Qualitative visual swimover surveys will be conducted bimonthly to detect gross changes within the permanent seagrass study sites. Study sites will be selected randomly within the seagrass community types mapped through remote sensing.

- Photo and count stations will be established at each of the permanent study sites. These stations will be sampled bimonthly to provide a permanent visual record and to calibrate rapid visual methods.

- Productivity plots will be established at each of the permanent study sites. Quarterly quantitative measurements of the seagrass standing crop and productivity and the epiphytic and macroalgal standing crop will be performed.

- Randomly selected faunal quadrats at each permanent study site will be sampled quarterly by using a suction dredge to estimate the abundance and community parameters of the epifauna and shallow-dwelling infauna.

C.2 SEAGRASS AND MACROALGAE

C.2.1 Remote Sensing

Changes in areal coverage of seagrass communities within each segment of the FKNMS will be determined through remote sensing. Aerocolor or false-color infra-red (IR) photography (and multispectral scanner imagery, if feasible) will be used to determine the areal coverage of the following seagrass "community types."

- Continuous seagrass meadows with moderate or dense seagrass
- Sparse seagrass
- Patchy seagrass within a hard bottom matrix
- Patchy seagrass with matrix of sparse seagrass
- Hard bottom with patchy seagrass
- Seagrass blowout areas

This monitoring effort will be a periodic repetition of the benthic mapping effort currently being conducted by NOAA and the FDNR. lecause of the great expense in conducting a full aerial photographic survey with full coverage of the FKNMS, only selected areas will be surveyed on a biannual basis. Three "photo-corridors" measuring 1 km wide will be surveyed biannually in each segment of the FKNMS. A full aerial photographic survey of the FKNMS will only be conducted on a 5- to 7-year basis.

During aerial photographic surveys, appropriate ground control points will be established and high resolution Global Positioning System (GPS) systems will be used to maximize geodetic control. Flight lines will be selected to obtain the best possible coverage at the greatest efficiency. Aerocolor or IR photographs will be taken at a 1:48,000 scale. Diapositives from photography will be manually classified or scanned and digitized at high resolution. Classification will be conducted from stereoscopic images with the necessary ground-truthing conducted.

C.2.2 Swimover Surveys/Transects

Bimonthly swimovers will be conducted at permanent study sites to conduct rapid qualitative assessments of species richness, standing crop, dominance, phenology, and epiphytism. Pairs of observers will be trained to conduct swimover surveys at each study site. These surveys will be conducted along the perimeter and on a diagonal of each demarcated 25 × 25 m study site. Each site will be permanently marked with durable markers at each corner (**Figure C-1**). The northernmost and southernmost corners will be marked with a buoy. Polyvinylchloride (PVC) stakes measuring 0.5-in. in diameter will be placed every 2 m on two parallel sides of the study site to guide the observers. Observations will be made within the 1-m wide belt transect between each corner. Each pair of observers will begin a survey from the southernmost corner of the study site. One observer will swim toward the western corner while the second observer swims along the diagonal toward the northern stake. The first observer will continue toward the northern corner and then back toward the southern corner along the diagonal. After completing the diagonal, the second observer will proceed from the north corner of the perimeter to the eastern corner and then back to the southern corner. Observations along the diagonal will be used to determine observer bias. Each observer will record (on a standardized form) an assessment of the following parameters.

- Percent of bottom covered by seagrasses and algae
- Percent composition by species for species with coverage greater than 10%
- Species present with coverage less than 10% will be listed
- Die-off status: 0=not active, 1=active
- Die-off conditions, estimated as
  0=none, 1=mottled, 2=patchy, 3=dead zone (extensive)
- Recolonization by *Halodule*, estimated as
  0=none, 1=slight (few runners), 2=some, 3=much (bottom obscured)
- Degree of epiphytism: fleshy or calcareous

C.2.3 Permanent Photo and Count Stations

Six permanent photo and count stations will be established at each study site. A set of three plots will be established randomly along the perimeters of the study site and marked with PVC stakes. These stations will be monitored bimonthly. Count stations will consist of 0.20 × 0.40-m quadrats divided into four 0.10 × 0.2-m sections labeled A through D (**Figure C-1**).

Within each section of a count station, the following parameters will be measured to describe the standing crop.

- Number of short-shoots for each seagrass species
- Number of blades per short shoot
- Number of new sho[illegible] fruits and flowers
- Canopy height
- Number of individuals of calcareous algae and presence of fleshy algae

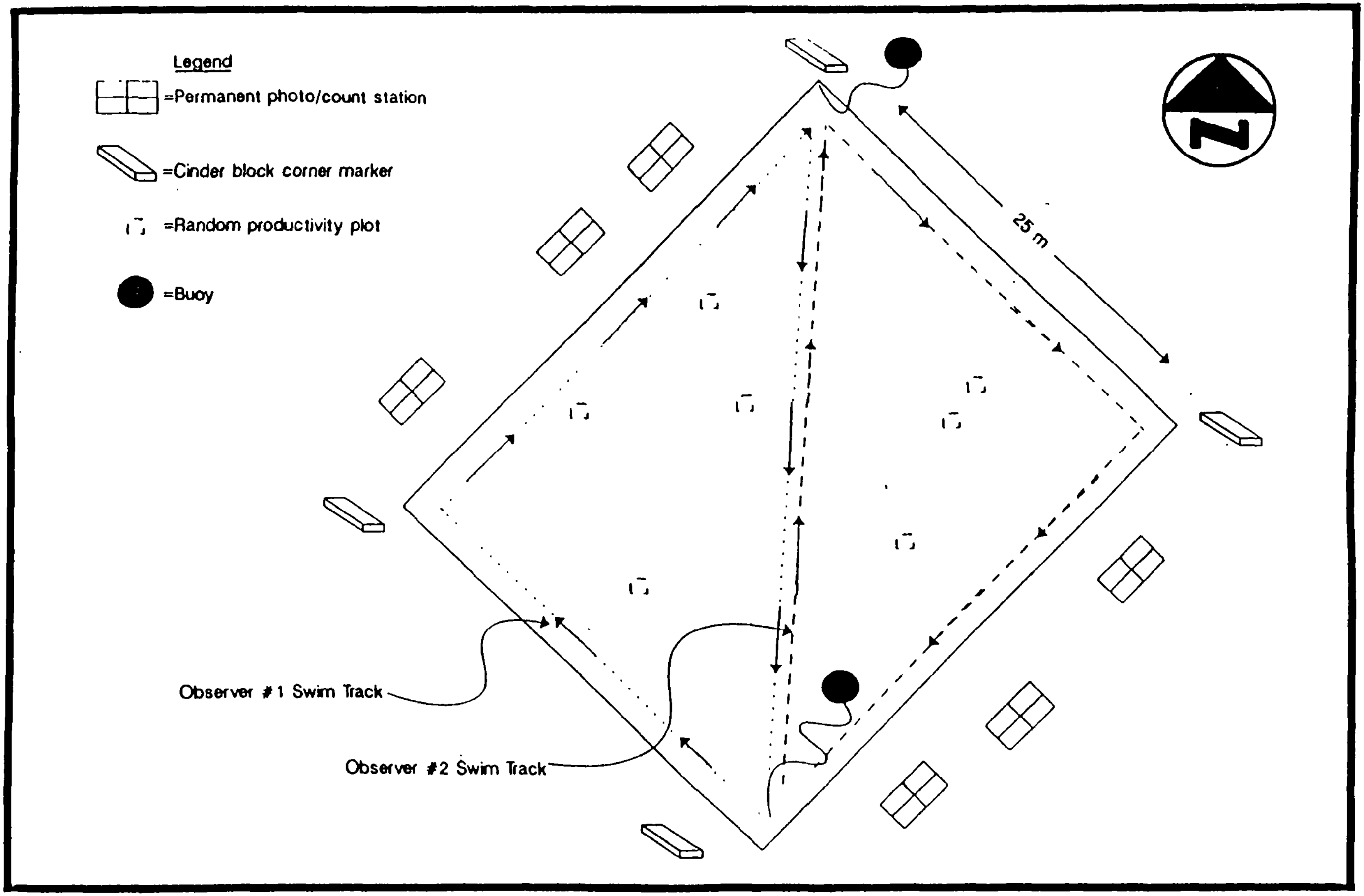


Figure C-1. Florida Keys National Marine Sanctuary seagrass monitoring study site.

In very dense grass beds, short shoots will be counted in all four sections, while the number of blades will be measured in only one section.

After the counts are conducted, 0.25 m^2 quadrats centered within the count stations will be photographed to provide a permanent visual record that can be used to calibrate rapid visual methods against quantitative methods.

C.2.4 Randomly Selected Productivity Plots

C.2.4.1 ABOVE-GROUND STANDING CROP AND PRODUCTIVITY

Seagrass productivity in six randomly selected 0.02 m^2 plots will also be monitored quarterly within each study site by using a modification of the leaf marking method (Zieman 1974). Seagrass productivity measurements will be made by randomly placing a 0.02 m^2 quadrat within each study site and marking the base of each blade within the quadrat with a needle. After 10 to 15 days, all the above-ground biomass (seagrass short shoots and blades, macroalgae) will be harvested using a sharp knife. Blades on each short shoot will be bound together by using a paper clip, and the short shoot will be carefully lifted out of the sediment. The material from each quadrat will be placed in a Ziploc® bag, stored under ice, and brought to the laboratory for processing. In the laboratory, the material will be cleaned of fine sediment, using fresh water, and sorted. If the samples cannot be processed immediately, they will be stored at -10 °C.

Linear and gravimetric measurements will be made on each sample to determine seagrass community parameters. For each sample, the number of short shoots will be determined and linear measurements will then be estimated from a subsample of three randomly selected short shoots.

The following measurements will be made for each subsample.

- Number of blades (per short shoot)
- Length (cm) of each marked blade
- Distance (cm) from the base of the blade to the needle mark
- Number and length (cm) of unmarked blades (fresh-growth)

From these measurements, an estimate for the whole sample of the following parameters will be reported.

- Above-ground standing crop, as
  - Total length (cm) of blades m^{-2} (cm old blades + cm new blades)
  - Number of short shoots m^{-2}
  - Mean number of blades per short shoot m^{-2}
  - Mean number of blades m^{-2}
- Productivity (cm new growth on old blades + cm new blades d^{-1})
- Leaf area index (LAI) (m^2 total leaf area m^{-2} ground surface)

After these measurements are made, the whole sample will be sorted by species into the following categories.

- New leaves
- Old leaf sections above the needle mark
- Old leaf sections below the needle mark

Subsamples will be removed and scraped clean of epiphytes to measure epiphytic growth. Epiphytes will be oven-dried and weighed. Subsampled blades will be combined with the remaining material, treated with a weak HCl solution to remove carbonates, rinsed with freshwater, and oven-dried at 100 °C to constant weight. Oven dry-weight of the sorted blades will be recorded to determine the following parameters:

- Standing crop in g m^{-2} (as oven dry-weight of all blades in a sample)
- Production in g m^{-2} d^{-1} (as oven dry-weight of new leaves and new growth on old leaves/by number of days growth)
- Specific growth rate or turnover rate as percent/day (production/standing crop)

Within each permanent and randomly selected plot, samples will also be collected to determine the standing crop of macroalgae. Samples will be collected from each plot to determine carbon:nitrogen:phosphorus (C:N:P) ratios in seagrasses, macroalgae, and epiphytic algae. Samples for carbon:nitrogen:phosphorus (C:N:P) analysis will be carefully scraped, washed in freshwater to remove epibionts and sediments, freeze-dried, and weighed. Samples will then be milled and stored under desiccant until analyzed. C and N contents will be determined in duplicate subsamples by flash-combustion and gas chromatography in a CHN analyzer. Total phosphorus content of duplicate subsamples will be determined as described by Fourqurean *et al.* (1992).

C.2.4.2 BELOW-GROUND STANDING CROP

After harvesting the above-ground biomass, duplicate cores will also be taken in the randomly selected 0.02 m^2 quadrats to determine the below-ground standing crop (rhizomes and roots). Cores will be returned to the laboratory under ice and cleaned of sediment by using a course sieve and a stream of freshwater. Cleaned samples will be frozen below 0 °C until processed. All below-ground parts will be sorted, freeze-dried, and weighed to determine below-ground standing crop (g roots and rhizomes m^{-2}). Subsamples will be taken and analyzed for carbohydrate content and for C:N:P as discussed above.

C.3 EPIFAUNA

Epifauna in the seagrass community will be monitored through collections from 0.2 m^2 quadrats using a suction dredge. Three to six randomly located quadrats will be sampled quarterly within each study site. A lift-pump will be used to sweep epifauna from a quadrat into a 3-mm-mesh collection bag. Each quadrat will be swept with the suction tube three times. Samples will be transferred from the collection bags into sample jars, stored under ice, and transported to the laboratory. All samples will be fixed in the field with 10%-buffered formalin, returned to the laboratory, rinsed with fresh water over a 3-mm-mesh sieve, and preserved with ethanol.

Each sample will be stained with Rose Bengal, then sorted to remove all epifaunal organisms. The organisms removed will be identified to the lowest taxonomic level possible, counted, and weighed. Species richness, diversity, density, and biomass in each study site will be determined from this data. Archival samples will be maintained.

Bibliography

Fourqurean, J.W., J.C. Zieman, and G.V.N. Powell. 1992. "Phosphorus limitation of primary production in Florida Bay: Evidence from C:N:P ratios of the dominant seagrass *Thalassia testudinum*." Limnol. Oceanogr. 37: 162-171.

Zieman, J.C. 1974. "Methods for the study of growth and productivity in the turtlegrass *Thalassia testudinum* Konig." Aquaculture 4:139-143.

APPENDIX D

Existing Monitoring and Research Programs

EXISTING MONITORING AND RESEARCH PROGRAMS

D.1 INTRODUCTION

An inventory of existing water-quality related monitoring and research programs was conducted in conjunction with the development of the Florida Keys National Marine Sanctuary (FKNMS) Water Quality Monitoring Program. The objectives in this effort were to

- Coordinate sampling sites and methods
- Identify potential information sources/experience to base sampling design and methods
- Identify agency resources that have potential to contribute to the proposed monitoring program

The number of existing agencies and organizations that actually perform water quality monitoring programs in the Florida Keys is minimal. There is a lack of consistent, long-term programs to gather water quality information within the FKNMS. Present efforts are primarily limited to short-term, geographically restricted research projects gathering water quality information in limited areas, mainly as ancillary information for research. The "long-term" programs are conducted primarily in the existing sanctuaries, the Everglades National Park (ENP) and Biscayne National Park (BNP) and natural reserves. However, these monitoring programs are limited in coverage and scope, with the most active sites located outside the FKNMS boundary. Existing monitoring programs are also not coordinated in terms of sampling designs and methodology, making it difficult to compare data. Coordination that does occur is usually fortuitous in that a particular laboratory was approached by different agencies or researchers to conduct a study or provide sampling and analytical services.

Information gathered from interviews with researchers and agency personnel is summarized below. The inventory that was conducted also included related work being done within Florida Bay and Biscayne Bay. In a number of instances, specific information on study sites, methodology, and funding support for each of these studies was difficult to determine. Because of proprietary reasons, some researchers did not want to share proposals that described their work. Some researchers did not have written project descriptions or scopes of work and did not provide any detailed project development information because the sites and methods were still being determined. The researchers also hesitated to share specific budgetary information. Due to their nature, some of these studies may also have been completed or changed by the time this report is released. Information on agency staffing and funding support was also difficult to assess because, in some cases, there were no direct staff or budgetary resources allocated for the particular monitoring program or project. In some instances, funding support for a particular project involved personnel time and limited expenses for supplies. When available, information on existing sampling sites is presented in Figures D-1 through D-3.

D.2 STATE AND LOCAL AGENCIES

D.2.1 Florida Department of Environmental Regulation

The Florida Department of Environmental Regulation (FDER) conducts discharge-related water quality monitoring primarily for compliance, enforcement, and permitting purposes. Unless the FDER is conducting an investigation, routine monitoring is done through the permit holders having major discharges. Two environmental specialists at the FDER Marathon Office are assigned to monitor permit holders. In addition, the FDER staff is conducting a study of water quality in wells receiving secondary treated effluents and surface water in Saddle Bunch Key. In Little Torch Key, there is a single, fixed surface water quality station where standard water quality parameters (temperature, conductivity/salinity, pH, and dissolved oxygen [DO]) including dissolved nutrients are monitored to satisfy Environmental Protection Agency (EPA) ambient monitoring requirements. Because of budgetary and personnel constraints, the FDER is able to maintain only one sampling station in the Florida Keys. The Marathon Office has experienced severe personnel cutbacks in the past few years and there is minimal laboratory space and equipment available (G. Rios and R. Helbling, FDER, personal communication, 1992).

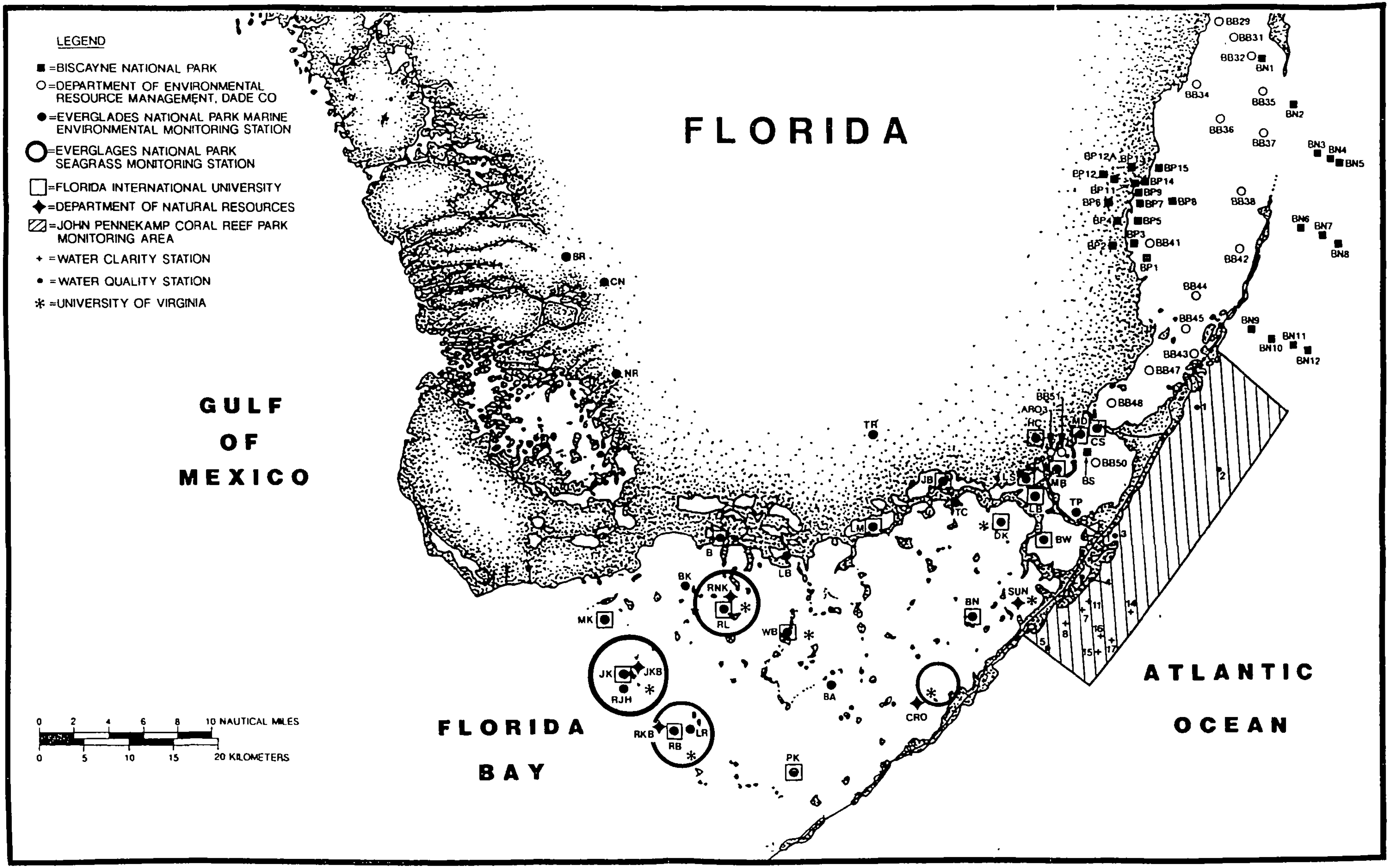


Figure D-1. Existing monitoring stations/sites of the Everglades National Park, Florida International University, University of Virginia, and Florida Department of Natural Resources in Florida Bay and the Department of Environmental Resource Management, Dade Co., and Biscayne National Park in Biscayne Bay.

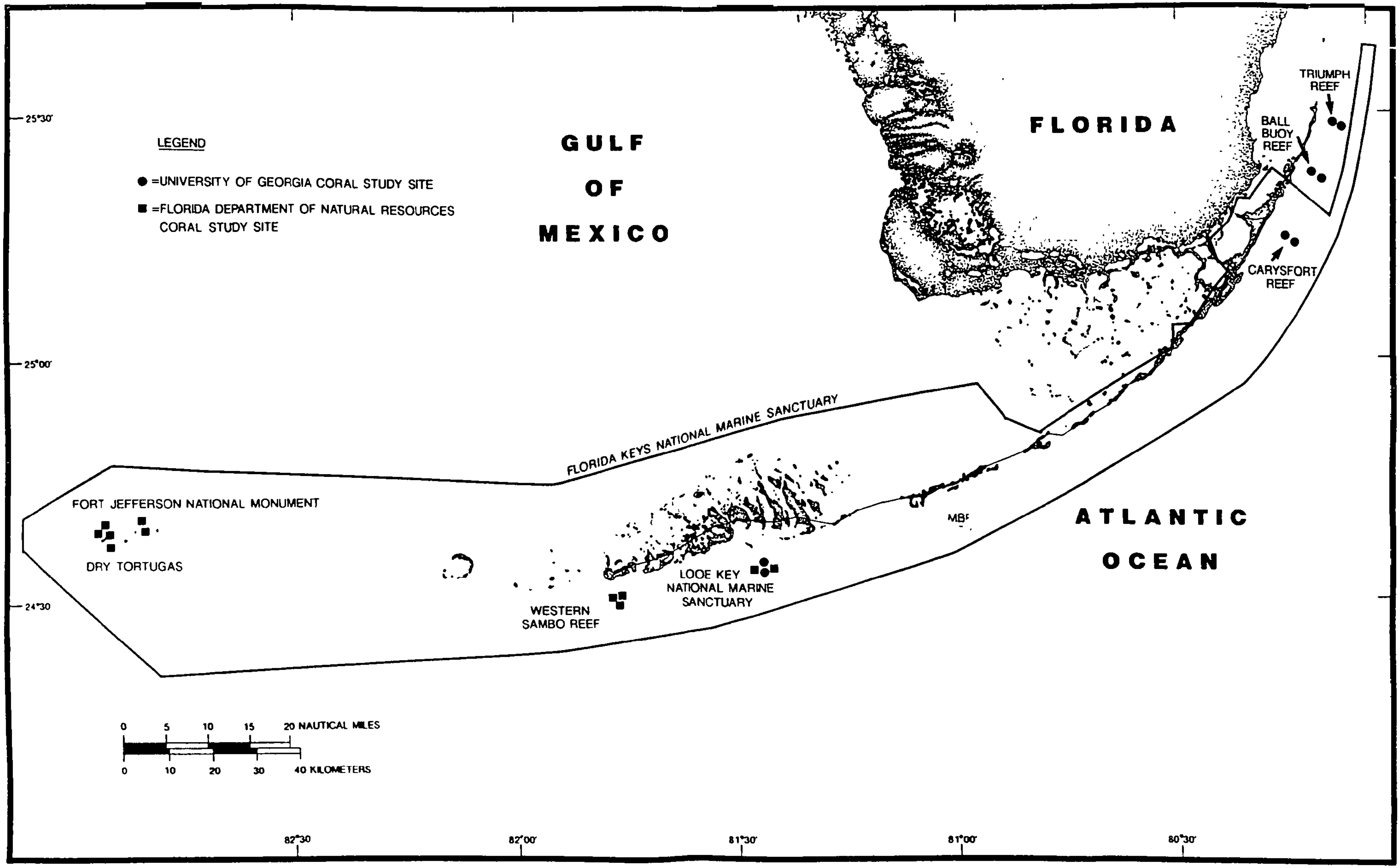
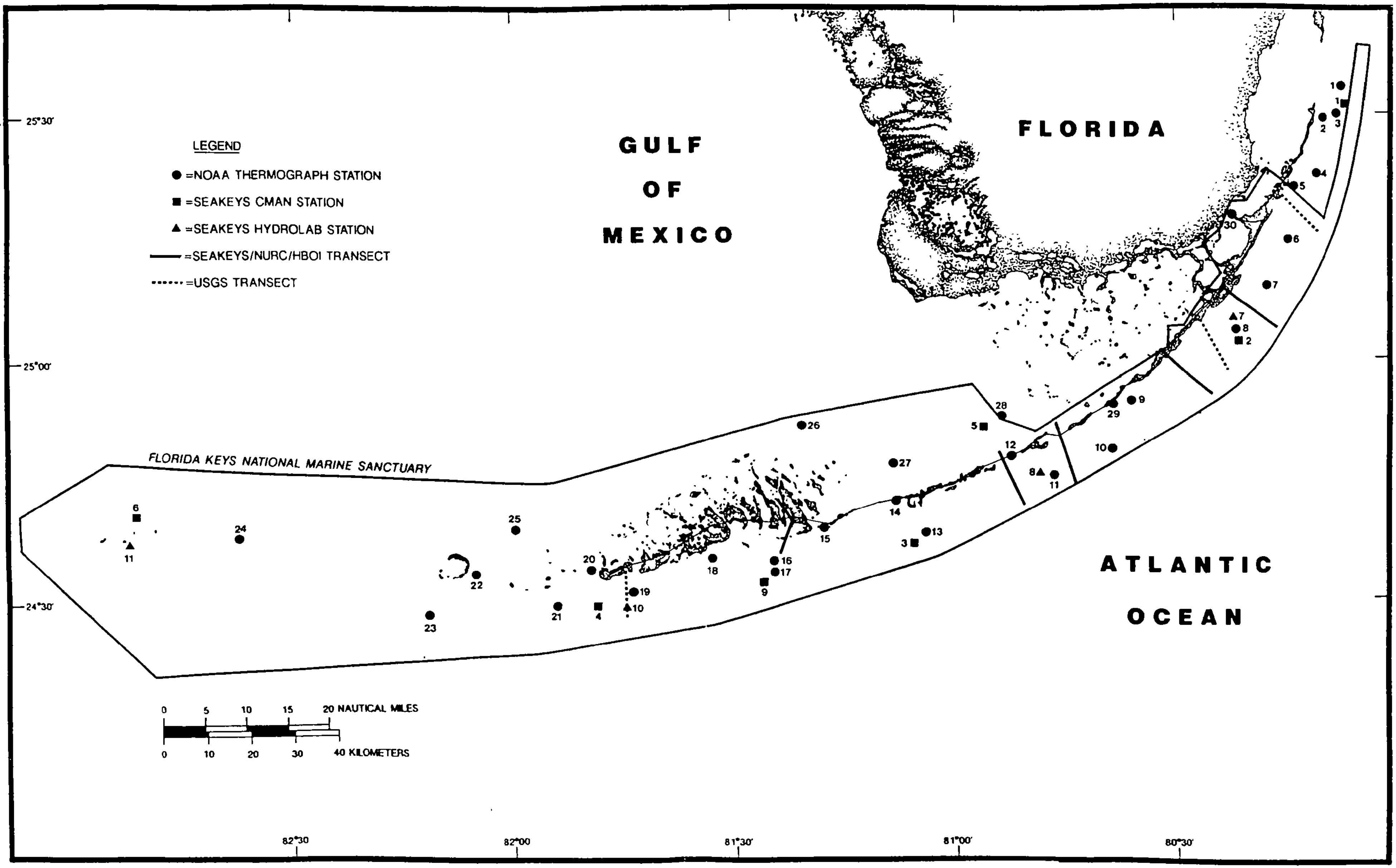


Figure D-2. Existing monitoring sites of Florida Department of Natural Resources and SEAKEYS/University of Georgia in the Florida Keys.



6D-4

Figure D-3. Existing monitoring stations/sites and transects of NOAA/KLNMS, SEAKEYS, SEAKEYS/NURC/HBOI and USGS.

D.2.2 Florida Department of Natural Resources

With support from the South Florida Water Management District (SFWMD), the Florida Marine Research Institute (FMRI) is studying the role of sediment chemistry in the die-off of seagrasses in Florida Bay. The influence of sediment sulfide and rhizome hypoxia on *Thalassia* mortality is being investigated at five sites within Florida Bay (Figure D-1). This study is being conducted by Dr. Paul Carlson, Laura Yarbro, Tim Barber, and Dr. Mike Durako of FMRI. The FMRI has substantial field and laboratory resources for water quality and biological research located in St. Petersburg. (P. Carlson, FMRI, personal communication, 1992).

Through one of its biologists, FMRI is involved with the SEAKEYS program in a study of population dynamics of coral reef communities in the Dry Tortugas and Lower Keys. This study involves the use of quantitative and qualitative measurements of coral cover in permanent quadrats and transects in five study sites in the Dry Tortugas and three study sites in the Lower Keys (Figure D-2). FMRI has been conducting long-term research on algae, corals, sponges, and fish of the Florida reefs. Biologists Walt Jaap, Jennifer Weaton, and Joe Kimmel continue to conduct research with financial support from the National Park Service, General State Revenue, the Areas of Critical State Concern Trust Fund, and the Salt Water Fishing License Trust Fund. They are primarily assisted by FDNR staff with additional assistance provided by staff at LKNMS and John Pennekamp Coral Reef State Park. Jim Beets, David Ballentine, and George Schmahl work collaboratively with the FMRI researchers. (W. Jaap, FMRI, personal communication, 1992, 1993).

The Coastal and Marine Resource Assessment (CAMRA) program at FMRI is developing the Marine Resources Geographic Information System (GIS). The FMRI is also coordinating a 2-year benthic mapping effort for the Florida Keys, Biscayne Bay, and Florida Bay with the National Oceanic and Atmospheric Administration (NOAA). The study will produce benthic habitat/resource maps with 20 to 25 mapping classes at 1:24,000 scale through aerial color photography. The mapping effort will produce both traditional map products and GIS data layers by the end of 1993. This effort will cost approximately $ 0.5 million over 2 years and is supported by numerous sources. The FMRI is also under contract to Monroe County to produce a GIS data layer for on-site sewage disposal systems (OSDS) in the Florida Keys. This product will be available in late 1992 (K. Haddad, FMRI, personal communication, 1992).

The CAMRA GIS laboratory has a staff of 10 and receives support from numerous sources including direct state appropriations, the Marine Conservation Trust Fund, the Coastal Protection Trust Fund, and Coastal Zone Management grants. The laboratory has up-to-date hardware and software resources that are utilized by highly trained and experienced technical personnel. CAMRA is also actively involved with the NOAA COASTWATCH program that will make available imagery from an ocean color scanner (Sea-Viewing Wide Field of View Sensor [SEAWIFS]) on a NASA satellite to be launched in 1993. This imagery, and the COASTWATCH program in general, may have some applicability to water quality monitoring in the Keys. FMRI is also studying benthic algae distribution in the Keys reef tract by using aerial photography (K. Haddad, FMRI, personal communication, 1992).

The South Florida Regional Laboratory (SFRL) in Marathon conducts several research projects on lobsters, conch, bonefish, and marine fisheries. Four professional biologists conduct research on juvenile ecology, recruitment, recreational and commercial fisheries, adult behavioral ecology, and overfishing of the spiny lobster. The population abundance, larval and juvenile biology, growth, mortality, and aquaculture of the queen conch is being studied by a professional biologist and four technicians. A professional biologist is also monitoring catch, effort, and structure of numerous fisheries in the region. These studies are supported primarily by state funds. The SFRL has basic monitoring equipment, four vehicles, and four boats based locally, but these are not available to visiting scientists (J. Hunt, FDNR, personal communication, 1992).

The Florida Institute of Oceanography (FIO) and the FDNR operate the Keys Marine Laboratory in Layton on Long Key. The facility is centrally located and has substantial physical facilities and space. The Keys Marine Laboratory provides support for marine research and education and consists of classrooms, office space, dormitories, laboratory and wetlab space, three boats, and a truck. However, only very limited laboratory equipment is available. Dockage with access to Florida Bay is available. A staff of five maintains the facility (J. Swanson, FDNR, personal communication, 1992).

The FDNR Division of Parks and Recreation operates the John Pennekamp Coral Reef State Park. Basic water quality parameters and dissolved nutrients (analysis performed by an outside laboratory) are monitored monthly at five sites within the park (Figure D-1). In collaboration with FMRI, Dr. R. Skinner and Anne Deaton monitor boat groundings in Mosquito Banks and Basin Hill Shoals. A study to examine the effects of boat traffic on water clarity has been recently initiated by the park. A professional biologist and a technician based in the park conduct these studies using state support (R. Skinner and A. Deaton, John Pennekamp Coral Reef State Park, personal communication, 1992).

D.2.3 South Florida Water Management District

Much of the water quality monitoring work conducted by the SFWMD is contracted through the ENP, BNP, and Dade County Department of Environmental Management (DERM). Water quality monitoring (that the district is directly involved in) is associated with the impacts of freshwater releases into Card Sound when the plug at the C-111 canal is opened for flood control purposes. The district monitors surface water quality (basic parameters and nutrients) and has recently established a pair of benthic monitoring transects at the C-111 discharge. The SFWMD is currently negotiating to contract a study to Biscayne National Park to conduct the L-31E water flow redistribution monitoring. The SFWMD also contracted the monitoring of a well into the Floridian aquifer within John Pennekamp Coral Reef State Park (R. Alleman, SFWMD, personal communication, 1992).

D.2.4 Dade County Department of Environmental Resource Management

The DERM has a large, long-term water quality monitoring program in place. The DERM monitors approximately 25 water-quality parameters at about 90 stations within Biscayne Bay, and in upland areas. Some of the monitoring has been conducted for over 12 years. Basic water-quality parameters, nutrients, and epibenthic habitats are monitored monthly in over 20 stations within Biscayne Bay. This monitoring effort will continue through June 1993 with support from SFWMD through the SWIM program ($200,000 annually). A staff of five to six professional biologists conducts field work, laboratory analysis, and data management. A number of toxics-related monitoring and research projects contracted by the DERM are being conducted. Pesticides and metals in the sediments of South Dade and Biscayne Bay tributaries have also been monitored; this study is in its final reporting stage. DERM also provides sediment quality data for correlation with a study of fish deformities conducted by the Rosenstiel School of Marine and Atmospheric Sciences, and a survey of general biotoxicity is underway. Toxic contaminants are also monitored in bivalves in Biscayne Bay. A study of the influence of the South Dade Landfill contaminants in Biscayne Bay is also in progress. At the Black Point area, water toxicity and nutrient enrichment is being studied (R. Alleman, SFWMD; and C. Weaver, DERM; personal communication, 1992).

D.2.5 Monroe County

Monroe County does not have an ambient water quality monitoring program, although it has supported researchers to study some water quality issues. The county contracts with its consulting engineers (Post, Buckley, Schuh and Jernigan) to quarterly monitor the groundwater in test wells at closed and active landfills at Key Largo (three wells), Long Key (three wells), Cudjoe Key (five wells plus one background surface water quality station). These wells are monitored for basic water-quality parameters, dissolved nutrients, total nitrogen (TN), total phosphorus (TP), total organic carbon (TOC), total suspended solids (TSS), and heavy metals (K. Demaria, Post, Buckley, Schuh and Jernigan, personal communication, 1992).

D.3 FEDERAL GOVERNMENT

D.3.1 Environmental Protection Agency

The EPA SUPERFUND branch has ongoing monitoring efforts at Homestead Air Force Base and Military Canal (R. Alleman, SFWMD; personal communication, 1992). Plans are being developed for monitoring water quality and biological resources associated with the Key West Ocean Outfall. The monitoring program will be implemented by the EPA Gulf Breeze Laboratory (R. Ferry, EPA Region IV, personal communication, 1992).

D.3.2 National Oceanic and Atmospheric Administration/National Marine Fisheries Service

Visual census techniques are being used at the Key Largo National Marine Sanctuary (KLNMS) and Looe Key National Marine Sanctuary (LKNMS) to monitor coral reef fish populations. These censuses have been conducted annually for over 10 years. Currently, there is no direct support for this census except for personnel time and logistical support from the sanctuaries (J. Bohnsack, National Marine Fisheries Service [NMFS], personal communication, 1992).

D.3.3 National Oceanic and Atmospheric Administration/Key Largo National Marine Sanctuary

There is no formal water quality monitoring program conducted by the KLNMS. The monitoring that is conducted is site-specific and project related. Water quality at Algae Reef within the sanctuary is monitored primarily in conjunction with other studies of benthic algal ecology. The study is investigating whether groundwater seepage occurs by using seepage meters and piezometers. This study is a collaboration between Florida International University (FIU) and KLNMS with support from NOAA, Florida Fishing Classic, and KLNMS (logistics and personnel time) (L. Richardson, FIU, and J. Halas, FDNR, personal communication, 1992).

The KLNMS has a system of temperature monitoring stations (recording thermographs) along the reef tract and in other areas of the Keys (Figure D-3). The thermographs are deployed for several months to a year, logging temperature every 2 h. The available data are still being processed. There are 28 to 30 stations along the reef tract on offshore reefs and tidal passes. The duration of this study is indefinite and is funded by the National Ocean Service with approximately $13,000 for equipment purchases. Personnel time and logistical support for installation, maintenance, and operation is provided by KLNMS (H. Hudson, NOAA, personal communication, 1992). There are two professional biologists, four patrol officers, and nine administrative personnel assigned to the KLNMS. One of the professional biologists shares his time between KLNMS and the National Undersea Research Center (NURC) in Key Largo. Most of the personnel are in state positions (the State of Florida operates the KLNMS under a Memorandum of Agreement [MOA] with NOAA [P. Ingram, KLNMS, personal communication, 1992]).

D.3.4 National Oceanic and Atmospheric Administration/Looe Key National Marine Sanctuary

The LKNMS is operated by the FDNR with support under a MOA with NOAA. It does not have nor does it provide direct funding support for a water quality monitoring program. A number of researchers have projects within the sanctuary that are provided substantial logistical support. Field sites, workspace, personnel, and boat time are provided by LKNMS to a number of permitted research projects. LKNMS has no monitoring equipment but has four vehicles and operates seven boats. There is some monitoring equipment used for an environmental education program. The studies permitted and conducted at LKNMS (described elsewhere in this document) include water quality, population dynamics, and biology of coral reef organisms (G. Schmahl and R. Wingrove, LKNMS, personal communication, 1992).

D.3.5 National Oceanic and Atmospheric Administration/Florida Keys National Marine Sanctuary

The FKNMS office in Marathon does not have equipment, vehicles, or boats other than those made available to its personnel from the LKNMS and KLNMS. There are five personnel assigned to the Marathon Office: a Sanctuary Manager; two program specialists; an administrative assistant; and a volunteer coordinator. These personnel have primarily administrative and environmental education responsibilities. A NOAA regional biologist shares his time between the Marathon office and KLNMS (P. James, FKNMS, personal communication, 1992).

D.3.6 National Oceanic and Atmospheric Administration/National Undersea Research Center

The NURC facility in Key Largo is part of NOAA's program that provides funding and logistical support for marine research. NURC is one of the most well-equipped and well-staffed laboratories for conducting research in the Keys. Several short-term, water-quality related projects in the Key Largo area are being conducted under funding from NURC. The projects listed below are supported in 1992 at about $20,000 (S. Miller, NURC, personal communication, 1992). These projects are being conducted by researchers from different areas of the United States. The projects are investigating the following:

- Causes, mechanisms, and impact of *Codium isthmocladum* blooms on reefs
- Traditional spawning sites of pelagic spawning reef fishes
- Decadal-scale changes in benthic foraminiferal assemblages in reef tract sediments
- *In situ* productivity measurements of the deep-water algae, *Anadyomene menziesii*
- Nutrient relations of benthic macroalgae along the Florida Reef Tract
- Sea-level effects and geostrophic-current interactions along a reef-dominated carbonate bank margin and upper slope, in the southern Florida Keys
- The role of secondary metabolites in reducing invertebrate egg and larval mortality from predation and UV exposure
- Hydrographic cross-sections of temperature, salinity, and dissolved oxygen (DO) in the Upper Keys
- Bioerosion on Florida reefs: trends, causes, and significance in an era of global changes
- Carbon:nitrogen:phosphorus (C:N:P) ratios in seagrasses as a potential indicator of nutrient limitation

Recently, NURC has set up a analytical laboratory for nutrient analysis under contract with Dr. Ron Jones of FIU. Other than the equipment costs, the laboratory is operated by a technician for $25,000. NURC and its analytical laboratory is involved in a joint effort with SEAKEYS and Harbor Branch Oceanographic Institution (HBOI) to conduct water quality monitoring (basic parameters and nutrients) weekly along two transects in the Key Largo area (**Figure D-3**) through the summer of 1992. At least four boats and vehicles, field equipment, and scuba diving gear are available to researchers at the facility (which has a permanent staff of three). By late 1992, NURC will have installed the Aquarius underwater habitat at Conch Reef.

D.3.7 Biscayne National Park

The BNP is conducting a long-term water quality monitoring study in 29 stations within Biscayne Bay; this study is associated with the South Dade landfill (**Figure D-1**). The stations are monitored monthly for standard water-quality parameters (by using a Hydrolab Surveyor II) and inorganic nutrients. Funding, personnel time, and logistical support are provided by the BNP. Nutrient analysis (ammonium, phosphate and nitrate by autoanalyzer and ammonia with an ion selective probe) is conducted in their laboratory. The study is supported by internal funds and is conducted by three professional biologists. The population dynamics of sponges is also being studied in Biscayne Bay (R. Curry and B. Nicholas, BNP, personal communication, 1992).

D.3.8 Everglades National Park/South Florida Research Center

The ENP operates an extensive marine monitoring network in Florida Bay. The network is designed primarily for hydrology-oriented monitoring in Florida Bay, Barnes Sound, Shark Slough, and Broad River, and Uplands of the Everglades. The ENP with the SFWMD, also operates a meteorological tower in Joe Bay. The basic monitoring station is a platform with a float and pulley system that is hooked to a Leupold and Stevens recorder rigged with a potentiometer that logs into a single channel Telog datalogger. The system measures depth/level averaged over a 10-min period, to an accuracy of 0.300 ft. Salinity and temperature are also monitored with Hydrolab sensors in northeast Florida Bay (ENP has 18 Hydrolabs and 4 Rosemont conductivity sensors). A professional biologist manages the monitoring program with three technical staff members. The ENP contracts with Dr. Ron Jones of FIU, with support from the SFWMD, to monitor water quality in more than 25 stations in Florida Bay and Barnes Sound. Recreational fisheries are monitored within the park by conducting interviews with fishermen at Flamingo boat ramp. Periodic monitoring of seagrass and epifauna in permanent study sites is also performed by using a combination of rapid qualitative methods and quantitative methods (see **Figure D-1**). Support for this monitoring comes from several different sources. A research project to study the effect of sea-level rise on the mangrove fringe and to model mangrove development is also underway with support from the National Park Service global change initiative. The ENP is also conducting a project to develop a hydrologic model of Florida Bay using salinity as a conservative tracer of water movement. There are several highly trained and experienced scientific personnel at the South Florida Research Center; however, due to a limited budget and an enormous geographic coverage, research activities are constrained. Lack of funding does not allow research work at Ft. Jefferson National Park which ENP also administers. The center has a GIS laboratory and a data management effort which can provide useful information to the FKNMS water quality monitoring effort (M. Robblee and D. Smith, ENP, personal communication, 1992).

D.3.9 United States Geological Survey

The United States Geological Survey (USGS) is conducting a research project to study the hydrogeology and nutrient contamination in groundwater along transects from the Keys to the reef tract with support from EPA and FDER. The project involves drilling seven wells in North Key Largo (five in the Sound and two onshore), seven offshore wells in central Key Largo, and five wells off Stock Island with two onshore (**Figure D-3**) (E. Shinn, USGS, personal communication, 1992).

D.4 NONGOVERNMENTAL/ENVIRONMENTAL ORGANIZATIONS

D.4.1 Environmental Defense Fund and The Nature Conservancy

The Environmental Defense Fund (EDF) does not conduct monitoring or research on water quality directly but it pursues activities which spur research to help policy evolve to protect environmental quality and natural resources. EDF has a cooperative project with The Nature Conservancy (TNC) with $285,000 in funding for 3 years from the MacArthur Foundation (separate from SEAKEYS). The cooperative project focuses on the development and advocacy of policies and research aimed at protecting marine biological diversity in the Florida Keys. The funding provides for the partial support of a professional biologist at EDF (R. Fujita) and TNC. The project supports research to monitor coral reef health by the remote sensing of benthic macroalgal growth using a Eiconix Digital Camera and multispectral scanner. In addition, TNC is documenting numbers and activities of visitors to reef areas by conducting flyovers. TNC will also conduct a pilot study/engineering feasibility study of wastewater treatment technologies for homes and small communities, and will be working with Monroe County under a MOA. The MacArthur Foundation grant is also providing support ($17,500) for the joint NURC/SEAKEYS/HBOI water quality monitoring project described in more detail below (R. Fujita, EDF; and D. Axelrad, TNC, personal communication, 1992).

TNC has an office in Key West but does not have a water-quality monitoring program. The office has two professional biologists and five administrative personnel. The staff's current activities are primarily devoted to environmental education, stewardship, and management of environmental programs. TNC provides half-time support f - the volunteer coordinator's position at the FKNMS office in Marathon and half-time support for a position at the FDNR Marathon Office involved in the visitation survey. While funding is still uncertain, TNC is planning a project to gather anecdotal water quality information in cooperation with the Center for Marine Conservation (CMC). TNC does not have any monitoring resources available (D. Axelrad, TNC, personal communication, 1992).

TNC is supporting Dr. Kathleen Sullivan who is working at the South Florida Research Center. She is developing a system for the classification of marine habitats to organize biodiversity and conservation information for the Biological Conservation Database (BCD). BCD is a relational database developed by TNC Science Programs and employed by state Heritage Programs to manage conservation information. She is also supervising a volunteer coral reef monitoring project initiated by TNC in collaboration with Mary Enstrom of the FKNMS.

D.4.2 Florida Keys Land and Sea Trust

The Florida Keys Land and Sea Trust (FKLST) is not involved in any water quality monitoring at present. A staff biologist previously involved with water quality monitoring is writing reports, but will have returned to graduate school by the time this report is released. FKLST has considered some possible projects that are more impact-oriented and remedial in nature such as investigating water quality in canals being developed and restored, and the effects of re-aeration on water quality. However, with the departure of the technical personnel, the continuation of the study is uncertain. FKLST operates a marine science center at Vaca Key that has facilities and resources that may be of use to a water-quality monitoring program. Currently, they do not have technical personnel available at the facility and the future of the program is still unclear. The marine science center has a 480 sq ft laboratory, office area, a wetlab/seawater system, and dockage space. Water-quality related equipment is available, including a Hydrolab Surveyor II, a pH meter, spectrophotometers, a light meter, oxygen meters, ovens and furnaces, balances, and basic laboratory equipment. Personal computers and peripherals are also available. The center also maintains a dive locker and diving and underwater photography equipment (M. Clark, FKLST, personal communication, 1992).

D.4.3 National Audubon Society

The National Audubon Society (NAS) is supporting and conducting a groundwater study cooperatively with TNC and a graduate student from the University of South Florida to study background levels, seasonal dynamics, and effects of vegetation on groundwater. Standard water-quality parameters and inorganic nutrients on four Keys (Upper Sugar Loaf, Big Pine, Lignum Vitae Key, and North Key Largo) are being measured. Sampling was conducted biweekly for the first 2 years and is now conducted on a monthly basis. The NAS also has surface water reference stations, and is planning a study to look at shallow injection wells or septic systems. The NAS also maintains groundwater level and tidal stations with three continuous recorders in Key Largo (groundwater, Barnes Sound, and Atlantic Ocean); there are also recorders on Lignum Vitae Key.

The NAS Tavernier Office and Research Department currently has four Ph.D. and 10 science/conservation support staff, and administrative personnel. In addition, the NAS has seven boats for research purposes and wetlab facilities. Their laboratory equipment includes filtration apparatus, microscopes, balances, ovens and furnaces, a spectrophotometer, and basic laboratory equipment. Surveying equipment, pH meters, oxygen meters, a salinity/conductivity/temperature meter, current meters, water level recorders, weather stations, light meters, and field plant physiology equipment are available along with various other sampling equipment. In addition, computers and peripherals are available (J. Meeder and M. Ross, NAS, personal communication, 1992).

D.5 ACADEMIC INSTITUTIONS

D.5.1 College of Charleston

If funding is available, Dr. Phil Dustan plans to continue the coral reef community analysis (recruitment, growth, interspecific competition) at Carysfort Reef that he began several years ago. Currently, he is working with FDNR to analyze aerial photography to study benthic algal distributions, with support from the EDF/TNC MacArthur Foundation grant.

D.5.2 Florida International University

Dr. Ron Jones conducts a water quality monitoring effort in Florida Bay through contract from ENP and funding from SFWMD. Basic water quality parameters, dissolved nutrients, TN, TP, organic carbon, alkaline phosphatase and chlorophyll *a* concentrations are measured biweekly in several sites in Whitewater Bay, Florida Bay, and Shark River (**Figure D-1**). Dr. Jones operates the analytical laboratory at the Drinking Water Center at FIU which has an optimized Alpkem rapid flow analyzer system which provides levels of detection of 0.1 μM for ammonia, 0.005 μm for nitrite, and 0.01 μM for phosphate. Dr. Jones also has a contract with NURC to set up and operate the nutrient analysis lab in the NURC facility in Key Largo. The contract provides support for a graduate student and operation. The analytical facility primarily supports the joint NURC/SEAKEYS/HBOI monitoring project. Dr. Jones also has a cooperative agreement with NAS to provide analytical services for groundwater samples.

Dr. Laurie Richardson is involved in a number of projects in the Keys. She has a two-year study of black-band disease in coral reef communities funded by NOAA. Dr. Richardson is also studying *Lyngbya* blooms in Algae Reef with support from The South Florida Fishing Classic Tournament. A project funded by the National Aeronautics and Space Administration will study algal pigments by remote sensing. Dr. Richardson has received a third year of funding from Sea Grant to look at algal distributions by using a field spectral radiometer coupled with pigment analysis. She works with Dr. Jones on nutrient analysis for the studies at Algae Reef.

Dr. Jim Fourqurean has recently joined the Southeast Environmental Research Program as a Research Associate. He will be pursuing a program of research on seagrass ecology and the biogeochemistry of the coastal ocean, particularly in Florida Bay. He is working with Dr. Jay Zieman of the University of Virginia on a project funded by NURC. They will be studying the use of a technique used in Florida Bay to examine phosphorus partitioning based on C:N:P ratios along transects from the Keys to the reef tract, primarily in the Key Largo area. They conducted their first sampling effort the second week of June 1992 and a second effort in late summer 1992. Funding is also available to continue their study in 1993. They receive logistical support from NURC and funding for travel and analytical services.

D.5.3 Florida State University

Bill Herrnkind pursues a program of research on the biological processes regulating recruitment of spiny lobsters. He is studying the factors which control the population size and the ecological conditions on which juvenile lobsters depend. He collaborates with Dr. Mark Butler of Old Dominion University and John Hunt of FDNR. His work was supported financially by SeaGrant and recently by FDNR with logistical support. With the occurrence of catastrophic changes in Florida Bay, his interest has been directed towards studying the impact of the loss of shelter on the recruitment of juvenile lobsters. Dr. Herrnkind and his collaborators have recently proposed to U.S. Department of the Interior to study the efficacy of mitigation measures to offset the loss of habitat using artificial shelters.

D.5.4 Harbor Branch Oceanographic Institution

Dr. Brian Lapointe is conducting a water quality study along a transect from Big Pine to Looe Key in conjunction with water quality monitoring by NURC and SEAKEYS. In addition, Dr. LaPointe has work involving three transects from the Key West Outfall, Big Pine Key to Looe Key, and Long Key to Alligator Reef, supported by NOAA/Office of Coastal Zone Management and Monroe County. Dr. LaPointe has deployed Hydrolabs along these four stations.

As part of the SEAKEYS program, Dr. Ned Smith is studying currents and transport patterns within the Florida Keys. At the Looe Key area, he is using current meters deployed at strategic sites in Hawk Channel to determine the role of Hawk Channel in along-shelf transport. He is also quantifying the tidal and nontidal exchange through selected, major channels from Key Largo to Upper Matecumbe Key. Using a modeling approach, he is determining water residence times in Biscayne Bay. The SEAKEYS program provides approximately $60,000 annually for 3 years for his study.

D.5.5 Florida Institute of Oceanography

Dr. John Ogden manages the SEAKEYS program, now in its third year, with approximately $1.1 million in funding from the MacArthur Foundation for 5 years. FIO also jointly operates the Keys Marine Laboratory, the base of operations for SEAKEYS. A field manager/professional biologist and two technicians/research assistants maintain and operate the Coastal Marine Automated Network (CMAN) stations installed at four sites along the reef tract (Figure D-3). These stations provide hourly data on wind speed, wind direction, peak gusts, barometric pressure, air temperature, photosynthetically active radiation (PAR) in air, underwater PAR, and salinity. These data are transmitted by satellite to the National Data Buoy Center and can be accessed at near real time. Two additional CMAN stations are funded but are not installed to date. FIO also maintains five Hydrolab Datasonde III stations for FMRI (Figure D-3). These stations monitor and log hourly water temperature, salinity, conductivity, water level, and DO. FIO is the coordinating institution for the Caribbean Marine Productivity Program (CARICOMP) which represents a network of marine research stations from countries in the Caribbean Basin.

D.5.6 Old Dominion University

Dr. Mark Butler collaborates with Dr. Herrnkind of Florida State University and John Hunt of FDNR in studying spiny lobster biology in South Florida. He has worked in the area for over 10 years studying recruitment of lobsters, particularly in Florida Bay. His research on the availability of nursery habitats and controls on settlement of juvenile lobsters was supported until recently by SeaGrant, NURC, and Earthwatch. FDNR currently provides logistical support for his research. The recent occurrence of sponge dieoffs in Florida Bay has directed Dr. Butler and his collaborators' efforts to study the impact of sponge dieoffs on lobster recruitment. Dr. Butler and his collaborators are developing a method for assessing and documenting the status of nearshore hardbottom areas using an underwater video camera and GPS. The video transect information is coupled with quantitative measurements of bottom cover and diver counts of juvenile lobsters. A long-term tagging program to monitor lobster populations has also been established in 27 sites.

D.5.7 University of Georgia

As a co-principal investigator on the SEAKEYS program, Dr. Jim Porter is conducting a study of the population ecology of Floridian reef corals. The SEAKEYS program provides about $60,000 annually for 3 years for his study in the reefs of the Upper and Lower Keys (Figure D-2). With support from BNP/National Park Service, Dr. Porter studies the population biology of coral reef communities in BNP utilizing a quantitative photographic method for monitoring changes in coral cover in permanent quadrats in the Upper Keys. Technical support includes a doctoral candidate and a graduate student. Walter Jaap of FDNR and Elizabeth Gladfelter of Fairleigh Dickinson University are collaborating with him on this study.

D.5.8 University of Miami

Dr. Peter Glynn and a graduate student are conducting a study to determine the impact of toxics on marine organisms with support from the MacArthur Foundation. Water, sediment, corals, suspension feeding mollusks, sponges, lobster, and snapper are collected along a transect from Carysfort Reef south to Basin Hill Shoals once a year (twice during the first 2 years of the study). The samples are analyzed by laboratories at the Rosenstiel School of Marine and Atmospheric Sciences for pesticides, polynuclear aromatic hydrocarbons, and heavy metals by using broad spectrum scans. The emphasis will shift to laboratory investigations for the remaining 2 years of the project.

Dr. Sam Snedaker and a graduate student are conducting a study of the sources of pesticide contamination in coral tissues in the Keys to continue investigating the findings of a study by Dr. Peter Glynn (who found pesticides in coral tissues). Dr. Snedaker is testing the applicability of using semi-permeable membrane devices to sample pesticides. These devices will be deployed near the CMAN stations and at additional sites along the reef tract. A broad scan for pesticides using contract labs was begun 1.5 years ago and will continue for another 2 years with MacArthur Foundation support.

Dr. Alina Szmant plans to extend her SEAKEYS-supported water quality work with a study of nutrients in sediments. With SEAKEYS support, Dr. Szmant is participating in the joint NURC/SEAKEYS/HBOI monitoring of two transects from Long Key to the reef tract (Figure D-3). Dr. Szmant plans to continue work in the Lower Keys (including Key West), study the Key West Outfall, and run transects from inshore to offshore to examine water column and pore water nutrients. She is also studying sediment nutrient fluxes by using chambers, and plans to conduct manipulative experiments with enrichments of nitrogen and phosphorus in reef environments so that indicator scenarios of nutrient enrichment can be developed. The study will be conducted with support from MacArthur Foundation, SeaGrant, and NOAA. The studies will also focus on more process-oriented/experimental work with NURC support. Dr. Szmant and a research associate Dr. Peggy Fong are also conducting a study of algal films on reefs.

D.5.8 University of Virginia

Dr. Jay Zieman is continuing seagrass research and monitoring work at several sites within Florida Bay (Figure D-1). Dr. Zieman is also working with Dr. Jim Fourqurean of Florida International University on a NURC-funded project to study C:N:P ratios in seagrasses. Dr. Zieman also has a graduate student conducting a study of epiphytes and seagrass productivity in several sites in Florida Bay with support from ENP. He is also the head Principal Investigator of an EPA-funded study of the effects of reduced light on seagrass growth and biochemical parameters. The study is funded for two years ($150,000 per year) as part of the EPA Coastal Submerged Aquatic Vegetation Initiative. His collaborators on the study are Drs. Jim Fourqurean, Ken Dunton, Ken Heck, Mike Durako, Paul Carlson, Margaret Hall, and Mike Robblee.

APPENDIX E

Volunteer Monitoring

EPA. 1988b. Lake restoration guidance manual: monitoring. EPA 440/5-88-002. Criteria and Standards Division. Environmental Protection Agency, Washington, DC.

EPA. 1989. Chesapeake Bay citizen monitoring program report. CBP/TRS 27/89. Environmental Protecti n Agency, Chesapeake Bay Program, Annapolis, MD.

EPA. 1990a. Volunteer water monitoring: A guide for state managers. EPA/440/4-90-010. Environmental Protection Agency, Office of Water, Washington, DC.

EPA. 1990b. National directory of citizen volunteer environmental programs. EPA/503/9-90-004. Environmental Protection Agency, Office of Water, Washington, DC.

VOLUNTEER MONITORING

E.1 VOLUNTEER MONITORING PROGRAM

A volunteer monitoring program, if designed, supported, and managed properly, can be valuable to the Florida Keys National Marine Sanctuary (FKNMS) water quality monitoring program by increasing the availability of resources that can be brought to bear on the questions being addressed. Citizen/volunteer monitoring may be advantageous to the program, based on the following considerations:

- The geographic and logistical realities of conducting a comprehensive monitoring program require that all possible and practical avenues of collaborative effort be explored.

- There are some types of information that properly trained and supervised volunteers can collect and process that can be useful and valuable.

- In some instances, personnel time is the most expensive cost in acquiring environmental information, and volunteers with proper training and close supervision can acquire this information.

The incorporation of volunteer/citizen monitoring in the water quality monitoring program provides a sense of empowerment and participation in the process, and engenders public support for the program and the goals for which the FKNMS was created. Volunteer monitoring has been recognized on a national basis to have a value to environmental programs, resource management, and water quality protection efforts (Environmental Protection Agency [EPA] 1989, 1990a,b).

EPA actively supports and encourages the use of citizen volunteers in monitoring programs (EPA 1990a,b). There is a large variety of collaborative efforts involving citizen volunteers. The monitoring programs include participation by homeowners, school children, tourists, technical personnel, law enforcement, and resource managers. Sources of support for volunteer monitoring programs are also varied, including membership donations, corporate sponsors, foundation grants, and federal and state support.

In Florida, there are several active citizen monitoring programs. These include

- Adopt-a-Shore, Clean Florida Commission
- Florida LAKEWATCH
- Friends of Perdido Bay
- Lake Monitoring Volunteer Program
- Marine Resources Council of East Florida
- Sarasota Bay National Estuary Program
- Indian River Lagoon National Estuary Program

In addition to the advantages of using volunteers for monitoring, there are also limitations that must be recognized.

- Technical knowledge and competence
- Time (reliability and consistency)
- Logistics
- Strength and stamina
- Liability and risk

The areas of the monitoring program where volunteers can assist include

- **Field work**
  Field measurements or data collection
  Sample collection, stabilization, and transport
  Logistics/transportation or access to sites

Security and maintenance
Collection of anecdotal information
Conducting censuses

- **Laboratory work**
  Sample processing
  Sample counts
  Sample identification
  Sample analyses

- **Data management**
  Data entry and verification
  Data reduction
  Simple descriptive statistical analysis
  Data graphing

- **Report production**

- **Information dissemination**

Some ideas or concepts that could be explored for use in the monitoring program include

- **Earthwatch Concept**
  Establishing a program where out-of-state volunteers actually help pay for the cost of the monitoring program. This may be studied from a potential ecotourism angle.

- **Homeowners**
  Determining if homeowners or associations can support monitoring efforts financially or logistically.

- **High schools and colleges**
  Determining if high school and college students or organizations can take part in monitoring for classes.

- **Community college administration**
  Determining if the local community college has the expertise and resources to manage the volunteer network.

- **Foundation support for monitoring**
  Determining what sources of foundation support are available (e.g., SEAKEYS).

- **Development of citizen monitoring tools and modules**
  Developing or acquiring the tools volunteers are to use. They must be specific to the system and the data quality objectives.

- **Development of initial and refresher training sessions**
  Developing training programs for the citizen monitors.

- **Environmental Hotline**
  Establishing a toll-free number that the public can call to report potential and active environmental problems or environmental crimes (e.g., bilge pumping, oil and hazardous material spills), and receive periodic updates on monitoring activities (e.g., Alliance for the Chesapeake Bay, 1-800-662-CRIS; Galveston Bay NEP, 1-800-3 OUR BAY.

The minimum requirements that should be satisfied for a full-scale implementation of a volunteer monitoring program should be to

- Design and implementation of a pilot program to test or validate the concept, mechanism, participation, and usefulness of the volunteer program
- Develop an acceptable quality assurance/quality control (QA/QC) program
- Acquire of adequate and programmed financial support
- Establish a clear definition of persons/institutions to be responsible for the coordination and management of monitors
- Provide for active feedback to volunteers and the continuing evaluation of the utility of the program
- Formulate clear and programmed provisions for data management
- Establish a clear statement of utility of data and importance to overall monitoring program
- Create a clear statement of data quality objectives

Other, secondary considerations that will need to be clarified are the

- Cost of the program and source of support
- Recognition and feedback mechanisms
- Tax deductible contributions
- Liability and insurance questions

Implementation of the program should be phased, with feedback and revisions of the components as required. Because of their nature and status, environmental organizations and academic institutions are probably the best sectors for managing and implementing the volunteer program.

E.2 AVAILABLE LITERATURE

A number of publications are available for guidance regarding the design of a volunteer monitoring program. There are also software packages that have been developed for managing data for large monitoring programs (Alliance for the Chesapeake Bay 1992).

Alliance for the Chesapeake Bay. 1987. A quality assurance project plan for the citizen monitoring program. Annapolis, MD.

Alliance for the Chesapeake Bay. 1988. An introduction to water quality monitoring using volunteers: A handbook for coordinator. Annapolis, MD.

Alliance for the Chesapeake Bay. 1992. *Citizen monitoring manual.* Annapolis, MD.

EPA. 1988a. Citizen volunteers in environmental monitoring: summary proceedings of a national workshop. Office of Water. Environmental Protection Agency, Washington, DC.

TASK 7 — RESEARCH PROGRAM

CONTENTS

TABLE

FIGURE

APPENDIX C

Seagrass Monitoring Protocols

ACRONYMS

CMAN	Coastal Marine Automated Network
DO	dissolved oxygen
EMAP	Ecological Monitoring and Assessment Program
EPA	Environmental Protection Agency
FDER	Florida Department of Environmental Regulation
FDNR	Florida Department of Natural Resources
FKNMS	Florida Keys National Marine Sanctuary
FWS	U.S. Fish and Wildlife Service
NOAA	National Oceanic and Atmospheric Administration
OSDS	on-site sewage disposal system
QA	Quality Assurance
QC	Quality Control
QAPjP	Quality Assurance Project Plan
SFWMD	South Florida Water Management District
USACE	U.S. Army Corps of Engineers
USGS	United States Geological Survey

1.0 INTRODUCTION

The objective of Task 7 is to develop a research program to identify and understand the cause/effect relationships involving pollutants, transport pathways, and the biological communities of the Florida Keys National Marine Sanctuary (FKNMS). The research program will support and augment the monitoring program discussed in Task 6. Monitoring program and research program results will be used with institutional and engineering options (Tasks 3 and 4) by Sanctuary managers to accomplish the objectives of the Water Quality Protection Program (see preface for discussion of interrelationships of tasks and Sanctuary management). This report specifies research objectives; identifies research components, general study approaches, and relative cost ranges; discusses quality assurance/quality control (QA/QC) procedures and data management; and provides recommendations for program evaluation and dissemination of information.

The research program is closely related to the monitoring program discussed in Task 6. The monitoring program will focus on documenting status and trends and measuring the success of remedial actions, whereas the research program will focus on processes and cause/effect relationships. One way in which the research program will interact with the monitoring program is through the development of new monitoring tools (e.g., indicators). In addition, the monitoring program will provide data for validation and refinement of predictive models developed through research.

In contrast to the water quality monitoring program, the research program does not define specific methods and approaches. Rather, research objectives and program components are presented, and general types of approaches are identified. It is anticipated that activities within the research topic areas will be funded on a competitive basis. Researchers will propose specific approaches and methodologies appropriate to the topic under consideration.

2.0 BACKGROUND

The research program was developed based on

- The Task 7 objective (stated above)
- Recommendations from previous workshops
- Phase I literature review and technical workshops
- Phase II Monitoring/Research Workshops (July 1992)

2.1 PREVIOUS WORKSHOPS

The research program incorporates the recommendations from several previous research workshops held in recent years:

- Workshop on Coral Reef Research and Management in the Florida Keys (Miller 1988)
- Workshop on Coral Bleaching, Coral Reef Ecosystems and Global Climate Change (D'Elia *et al.* 1991)
- The Florida Keys Environmental Summit (Olson 1991)
- Undersea Research Needs in the Florida Keys (Simmons 1991)
- National Oceanic and Atmospheric Administration (NOAA) Research Planning Workshop for the FKNMS (Harwell 1991)

The NOAA Research Planning Workshop is of special importance because it integrated research recommendations from previous workshops. The water quality research program described herein is narrower in scope than the research plan discussed at the NOAA Research Planning Workshop because it focuses only on water quality issues. For example, this research program does not address fishery management issues or physical/mechanical damage to coral reefs. The water quality research program will complement NOAA's comprehensive research plan, which will include these other topics.

Some key recommendations of the NOAA Research Planning Workshop are listed below (many other recommendations pertain to baseline characterization, monitoring, or administrative issues).

- Understand the regional ecosystem implications and manage the ecosystem in a holistic manner, including across jurisdictional boundaries
- Create predictive models to address critical issues
- Perform short-, medium-, and long-term research to develop an understanding of processes and mechanisms and to understand the interactions of stress parameters
- Perform comparative studies of similar systems in other geographical regions
- Examine the effects of xenobiotics and other toxicants, including dose-response information

2.2 PHASE I LITERATURE REVIEW AND WORKSHOPS

Water quality and ecological problems were identified and discussed in the Phase I report, based on a literature review. Technical workshops were held in February 1992 to discuss problems in four main areas:

- Coral communities
- Submerged and emergent aquatic vegetation
- Nearshore and confined waters
- Spills and hazardous materials

At the workshops, data gaps were noted in discussions of particular ecological problems. However, neither the literature review nor the workshops were specifically designed to identify data gaps or research needs in a systematic way. The Phase I report and problem statements were reviewed, and the following general conclusions were drawn concerning the adequacy of the information base.

- **Water quality status and trends**
  There are insufficient water quality data to document the extent, severity, and trend of water quality problems and to correlate biological changes with water quality parameters. This information will be gathered through the comprehensive water quality monitoring program (see Task 6).

- **Biological community status and trends**
  There is a lack of long-term, comprehensive biological and environmental data from FKNMS biological communities such as coral reefs and other hard bottom communities, seagrass communities, and mangrove communities. This information will be gathered through the comprehensive water-quality monitoring program (see Task 6).

- **Unquantified or poorly known nutrient loadings**
  Available information regarding nutrient loadings to FKNMS waters is insufficient to estimate the relative contribution of anthropogenic and natural sources. Nutrient loadings from wastewater and stormwater were estimated in Tasks 3 and 4. However, the accuracy of the stormwater values is uncertain because there are no data specific to the Keys; loadings were estimated from literature values for various land-use categories. In addition, two potentially major nutrient sources were not quantified:
  - Atmospheric deposition (wetfall and dryfall)
  - Advective inputs from adjacent areas (Florida Bay, Biscayne Bay, Florida Current)

  Also, there is no information about nutrient loadings to canals from weed wrack decomposition, which could be significant locally (though probably not regionally).

- **Fate of wastewater nutrients in groundwater**
  Nutrients in domestic wastewater discharged into groundwater (e.g., through injection wells and on-site sewage disposal systems [OSDS]) have been suggested as possible causes of problematic algal growth on Florida Keys coral reefs (see the Phase I report). The fate of wastewater nutrients in groundwater is not well understood. Nutrient loadings to groundwater can be estimated, but we do not know what proportion of the nutrients is eventually released into FKNMS waters and whether the relative abundance of different nutrients (forms of nitrogen and phosphorus) is altered. Information is needed as to whether and in what quantities wastewater nutrients from injection wells are reaching offshore reefs.

- **Ecological effects of altered water quality**
  Numerous ecological problems in FKNMS biological communities have been discussed in the Phase I report and workshops. However, causes are in most cases not understood well enough to (1) determine whether anthropogenic pollutants (e.g., nutrients) are having adverse ecological effects beyond confined waters (e.g., canals), and (2) predict confidently the ecological benefits of pollution reduction measures. Information is needed showing causal linkages between pollutants and specific ecological problems so that resource managers can evaluate the need for engineering and/or management actions to reduce pollutants.

2.3 PHASE II MONITORING/RESEARCH WORKSHOPS

A preliminary draft version of the research program was circulated to scientists for review prior to the Monitoring/Research Workshops held July 14-16, 1992, in Marathon, Florida. The program was revised based on numerous comments and suggestions provided by workshop participants. In addition to numerous specific comments, the following major points influenced the development of the research program.

- **Florida Bay/Everglades influence**
  The FKNMS is strongly interconnected with Florida Bay and the Everglades. Water transport from Florida Bay through the passes is recognized as a significant potential influence on water quality in the FKNMS. Major concerns are changes in salinity, temperature, turbidity, and nutrients associated with water moving through the passes and onto the reef tract. Participants indicated that studies are needed to estimate long-term net transport and episodic transport from Florida Bay, as well as ecological effects of this transport. Participants also emphasized that research should not be limited by the jurisdictional boundaries of the FKNMS. Agencies should work to ensure the adequate funding of research in the Florida Bay/Everglades system, because effective understanding and management of the FKNMS depends on what is occurring to water quality "upstream."

- **Modeling as research framework**
  Modeling can and should provide a framework for research, monitoring, and management. Participants recommended that predictive models be developed to provide information for management decisions.

3.0 RESEARCH GOALS

The objective of the Water Quality Protection Program is to "restore and maintain the chemical, physical, and biological integrity of the FKNMS, including restoration and maintenance of a balanced, indigenous population of corals, shellfish, fish and wildlife, and recreational activities in and on the water" (Florida Keys National Marine Sanctuaries and Protection Act). Within this context, the purpose of the research program is to identify and understand cause/effect relationships involving pollutants, transport pathways, and the biological communities of the FKNMS. Based on this general objective and the previously discussed guidance, the research program was designed with three main goals:

(1) **Develop predictive models**
Predictive models should be developed based on our understanding of cause/effect relationships. These models, used with appropriate scientific guidance, would allow resource managers to predict and evaluate the outcome of various management strategies (e.g., engineering and/or institutional options discussed in Tasks 3 and 4). Two types of models are envisioned.

- **Transport/water quality model**
  This model, consisting of a hydrodynamic component coupled to a water quality component, would simulate temporal and spatial variations in water quality parameters. In addition to the FKNMS, the model would include all adjacent areas (e.g., Florida Bay, Biscayne Bay, Florida Current) necessary to understand water transport and water quality within the FKNMS.

- **Ecological model(s)**
  The ecological model(s) would be coupled to the transport/water quality model. Such models would be used to predict ecological effects of alterations in pollutant loadings in the Keys and altered water flow into Florida Bay from the Everglades.

(2) **Provide answers to specific management questions and concerns**
The research program should include studies to help answer current and future management questions and concerns. The four main areas of current research needs are:

- **Unquantified or poorly known nutrient loadings**
  Estimate unquantified, but potentially major, nutrient loadings, including atmospheric deposition and advective inputs from Florida Bay, Biscayne Bay, and the Florida Current.

- **Fate of wastewater nutrients in groundwater**
  Determine the fate of wastewater nutrients discharged into groundwater.

- **Influence of Florida Bay on water quality**
  Understand the effect of water transport from Florida Bay, including long-term net transport and episodic transport, on water quality and resources in the FKNMS.

- **Ecological effects of altered water quality**
  Identify and document causal linkages between pollutants and ecological problems in each major ecosystem.

(3) **Develop monitoring tools and methodologies**
The research program should identify and evaluate indicators (biochemical and ecological measures to provide early warning of widespread ecological problems) in each type of ecosystem. These measures could be incorporated into the water quality monitoring program and may provide the basis for resource-oriented water quality standards (biocriteria) for the FKNMS. The program should also identify and evaluate other monitoring tools and methodologies to detect pollutants and identify the cause/effect relationships involving water quality and biological resources.

4.0 PROGRAM COMPONENTS

Based on the goals and information needs stated in Section 3.0, the research program has been designed with three main components.

(1) Model development
(2) Investigation of specific questions/problems
(3) Monitoring tool development

Table 7-1 summarizes the program components in terms of goals, time frame, types of research involved, and relative cost range. Figure 7-1 illustrates the relationships among research and monitoring components.

4.1 MODEL DEVELOPMENT

Monitoring/Research Workshop participants recommended that predictive models should serve as the framework for the research program. Two types of models are proposed as the endpoints for the research program: (1) a transport/water quality model, and (2) predictive ecological model(s) coupled to the transport/water quality model. The models should include all adjacent areas (e.g., Florida Bay, Biscayne Bay, Florida Current) necessary to understand water transport, water quality, and biological effects within the FKNMS. Such models could be used to predict the effects of alterations in pollutant loadings in the Keys and altered water flow into Florida Bay from the Everglades.

Model development is expected to be a long-term process, with initial conceptual models being refined and made increasingly quantitative over a period of years. An initial Modeling Workshop is proposed to discuss modeling approaches, develop preliminary conceptual models, and define specific information needs for the models. Studies will be needed in at least four areas to support model development.

- Nutrient budgeting
- Circulation
- Groundwater hydrogeology
- Ecology

Some of this supporting information will come from studies investigating specific questions and problems discussed in Section 4.2 and additional study needs will be identified at the Modeling Workshop. Acquisition of sufficient supporting data to construct realistic models may be the most difficult, complex, and expensive part of the model development process.

4.1.1 Transport/Water Quality Model

A major goal of the research program is to develop a predictive transport/water quality model. The model would allow managers to evaluate the water quality consequences of actions to reduce or eliminate pollutants, or to alter flow regimes (e.g., freshwater flow from the Everglades into Florida Bay).

A water quality model typically consists of two main components: (1) a hydrodynamic model and (2) a water quality component. The hydrodynamic component simulates water flow into and out of each segment of the system, including external exchanges. For modeling purposes, a segmentation scheme for the FKNMS should be adopted that is consistent with the segmentation scheme used for the monitoring program (Task 6); to achieve greater spatial resolution, the model could subdivide each segment into many smaller cells, if appropriate. The water quality component calculates water quality parameters (e.g., nutrient concentrations) in each segment. These parameters change over time as a result of water flow into and out of each segment and processes within each segment. One of the most elaborate existing models, developed for Chesapeake Bay, also includes a third component that models benthic nutrient fluxes in relation to water quality conditions (Cerco 1991).

Table 7-1. Research program components.

Component	Types of Research	Time Frame[a]	Cost Range[b]	Goals/Uses of Research
1. MODEL DEVELOPMENT (a) *Transport/water quality model* (b) *Ecological model(s)*	• Modeling workshop • *Hydrodynamic modeling* • Ecological modeling • *Nutrient budgeting* • Groundwater studies • *Circulation studies* • Ecological studies • Monitoring program (input, validation)	Short term (initial *conceptual models*) *Long term (validated* quantitative models)	Low (initial conceptual *models*) *High (validated quantitative* models)	Predict effects of engineering and management actions on water quality and biological resources (e.g., evaluate "what if" scenarios)
2. SPECIFIC QUESTIONS/ PROBLEMS				
(a) Unquantified nutrient loadings	• Literature review • Field studies (identified after literature review)	Short term	Low to medium	Compare magnitude of anthropogenic and natural nutrient loadings; needs to be considered in evaluating engineering and/or management actions to reduce anthropogenic loadings
(b) Fate of wastewater nutrients in groundwater	• Geological studies (map confining layers) • Groundwater sampling and analysis	Short term	Medium	Evaluate whether wastewater nutrients from injection wells are reaching reef tract; if so, this may justify engineering and/or management actions
(c) Influence of Florida Bay on water quality and resources	• Field circulation studies • Circulation modeling • Ecological studies	Medium to long term	Medium to high	Understand a major external influence on water quality; this provides context for decisions about engineering and/or management actions to reduce pollutants
(d) Ecological effects of altered water quality	• Experimental studies (lab, mesocosm, *in situ*) • Historical studies (sclerochronology, geological reconstruction) • Geographic comparisons	Short to long term	Medium to high (overall) Low to medium (individual studies)	Document causal linkages between pollutants and ecological problems; if detected, these linkages could justify engineering and/or management actions to reduce pollutants
3. MONITORING TOOL DEVELOPMENT (a) Indicators (b) Other tools/methods	• Literature review • Lab, mesocosm, *in situ* studies to evaluate • Monitoring program (validation)	Short to long term	Medium (overall) Low to medium (individual studies)	Enhance the monitoring program by making it easier and less expensive to detect altered water quality and ecological changes at an early stage

[a]Time frame: Short term (1-2 years); medium term (2-5 years); long term (greater than 5 years).
[b]Cost range (over the stated time frame): Low (less than $100,000); Medium ($100,000 to $1 million); High (over $1 million).

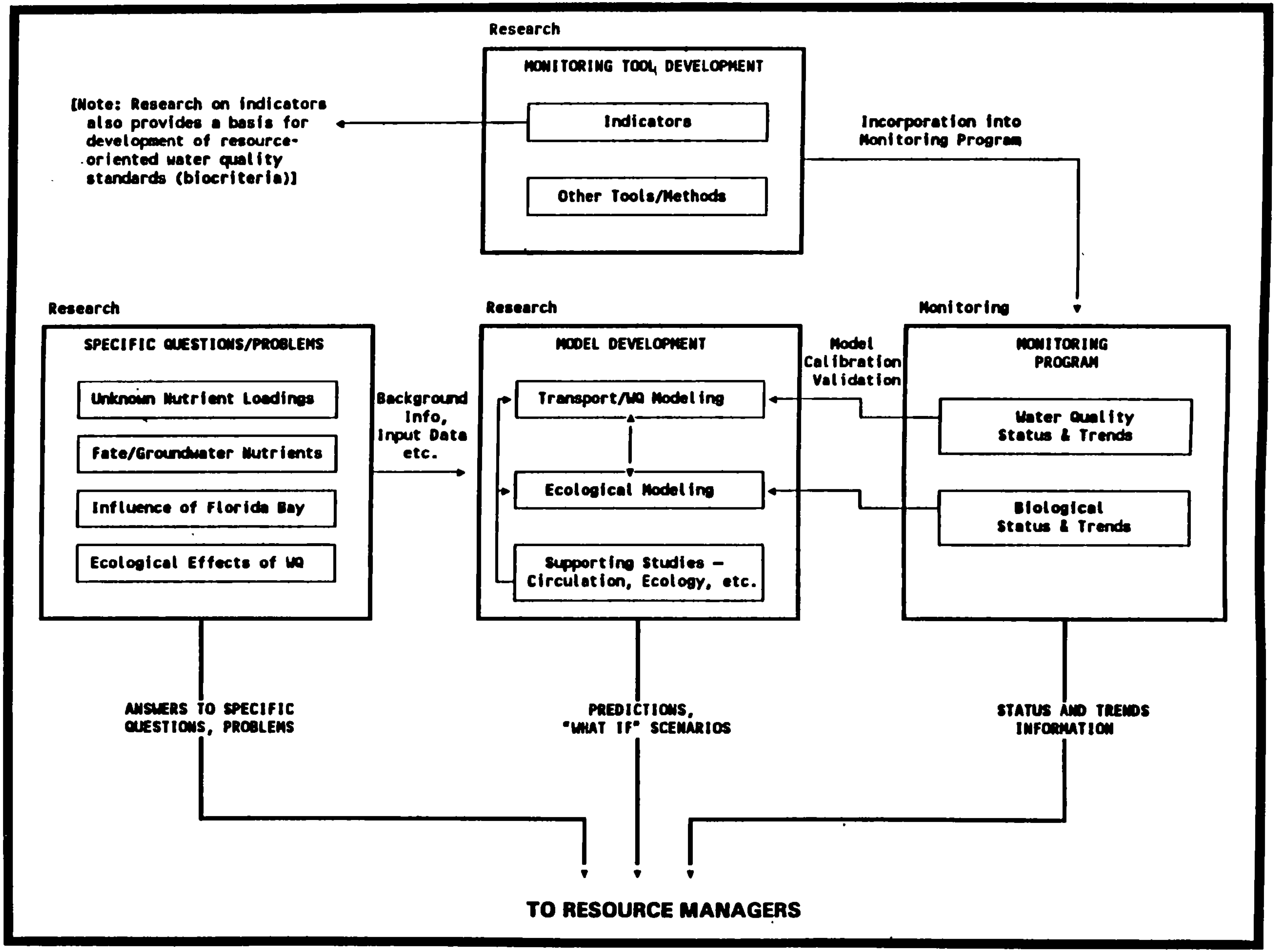


Figure 7-1. Relationships among research and monitoring components.

The hydrodynamic component of a water quality model can vary in complexity depending on the nature of the system, the level of accuracy desired, and other factors such as cost and time considerations. Costanza *et al.* (1990) used a two-dimensional hydrodynamic/water quality model as the basis for their model simulating long-term changes in the spatial pattern of coastal ecosystems. The two-dimensional hydrodynamic model approximates the major, long-term effects in the shallow Louisiana study area (Costanza *et al.* 1990). In contrast, a more complex, three-dimensional water quality model was developed for Chesapeake Bay (Cerco 1991; Blankenship 1992). This model required several years and about $3.5 million to develop, and it is so calculation- intensive that it runs on a CRAY supercomputer. However, the same type of model is being considered or used for two other estuaries — Tar river, North Carolina, and Back Bay, Mississippi. These models will run on a 386 or 486 personal computer, and total cost is expected to be $300,000 to $500,000 per estuary (J.M. Greenfield, 1992, personal communication, EPA Region IV).

The Tampa Bay National Estuary Program (1992a), faced with a similar need for predictive capability, is following a staged approach:

- Evaluating statistical associations between water quality, physical, and biological measurements, using existing data. This is a relatively inexpensive analytical process to help identify potential cause/effect relationships.
- Developing a simplistic box model incorporating estimates of physical, chemical, and biological processes. A box model can allow prediction of changes in water quality with varying inputs, using a less extensive database than required for the statistical approach.
- Nurturing the ongoing development of a three-dimensional hydrodynamic model for Tampa Bay.
- Working toward eventual development of a comprehensive, three-dimensional water quality model.

Appropriate water quality modeling strategies for the FKNMS will be discussed and evaluated at the proposed Modeling Workshop.

4.1.2 Ecological Model(s)

The transport/water quality model will allow predictions of water quality alterations resulting from pollutant reductions and altered water flow into Florida Bay from the Everglades. This approach can be carried further by constructing one or more ecological models coupled to the transport/water quality model. The influence of ecological processes on water quality would be included in this coupling. The ecological model(s) would help to predict long-term ecological consequences of water quality alterations.

The type of ecological model(s) appropriate for FKNMS ecosystems should be determined through a proposed Modeling Workshop. The purpose of the workshop will be to discuss modeling objectives, devise preliminary conceptual models, and identify data needs for model input and validation. One modeling approach cited at the Monitoring/Research Workshops (July 1992) is discussed below, but this is not meant to preclude other approaches.

Ecosystem models typically focus on temporal changes, while considering the system to be spatially homogeneous. However, there have been recent attempts to model both spatial and temporal variability of the ecosystems at the broad scale of the landscape (Turner 1989). Advances in computer technology and remote sensing have allowed the development of a new class of spatially articulate, process-based ecosystem simulation models (Costanza *et al.* 1990; DeBellevue and Costanza 1991). These "landscape models" operate at a broad spatial scale appropriate to the consideration of the Everglades/Florida Bay/Florida Keys system that includes the FKNMS. Using such a model, Costanza *et al.* (1990) simulated Louisiana coastal landscape dynamics with a system of 2,479 one-square-kilometer spatial cells over a period of more than 50 years beginning in 1956. The model accounted for 90% of the spatial variation in the 1978 calibration data and 79% of the variation in the 1983 verification data.

As discussed here, a landscape model is essentially a spatial array of process-based ecosystem models connected by fluxes of water, nutrients, etc., with rules governing the successional or other changes in the structure of the system (Costanza *et al.* 1990). Construction of such a model therefore requires an understanding of the processes affecting the dynamics of each type of biological community. Initial models based on incomplete understanding may yield gross approximations of system behavior. As understanding improves and more calibration data become available (through the monitoring program), model predictions can be expected to improve in accuracy.

A landscape simulation model is being developed by the South Florida Water Management District (SFWMD) to simulate and predict changes in the vegetation patterns in response to alterations of the sources of inflows (change in location of inflow, or quantities) and water quality in the Everglades (SFWMD 1992). Landscape model development for the Sanctuary should be coordinated with SFWMD model development to ensure that the models are compatible.

4.1.3 Supporting Studies

Development of the transport/water quality model and ecological model(s) will require supporting data for model input and validation. These data will come from literature review and field sampling/observations. Data needs will be defined at the proposed Modeling Workshop. Supporting data will be needed in at least four main areas:

- **Nutrient budgeting**
  A major objective of the transport/water quality model will be to predict the effects of altered nutrient inputs on nutrient concentrations and gradients in the FKNMS. This will require data on nutrient inputs to the system from all anthropogenic and natural sources, as well as nutrient cycling and transformations.

- **Circulation**
  Development of the transport/water quality model will require information on circulation within the FKNMS and to/from adjacent areas, including Florida Bay. Information on the influence of the Florida Current will also be required. The adequacy of existing circulation data for constructing a preliminary transport/water quality model will be discussed and evaluated at the proposed Modeling Workshop.

- **Groundwater hydrogeology**
  Transport and transformations of groundwater nutrients would need to be taken into account in the transport/water quality modeling process. Possibly, a groundwater transport submodel would be constructed. At the minimum, assumptions would need to be made about the discharge rates of groundwater nutrients into coastal waters.

- **Ecological processes**
  An understanding of the processes causing changes in the biological communities is necessary for construction of the individual ecological models that may be coupled to produce a landscape level ecosystem model. The level of detailed ecological understanding required for the models needs to be discussed at the proposed Modeling Workshop.

4.2 INVESTIGATION OF SPECIFIC QUESTIONS/PROBLEMS

4.2.1 Unquantified or Poorly Known Nutrient Loadings

Phase I workshop panelists and NOAA Core Group members have identified nutrients as being the pollutants of greatest concern regarding water quality and resource problems in the FKNMS. Similarly, the degree of nutrient loading to coastal and estuarine waters has been identified as a serious problem in many areas of the U.S., including Boston Harbor, Chesapeake Bay, Kaneohe Bay (Hawaii), and Tampa Bay (NOAA 1991; Tampa Bay National Estuary Program 1992b).

In the FKNMS, anthropogenic nutrient inputs from wastewater discharges are known to result in problems such as degraded water quality in canals (Lapointe *et al.* 1990) and increased epiphyte growth on seagrasses in localized "hot spots." There is concern that increasing anthropogenic nutrient loadings will eventually lead (or are already leading) to a more general degradation of water quality in nearshore waters beyond the canals and in other hot spots. In addition, nutrient inputs to groundwater have been suggested as possible causes of problematic algal growth on Florida Keys coral reefs (see the Phase I report).

Nutrient loadings from domestic wastewater and stormwater have been estimated in Tasks 3 and 4; however, loadings were not estimated for two potentially significant nutrient sources.

- **Atmospheric inputs (wetfall and dryfall)**
  Atmospheric inputs have shown to be significant in the nutrient budget of some estuaries (NOAA 1991; Fanning 1992). Because the surface area of water in the FKNMS is so much greater than that of land (where rainfall collects as stormwater runoff), direct atmospheric inputs to surface waters could be significant.

- **Advective inputs**
  Information is needed on the fluxes of nutrients in waters from adjacent areas such as Florida Bay and Biscayne Bay. In addition, the Florida Current is a source of nutrient inputs via shoreward incursion of spinoff eddies and filaments.

Studies are needed to estimate the magnitude of these nutrient inputs relative to anthropogenic loadings. Atmospheric inputs should be initially estimated through a literature review of data applicable or transferable to the Keys. Advective inputs will be more difficult to estimate and may require some preliminary circulation modeling using a simple segmentation framework (e.g., Klein 1993). In addition to estimating loadings, these studies should estimate the level of uncertainty in the values (e.g., provide a range of values), identify data of uncertain quality, and recommend field data gathering if necessary.

Two other sources of nutrient loadings should be investigated, but with a lower priority.

- **Stormwater runoff**
  Stormwater nutrient loadings were calculated in Tasks 3 and 4 based on the literature values for various land-use categories. These calculations suggest that stormwater nutrient loadings are much lower than wastewater nutrient loadings. However, little is known of nutrients or other chemical constituents of stormwater runoff in the Florida Keys. Better estimates, based on Keys-specific data, could be produced.

- **Weed wrack in canals**
  Deposition of windblown debris in canals has been mentioned in several studies as a reason for reduced water quality relative to the ambient conditions. However, this has not been well studied, and the contribution of nutrients from weed wrack relative to other sources is unknown. This decomposition could be a significant contributor of nutrients locally, although it is not likely to be significant regionally.

In the long term, data concerning nutrient loadings should be incorporated into the predictive transport water quality model to allow managers to evaluate "what if" scenarios, for example. This could require a more comprehensive budgeting of nutrient inputs, outputs, and transformations, rather than simply a tabulation of loadings. Examples of factors to be considered in refining nutrient budgets include the contribution or loss of nutrients to the water column by sediment resuspension; effects of plant activity on sediment nutrient cycling, including the effects of plants having deep roots; and effects of bioturbation on sediment and nutrient dynamics.

4.2.2 Fate of Wastewater Nutrients in Groundwater

As discussed in the Phase I report, large volumes of wastewater are discharged into groundwater, both through injection wells and OSDSs. The fate of nutrients in groundwater is not well understood. Several questions need to be answered.

- Are nutrients discharged into groundwater through injection wells reaching offshore reefs? If so, in what quantities? Is this a localized or widespread phenomenon in the FKNMS?
- Are all nutrients discharged into groundwater eventually released into coastal surface waters? Does the answer differ for OSDSs and injection wells?
- During movement of groundwater, are there changes in the relative abundance of nutrients (forms of nitrogen and phosphorus) due to physical/chemical or biological processes?

Studies to address these questions may involve nutrient sampling of groundwater from monitoring wells or seepage meters (Simmons and Netherton 1986), as well as geological work to map and determine the confining capability of impermeable horizons (unconformities) (e.g., Shinn 1992).

A study (Shinn 1992) to answer the first question is currently being conducted by Dr. Eugene Shinn of the U.S. Geological Survey (USGS). This study involves drilling monitoring wells and mapping confining layers along onshore/offshore transects at north Key Largo, middle Key Largo, and Stock Island near Key West. Additional studies may be needed depending on the results of the study. In addition, one workshop participant suggested that studies may need to be conducted at a finer scale to determine if groundwater discharge into coastal waters occurs as a broad-scale seepage phenomenon or as localized "point source" inputs through joints and solution holes.

4.2.3 Influence of Florida Bay on Water Quality and Resources

Water transport from Florida Bay through the passes is recognized as a significant potential influence on water quality in the Sanctuary. Major concerns are changes in salinity, temperature, turbidity, and nutrients associated with water moving through the passes in the lower and middle Keys and onto the reef tract. For example, the Florida Institute of Oceanography has documented boluses or filaments of Florida Bay water, identified by slightly elevated temperature and salinity, moving across Hawk Channel onto the reef tract (Ogden 1992).

One aspect of the proposed research should involve an historical assessment of Everglades/Florida Bay/Florida Keys hydrology, as it has affected water quality and biological communities in the Sanctuary. This would clarify the role of freshwater inflows and water quality from the Everglades, and other freshwater discharges to the southwest shoreline of Florida, to Florida Bay and the Sanctuary. This research would examine the effects of structural modifications and changes in timing and volume of freshwater releases from existing structures, as well as land practices affecting the water quality of runoff.

A second aspect of the proposed research would involve circulation studies to estimate present-day long-term net transport and episodic transport from Florida Bay to the Sanctuary. Circulation studies to estimate transport will likely involve a combination of field studies (current meter deployments) and modeling. Ongoing circulation studies to estimate long-term net transport are being conducted by Dr. Ned Smith of the Harbor Branch Oceanographic Institution (Lapointe *et al.* 1992; Smith 1992). Continuous hydrographic data from Coastal Marine Automated Network (CMAN) stations in the Sanctuary and Florida Bay, established during the SEAKEYS program (FIO 1991) could aid in circulation studies.

A third aspect of this research would involve studies to document ecological impacts, if any, of Florida Bay waters on Sanctuary communities, including seagrasses, coral reefs, nearshore hard-bottom communities, and potentially endangered or threatened species. Documentation of hypothesized impacts could provide a stronger basis for action to restore historical freshwater flow to Florida Bay.

The National Park Service has recently taken the lead in forming an interagency working group to address monitoring and research goals and management objectives for Florida Bay. Other participants include the Environmental Protection Agency (EPA), Florida Department of Environmental Regulation (FDER), NOAA, the SFWMD, the U.S. Army Corps of Engineers (USACE), the U.S. Fish and Wildlife Service (FWS), the Office of the Governor, the Florida Department of Natural Resources (FDNR), and Monroe County. Sanctuary participation in this working group will promote cooperative and coordinated research and monitoring efforts to gain information about the influence of Florida Bay on the Sanctuary.

4.2.4 Ecological Effects of Altered Water Quality

Numerous ecological problems in the FKNMS biological communities have been discussed in the Phase I report and workshops, such as problematic algal growth on coral reefs, declines in individual growth of seagrasses, sponge die-offs, and lack of coral recruitment. The causes of these ecological problems are, in most cases, not understood well enough to (1) determine whether anthropogenic pollutants (e.g., nutrients) are having adverse ecological effects beyond confined waters (e.g., canals), and (2) predict confidently the ecological benefits of pollution reduction measures. Information showing causal linkages between pollutants and specific ecological problems is needed so that resource managers can evaluate the need for engineering and/or management actions to reduce pollutants.

The research needs identified here pertain to ecological problems that are known or suspected to be water quality related. Ideally, these problems should be evaluated from a whole-system perspective, with water quality as just one consideration. The research needs identified here will be incorporated into a comprehensive management plan (including research and monitoring) being developed by NOAA, that will address all issues relevant to the protection and restoration of FKNMS ecosystems.

4.2.4.1 PROBLEMS/ISSUES IDENTIFIED

4.2.4.1.1 Hard Bottom Communities

Panelists at the Phase I Coral Community Assessment Workshop discussed eight specific problems in the Florida reef tract (listed below). Generally, the panelists agreed that there are insufficient data regarding all of the problems. Some participants did not consider all of the topics identified to be problems, but rather, issues. The monitoring program (discussed in Task 6) will provide relevant information; however, more research and data are needed to determine the causes of these problems, including how water quality parameters affect each of the problems discussed.

- Coral disease
- Coral bleaching
- Problematic algal growth
- *Lyngbya* (algal) growth
- Lack of coral recruitment (offshore)
- Decreased coral growth rate (individual)
- Decreased coral abundance
- Decreased community diversity (species other than coral)

Panelists identified coral disease and problematic algal growth as the problems most directly related to water quality. Of the water quality parameters discussed at the Coral Community Assessment Workshop, nutrients were clearly of the most concern. Ecological studies are needed to identify limiting nutrients, estimate nutrient thresholds (water and sediment concentrations), and evaluate interactive effects of nutrients and other water quality parameters (such as temperature, salinity, sedimentation, and exposure to toxics).

All of the discussion of hard bottom communities in the Phase I literature review and workshops focused on coral reefs. Although extensive low-relief hard bottom areas occur nearshore in the FKNMS, much less is known about the ecology of these communities. Because these communities are closer to shore than the reef tract, they are more likely to be exposed to altered water quality as a result of anthropogenic pollutants. The water quality monitoring program (Task 6) will document the status and trends of these communities, but studies are needed to evaluate the effects of water quality parameters on these communities.

4.2.4.1.2 Seagrass Communities

Panelists at the Phase I Submerged and Emergent Aquatic Vegetation Assessment Workshop identified and discussed five ecological problems in the seagrass communities.

- Increased seagrass epiphyte growth
- Decreased seagrass growth rates (individual)
- Decreased community diversity
- Decreased seagrass recruitment
- Hypoxia

Epiphyte growth in relation to anthropogenic nutrient loading was identified as a priority problem. This is known to be a problem in hot spots and possibly elsewhere. Ecological studies are needed to estimate the nutrient thresholds and evaluate the interactive effects of nutrients and other water quality parameters.

4.2.4.1.3 Mangrove Communities

Panelists at the Phase I Submerged and Emergent Aquatic Vegetation Assessment Workshop discussed several problems concerning mangrove communities in the FKNMS. While habitat loss due to dredging and construction has historically been the greatest problem, there are unanswered questions concerning both effects of water quality parameters on mangroves and the effects of mangrove communities on water quality such as:

- Decreased individual tree growth
- Decreased geographic extent of mangrove habitat
- Decreased functional value of mangrove habitat
- Effects of mangrove habitat loss on water quality

The effects of mangrove habitat loss on water quality is of particular interest because of the documented importance of mangroves as filters. For this reason, areal coverage of mangroves will be estimated by remote sensing during the monitoring program (Task 6). Nutrient fluxes from mangrove systems differ drastically from those associated with housing developments and boat basins. In addition, groundwater below mangrove habitats differs in nutrient concentrations from groundwater under upland communities. These relationships could be further quantified.

4.2.4.2 STUDY APPROACHES

At the Monitoring/Research Workshops, three general approaches to investigating causal relationships were discussed.

- Experimental studies
- Historical studies
- Geographic comparisons

4.2.4.2.1 Experimental Studies

Laboratory, mesocosm, and *in situ* studies can be performed to discern relationships between water quality parameters (singly and in combination) and ecological problems. Experimental studies could include studies to identify limiting nutrients, estimate nutrient thresholds, and document interactive effects of nutrients and other water quality parameters. Possibly, isotopic nutrient fingerprinting techniques (Coffin *et al.* 1991) could be used to investigate linkages between wastewater nutrients and problems such as algal growth on coral reefs.

As another example, *in situ* studies could be conducted to evaluate problems with recruitment, growth, and abundance of the principal reef building Scleractinia, *Montastraea annularis* and *Acropora palmata*. The life cycle of these species could be studied at several locations to determine problems in reproduction, larval viability, recruitment, growth, and survival.

4.2.4.2.2 Historical Studies

Another approach to discerning the cause/effect relationships between water quality and biological communities is to examine the historical record, as preserved in sediments and coral growth bands. These data can reveal past relationships between environmental conditions and biological communities, leading up to the present situation. Sclerochronology studies (history of corals) can be used to correlate coral growth rates with the historic record of human activities (e.g., periods of dredging, construction in the Keys) as well as natural events (e.g., hurricanes, cold winters) (Hudson *et al.* 1989). Fluorescent banding in corals has been used to hindcast freshwater flows from Taylor Slough and Shark River Slough, the two main freshwater outlets from the Everglades (Smith *et al.* 1989).

Recent geological reconstruction is another approach to examining the historical record for environmental relationships (Shinn 1991). According to participants of the Climate and Global Change Working Group at the NOAA Research Planning Workshop, these studies should encompass the past few thousand years, focusing on sea level, temperature, nutrients, and sediments (Shinn 1991).

4.2.4.2.3 Geographic Comparisons

Comparisons with similar communities in other geographic areas could help to determine whether some ecological problems are local, regional, or global in nature. Studies could compare data from the Florida reef tract with information from other areas, both stressed and unstressed, to provide a context for assessments of the local changes in reef health. For example, pristine and moderately disturbed sites in the Caribbean Basin and the Bahamas could be compared with the Florida reef tract to assess whether algal growth is a result of nutrient enrichment or lack of grazing pressure. Such comparative studies could also provide insight into the problem of coral disease. Another benefit of comparative studies would be in the form of sharing experience and technology with foreign researchers, including Australian scientists involved in research and monitoring efforts on the Great Barrier Reef.

4.3 MONITORING TOOL DEVELOPMENT

4.3.1 Indicators

The monitoring program (developed in Task 6) will provide information about the status and trends of biological communities in the FKNMS. However, because of the complexity and natural variability of these communities, it is often difficult to detect changes (other than catastrophic ones) before serious damage has occurred. For this reason, a major component of the research program will be to develop indicators that can provide an early warning of environmental problems or degradation. Development of indicators (e.g., biochemical and ecological measures) could make monitoring simpler, less expensive, and more sensitive to changes in water quality.

A second goal of research on indicators would be to provide the basis for developing resource-oriented water quality standards (biocriteria) for the Sanctuary. Biocriteria are "numerical values or narrative expressions that describe the reference biological integrity of aquatic communities inhabiting waters of a given designated life use" (EPA 1990). Biocriteria are valuable because they directly measure the condition of the resource at risk, detect problems that other methods (e.g., chemical analyses of water quality) may miss or underestimate, and provide a systematic process for measuring progress resulting from the implementation of water quality programs (EPA 1990). EPA is directing states to adopt narrative biological criteria into state water quality standards over the next few years.

The term "indicator" as used here refers to a "response indicator" in the terminology used by the Ecological Monitoring and Assessment Program (EMAP) (Messer 1990; Scott 1990). In EMAP, a response indicator is a "characteristic of the environment measured to provide evidence of the biological condition of a resource at the organism, population, community, or ecosystem process level of organization." Specifically of interest are response indicators that are anticipatory — that is, they provide an early warning of widespread ecological effects. Other types of indicators defined in EMAP include exposure and habitat indicators and stressor indicators.

Indicators for FKNMS communities could be biochemical measures (e.g., concentrations or ratios) or ecological measures (e.g., abundance of particular species) that are sensitive to the stressors affecting the community of interest. Desirable characteristics include the following (Scott 1990):

- Anticipates widespread ecological effects (provides early warning)
- Responds to stressors of concern to management (e.g., nutrients, salinity, temperature, turbidity, dissolved oxygen [DO], etc.)
- Relates unambiguously and monotonically to an endpoint
- Correlates with changes in processes or other unmeasured components
- Integrates effects over time and space
- Can be measured and quantified in a cost-effective manner
- Has a standard method of measurement with low measurement error
- Has a historical database, or the capability of generating one

Several types of potential indicators are being studied that may be useful for monitoring Sanctuary communities and developing biocriteria. Amphipod crustaceans have long been known to be sensitive environmental indicators and could be incorporated into tropical monitoring programs, provided sufficient taxonomic and natural history investigations have been completed (Thomas 1992). Santavy *et al.* (1992) are studying microbial community dynamics in coral mucus, using microbiological, biochemical, and molecular methods. The results may be used eventually to develop a predictive model for coral health based on the microbial population inhabiting coral mucus and to determine the corals' responses to stresses for defining *in situ* sublethal impacts that may lead to long-term ecological damage. Another example is the development of techniques for detecting ecological problems in nearshore hard-bottom communities (e.g., Chiappone and Sullivan 1992). Because these communities are closer to the source of land-based pollution in the Keys, degraded water quality that could ultimately affect the offshore reef tract might be detected earlier by monitoring the nearshore communities.

Panelists at the Monitoring/Research Workshops stated that although potential indicators exist in the major biological communities, these are not well established enough to be used in the monitoring program now. In general, the panelists agreed that it would be appropriate to develop a suite of indicators, including both biochemical and ecological measures, to detect the influence of stresses in each system. Development of indicators for each community type will involve a literature review, experimental studies (laboratory, mesocosm, and/or *in situ*), and field validation (presumably through the monitoring program).

4.3.2 Other Monitoring Tools and Methodologies

As discussed above, indicators are one type of monitoring tool that will be a major focus of the research program. The program will also focus on identifying and evaluating other monitoring tools and methodologies to detect pollutants and identify cause/effect relationships involving water quality and biological resources. New monitoring tools and methods are being developed continually through various research programs in the United States, and some of these may be applicable to the FKNMS monitoring program. However, additional or modified methods may be necessary because of the unique biota and environmental conditions in the FKNMS.

An example of this research component would be the development or refinement of continuous, *in situ* sampling techniques and equipment. Limited continuous recording of some physico-chemical parameters is included in the monitoring program (as described in Task 6). Parameters of primary interest to the monitoring program (e.g., nutrients) are not amenable to continuous sampling and analysis at present. Continuous recording of other parameters such as DO and light is hampered by the need for frequent servicing of equipment (e.g, cleaning of probes). Research should focus on developing or refining techniques for routine use in the monitoring program.

Another possible focus of study would be the identification and evaluation of pollutant tracers. EPA has proposed using isotopic nutrient fingerprinting techniques (Coffin *et al.* 1991) to attempt to identify the benthos around Southeast Florida sewage outfalls that are incorporating wastewater nutrients (R. Ferry, EPA, personal communication, 1992). These and other specific tracers should be investigated for possible incorporation into the monitoring program.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

The research program will involve numerous researchers, agencies, and institutions. In accordance with the policies of EPA, NOAA, and the Florida Department of Environmental Regulation (FDER), the FKNMS research program will adhere to existing rules and regulations governing QA and QC procedures as described in EPA guidance documents.

QA refers to "those operations and procedures which are undertaken to provide measurement data of stated quality with a stated probability of being right" (Taylor 1985). Essentially, QA is the total integrated program for assuring reliability of monitoring and measurement data. QC refers to "procedures that reduce and maintain random and systematic errors within specified tolerable limits" (Taylor 1985).

A Quality Assurance Project Plan (QAPjP) will be required for all research projects undertaken with support under the FKNMS. Through the QAPjP, participants will state well-defined objectives and commit to incorporating QC procedures. In addition, the investigators will document their QC procedures and evaluate the quality of the data being produced.

QAPjPs will be prepared according to the format prescribed by EPA in the following documents:

- Guidance for the Preparation of Combined Work/Quality Assurance Project Plans for Environmental Monitoring (EPA 1984)
- Guide for Preparation of Quality Assurance Project Plans for the National Estuary Program (EPA 1988)

This format is designed to ensure that proper quality control procedures are integrated into every project. Review and final approval of QAPjPs will be the responsibility of the EPA Region IV QA Officer.

In addition to the documents cited above, there is substantial literature on quality assurance and analytical quality control that may be consulted for the preparation of the QAPjP (EPA 1979; Kirchner 1983; Taylor 1978, 1985, 1987; Taylor and Stanley 1985).

6.0 DATA MANAGEMENT

Data management for the research plan will follow that described for the water quality monitoring program (Task 6). A formal data management plan will be developed by the entity designated to perform data management. As part of the contractual agreements, the terms of data submittal by independent researchers and institutions to the FKNMS data management system should be formalized.

7.0 ADMINISTRATIVE RECOMMENDATIONS

7.1 PROGRAM EVALUATION

The research program should provide critical information to resource managers through model predictions, answers to specific questions/problems, and enhanced monitoring capabilities. Some components of the research program are designed to provide answers as soon as possible, whereas others are designed to produce useful tools over the long term. The FKNMS should establish a mechanism for annual scientific/management review of the research program to ensure that

- Program goals are appropriate
- Each program component is focused on, and progressing toward, a specific goal
- Newly identified research needs are being incorporated into the program
- The program is producing the kind of information needed by resource managers

7.2 DISSEMINATION OF INFORMATION

As part of the research program, implementing agencies will need to disseminate information about research projects and findings to the scientific community. This will help to stimulate discussion and avoid the duplication of effort in preparing research proposals. The FKNMS should

- Develop a compendium of ongoing and planned research (whether funded through the FKNMS program or not) that would be updated periodically
- Sponsor information transfer meetings to keep researchers and managers abreast of research findings and management actions in the FKNMS
- Support publication of research findings in peer-reviewed scientific journals

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TASK 8 — A PUBLIC EDUCATION AND OUTREACH PROGRAM

CONTENTS

APPENDICES

TABLES

ACRONYMS

CMC	Center for Marine Conservation
EPA	Environmental Protection Agency
FDER	Florida Department of Environmental Regulation
FDNR	Florida Department of Natural Resources
FKNMS	Florida Keys National Marine Sanctuary
FREE	Florida Resources in Environmental Education
KLNMS	Key Largo National Marine Sanctuary
LKNMS	Looe Key National Marine Sanctuary
NOAA	National Oceanic and Atmospheric Administration
NURC	[NOAA] National Undersea Research Center
TNC	The Nature Conservancy

TASK 8 — A PUBLIC EDUCATION AND OUTREACH PROGRAM

1.0 BACKGROUND

On November 16, 1990, Congress passed the Florida Keys National Marine Sanctuary and Protection Act (Pub. L.101-605, 104 Stat. 8089, 16 U.S.C. §1488 note [1990]). The Act directs the U.S. Environmental Protection Agency (EPA) and the state of Florida to develop a comprehensive Water Quality Protection Program for the Sanctuary. This program includes a provision for the public to have an adequate opportunity to participate in all aspects of program development and implementation. Furthermore, the Act specifies that the program must include a monitoring program to determine the sources of pollution in the Sanctuary, evaluate the effectiveness of efforts to reduce or eliminate those pollution sources, and evaluate progress toward protecting and restoring the coral reefs and other marine resources. A public participation, education, and outreach program is an integral part of the overall Water Quality Protection Program goal of reducing pollution sources and their impacts on Sanctuary resources, and increasing public acceptability and support of EPA's program. Public interest in and concern about water quality in the Florida Keys is supported by an August 1, 1992 survey of Florida Key residents designed to identify what people feel are the most significant environmental problems facing the Florida Keys. Overdevelopment and water quality degradation were the two problems most frequently chosen (Faanes 1992).

The Water Quality Protection Program for the Florida Keys National Marine Sanctuary (FKNMS) developed by EPA and the state of Florida will be reviewed by the National Oceanic and Atmospheric Administration (NOAA) for inclusion in the comprehensive management plan that NOAA is required to prepare and implement to guide the use of the Sanctuary.

2.0 PUBLIC EDUCATION AND OUTREACH PROGRAM PLAN GOAL AND REPORT STRUCTURE

This report represents the first in what is anticipated to be an ongoing series of documents that communicate the plans and results of implementing a public education and outreach program plan for the FKNMS water quality protection program. As such, it is designed to achieve three fundamental objectives: first, to initiate the process of identifying and interacting with key stakeholders; second, to use the information obtained through those interactions to create an "umbrella framework" to structure the ongoing planning process; and third, to list and describe specific activities (augmenting NOAA's Draft Education Action Plan) to launch the plan implementation process. The goals of this planning process are to:

- Increase public awareness of the EPA Water-Quality Protection Program, the Sanctuary, and its resources
- Increase public understanding of the sources of pollution and their impacts on Sanctuary resources
- Solicit and incorporate public input into the Water Quality Protection Program
- Gain sufficient acceptance of the program so that it can be successfully implemented

This strategy is described in the following three sections (Sections 3.0 through 5.0). Section 3.0 identifies the various public groups interested in the EPA Water Quality Protection Program. Section 4.0 describes a directory developed by the NOAA Sanctuary education staff that lists organizations conducting existing public education and outreach programs and activities in the Florida Keys. Section 5.0 is the first phase of developing a public education and outreach program plan. It provides a conceptual framework for developing a public education and outreach program plan that is presented in Section 5.1 — Evaluation of Identified Public Education and Outreach Needs, and Section 5.2 — Public Education and Outreach Program Plan. Public education and outreach needs identified by participants of NOAA-hosted workshops and strategy sessions are used as the baseline for Section 5.1. These identified needs were organized into the following categories:

- General education
- General outreach
- Water quality
- Land use

- Boating and diving
- Fishing

The specific needs identified under each of these categories are not complete and will need to be further developed. A preliminary matrix and corresponding text are provided to illustrate how EPA might determine to what degree the identified needs are currently being addressed. Interviews with a limited number of public and private organizations were conducted to determine how their programs and activities are addressing these needs. Because of budget limitations, interviews were conducted with only 21 of the more than 70 organizations whose focus is to protect the waters and habitats of the Florida Keys. The selection of organizations to be interviewed was accomplished by targeting a diversity of organizations that (1) focus on water quality issues, and (2) were easily contacted by telephone. Although the size of the survey was limited, it provides insight into the range of existing programs and activities. It also provides a framework for conducting a more thorough review and analysis of these programs and activities.

Section 5.2 is presented as a living document that will be revised as circumstances change and new information is obtained. The program plan is comprised of three iterative steps.

(1) Institutional Assessments and Coordination
(2) Public Involvement
(3) Public Education and Outreach

The report also includes two appendices. Appendix A provides a description of the 21 organizations interviewed. Appendix B contains a list of additional organizations the NOAA Sanctuary education staff felt were important to contact to provide a more comprehensive perspective of existing programs and activities. Examples of public information materials developed by these organizations were collected and have been submitted to EPA.

A preliminary draft of this report was reviewed by Ms. Lauri MacLaughlin — Education Coordinator for the Looe Key National Marine Sanctuary (LKNMS) — who recommended additional sources of public education information. These sources should be contacted as part of the networking with other agencies and organizations to revise and expand the public education and outreach plan.

3.0 STAKEHOLDERS

Table 8-1 lists the various public groups that have a stake in the EPA Water Quality Protection Program. These various public groups are referred to as stakeholders. To a large degree, the stakeholders identified for this program are similar to those identified by NOAA during the development of its Comprehensive Management Plan for the Sanctuary.

4.0 FLORIDA KEYS ENVIRONMENTAL EDUCATION

4.1 THE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION FLORIDA KEYS ENVIRONMENTAL EDUCATION RESOURCE DIRECTORY

NOAA Sanctuary education staff are in the final stages of producing the *Florida Keys Environmental Education Resource Directory* (NOAA 1992), a primer of the organizations that offer information and resources on environmental education in the Florida Keys. The *Directory* has proven to be extremely helpful in identifying ongoing programs.

Table 8-1. Stakeholders of the Florida Keys National Marine Sanctuary

Boaters
- Recreational
- Sales/rental business personnel (retailers)
- Commercial

Divers/Snorkelers
- Recreational, including spearfishermen
- Sales/rental business personnel and charter boat personnel (retailers)
- Commercial (e.g., salvage workers)

Fishermen
- Recreational
- Sales personnel (e.g., gear and fishing boat charter personnel)
- Commercial

Bird Watchers

Campers

Other Coastline and Beach Users
(e.g., swimmers, walkers/explorers, picnickers, sunbathers, and bridge fishermen)

Businesses
- Realtors
- Homeowner associations
- Hoteliers
- Other tourist businesses

Industry
- Seafood processors
- Construction
- Aquaculture
- Agriculture
- Other industries with direct discharge permits and/or potential large runoff because of paved surfaces

Commercial Businesses

The Media

Tourists

Educators

Students

Youth Organizations (e.g., Boy Scout Sea Base)

Elderly

Civic Groups

Residents (full-time and seasonal)
- Coastal
- General (mainland and inland)

Federal, State, and County Officials and Staff

The Sanctuary education staff sent out pre-workshop materials for a Florida Keys National Marine Sanctuary Education Workshop that was held in September 1991. These materials asked potential participants their interest in having a directory as a guide to the organizations that offer information and resources on environmental education in the Florida Keys. Based on the positive responses received, the Sanctuary education staff developed the *Directory*. It is in draft form at present and should be available in the Fall of 1992. The *Directory* is organized alphabetically by organization and by subject matter. For each organization the following information is provided:

- Organization name
- Address
- Telephone number
- Contact name
- Purpose
- Type of organization
- Focus
- Speakers available
- Volunteer/intern opportunities
- Geographic focus
- Publications
- Education programs
- Audio-visual materials

Under "focus" of the organization, the *Directory* lists the organization's various subject areas of interest and supporting program and/or activities. The *Directory* is also organized by other areas, including

- Terrestrial fauna
- Terrestrial flora
- Coastal habitats
- Mangroves
- Marine fauna
- Marine flora
- Backcountry habitats
- Threatened or endangered species
- Marine mammals
- Sea turtles
- Migrating birds
- Nearshore
- Open ocean
- Coral reefs
- Benthic systems
- Oil drilling/spills
    - Sewage outfalls
- Water quality
- Marine debris
- Recycling/energy
- Periodicals and newsletters

The *Directory* will be available as a printed document. Although there are currently no plans to make it available electronically, the *Directory* could prove to be an even more valuable resource if it could be accessed electronically.

4.2 FLORIDA RESOURCES IN ENVIRONMENTAL EDUCATION (FREE) FOR TEACHERS

Florida Resources in Environmental Education (FREE) for Teachers is an education system that may be accessed electronically. *FREE for Teachers* is an on-line clearinghouse of Florida-based environmental education materials, programs, and information. It was established by the Florida Department of Education Office of Environmental Education. Four databases can be accessed through *FREE for Teachers*: (1) FUND — A listing of information on grants and awards from foundations, and other funding sources for environmental education; (2) ERIS — An annotated listing of environmental education products developed by Florida educators under the Department of Education mini-grant program of 1973-1985; (3) PGMS — A list of abstracts of environmental education materials and programs developed by state agencies, non-profit groups, and other organizations; and (4) SPKR — A listing of state agency, non-profit, and private-sector environmental information/education speakers, and their speaking areas, topics, and audience levels.

5.0 A FRAMEWORK FOR DEVELOPING A PUBLIC EDUCATION AND OUTREACH PROGRAM PLAN

Developing a public education and outreach program plan is an iterative process. It is necessary to identify education and outreach needs, identify and be familiar with the ongoing education and outreach activities to determine where the gaps are in meeting the needs, and to develop a program that addresses these gaps. Every step in this process changes as education and outreach needs change and new public and private activities are created to address these needs. It is, therefore, essential that the agencies and organizations developing and conducting educational and outreach programs and activities coordinate closely. Furthermore, a public involvement program and supporting activities are needed to evaluate education and outreach programs and activities to ensure that they are on target.

This section is divided into two sub-sections. The first is an evaluation of public education and outreach needs and the second is a description of the three steps that comprise a public education and outreach program plan to address the needs.

5.1 EVALUATION OF IDENTIFIED PUBLIC EDUCATION AND OUTREACH NEEDS

NOAA Sanctuary education staff hosted workshops to identify education and outreach needs. Workshop participants were government officials and representatives of private organizations whose focus is to protect the Florida Keys. In addition, the NOAA Sanctuary education staff held strategy identification sessions with government agency officials; education was one component of these strategy sessions. The public education and outreach needs identified in the workshops, and the education needs identified in the strategy sessions were organized together into the categories listed in Section 2.0 and displayed along the Y axis of the preliminary matrix illustrated in **Table 8-2**. Because of the inter-relationship between water quality needs and the other needs suggested by the participants, the table includes both. Furthermore, the scope of this report was designed to include public education and outreach needs for protecting water quality and the biological habitats of the Keys.

The preliminary matrix depicted in **Table 8-2** links the public education and outreach needs identified in the NOAA workshops and strategy sessions with a limited set of public and private ongoing programs and activities. The NOAA *Florida Keys Environmental Education Resource Directory* was used to identify organizations conducting public education and outreach programs and activities. Only a limited number (13 private and 8 public organizations) of the more than 70 organizations listed in the *Directory*, were selected to be interviewed to identify how their programs and activities address identified education and outreach needs. **Table 8-2** illustrates the matches between programs/activities and public education needs. If the matrix were comprehensive (i.e., included information from all organizations listed in the *Directory)*, the gaps in the matrix would correspond to gaps in public education and outreach efforts. This preliminary matrix can be used to guide a more thorough analysis of the existing programs and activities. For more information on the organizations interviewed, refer to **Appendix A**. Examples of the public information materials available from these organizations were collected and submitted to EPA.

In Sections **5.1.1 through 5.1.6**, a discussion is provided for each of the six subject areas listed in **Table 8-2**. When appropriate, these discussions include a description of additional issues that were suggested by those interviewed as needing education and/or outreach support.

5.1.1 General Education

Three recommendations for education support made by the NOAA workshop and strategy session participants have been placed under the heading, General Education. These education needs include a comprehensive environmental education plan for Monroe County; field trip opportunities, classes, internships, laboratories, field study, and speaker provisions; and educational information to scientists on the impacts caused by their activities. The comprehensive environmental education plan is being developed by Ms. Jeanne Sanford of Monroe District Schools. Currently, *The Monroe County Environmental Story*, a reference developed by the Monroe County Environmental Education Council, is one of the best resources for teachers to use in presenting an overview of the environmental issues confronting the Florida Keys. The G.R.E.E.N. Team (contact Ms. Laura Causey) has produced another educational resource, the *G.R.E.E.N. Book*, (L. MacLaughlin, LKNMS, personal communication, 1992). The NOAA Sanctuary education staff has developed its own Draft Education Action Plan, one objective of which is to

Table 8-2. A preliminary matrix of organizations' programs and activities corresponding to public education and outreach needs.

Organizations **Private** Categories of Public Education and Outreach Needs Identified in NOAA Workshops	Center for Marine Conservation	Florida Association of Dive Operators	Florida Keys Audubon Society	Florida Keys Citizens Coalition, Inc.	Florida Keys Land and Sea Trust	Florida Keys Wild Bird Rehabilitation Center	Last Stand	Marine Continuum Foundation	Marine Resources Development Foundation	Monroe County Environmental Education Council	National Audubon Society	Nature Conservancy, The	Reef Relief
General Education													
• comprehensive environmental education plan for Monroe County													
• field trip opportunities, classes, internships, labs, field study, and speaker provisions								√	√	√		√	√
• education information to scientists on their activities' impacts									√				
General Outreach													
• "Gateway to the Keys" campaign–information stations on roads, at airports, car rental companies, and visitor centers													
• speakers' bureau	√	√		√	√	√	√	√	√	√	√	√	√
• information included with utility bills and license/registrations													√
• trade show information booths	√							√	√				√
• public service announcements									√	√		√	√
• multilingual materials	√				√			√					√
• cooperation with marine industries on environmental education	√												√
• extra-curricular organization support (e.g., ecology clubs, scouts)			√					√	√			√	
• "Adopt a Reef" program													
• establish static displays at appropriate locations								√	√				
• traveling displays								√					√

Key:

√ - Indicates a need being met to some degree by the organization's program or activity.

Table 8-2. A preliminary matrix of organizations' programs and activities corresponding to public education and outreach needs. (continued)

Private Categories of Public Education and Outreach Needs Identified in NOAA Workshops	Center for Marine Conservation	Florida Association of Dive Operators	Florida Keys Audubon Society	Florida Keys Citizens Coalition, Inc.	Florida Keys Land and Sea Trust	Florida Keys Wild Bird Rehabilitation Center	Last Stand	Marine Continuum Foundation	Marine Resources Development Foundation	Monroe County Environmental Education Council	National Audubon Society	Nature Conservancy, The	Reef Relief
Water Quality													
• *domestic wastewater reuse*										√			
• weed wrack prevention and removal									√				
• commercial and recreational seafood processors' discharges elimination												√	
Land Use													
• shoreline use control (e.g., dumping waste)	√			√		√			√	√			
• stormwater control (e.g., promote permeable surfaces and buffer vegetation)	√							√		√		√	√
• sewage treatment, including non-point source injection wells							√		√	√		√	√
• hazardous materials (e.g., amnesty days for household hazardous wastes)									√			√	√
• land development impact awareness/ growth management options									√	√			√
Boating and Diving													
• boating etiquette signs at boat ramps	√												
• sea grass loss education program	√								√		√	√	
• boating impact education materials	√							√	√	√			√
• dive and rental boat operator resource education program													√

Table 8-2. A preliminary matrix of organizations' programs and activities corresponding to public education and outreach needs. (continued)

<u>Private</u> Categories of Public Education and Outreach Needs Identified in NOAA Workshops	Center for Marine Conservation	Florida Association of Dive Operators	Florida Keys Audubon Society	Florida Keys Citizens Coalition, Inc.	Florida Keys Land and Sea Trust	Florida Keys Wild Bird Rehabilitation Center	Last Stand	Marine Continuum Foundation	Marine Resources Development Foundation	Monroe County Environmental Education Council	National Audubon Society	Nature Conservancy, The	Reef Relief
Fishing													
• training on environmentally sensitive harvesting/collecting methods (e.g., lobster and tropical species) and aquaculture alternatives to harvesting wild ornamental species													
• brochure/guides on harvest regulations and species identification													√
• program to reduce adverse environmental effects from hook and line fishing						√			√	√			

Table 8-2. A preliminary matrix of organizations' programs and activities corresponding to public education and outreach needs. (continued)

Organizations **Public** Categories of Public Education and Outreach Needs Identified in NOAA Workshops	Federal:	Everglades National Park	Key Largo National Marine Sanctuary (NOAA)	Looe Key National Marine Sanctuary (NOAA)	State:	Bahia Honda State Park	Department of Environmental Regulation	Florida Park Service (Department of Natural Resources)	Long Key State Recreation Area (Department of Natural Resources)	County/Local:	Monroe County Cooperative Extension Services	Monroe County Environmental Resources Department
General Education												
• comprehensive environmental education plan for Monroe County			√	√								√
• field trip opportunities, classes, internships, labs, field study, and speaker provisions		√	√	√				√			√	
• education information to scientists on their activities' impacts												
General Outreach												
• "Gateway to the Keys" campaign–information stations on roads, at airports, car rental companies, and visitor centers			√									
• speakers' bureau			√	√		√	√	√	√		√	√
• information included with utility bills and license/registrations												
• trade show information booths			√	√								
• public service announcements			√	√							√	
• multilingual materials			√	√							√	
• cooperation with marine industries on environmental education			√	√							√	√
• extra-curricular organization support (e.g., ecology clubs, scouts)			√	√							√	√
• "Adopt a Reef" program												
• establish static displays at appropriate locations			√	√								
• traveling displays			√	√							√	

Table 8-2. A preliminary matrix of organizations' programs and activities corresponding to public education and outreach needs. (continued)

Public Categories of Public Education and Outreach Needs Identified in NOAA Workshops	Federal:	Everglades National Park	Key Largo National Marine Sanctuary (NOAA)	Looe Key National Marine Sanctuary (NOAA)	State:	Bahia Honda State Park	Department of Environmental Regulation	Florida Park Service (Department of Natural Resources)	Long Key State Recreation Area (Department of Natural Resources)	County/Local:	Monroe County Cooperative Extension Services	Monroe County Environmental Resources Department
Water Quality												
• domestic wastewater reuse							√					√
• weed wrack prevention and removal												√
• commercial and recreational seafood processors' discharges elimination											√	
Land Use												
• shoreline use control (e.g., dumping waste)			√	√				√	√		√	√
• stormwater control (e.g., promote permeable surfaces and buffer vegetation)							√				√	√
• sewage treatment, including non-point source injection wells							√					√
• hazardous materials (e.g., amnesty days for household hazardous wastes)							√		√			
• land development impact awareness/ growth management options												√
Boating and Diving												
• boating etiquette signs at boat ramps			√	√				√			√	
• sea grass loss education program			√	√				√			√	√
• boating impact education materials			√	√				√	√		√	
• dive and rental boat operator resource education program			√	√					√		√	

Table 8-2. A preliminary matrix of organizations' programs and activities corresponding to public education and outreach needs. (continued)

Public Categories of Public Education and Outreach Needs Identified in NOAA Workshops	Federal:	Everglades National Park	Key Largo National Marine Sanctuary (NOAA)	Looe Key National Marine Sanctuary (NOAA)	State:	Bahia Honda State Park	Department of Environmental Regulation	Florida Park Service (Department of Natural Resources)	Long Key State Recreation Area (Department of Natural Resources)	County/Local:	Monroe County Cooperative Extension Services	Monroe County Environmental Resources Department
Fishing												
• training on environmentally sensitive harvesting/collecting methods (e.g., lobster and tropical species) and aquaculture alternatives to harvesting wild ornamental species												
• brochure/guides on harvest regulations and species identification			√	√				√			√	
• program to reduce adverse environmental effects from hook and line fishing			√	√								

have the NOAA Sanctuary serve as an umbrella organization for environmental education in the Florida Keys. Strategies and supporting activities are described in NOAA's plan. Those activities for which EPA participation is appropriate were modified based on EPA's role and are listed in **Section 5.2.3**.

Several organizations provide support for field trips, laboratories, internships, and available speakers. The coordination of these opportunities and increasing public awareness that these opportunities are available may be the needs that require attention.

Few programs designed to increase scientists' awareness of the possible impacts that can result from their field studies were found. However, the Marine Resources Development Foundation, associated with the Marine Lab Undersea Laboratory, does provide instruction on how to minimize impacts while conducting research. The NOAA National Undersea Research Center (NURC), which sponsors research in the Keys, might have relevant materials (L. MacLaughlin, LKNMS, personal communication, 1992).

5.1.2 General Outreach

Most of the activities listed under General Outreach in **Table 8-2** are directed toward public relations. Initially, those organizations interviewed were asked about their general outreach activities, but were not asked whether they conduct the specific activities listed in Table 8-2. The organizations that were interviewed were asked to review an early draft of Table 8-2; those that responded provided more detail regarding their activities, which was added to the table. One issue stressed by several of the organizations interviewed was the need to have materials available in Spanish and English. Some of the examples of education materials that were received were bilingual. One of those interviewed argued for bilingual interactive displays.

Most of the organizations interviewed have speakers available to give lectures on the topics of interest to that organization. Refer to the organizational listings in the *Florida Keys Environmental Education Resource Directory* for details on speaker availability. The Nature Conservancy (TNC), through its new Volunteer Program (which is funded 50:50 by TNC and NOAA), and NOAA, independently, have taken active roles in public outreach in the Florida Keys. Other organizations active in this area are the Marine Continuum Foundation, the Marine Resources Development Foundation, Reef Relief, the Center for Marine Conservation (CMC), and the Monroe County Cooperative Extension Services.

NOAA's Draft Education Action Plan was reviewed to identify the outreach activities that NOAA felt needed to be conducted. Those activities for which EPA participation is appropriate were modified based on EPA's role and are listed in **Section 5.2.3**.

5.1.3 Water Quality

Several of the organizations contacted have programs and/or activities that cover water quality issues to some degree. For example, the Florida Keys Land and Sea Trust has a report that gives an overview of the importance of maintaining water quality. The Marine Resources Development Foundation has general field program articles, conducts laboratory and field activities regarding water quality, and has a slide show that covers the issue. In addition, *The Monroe County Environmental Story* provides an overview of the issue. The Monroe County Environmental Resources Department has programs on domestic wastewater reuse and weed wrack prevention and removal. The Florida Department of Environmental Regulation (FDER) has a program on domestic wastewater reuse. The Marine Resources Development Foundation, TNC, and the Monroe County Cooperative Extension Services have programs on the elimination of commercial seafood processors' discharges. A TNC report, *Water Quality Problems and Issues in the Florida Keys*, is a resource that covers water quality and several other issues.

One issue requiring attention that was raised by one of those interviewed is the need to increase public awareness of the recent (Fall 1991) ban on the use of detergents containing more than 0.5 % phosphorus by weight and automatic dishwater detergents containing more than 1.1 g of phosphorus per tablespoon. The interviewee also commented that enforcement support is needed. Because of the widespread use of phosphorus, the issue appears well suited for a public education campaign.

The needs identified by the participants of the NOAA workshops and strategy sessions do not cover the full magnitude of water quality issues that EPA will need to consider. Many of the factors that affect water quality (e.g., sewage outfalls, overall shoreline use, and hazardous materials) are discussed in Section 5.1.4.

5.1.4 Land Use

Many programs and activities were found that cover the diverse land-use issues that can ultimately affect water quality and habitats in the Sanctuary. The five land-use issues reviewed were shoreline use control, stormwater control, sewage treatment, hazardous materials, and land development. Each issue, including a description of possible education and outreach needs, is discussed below.

Several existing programs are aimed at controlling shoreline use. For example, both CMC and Reef Relief sponsor beach and overall island cleanup campaigns with support from many other organizations (e.g., NOAA, SEACAMP, Florida Park Service); the Florida Keys Citizens Coalition, Inc. produces mailings; the Florida Keys Wild Bird Rehabilitation Center distributes handouts focusing on protecting wetlands; and the Monroe County Environmental Education Council's book, *The Monroe County Environmental Story,* covers shoreline use. Reef Relief also distributes a booklet, *Household Guide to Coral Reef Protection*, covering issues such as environmentally sensitive landscaping techniques and water conservation. The Reef Relief representative interviewed sees a significant increase in business and residential recycling efforts and a shift toward using mulch instead of fertilizers. The Monroe County Recycling Program has been suggested as an additional source for information on recycling activities in the Keys (L. MacLaughlin, LKNMS, personal communication, 1992). Examples of shoreline protection programs run by governmental organizations include the Florida Department of Natural Resources (FDNR) information signs in parks and lectures; the Monroe County Environmental Resources Department lectures and slide shows; and the Monroe County Cooperative Extension Services materials on recycling and environmentally sensitive techniques for landscaping. It is not clear how well these programs and activities are being coordinated. Education and outreach are critical in this area because of the nonpoint nature of pollution inputs from shoreline activities.

Based on information from the organizations interviewed, programs on stormwater control do not appear to be as common as shoreline protection programs. Stormwater programs that were identified include articles published by the Marine Continuum Foundation, *The Monroe County Environmental Story* by the Monroe County Environmental Education Council, materials by Reef Relief, *Water Quality Problems and Issues in the Florida Keys* by TNC, the stormwater management plan by the Monroe County Environmental Resources Department, and materials by the Monroe County Cooperative Extension Services. The FDER finds stormwater control to be a major issue for the Florida Keys because developments less than 10 acres in size or with less than 2 acres of impervious surface are exempted from regulations requiring stormwater to be treated before it is discharged off-site (Florida Keys Subcommittee, Coastal Resources Interagency Advisory Committee 1991). Education and outreach are critical to make businesses and industries, as well as homeowners, aware of the damage that can result from contaminated stormwater polluting Florida's waters.

Sewage treatment is another issue that appears to require attention. Monroe County has an estimated 5,000 unpermitted and unregulated cesspools and thousands of injection wells used in sewage treatment (Florida Keys Subcommittee, Coastal Resources Interagency Advisory Committee 1991). Several private organizations (e.g., Last Stand and Reef Relief) have strongly advocated that injection wells be banned. Because a large proportion of the population in the Keys uses septic systems, other organizations (e.g., Marine Resources Development Foundation, Monroe County Environmental Education Council, TNC, and Reef Relief) provide information on how to ensure that a septic system is operating correctly. The existence of so many unregulated systems supports the need for a strong public education and outreach program. Related to this issue, on October 1, 1993, all dumping of raw human wastes from vessels upon state waters will be prohibited. Because this deadline is only a year away and enforcement of this issue is difficult, a public education campaign by the State and EPA should be implemented soon. Again, it is difficult to assess the full degree to which these issues are being addressed because of the limited number of organizations interviewed.

As indicated by the interviews, the control of hazardous materials is another issue that may require attention. Education programs and materials on managing hazardous materials are not covered very well by the private or public organizations interviewed. The Marine Resources Development Foundation includes the issue as a minor component of one of its slide shows. Reef Relief covers the use of pesticides and chemicals in its booklet, *Household Guide to Coral Reef Protection*. TNC also focuses on the need to safely manage hazardous materials. The government organizations interviewed have some materials, but a stronger campaign may be needed to improve public awareness and understanding of the linkages between hazardous material management (and often mismanagement) and impacts to the ecosystem. One interviewee saw the need for more amnesty days to provide a drop-off point for people to turn in their household hazardous waste.

Participants at the NOAA workshops and strategy sessions noted the need to improve public education and outreach on growth management options and on the impacts of land development. Reef Relief has two booklets that touch on these issues, the *Handbook of Environmentally Safe Business Practices for the Hospitality Industry* and the *Household Guide to Coral Reef Protection*. Neither of these booklets, however, covers these issues in great detail. *The Monroe County Environmental Story* addresses land development as does the Marine Resources Development Foundation. Government agencies will have to be interviewed more thoroughly to identify the programs and activities they have on these issues.

Land development and growth management are issues that are prime topics for public involvement programs. Various stakeholders are interested in land development and growth management. Government agencies have a responsibility to involve the stakeholders in determining regulations and guidelines. As an example of this responsibility, the role public involvement had in compiling the Monroe County Land Use Plan should be determined by contacting the Monroe County Planning Department (L. MacLaughlin, LKNMS, personal communication, 1992). This contact would be made as part of the next phase of networking with agencies and organizations.

5.1.5 Boating and Diving

Although boating and diving education and outreach needs were raised by the NOAA workshop and strategy session participants, it appears that the needs are being fairly well addressed by existing activities. For example, Florida Sanctuaries (NOAA), FDNR, and the Monroe County Cooperative Extension Services (with support from Sea Grant) are all involved in erecting boating etiquette signs at boat ramps in the Florida Keys. One specific item raised by the NOAA workshop and strategy session participants was the need for boaters to avoid letting their propellers disturb seagrass (i.e., prop dredging). TNC and the Monroe County Cooperative Extension Services distribute materials on such seagrass loss. The CMC publishes *Sanctuary Currents*, a newsletter to increase public awareness on this issue and other resource conservation issues. The Florida Park Service and Monroe County Environmental Resources Department also have materials on seagrass loss. The FKNMS produces a newsletter, *Inside The Florida Keys National Marine Sanctuary*, that covers this and other issues.

Based on the 21 interviews conducted, boating impacts is the boating and diving issue that appears to have received the most attention. The CMC distributes brochures and makes slide presentations related to boating impacts. The Marine Continuum Foundation gives slide shows and the Monroe County Cooperative Extension Services has materials on this topic. Reef Relief distributes brochures, has a video, and makes public service announcements on boating and diving issues. NOAA has a brochure on reef etiquette available at its LKNMS, Key Largo National Marine Sanctuary (KLNMS), and FKNMS offices. NOAA also airs public service announcements on radio and television, gives slide presentations, and airs a monthly television program that addresses boating impacts on the Keys. The Florida Park Service has a brochure entitled *Don't Litter While Canoeing*. Finally, Long Key State Recreation Area has a brochure on boating impacts.

The interviews conducted identified Reef Relief, Florida Sanctua-ies (NOAA), and Long Key State Recreation Area as sources of informative materials on etiquette (e.g., coral protection techniques and the avoidance of prop dredging or running aground) for customers of dive rental equipment retailers and rental boat operators.

Overall, it appears that the four issues raised during the NOAA workshops and strategy sessions (Table 8-2) are being fairly well covered by existing programs and activities. However, the success of the coordination of these various programs and activities is difficult to determine.

One person interviewed offered a policy recommendation for consideration that, if implemented, would require a public education campaign. The recommendation was to establish "no access" or "no take" zones for coral reefs and to establish a reef-use rotation system, as is done in farming, to allow reefs to return to their natural state. Another suggestion made for protecting reefs was to assign interpretative officers to the heavily visited reefs to determine what impact they are receiving and to intercept violators (this is being implemented at LKNMS and KLNMS; expansion of the program is planned).

5.1.6 Fishing

Many programs and activities focusing on fishing were identified. The three specific issues raised at the NOAA workshops and strategy sessions (Table 8-2) were found to be covered to some degree by the 21 organizations interviewed. First, no informative materials or training programs were found that specifically target environmentally sensitive harvesting/collection methods or aquaculture alternatives to harvesting ornamental species (e.g., "live rock"). In contrast, brochures on harvest regulations and materials on species identification were found (e.g., Reef Relief, the Monroe County Cooperative Extension Services, the FDNR, and the Florida Sanctuaries [NOAA]). Ms. Lauri MacLaughlin, Education Coordinator from the LKNMS, provided brochures from agencies that were not included in the survey. These brochures are among those submitted to EPA as mentioned in Section 2.0.

The third issue raised was the need for programs to reduce adverse environmental effects of hook and line fishing. This issue does appear to be receiving some attention. For example, the Marine Resources Development Foundation has a slide show available that covers this issue. The Monroe County Environmental Education Council book, *The Monroe County Environmental Story*, also covers this issue. The Florida Keys Wild Bird Rehabilitation Center gives lectures on the issue and distributes informative bulletins; however, the representative interviewed mentioned that posters should be placed on fishing docks to increase public awareness on the possible adverse impacts that can result from mishandled fishing line and hooks. In addition, NOAA has an underwater reef cleanup program that includes training.

5.2 PUBLIC EDUCATION AND OUTREACH PROGRAM PLAN

As mentioned previously, public education and outreach needs must be built on the current foundation of ongoing programs and activities. The preliminary matrix provided in Table 8-2 represents the first step taken to build this strategy. The next step for EPA will be to provide local staff support to work closely with the various public and private organizations, focused on protecting the Florida Keys, to expand and fill in the matrix. Because EPA is interested not only in water quality, but also in the biological environments of the Florida Keys, the matrix will need to include a complete list of all public education and outreach needs corresponding to all existing programs and activities. Only at that point will it be possible to identify true existing gaps in addressing the complete suite of public education and outreach needs. Expanding this matrix to include the other agencies and organizations having programs relevant to the Keys should be part of the next phase of developing and refining the program plan. In addition to building this foundation of information on existing programs and activities and education and outreach gaps, three steps must be taken to build the public education and outreach program plan for the Water Quality Protection Program.

The first step to conduct an institutional assessment to understand roles and responsibilities. Coordination and collaboration among these institutions will be necessary to leverage funding and to accelerate public awareness of water quality concerns and resource protection needs of the Florida Keys. EPA will need to identify the staff support necessary to work locally in the Keys and to meet with the various public and private organizations and educators to further develop and implement public education and outreach activities. The second step, is to develop and implement a public involvement plan to solicit input from the various organizations conducting education and outreach activities in the Florida Keys. Insight gained through conducting the institutional assessments and public involvement activities will provide valuable input into evaluating and refining the public education and outreach program plan. The activities listed and described under the third step — public education and outreach — are preliminary and will likely be refined and expanded based on the results of the first two steps. These activities do, however, provide a basis of what is needed to increase public awareness of water quality protection. These three steps are iterative in that activities conducted under each will be modified based on the results of routinely evaluating the program plan.

5.2.1 Step 1 — Institutional Assessments and Coordination

An integral part of developing a public education and outreach program plan is to conduct institutional assessments to clarify current and planned roles and responsibilities for protecting the Sanctuary and to identify institutional interests and capabilities in public education and outreach in support of protecting the Sanctuary. These institutional assessments will begin with an internal assessment of EPA's interests and capabilities in terms of staff capabilities and resource availability. Part of this internal assessment is to clarify EPA's own priorities and constraints, and formulate objectives for the public involvement, education, and outreach effort that it will support from a policy and budget standpoint. Overall, the goal is to ensure that the most important needs are addressed first, duplication is minimized among organizations, and the broadest benefits result (i.e., greatest range of stakeholders are reached).

An assessment of the interests, roles, responsibilities, and constraints of other organizations will identify those that have a role in or influence over water quality protection in the Florida Keys. Of particular interest are those that engaged in programs or activities that need to be considered in the design and implementation of EPA's education and outreach program. This external institutional assessment will allow evaluation of the need for EPA to inform and/or coordinate with other organizations. For example, because of the State of Florida's role in water quality, EPA will need to work closely with representatives of the state in developing and implementing its public education and outreach program plan in support of the Water Quality Protection Program.

EPA education efforts will also need to be coordinated closely with the NOAA Sanctuary education staff who developed the Draft Education Action Plan — a plan designed to address many of the education and outreach needs identified at NOAA's education workshops and strategy sessions. This plan focuses on expanding NOAA's existing education program as well as implementing new techniques for increasing the scope and distribution of its education messages. The plan broadens environmental education on an ecosystem level with programs focusing on the relationships of all components of the Florida Keys ecosystem, including the human factor — a strategy taken in response to the broader protection mandate established in the Florida Keys National Marine Sanctuary and Protection Act (i.e., addressing water quality and the terrestrial factors that influence ecosystems). Because one stated objective of the draft education action plan is for NOAA to serve as an umbrella organization for environmental education coordination in the Florida Keys, EPA will need to coordinate closely with this effort. The NOAA Sanctuary Education Action Plan will be available for review and comment as part of NOAA's overall Comprehensive Management Plan in late fall 1992.

These institutional assessments will also provide the information needed to assess the implications of implementing particular programs and activities and aid in the identification of alternative implementation strategies that could maximize the collective effectiveness of public education efforts. As an example, the impact and potential overlap that an education program on the management of household hazardous waste will have on the State of Florida's Department of Environmental Regulations' programs and activities needs to determined.

In summary, the internal and external institutional assessments will be designed to help EPA understand how to collaborate with other agencies' programs and activities most effectively, thereby leveraging funds and providing more integrated programs to the public. Task 2 of the Water Quality Protection Program (Phase II) provides a description of the relevant institutions' roles and responsibilities and therefore provides a good foundation for the conducting institutional assessment.

Specific actions that support this step include:

Action 1 — Develop an Agency Network

- Develop a network of agency participants that represent all of the various Sanctuary missions and associated responsibilities. One task for the network participants would be to develop an organizational roles and responsibilities diagram, agreeable to all parties, for distribution to all interested organizations. In turn, all interested public and private parties would understand how the various Florida Keys protection programs and activities relate to each other, a need identified in the U.S. Fish and Wildlife Service survey (Faanes 1992). EPA's public education and outreach program activities and associated information materials could describe EPA's specific role and how it relates to the other organizations regulating, managing, and overseeing the Sanctuary. EPA would need to coordinate with other relevant agencies to help determine who may be best suited to conduct each activity.

Action 2 — Improve Coordination and Communication Among Governmental Organizations Involved in Protecting the Sanctuary

- Develop a central repository of all public information materials generated on the FKNMS. This is an obvious extension of the *Florida Keys Environmental Education Resource Directory*. The members of the network, as suggested above, could determine where this repository would best be housed (e.g., by the NOAA FKNMS Office or by the FKNMS Advisory Council).
- Develop an electronic version of the *Florida Keys Environmental Education Resource Directory* for ease in updating and improving access to information. One possibility would be to add the *Directory* as a database to the *FREE for Teachers* system.
- Broaden the distribution of the Monroe County Environmental Education Advisory Council's calendar of upcoming environmental education events.
- Assign someone (perhaps a public relations staff member) in Washington, DC, the responsibility of keeping local public, media, and other conservation groups apprised of activities that could affect the regulation and management of the Sanctuary.
- Establish a coordinator in the Keys to facilitate communication between the various conservation organizations and the government agencies. [*NOTE:* EPA and NOAA may each wish to appoint a person for this and the previous function. Alternatively, a representative of the agency network could perform this function.]

Action 3 — Increase Public/Private Coordination and Collaboration Efforts

- Coordination and collaboration should not stop at the agency level, but should be broadened to include private organizations. Several of the organizations interviewed cited lack of coordination as being the largest problem in the area of public education and outreach. With more than 70 organizations having roles in protecting the Florida Keys, it is not surprising that coordination is difficult. As with agency coordination, better public/private coordination could minimize the duplication of effort, maximize the leveraging of funds to support related activities, and encourage the sharing of education and outreach materials.

5.2.2 Step 2 — Public Involvement

The Florida Keys National Marine Sanctuary and Protection Act calls for public involvement by the Secretary of Commerce in developing the Comprehensive Management Plan. EPA will provide for public involvement in developing its Water Quality Protection Program. The program will have a higher probability of achieving its goals and being able to implement its decisions if interested and affected parties (i.e., stakeholders) are given an opportunity to help design the program and participate in the decision-making process. As mentioned in Section 2.0, an essential first step is to make the public aware of EPA's overall role in protecting the Sanctuary and the existence and purpose of the Water Quality Protection Program. Intrinsic to the success of the program is enhancement of public understanding about pollution sources and their impacts on Sanctuary resources, and public acceptance of the decisions being taken by EPA to implement the program. A well-designed and implemented public education and outreach program, developed through a process of public involvement, is a critical element for increasing this awareness, understanding, and acceptance.

EPA will collaborate with the state of Florida to develop a description of the Water Quality Protection Program that sets forth in clear and understandable terms the decisions to be made and the decision-making process followed by both organizations in designing and implementing the Water Quality Protection Program. EPA and the state of Florida will develop a joint public involvement plan that provides stakeholders the opportunity to evaluate the scope, approach, alternatives, evaluation methods, and decision-making processes of the Water Quality Protection Program and to interact with program decisionmakers and technical experts as the details of the Program are being worked out.

5.2.2.1 PUBLIC INVOLVEMENT PLANNING

As recommended by Creighton (1992), the EPA project manager will assemble a public involvement planning team and work with them and the key technical specialists to take the following actions:

Action 1 — Establish the public involvement policy and approach that will be applied to the program and identify who else in EPA and the state of Florida needs to be consulted

Action 2 — Identify and clarify the decisions to be made during the course of the program (i.e., what the program is trying to accomplish), and prepare a description of the background of the project that includes a description of the issues or problems that need to be resolved

Action 3 — Define the decision-making process (which usually includes problem identification, alternative identification, alternative evaluation, alternative selection, and implementation design)

Action 4 — Identify stakeholders and determine how they will be involved in the decision-making process (and hence the public involvement program)

Action 5 — Assess the issues and concerns of the stakeholders and the level of controversy

Action 6 — Determine the desired public involvement outcomes for each of the steps in the decision-making process

Action 7 — Determine what audiences need to be involved and what information needs to be exchanged in order to achieve these outcomes

Action 8 — Select public involvement techniques to be used to fashion this information exchange and develop a schedule of activities

Action 9 — Implement the selected techniques

Action 10 — Evaluate the effectiveness of the plan and make modifications as needed. The primary questions that should be asked are:
(1) Are the intended audiences being reached and are their interests and concerns being addressed?
(2) What changes in attitudes, values, and ultimately behavior are being seen as a result of the public education and outreach program?

Insight gained in this evaluation process should be used to modify the public education and outreach program plan and associated activities.

A critical feature of effective public involvement is the interaction between the program team and the stakeholders for mutual exchange of information, perceptions, and values. Direct communication and exchange is needed among these parties. The program team should include the EPA and state of Florida project managers so that their commitment to involving the public in the decision-making process is demonstrated.

The responsibilities of the Florida Keys National Marine Sanctuary Advisory Council could be expanded to include designing, implementing, and evaluating the public education and outreach program plan. This approach appears appropriate because the Council was established to represent the various stakeholders of the Sanctuary. It is composed of Sanctuary managers, members of relevant governmental agencies, representatives of local industries, commercial users, conservation groups, the marine scientific and educational community, recreational user groups, and the general public. The EPA public education and outreach program plan could be presented to the Council for review and comment.

5.2.2.2 PUBLIC INVOLVEMENT PLAN IMPLEMENTATION

The public involvement plan should include the following actions that are opportunities for public involvement:

Action 1 — Establish a Program of Formal and Informal Meetings to Ensure Public and User Awareness and Participation in the Planning Process

- The public involvement plan will lay out a program of formal and informal meetings (open houses, workshops, focus groups, small group meetings) throughout Monroe County to which commercial and recreational users of Sanctuary resources, other interested parties and the general public will be invited. Decisionmakers and technical experts from the "resource managing" agencies will be at these meetings to make presentations, answer questions, and discuss issues with the participants. Special "Meet the Decisionmakers" and "Meet the Scientists" meetings will be held at regular intervals so that the public can become familiar with both the people and the issues associated with the program.

Action 2 — Establish a Program to Include Interested Publics in Sanctuary Monitoring, Interpretation, and Cleanup

The public involvement plan will establish mechanisms for volunteers to join with agency staff to observe and participate in some of the day-to-day activities of Sanctuary management, such as monitoring, interpretation and cleanup. This type of program not only demonstrates the willingness of the managing agencies to allow the public to observe day-to-day operations and procedures, but it also provides an effective educational and informational service. It also provides a mechanism for agency staff to become familiar with members of the public on a one-to-one basis, and to be exposed to the interests, concerns, and perspectives of people outside the agency in a non-confrontational setting.

Action 3 — Establish an Informational "Hot-Line" and Materials Dissemination Program

If warranted by public interest, EPA, in coordination with the other resource managing agencies, will establish an informational "hot-line" to provide answers to frequently asked questions and up-to-date information about Sanctuary-related activities, programs, and decisions. The hot-line could also serve as a mechanism by which interested parties could find out what resources (audio, visual, and printed materials, speakers: tours, user-friendly computer systems) are available about the Sanctuary and the Water Quality Protection Program, and what events/meetings are scheduled. If appropriate for the level of activity and decision-making in the program, EPA will also establish a "Sanctuary Newsletter" that is prepared and distributed to interested parties on a regular basis. The newsletter will include articles addressing issues of interest to the public, information about upcoming and recent decisions, meetings, reports and studies, a schedule of events, and opportunities for reader feedback to the agency Related activities concerning public information materials are described in section 5.2.3.2.

5.2.3 Step 3 — Public Education and Outreach

NOAA has developed a Draft Education Action Plan that includes specific activities NOAA is considering to conduct. This section lists those NOAA activities that could be augmented to include addressing water quality protection. EPA staff support and funding would be combined with NOAA, state of Florida agencies (e.g., the Department of Natural Resources), local agencies, and possible private organizations to develop a broader, ecological approach to protecting the Florida Keys. NOAA's plan states that its objective is to be the umbrella for all environmental programs within the Keys. Its target is to not duplicate existing educational programs, but to enhance and expand them while supporting new activities that will encourage the diversification of current programs. NOAA recognizes the need to encourage community cooperation and input prior to sanctuary management decisions, which EPA would also support through the previously described public involvement activities. These activities will help to modify the following list of public education and outreach activities that are believed to be worth supporting at this time. The following list of activities is divided into two categories:

- Education and Outreach Programs and Activities
- Public Information Materials

It is premature to develop implementation schedules and budgets for the following activities until the EPA project manager implements the public involvement plan (see Section 5.2.2) and determines the full scope needed. Furthermore, schedules and budgets should be based on the outcome of EPA's discussions with other agencies (e.g., the state of Florida) to determine how public education and outreach programs and activities will be coordinated.

5.2.3.1 EDUCATION AND OUTREACH PROGRAMS AND ACTIVITIES

Activity 1 — Develop a volunteer assistance program

Volunteers will be trained to educate primary and secondary grade levels as well as to conduct special adult classes and workshops on environmental awareness and understanding the Florida Keys ecosystem. NOAA's focus on aquatic habitats will be expanded to include broader water quality issues and upland sources of pollution that can impact the ecosystem.

Activity 2 — Develop presentations on Sanctuary resources

Presentations will be developed that are targeted for different audiences (e.g., distinguished by age, user group, and language ([e.g., Spanish and English]). The presentations will describe the goals and resources of the Sanctuary, and how individuals can help to protect the Sanctuary for our future generations.

Activity 3 — Sanctuary education coordination

Sanctuary educators (federal, state, and local government and private organizations) will form a group to coordinate their individual activities and to collaborate on more broadly based ecosystem activities.

Activity 4 — Establish an Education Advisory Council

An Education Advisory Council with broad representation will be established to provide advice to the Sanctuary educator group. The Education Advisory Council will set education priorities, secure and leverage funding, and coordinate educational efforts to prevent duplication.

Activity 5 — Conduct special outreach events

A variety of special outreach events will be held to enhance public awareness and appreciation for the Sanctuary and its resources. For example, a "Grand Opening" and a "Sanctuary Awareness Week" could be held. In addition, contests could be held to award and recognize contributions by individuals and/or organizations for their efforts to protect the Florida Keys. Special conferences and workshops will also be held to address specific education needs identified in the public involvement activities.

5.2.3.2 PUBLIC INFORMATION MATERIALS

Activity 1 — Develop and distribute printed materials

Printed materials to promote public awareness of the impacts their activities have on Sanctuary resources and environmental quality will be developed and distributed. Information will be printed in brochures, posters, newspapers, newsletters, and periodicals. The development of public information material will be coordinated, to the extent possible and appropriate, with other agencies and organizations to describe the full ecosystem and the impacts to it that result from misuse. For example, these materials will explain how land use techniques can damage marine water quality. EPA can use an approach similar to that used in news stories and education pieces that stress the importance of looking "upstream" or "upland" to identify the source of pollution. EPA would stress the need to manage and regulate the materials that find their way into the waters surrounding the Keys (e.g., nonpoint source pollution, stormwater input, hazardous material management). These materials will be distributed to locations accessible to all possible users of Florida Key waters and will be used in mailings.

Activity 2 — Establish an interagency visitor center to educate and orient Sanctuary users

EPA will coordinate with NOAA, other federal agencies, and state and local agencies to establish an interagency visitor center for the Sanctuary. The purpose of the center will be to provide educational information and orientation information on the Sanctuary. For example, maps of recreational areas and environmentally sensitive areas will be provided. Educational information will focus on describing the whole ecosystem and how upland activities can have a direct impact on water quality and the plants and animals living in these waters. Displays and brochures will include an overview of the "do's and don'ts" in the Sanctuary and general etiquette.

Activity 3 — Develop an interactive computer system containing information on the Florida Keys

EPA will work with NOAA, other federal agencies, and state and local agencies to develop an interactive computer system that could be used in the interagency visitor center described under Activity 2. This system will be user-friendly (e.g., use touch screens) to allow the user to pull up educational and orientation information.

Activity 4 — Construct signs/displays

EPA will coordinate with NOAA, federal, state, and local agencies to develop signs/displays at high-use areas (e.g., marinas, boat ramps, beaches, libraries, other public areas, and special event locations) to inform people of regulations and environmentally sound practices for the Sanctuary. Both permanent and portable signs and displays will be developed to enhance public awareness. Portable displays will be used at special events such as conferences and workshops. Many of these signs and displays will be bilingual. EPA's support will largely be in the area of water quality.

Activity 5 — Establish a Sanctuary library

All available audio/visual materials will be assembled to create a library for use by public and private organizations.

Activity 6 — Develop a limited number of new audio/visual materials

Gaps in available audio/visual materials will be identified during agency coordination activities. Materials will be developed to fill these gaps and added to the Sanctuary library. EPA, in particular, will support filling gaps on water quality issues and upland activities that can impact water quality.

Activity 7 — Establish an audio/visual materials loan program

EPA will coordinate with NOAA, and state and local agencies, to establish a check-out system to lend out audio/visual materials to public and private requesters.

Activity 8 — Develop a press package for media distribution

EPA will coordinate with NOAA and state and local agencies to develop a basic press package for distribution to media personnel. The package will include contacts within the various agencies for finding out more information on particular topics.

Activity 9 — Develop editorial responses for media distribution

EPA will coordinate with NOAA and state and local agencies to develop editorial responses to the typical questions and concerns citizens have about the Sanctuary. These responses will cover questions such as who is doing what to protect the Sanctuary, how are these activities coordinated, what is the status of the ecosystem, where is it sick and what trends are predicted, and what can individuals do to help the Sanctuary?

Activity 10 — Develop a program of public service announcements

EPA will coordinate with NOAA, state and local agencies, and private organizations to establish a program to promote Sanctuary goals and activities through public service announcements in South Florida. The purpose of these announcements will be to present an overview of the Sanctuary, its resources, and describe the activities (both water- and land-based) that can harm these resources. EPA's support will primarily be in the area of water quality issues, including household and commercial activities that can harm the waters of the Keys.

Activity 11 — Develop a "no cost" public service announcement for product placements

EPA will coordinate with NOAA and state and local agencies to print public service announcements on the packaging of products used in and around the waters of the Florida Keys to enhance public awareness of the impacts that can result from misusing the product or improperly disposing of it.

Activity 12 — Promote the Sanctuary through no-cost/low-cost ad space

EPA will coordinate with NOAA and state and local agencies to place advertisements that promote Sanctuary protection in locations where tourist information is already distributed.

6.0 REFERENCES

Creighton, J. 1992. *Developing Public Involvement Plan.* Software prepared for the Bonneville Power Administration.

Faanes, C.A. 1992. *Refuge Issues in the Florida Keys: The Need to Change Attitudes at Low Latitudes.* Prepared for the U.S. Fish and Wildlife Service.

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Hopper, C. N. 1992. Building coral reef conservation awareness through education and interpretation programs at the Waikiki Aquarium. Paper presented at the International Coral Reef Symposium, 7th. June 1992.

NOAA. 1992. *Florida Keys Environmental Education Resource Directory.* National Oceanic and Atmospheric Administration.

APPENDIX A

Organizations Interviewed about Their Environmental Education and/or Outreach Activities/Materials

Organizations Interviewed about Their Environmental Education and/or Outreach Activities/Materials

The information provided below came from the NOAA *Florida Keys Environmental Education Resource Directory* and from the individual interviews conducted.

PRIVATE ORGANIZATIONS

Center for Marine Conservation
One Beach Drive, S.E., Suite 304
St. Petersburg, FL 33701
Ms. Allison Rasmussen, (202) 429-5609
Ms. Heidi Lovett, (813) 895-2188

Purpose: Dedicated to protecting marine wildlife and their habitats and to conserving coastal and ocean resources.

Focus: Has programs and/or products on coastal (mangrove/nearshore) habitats, coral reefs, marine debris, marine mammals, open ocean, protected areas, recycling/energy, sea turtles, sewage outfall, and threatened or endangered species.

Target audience: General public.

Interest in participating in EPA's program design: Question not asked.

Funding source: Non-profit, membership dues and foundation grants.

Materials sent: Yes.

Florida Association of Dive Operators
Atlantis Dive Center
51 Garden Cove Drive
Key Largo, FL 33037
Lower Keys: Mr. Bob Holston, (305) 296-3823
Purpose: To protect and preserve the coral reefs and all of its inhabitants. Also to promote safety in SCUBA diving and awareness of our environment.

Focus: Has programs and/or products on coral reefs, marine debris, marine fauna and flora, marine mammals, open ocean, protected areas, sea turtles, and boat diving etiquette.

Target audience: Dive equipment retailers.

Interest in participating in EPA's program design: Yes, would like to be present at meetings; distribute materials to audience; and provide a user-group perspective.

Funding source: Non-profit.

Materials sent: Yes.

Florida Keys Audubon Society
1226 South Street
Key West, FL 33040
Ms. Greta E. Phillips-Ford, President, (305) 294-4927 or (305) 294- 3438 for bird sightings.

Purpose: To act locally and nationally on environmental issues.

Focus: Has programs and/or materials on backcountry region, coastal (mangrove/nearshore) habitats, marine debris, marine mammals, migratory birds, oil drilling/spills, protected areas, sea turtles, sewage outfall, terrestrial fauna and flora, threatened or endangered species, and water quality.

Target audience: General public.

Interest in participating in EPA's program design: Question not asked.

Funding source: Non-profit, membership dues plus special fund- raising events.

Materials sent: Yes.

Florida Keys Citizens Coalition, Inc.
P.O. Box 523
175 4th Street
Key Colony Beach, FL 33051
Mr. George Kundtz, Chairman, (305) 743-7944

Purpose: Dedicated to promote, preserve, and enhance the environment and quality of life in the Florida Keys.

Focus: Has programs and/or products on coastal (mangrove/nearshore) habitats, recycling, sewage outfall, water quality, and land use effect upon the environment and economy. After study of issues provides information to Monroe County, state and federal agencies, and the public in order to achieve "environmental and economic integrity." When necessary, takes legal action as they are currently doing by becoming intervenors in the new land-use planning process.

Target audience: General public and environmental groups.

Interest in participating in EPA's program design: Yes, with involvement with state, EPA, and the U.S. Army Corps of Engineers and have them support Florida Keys Citizens Coalition with resources.

Funding source: Non-profit.

Materials sent: Yes.

Florida Keys Land and Sea Trust
P.O. Box 536
5550 Overseas Highway
Marathon, FL
Dr. Chuck Olson, Director, (305) 743-3900

Purpose: To preserve the natural heritage of the Florida Keys through programs in land protection, marine conservation, and education.

Focus: Has programs and/or products on backcountry region, coastal (mangrove/nearshore) habitats, coral reefs, marine fauna and flora, open ocean, protected areas, recycling/energy, research on sewage outfalls, terrestrial fauna and flora, threatened or endangered species, and water quality.

Target audience: General public and, in particular, children of South Florida.

Interest in participating in EPA's program design: Maybe.

Funding source: Non-profit, membership dues, income from natural history museum and children's museum, and other funding.

Materials sent: Yes.

Florida Keys Wild Bird Rehabilitation Center
93600 Overseas Highway
Tavernier, FL 33070
Ms. Laura B. Quinn, Director, (305) 852-4486

Purpose: To rehabilitate injured and sick wild birds and promote education.

Focus: Has programs and/or products on coastal (mangrove/nearshore) habitats, marine debris, migratory birds, protected areas, recycling/energy, research on terrestrial fauna and flora, threatened or endangered species, and water quality.

Target audience: General public, emphasizing fishermen and children.

Interest in participating in EPA's program design: Yes, and would like to have EPA support this effort.

Funding source: Non-profit, donations from mailing list of 500 and other funding.

Materials sent: Yes.

Last Stand
P.O. Box 146
Key West, FL 33041
Mr. Jim Farrell, President, (305) 294-8422

Purpose: To protect and preserve quality of life, especially as it pertains to the environment.

Focus: Has programs and/or products on coastal (mangrove/nearshore) habitats, marine debris, protected areas, and citizen awareness campaigns to prevent loss of habitat areas from uncontrolled over-development.
Target audience: General public.

Interest in participating in EPA's program design: Yes.

Funding source: Non-profit.

Materials sent: Yes.

Marine Continuum Foundation
501 Sanctuary
Key Largo, FL 33037

Ms. Lucia Mercer, President, (305) 451-5607

Purpose: To support environmental education programs, biological research activities, and conservation or preservation projects that produce measurable results in a timely fashion.

Focus: Has programs and/or products on backcountry region, coastal (mangrove/nearshore), coral reefs, marine debris, marine fauna and flora, marine mammals, migratory birds, oil drilling, open ocean, protected areas, recycling, research, sea turtles, sewage outfalls, terrestrial fauna and flora, and threatened or endangered species.

Target audience: General public.

Interest in participating in EPA's program design: Yes.

Funding source: Private foundation.

Materials sent: Yes.

Marine Resources Development Foundation
P.O. Box 787
51 Shoreland Drive
Key Largo, FL 33037
Mr. Art Mitchell, Vice President for Education, (305) 451-1139 or (800) 741-1139

Purpose: The purpose of the environmental education programs of the Marine Resources Development Foundation is to produce an awareness of the complexity and fragility of interdependent natural systems represented locally by seagrass beds, mangrove forests, coral reefs, and hardwood hammocks. This awareness should foster appreciation, respect, and an active preservation ethic.

Focus: Has programs and/or products on backcountry region, coastal (mangrove/nearshore) habitats, coral reefs, marine fauna and flora, open ocean, terrestrial flora, and water quality.

Target audience: General public, children, and the elderly.

Interest in participating in EPA's program design: Yes. Would like to continue to make people aware of the water quality problem; could disseminate information to people in Florida and 600 teachers in their network; and develop new material if resources/staff were available.

Funding source: Non-profit and government agency support and tuition fee from students.

Materials sent: Yes.

Monroe County Environmental Education Council
c/o Seacamp
Route 3, Box 170
Big Pine Key, FL 33043
Mr. Dan Gallagher c/o Seacamp, (305) 872-2331

Purpose:

Focus: Has programs and/or products on backcountry region, coastal (mangrove/nearshore) habitats, coral reefs, marine debris, marine fauna and flora, marine mammals, migratory birds, protected areas, sea turtles, terrestrial fauna and flora, and threatened or endangered species.

Target audience: Monroe County teachers, environmental groups, educators, students, and residents.

Interest in participating in EPA's program design: Yes, but would like to know who would support and cover efforts and time involved; would like to have input into policy-making discussions; would like to work with Seacamp to distribute information materials.

Funding source: Non-profit government grants and revenue from sales of *The Monroe County Environmental Story*.

Materials sent: Yes.

Note: Interview needs to be conducted with Mr. Jon Andrew, President, who was not available during the survey period. His phone number is (305) 872-2239.

National Audubon Society
Field Research Department
Florida Keys Office
115 Indian Mound Trail
Tavernier, FL 33070
Ms. Nancy Paul, Office Manager, (305) 852-5092; interview was with Ms. Sandy Sprunt.

Overall Purpose: To promote conservation of wildlife, habitats, and energy, and ensure a healthier environment. Purpose of this office: To conduct research relevant to conservation issues important to the South Florida region and provide information to agencies charged with management of natural resources.

Focus: Has programs and/or products on backcountry region, migratory birds, research, terrestrial fauna and flora, and threatened or endangered species. Staff scientists have conducted research on the physical and biological components of the terrestrial, wetland, and estuarine systems of South Florida, with an emphasis on threatened and/or endangered species.

Target audience: General public.

Funding source: Non-profit.

Materials sent: No.

The Nature Conservancy
P.O. Box 4958
201 From Street, Building 21
Key West, FL 33041
Mr. Mark Robertson, Director of the Florida Keys Initiative, (305) 296-3880
Ms. Mary Enstrom, Marathon Office, (305) 743-2437

Purpose: To identify, protect, and manage the best remaining natural areas before they are lost forever.

Focus: Has programs and/or products on coastal (mangrove/nearshore) habitats, coral reefs, marine fauna and flora, protected areas, research, sewage outfalls, threatened or endangered species, water quality, human impacts on marine environment, and marine pollution.

Target audience: General public, including school children to senior citizens.

Interest in participating in EPA's program design: Yes.

Funding source: Non-profit; The Nature Conservancy's Volunteer Program is funded (50:50) by The Nature Conservancy and NOAA.

Materials sent: Yes.

Reef Relief
P.O. Box 430
Key West, FL 33041
Deevon Quirolo, (305) 294-3100

Purpose: An action-oriented, largely volunteer-staffed organization dedicated to preserving and protecting the living coral reef of the Florida Keys. Presently maintains 119 reef mooring buoys at seven reefs in the Keys that eliminate anchor damage to coral.

Focus: Has programs and/or products on backcountry region, coastal (mangrove/nearshore) habitats, coral reefs, marine debris, marine fauna and flora, marine mammals, oil drilling/spills, open ocean, sea turtles, sewage outfalls, threatened or endangered species, and water quality.

Target audience: General public, with an emphasis on boaters, fisherman, divers/snorkelers, residents, hotels, and tourists.

Interest in participating in EPA's program design: Yes.

Funding source: Non-profit, government agency support and donations.

Materials sent: Yes.

PUBLIC ORGANIZATIONS

Federal

Everglades National Park
P.O. Box 279
Homestead, FL 33030
Mr. Neil DeJong, Environmental Education Coordinator, (305) 242- 7753

Purpose: To conserve and protect National Park Service areas and to allow public use for future generations.

Focus: Has programs and/or products on backcountry region, coastal (mangrove/nearshore) habitats, marine debris, marine fauna and flora, marine mammals, migratory birds, protected areas, recycling/energy, research, sea turtles, terrestrial fauna and flora, threatened or endangered species, and water quality.

Target audience: General public, with a focus on grade school children.

Funding source: Federal funding.

Materials sent: Yes.

Key Largo National Marine Sanctuary
P.O. Box 1083
NM 100 Ocean Drive
Key Largo, FL 33037
Ms. Paige Gill, Education Coordinator, (305) 451-5321

Purpose: To protect the resources of the Florida Keys marine ecosystem, to support research and monitoring within the Sanctuary, to educate and interpret for the public regarding the Florida Keys marine environment, and to facilitate multiple resource use.

Focus: Has programs and/or products on backcountry region, coastal (mangrove/nearshore) habitats, coral reefs, marine debris, marine fauna and flora, marine mammals, oil drilling/spills, protected areas, recycling/energy, research, sea turtles, and threatened or endangered species.

Target audience: General public, with a focus on the boating/diving community and the school system.

Interest in participating in EPA's program design: Yes.

Funding source: Federal funding.

Materials sent: Yes, from Looe Key National Marine Sanctuary.

Looe Key National Marine Sanctuary
Route 1, Box 782
MM 37.5 Overseas Highway
Big Pine Key, FL 33043
Ms. Lauri MacLaughlin, Education Coordinator, (305) 872-4039

Purpose: To protect the resources of the Florida Keys marine ecosystem, to support research and monitoring within the Sanctuary, to educate and interpret for the public regarding the Florida Keys marine environment, and to facilitate multiple resource use.

Focus: Has programs and/or products on backcountry region, coastal (mangrove/nearshore) habitats, coral reefs, marine debris, marine fauna and flora, marine mammals, protected areas, recycling/energy, research, sea turtles, threatened or endangered species, and water quality.

Target audience: General public, with a focus on the boating/diving community and the school system.

Interest in participating in EPA's program design: Yes.

Funding source: Federal funding.

Materials sent: Yes.

State

Bahia Honda State Park
Route 1, Box 782
Big Pine Key, FL 33043
Mr. Benny Woodham, Park Manager, (305) 872-3897

Purpose: To provide resource-based recreation while preserving, interpreting, and restoring natural and cultural resources.

Focus: Has programs and/or products on coastal (mangrove/nearshore) habitats, marine debris, marine fauna and flora, marine mammals, migratory birds, protected areas, recycling/energy, research, sea turtles, terrestrial fauna and flora, and threatened or endangered species.

Target audience: General public.

Interest in participating in EPA's program design: Yes, and would like literature/displays from EPA.

Funding source: State funding.

Materials sent: No.

Florida Park Service District 9 Administration
MM 102.5 John Pennekamp Coral Reef State Park
PO Box 2660
Key Largo, FL 33037
Ms. Barbara L. Roberts, Education Specialist, (305) 451-3005

Purpose: To provide resource-based recreation while preserving, interpreting, and restoring natural and cultural resources.

Focus: Can arrange programs and/or provide products on backcountry region, coastal (mangrove/nearshore) habitats, coral reefs, marine fauna and flora, marine mammals, migratory birds, protected areas, recycling/energy, research, sea turtles, terrestrial fauna and flora, threatened or endangered species, and water quality.

Target audience: General public.

Funding source: State funding.

Materials sent: Yes.

Long Key State Recreation Area
P.O. Box 776
Long Key, FL 33001
Mr. Gary McKee, Park Manager, (305) 664-4815

Purpose: To provide resource-based recreation while preserving, interpreting, and restoring natural and cultural resources.

Focus: Has programs and/or products on coastal (mangrove/nearshore) habitats, coral reefs, marine debris, migratory birds, protected areas, recycling, sea turtles, terrestrial fauna and flora, and threatened or endangered species.

Target audience: General public, with a focus on campers and recreation area day users.

Interest in participating in EPA's program design: Yes, willing to assist with water sampling and educational input.

Funding source: State funding.

Materials sent: Yes.

County/Local

Monroe County Cooperative Extension Services
Public Service Building, Stock Island
5100 College Road
Key West, FL 33040
Mr. Doug Gregory, Director and Marine Agent, (305) 292-4501

Purpose: To promote public education on primarily marine and horticultural topics.

Focus: Has programs and/or products on backcountry region, coastal (mangrove/nearshore) habitats, open ocean, coral reefs, marine debris, marine fauna and flora, recycling/energy, sea turtles, terrestrial fauna and flora, threatened or endangered species, and water quality.

Target audience: General public.

Interest in participating in EPA's program design: Yes.

Funding source: Federal, state, and county funding.

Materials sent: No, but materials produced by the service were sent from Ms. Lauri MacLaughlin from the Looe Key National Marine Sanctuary.

Monroe County Environmental Resource Department
3101 Overseas Highway
Marathon, FL 33050
Mr. Robert Smith, Senior Biologist, (305) 289-6031

Purpose: Land use.

Focus: Has programs and/or products on coastal (mangrove/nearshore) habitats, coral reefs, marine fauna and flora, terrestrial fauna and flora, and threatened or endangered species.

Target audience: Professionals in this field.

Interest in participating in EPA's program design: Yes.

Funding source: County funding.

Materials sent: Yes.

APPENDIX B

Additional Organizations to Contact

Additional Organizations to Contact[a]

Name of Organization, Contact Person, and Telephone Number

Bureau of Submerged Lands and Aquatic Preserves
Florida Keys Aquatic Preserves
Ms. Annette Nielsen: (305) 289-2336

Florida Keys National Marine Sanctuary Planning Office
Mr. Billy Causey: (305) 743-2437

Florida Department of Education Office of Environmental Education
Florida Resources in Environmental Education: 1-800-542-FREE

National Marine Fisheries Service
(813) 893-3141

Monroe County Recycling Department
Ms. Connie Grabois: (305) 292-4433

Monroe County District Schools
Ms. Jeanne Sanford: (305) 296-6523

G.R.E.E.N. Team (member)
Ms. Laura Causey: (305) 289-2480

NOAA/National Undersea Research Center (NURC)
Mr. John Halas: (305) 451-1644 or
Mr. Ray Scharf, Diving Safety Officer
East Carolina University
Minges Coliseum
Greenville, NC 27858-4353

Monroe County Environmental Education Council
Mr. Jon Andrew (President): (305) 872-2239

National Wildlife Refuges: (Key Deer, Great White Heron, Key West Crocodile Lakes)
Mr. Jon Andrew (Manager): (305) 872-2239

John Pennekamp Coral Reef State Park
Mr. George Jones: (305) 451-1226

Clean Water Action
Ms. Joyce Newman: (305) 872-3725

Harbor Branch Oceanographic Institute
Dr. Brian Lapointe: (305) 872-2247

SEACAMP/Newfound Harbor Marine Institute
Ms. Leigh Williams and Dan Gallagher: (305) 872-2331

Monroe County Planning Department
(305) 292-4400

[a]List provided by Ms. Lauri MacLaughlin, Education Coordinator for the Looe Key National Marine Sanctuary.