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# THE DESIGN OF A MANAGEMENT INFORMATION SYSTEM FOR COASTAL RESOURCES PLANNING

Prepared by
The Center for the
Environment and Man, Inc.
under
Sea Grant Project GH-63
National Science Foundation

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February 1972

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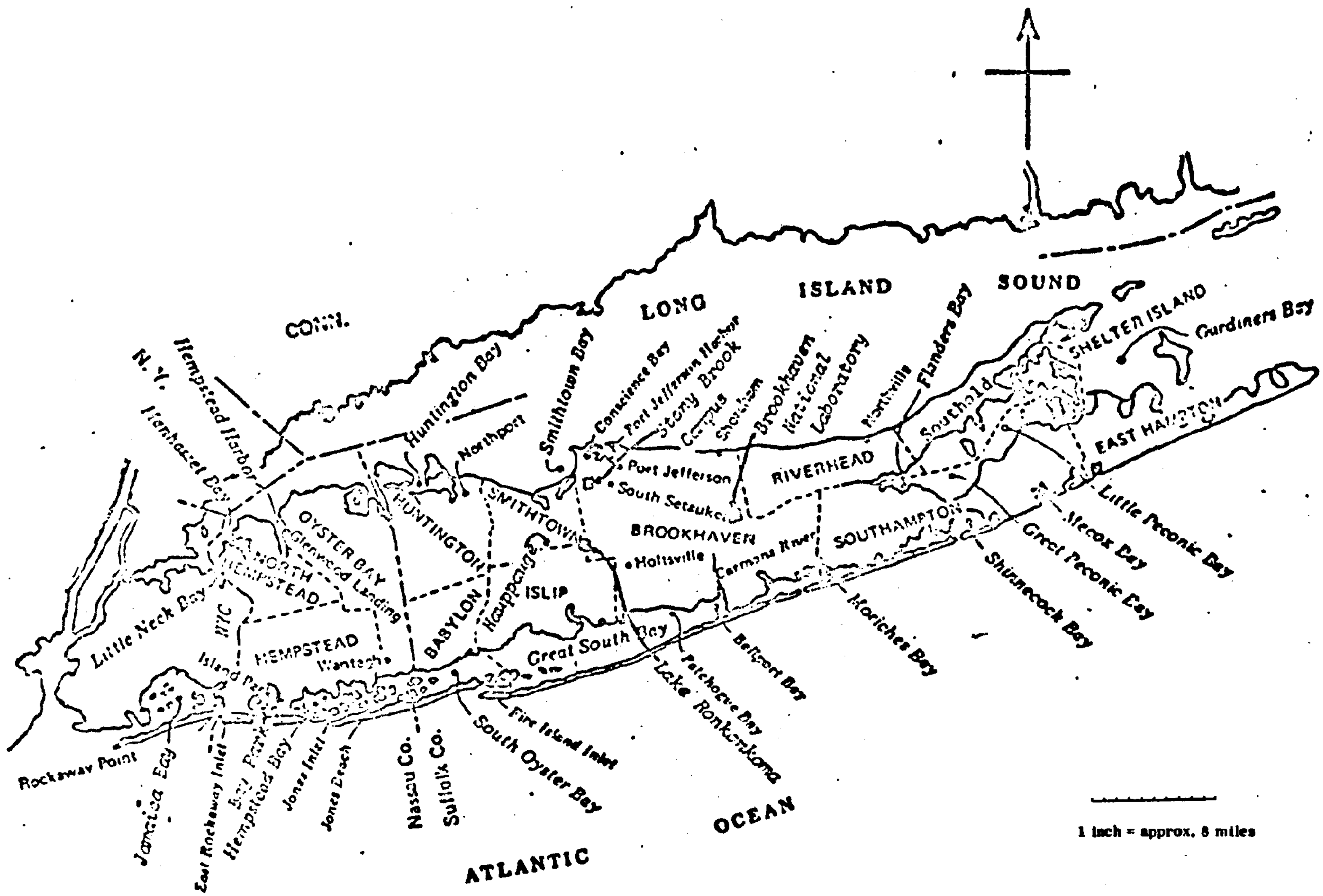
P. B. Cheney
J. T. Ball
E. R. Sweeton

## Regional Marine Resources Council

A COMMITTEE OF THE NASSAU-SUFFOLK REGIONAL PLANNING BOARD



CONN.
N.Y.
LONG ISLAND SOUND
ATLANTIC OCEAN
Hempstead Harbor
Manhasset Bay
Little Neck Bay
Huntington Bay
Northport
Smithtown Bay
Conscience Bay
Port Jefferson Harbor
Stony Brook
Campus
Shoreham
Brookhaven National Laboratory
Northville
Flanders Bay
SHELTER ISLAND
Gardiners Bay
Southold
EAST HAMPTON
RIVERHEAD
Port Jefferson
South Setauket
BROOKHAVEN
SOUTHAMPTON
Holtsville
Carmans River
OYSTER BAY
Glenwood Landing
NORTH HEMPSTEAD
HUNTINGTON
SMITHTOWN
Hauppauge
ISLIP
BABYLON
HEMPSTEAD
Wantagh
NYC
Island Park
Great South Bay
Rockaway Point
Jamaica Bay
East Rockaway Inlet
Bay Park
Hempstead Bay
Jones Inlet
Jones Beach
Nassau Co.
Suffolk Co.
South Oyster Bay
Fire Island Inlet
Lake Ronkonkoma
Patchogue Bay
Bellport Bay
Moriches Bay
Shinnecock Bay
Great Peconic Bay
Mecox Bay
Little Peconic Bay
1 inch = approx. 8 miles

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## FOREWORD

This report is part of a series prepared by The Center for the Environment and Man, Inc., for the Regional Marine Resources Council of the Nassau-Suffolk Regional Planning Board under the continuing program: The Development of Methodologies for Planning for the Optimum Use of the Marine Resources of the Coastal Zone. The program is being funded in part by the Sea Grant Program of the National Oceanic and Atmospheric Administration and is structured into six functional steps:

Functional Step One (Problems). Identifies, classifies and briefly analyzes the problems that confront planners and decision makers with regard to the area's marine resources.

Functional Step Two (Knowledge Requirements). Identifies the knowledge necessary for making sound decisions with regard to the use of the marine resources.

Functional Step Three (State of the Art). Determines the availability and applicability of existing knowledge and data.

Functional Step Four (Knowledge Gaps). Determines necessary data collection and research activity.

Functional Step Five (Data Collection and Research Program). Collects required data and performs necessary research.

Functional Step Six (Management Information System). Develops a system for organizing and synthesizing the knowledge and data and provides analyzed information to marine resource planners.

The current report is a discussion of the design for a management information system, and is a product of Functional Step Six of the Marine Resources Council program.

Views and conclusions contained in this report are those of The Center for the Environment and Man, Inc. They should not be interpreted necessarily as the official opinion or policy of the Marine Resources Council or the National Oceanic and Atmospheric Administration.

## TABLE OF CONTENTS

## I. INTRODUCTION

Coastal zone planning and resource management requires an understanding of the complex milieu of interactions and activities taking place throughout this region. Man is beginning to recognize that the old methods of dealing with individual issues and problems as single fragments of whole environmental systems, such as the coastal zone, frequently have led to counterintuitive reactions which have had an overall deleterious effect.

The answer in the search to understand these complexities frequently has been to recommend and conduct more research and data gathering. Large programs have been proposed and pursued without defining beforehand how the results of individual research and data collection projects will be used, how these results relate to those of other projects, and what methods might be applied for making results useful for planning and management decisions.

The Marine Resources Council program designed to support marine coastal zone planning on Long Island has been sensitive to the needs of the planner and decision maker. An integral objective of the program is to develop a blueprint or conceptual framework that relates data, information, predictive techniques, environmental interactions, methods of analysis and applications into one system of procedures, tools and instructions for use by planners. Previous reports in this program have discussed the need to establish knowledge requirements, to collect and synthesize this knowledge and to develop a series of models, tools and techniques.

The above are all general and abstract terms that only convey the concept of the needs for effective marine resource management. Collectively terms such as knowledge, data, framework, procedures, models, synthesis, etc. actually describe the components of a single system. When the hard products or activities associated with each of the respective terms are developed and joined into a logical operating system, a management information system results. Thus we are describing, in the present program context, a coastal zone management information system (MIS) for use by Long Island to aid in planning and management of their marine coastal resources.

The objective of this report is to present a design blueprint for development of the MIS. The general and specific characteristics, structure and function of the total system and its components, and examples of system application are described in the following sections. A suggested sequence and time schedule for system development and operational implementation is also discussed. The system presented has been specifically designed for use on Long Island based on the planning and decision problems pertaining to that region. The MIS is applicable to other geographical areas, however, in the sense that many of the problems, environmental conditions and planning needs are common to all coastal regions. Likewise, general management information systems design principles will apply to all systems possessing the characteristics and objectives of the one proposed here. Consequently the MIS discussed in this report can be generalized and transferable for use by other coastal regions.

Section II describes the general requirements and characteristics of the MIS. Specifications for the total system and each of its five components are discussed in Section III. Section IV describes application of the system; while the suggested schedule for system development and implementation is presented in Section V. More detailed specifications for each of the five major components are covered in Appendixes A through E respectively.

## II. GENERAL REQUIREMENTS AND CHARACTERISTICS OF THE MANAGEMENT INFORMATION SYSTEM

The purpose of the management information system for coastal zone planning and management is to provide information which will assist the decision maker to accomplish these four basic objectives:

1) to know the existing condition of the environment in time and space;

2) to predict the influence of causal factors upon the condition of the environment in time and space;

3) to assess the effect of the conditions on marine-related activities; and

4) to select from those alternatives the combinations of activities and conditions which best meet the mix of stated goals and needs.

The system will carry out its purpose by performing five general functions which are:

1) to identify and describe what is involved in the problem as put forth for analysis;

2) to identify data and relationships which will form the basis of the analysis;

3) to provide the data for analysis in a usable fashion;

4) to synthesize and analyze the data to provide information; and

5) to present the resulting information in a manner consistent with the needs of the decision maker.

The system should be so designed and constructed that it can be maintained at the existing level of practical knowledge; and, as new research results become available, can be updated without complete redesign efforts.

The system must exhibit flexibility in its uses. Single purpose systems can be designed to operate with greater efficiency. But they cannot respond to needs beyond their narrowly intended purpose. Such a system would not satisfy the requirements for something as broadly defined as coastal zone management and planning. A system for this purpose will provide a variety of kinds of information in varying degrees of detail to respond to the purposes for which it is intended.

A major characteristic of the system which will meet these requirements is its modular design. That is, the system is structured as a collection of "packages" or components each of which has a specific function, and each of which can provide useful information either independent of the other components or in conjunction with one or more of them. For the purposes of system development and maintenance, each component will be structured for periodical updating to conform to the state of existing knowledge without requiring concurrent attention of the other components. The modular design also aids in providing the needed flexibility of use. If the need is for a straight data display, for example, there is no need to "activate" all other parts of the system such as data processing routines, statistical analysis packages, or analytical procedures.

The modular design also provides for early implementation of those components for which the state of knowledge is adequate and for which adequate operational need exists.

Modular design and construction, with modules at various stages of development, will mean that the system, at least in the forseeable future, will consist of a mix of man and machine performed functions.

Modular design also means that the system should have an executive control component which governs the system operation. Such a component would provide the interface between the "man" and the "machine." In computer terminology the executive control corresponds to the main program while the other components of the system are subroutines brought into action as the need arises. Within this context the executive control would accept the operating instruction (input), access the subroutines, and present the results (output). For some time to come the analyst may be required to perform many of the functions which are the ultimate responsibility of an executive control. But, even if the component has no more than a read/write and calling function it will be a part of the system from the beginning so that, as the system grows, the executive control will grow in conjunction with the other components and maintain an integrated MIS.

As the system is developed over time, it should be operational at all times regardless of the state of knowledge or existing data. The decision makers and planners have problems now that cannot wait for "better" knowledge. Decisions which influence the state of the marine environment and the use of marine resources are made daily. Whenever the MIS can provide information to help in these decisions with more timely data, more accurate analysis and prediction, or a more systematic and thorough approach, it should be available. If it is not made operational from its inception it will serve no real purpose to planners and managers.

## III. SPECIFICATIONS FOR THE MANAGEMENT INFORMATION SYSTEM

### A. General System Design

The management information system (MIS) has been designed as a structure of self-contained components. Each component has one or more specific functions to perform in providing marine resource information to planners and decision makers. Each component can be used either independently or in conjunction with one or more of the others, depending upon the analysis to be performed and the kind of information requested.

The components are:

1) data storage and retrieval—providing a storehouse of physical, economic and social data required for attacking the particular kinds of problems faced by resource planners. Also provided is the capability to retrieve data in a selective manner, by subject, time and geographic location for use in a variety of analyses;

2) environmental relationships—containing available knowledge about cause-effect relationships, particularly in the physical, chemical, biological processes which underlie problems associated with the environment and marine resource utilization;

3) analytical design—containing the approaches which specify the data kind, form and extent, the sequence of steps and analytical procedures and the output information which will aid the user in resolving a given decision problem;

4) synthesis and analysis—providing a data manipulation capability ranging from data presentation methods (such as isopleth mapping) and simple tabulations to complex analytical procedures for predicting the consequences of a proposed action (based on the current state of the art); and

5) executive control—providing an overall system management function to receive input information; to maintain and update the data storage and retrieval component; to call appropriate parts of the system into operation; and to provide results in a manner consistent with the needs to handle the problem at hand.

The five components are designed to carry out the five general functions of the MIS, listed in Section II. But, the relationship between a component and function is not "one to one." That is, several components will contribute to a single function and a specific component will contribute to several functions. Table III-1 identifies these

TABLE ~~III~~-1

RELATIONSHIP OF MIS COMPONENTS TO FUNCTIONS

| | Function | | | | |
|---|---|---|---|---|---|
| Component | 1 Identify & Describe Problem | 2 Identify Data Needs & Relevant Relationships | 3 Provide Data as Needed | Synthesize Analyze and Prepare Results | 5 Present Results |
| 1. Data Storage & retrieval | Provides data to aid in establishing & verifying the problem | | Maintain current data file & re-trieve as required | | Provides direct unprocessed data for output |
| 2. Environmental Relationships | Develop compre-hensive network for the problem (cause-effect) | Specifies links & cause-effects, parameters and data required | | Provides parameter & form of relationships | Provides direct unprocessed outputs of net-works & ma-trices of re-lationships |
| 3. Analytical Design | Identify considera-tions and sequence of steps for pro-blem analysis | Specifies boundaries and times of data and provides alternates when data is missing | | Specifies types of analyses & outputs required | |
| 4. Synthesis & Analysis | | | | Use data & relationships to conduct specified analysis | Provide results for output |
| 5. Executive Control | Receive input | Calls in 2 & 3 | Updates data error checks & maintains data file | | Presents output results in man-ner required by user |

function-component interrelationships and briefly describes the contribution of each component to the respective functions.

The components will be designed to perform their appropriate functions independently. But the real value comes through the systematic interrelating of the components to perform comprehensive analyses. Figure III-1 depicts the dynamics of the interaction among the respective components; while Table III-2 briefly describes the nature of the interrelationships.

A detailed discussion of the individual components follows.

## B. Data Storage and Retrieval

This component of the MIS is composed of three basic files:

1) the environmental data file (EDF)—to provide data describing the conditions of the physical environment on Long Island;

2) the resource use data file (RDF)—to provide data describing the marine related activities, uses of marine related resources and associated problems; and

3) the literature reference file (LRF)—to provide the reference sources of specific information pertinent to a particular problem analysis.

The objective of the environmental data file (EDF) is to provide specific quantitative data which will describe the physical, chemical and biological characteristics of the Long Island coastal waters and adjacent shores on a geographic basis. It will contain data describing physical characteristics such as topography, surface material, water depth and area, benthic materials; chemical conditions—primarily water quality parameters; and biological condition such as types and population characteristics of indigenous species of shell fish, finfish and other important marine and shore based fauna and flora. The data required for management which correspond to the above were specified in knowledge requirements Categories II and III in the report on knowledge requirements (TRC Report 4047-387).[1/]

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[1/] "The Development of a Procedure and Knowledge Requirements for Marine Resource Planning. Functional Step Two Knowledge Requirements." Prepared for Marine Resources Council, Nassau-Suffolk Regional Planning Board. Travelers Research Corp., Feb. 1970

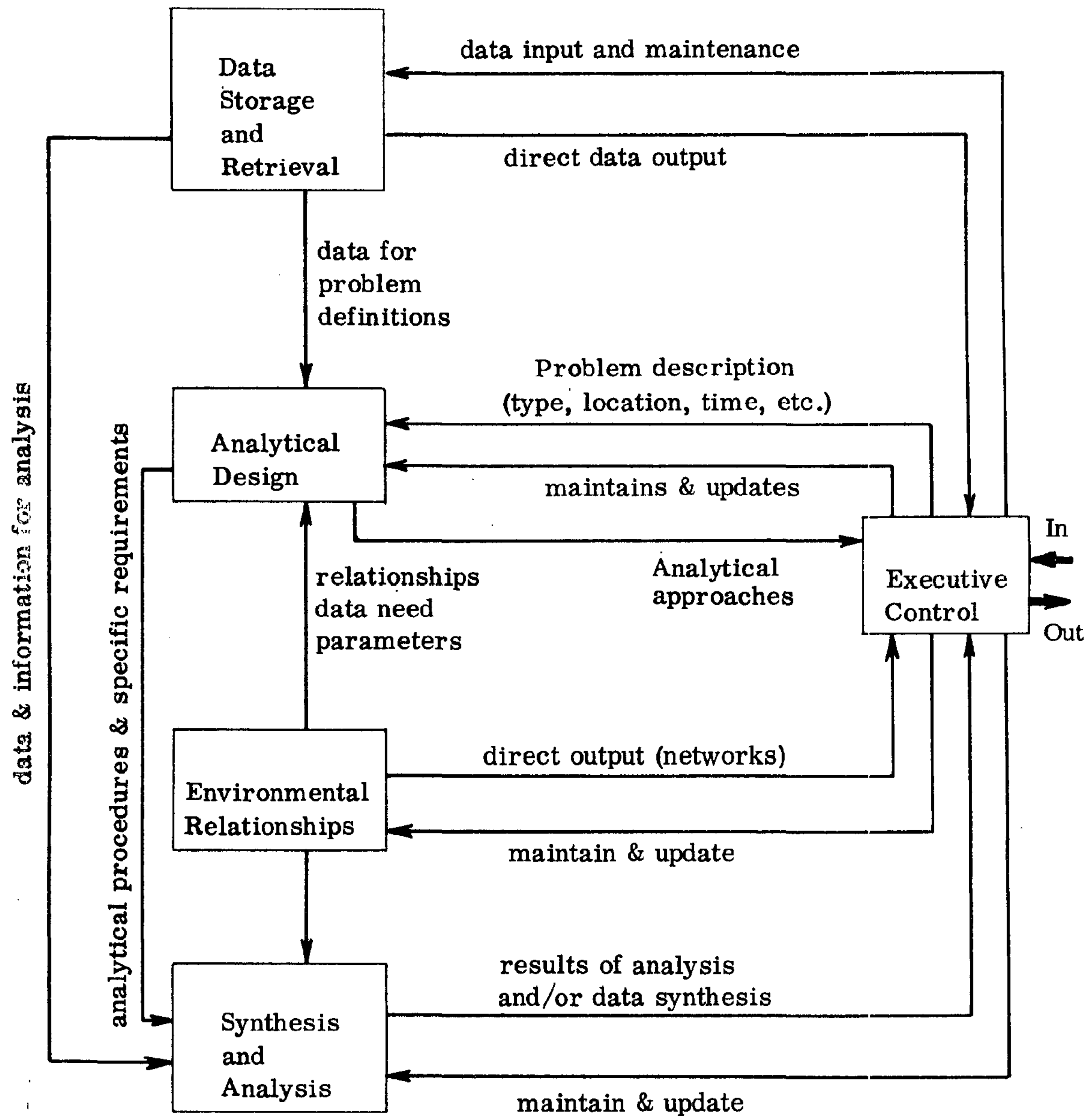


Fig. III-1. System components and interrelationships.

TABLE III-2
MIS COMPONENT INTERRELATIONSHIPS

| | Data Storage and Retrieval | Environmental Relationships | Analytical Design | Synthesis and Analysis | Executive Control |
|---|---|---|---|---|---|
| Data Storage and Retrieval | | | Provides data for verifying problem and specifying analytical approach | Provides data for analysis | Provides data for direct unprocessed output |
| Environmental Relationships | | | Provides specific relationships which are significant for analysis | Provides form and parameters of relationships (equations, etc.) | Provides networks and information for direct unprocessed output |
| Analytical Design | Identifies specific data needs for particular problems | Identifies specific problem or "use" for which relationships are needed | | Specifies analytical techniques and required output. Provides alternatives. | Specifies analytical approaches for direct output |
| Synthesis and Analysis | | | | | Provides analytical results for output |
| Executive Control | Maintains and updates data files—performs error checks | Maintain and update state-of-the-art | Provides input describing problem or "use application. Maintains and updates to state-of-the-art. | Monitors and maintains analytical techniques. Maintain and update state-of-the-art. | |

The EDF must be constructed to allow variable length records of specific data for any particular location and must be amenable to relatively easy updating and expansion as new or more reliable data become available. It must also be constructed to facilitate retrieval of one or more data items for one or more locations.

To fill the need for associating data of this type (and others as well) with specific locations an area grid system is recommended for Long Island and surrounding areas. The grid will contain x, y coordinates to locate the point positions of measured and observed data; grid cells will serve as units of area for aggregating data; and the overall grid system will serve as a framework for presenting data in map form. Several existing grid systems were investigated and evaluated for their potential usefulness for the marine resource management and planning activity on Long Island. The universal transverse mercator system (UTMS) was selected and is recommended for this MIS component. A discussion of the systems investigated, their characteristics and the criteria used for evaluation is located in Appendix A.

The objective of the resource use data file (RDF) is to provide information about human activities which are related to the utilization of the marine environment and resources. The RDF will consist of a series of records containing information about the location and extent of such activities presently in existence as well as planned and/or projected activities. The information contained in the file corresponds to knowledge requirement Categories I and IV (see Table III-3). The information is classified according to the specific dimensions by which one describes and evaluates marine resources conflicts and problems. These dimensions were presented in TRC Report 7722-347b[1/] and are listed for reference in Table III-4. The dimensions information will consist of a series of records, each describing a particular problem or conflict in a specific area. The record will contain information about the location, extent and severity of problem, the people involved, the economic considerations, the probable causes of dissatisfaction, and other factors important to the full understanding

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1/ "The Development of a Procedure and Knowledge Requirements for Marine Resource Planning. Functional Step One, The Classification of Marine Resource Problems of Nassau and Suffolk Counties." Prepared for the Marine Resources Council Nassau-Suffolk Regional Planning Board. Travelers Research Corp., April 1969 problem or location on Long Island with respect to marine resources and the marine environment. For example, he may want to locate references on literature dealing with design of sewer outfalls in general. Such a list could be compiled. Or, he may want information on all biological studies conducted in Great South Bay; this also could be compiled. It should be emphasized that this literature reference file would contain sufficient information to describe a document and also, to identify where the document can be obtained. It will not contain the document itself.

Appendix A describes this component in greater detail.

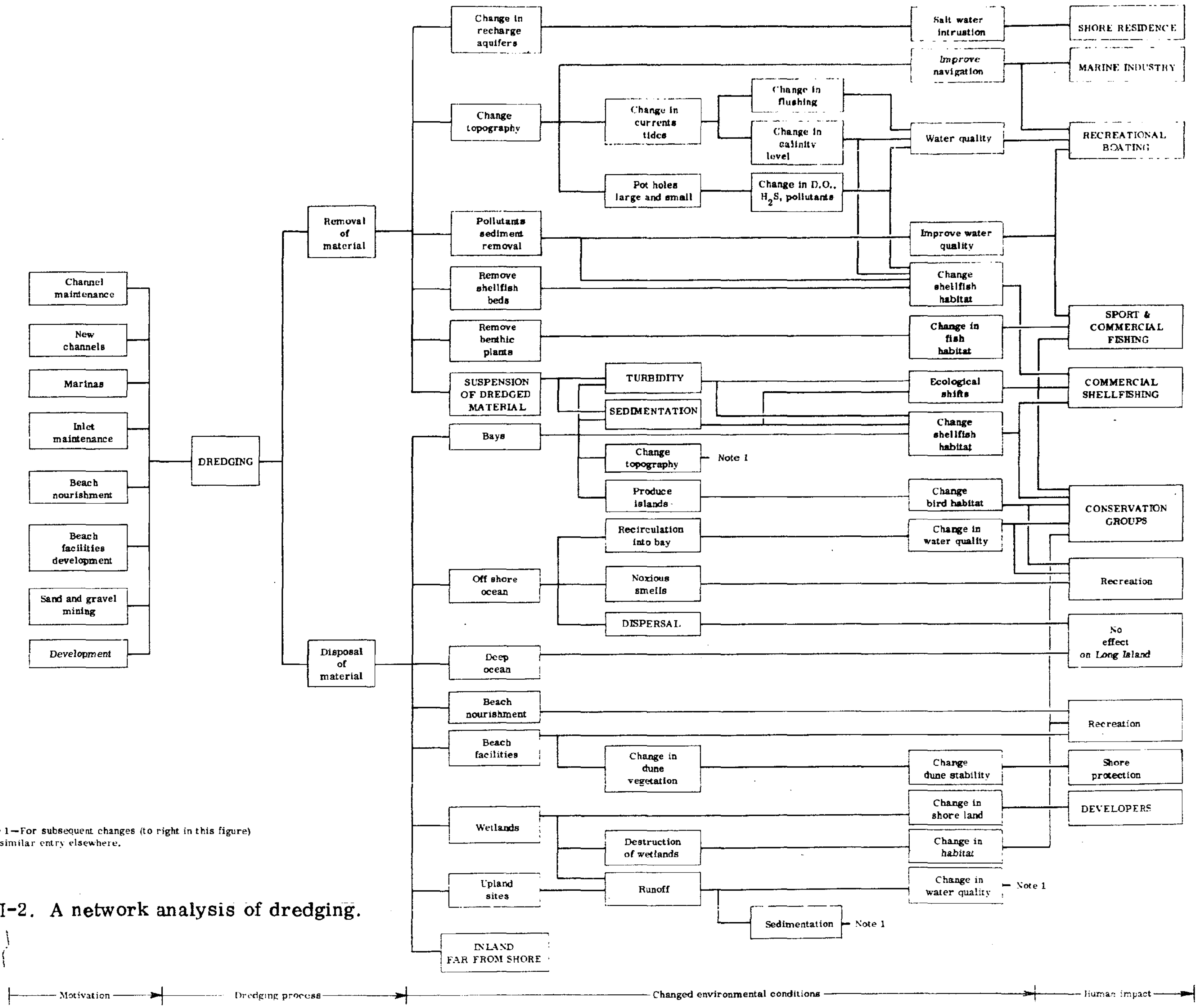
C. Environmental Relationships

In the analysis of environmental problems the usual approach is to search out the factors which created the problem (the problem being defined as a dissatisfaction with one or more environmental conditions). Such factors may be natural occurrences (such as storms, erosion, etc.) or activities conducted by man. In any event they can be considered causal factors. Such factors alter existing environmental conditions in some way and these resultant changes, in turn, have an impact on man's uses of the environment and its resources.

The environmental relationships component of the MIS is based upon this concept of cause-environmental condition-effect links. When the various links are put together in a composite so that causes and effects can be traced through a number of steps the result is a network of cause-condition-effect relationships. Specific networks can be constructed for each class problem or/and activity which may have an impact on environmental conditions.

Each link in a network conceptually implies a relationship that, with perfect knowledge, could be specified mathematically or probabilistically in the form of an equation. If the equations were developed, and the data for calculations was available, the effects of a change in a causal factor on environmental conditions and consequently on activities could be predicted. Unfortunately, however, this is not the situation that exists today. With today's imprecise and incomplete knowledge many links in such networks are only qualitatively identified, or suspected, with no understanding of their quantitative nature. But even with this incomplete knowledge the networks can provide a valuable tool to organize the information, guide in the formulation of an approach and conduct an analysis. Their use can insure that most important considerations have been taken into account without overlooking possible side-effects. Figure III-2 illustrates the network concept. This example is for an analysis of the implications of dredging. Tracing through the diagram will assist one to systematically consider the possible changes which may occur; to discard those which don't apply in that particular case and to evaluate as well as can be done within the state of knowledge those which appear to be significant.

This component will contain the storehouse of cause-environment conditions-effects relationships which are used to make up the networks for the major classes of problems. The relationships will be stored in the form of three basic matrices. The first will have causes on one axis and environmental conditions on the other. The second will have environmental conditions on both axes. And, the third matrix will have environmental conditions on one axis, and affected activities on the other. Each cell of the matrices will contain a "zero" if no relationship between the elements exist and a "one" if a relationship exists, or potentially exists. Using these matrices as an information source one can develop a network similar to the dredging network for a particular problem. Figures III-3, III-4 and III-5 illustrate the matrices and their elements. Eventually as more knowledge is brought together, the cells of the matrices will contain more informed qualitative, and finally quantitative, information about each relationship or link. Specification of the final quantitative form of the relationship together with the important variables and parameters is the important ultimate objective. The cells of the matrices become reference points for storing quantitative information. This component also will contain information describing the environmental requirements and limiting factors for the important uses of the marine environmental resources such as water quality standards. Each use, or human activity conducted in the coastal zone, has certain requirements in terms of environmental conditions. For example, water contact recreation such as swimming requires that the water temperature be within certain limits, that the water be of some minimum depth, that coliform counts not exceed certain maximum allowable limits. These limits have been set for water quality condition in the form of water quality standards. Where such standards pertaining to uses and environmental conditions do exist they will be included. The concept of standards or requirements for particular uses will be expanded as knowl-




Note 1—For subsequent changes (to right in this figure) see similar entry elsewhere.

Fig. III-2. A network analysis of dredging.

| | | ONSHORE | | | | | | | | | | | OFFSHORE | | | | | | | | | | | | | | | | | WET-LAND | | | | AIR | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CAUSAL FACTORS / ENVIRONMENTAL CONDITIONS AFFECTED | 1.2.1.1.1 Surface elevation change | 1.2.1.1.2 Surface area change | 1.2.1.1.3 Surface shape change | 1.2.1.1.4 Surface hydrology change | 1.2.1.1.5 Subsurface geology change | 1.2.1.1.6 Subsurface hydrology change | 1.2.1.1.7 Surface cluttering - surface materials | 1.2.1.2.1 Surface chemical composition change | 1.2.1.2.2 Subsurface chemical composition change | 1.2.1.3.1 Surface biological organism change | 1.2.1.3.2 Subsurface biological organism change | 1.2.2.1.1.1 Floor bottom topography change | 1.2.2.1.1.2 Channel depth and/or width change | 1.2.2.1.1.3 Shoaling (natural) | 1.2.2.1.1.4 Pitting | 1.2.2.1.1.5 Change in depth | 1.2.2.1.1.6 Floor bottom shape change | 1.2.2.1.1.7 Floor bottom material composition change | 1.2.2.1.2.1 Change in chemicals on floor | 1.2.2.1.2.2 Change in chemicals under floor | 1.2.2.1.3.1 Change in biological organisms on floor | 1.2.2.2.1.1 Solid material content change | 1.2.2.2.1.2 Settleable, floating and suspended solids | 1.2.2.2.1.3 Water temperature change | 1.2.2.2.2.1 Surface water chemical changes | 1.2.2.2.2.2 Subsurface water chemical changes | 1.2.2.2.3.1 Surface water biological changes | 1.2.2.2.3.2 Subsurface water biological changes | 1.2.3.1.1 Surface area change | 1.2.3.2.1 Surface chemical composition change | 1.2.3.2.2 Subsurface chemical composition change | 1.2.3.3.1 Biological composition change | 1.2.4.1.1 Air particulate content change | 1.2.4.1.2 Air clarity change | 1.2.4.2.1 Airborne chemical agent content change | Change in visual appearance | Change in noise level | Generation of obnoxious odors | Change in level of radio activity |
| 1.1.1.1.1 | Air circulation | ● | ● | ● | | | | ● | | | ● | | | | | | | | | | | | | | ● | | | | | | | | | ● | ● | ● | | | | ● |
| 1.1.1.1.2 | Moisture-amount and distribution | | | | | | | | ● | | ● | | | | | | | | | | | | | | | ● | | | | | | | | | | | | | | |
| 1.1.1.1.3 | Solar radiation | | | | | | | | | | ● | | | | | | | | | | | ● | | | ● | | | ● | | | | | ● | | | | | | | |
| 1.1.1.2.1 | Water circulation | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | | | | | | ● |
| 1.1.1.3.1 | Erosion | ● | ● | ● | ● | | | | | | | | ● | ● | | | ● | ● | ● | | | | | ● | | | | | | ● | | | | | | | | | | |
| 1.1.1.3.2 | Sedimentation | ● | ● | ● | ● | | | | | | | | ● | ● | ● | | ● | ● | ● | ● | | | ● | | | | | | | ● | | | | | | | | | | |
| 1.1.2.1.1 | Crop production | | | | | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | |
| 1.1.2.1.2 | Livestock production | | | | | | | | ● | | ● | | | | | | | | | ● | | | | | | | | | | | ● | | | | | | ● | | ● | |
| 1.1.2.1.3 | Pesticide and fertilizer application | | | | | | | | ● | | | | | | | | | | | ● | | ● | | | | ● | | ● | | | ● | ● | ● | ● | | ● | | | ● | |
| 1.1.2.2.1 | Finfishing | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | ● | | | | ● | | ● | |
| 1.1.2.2.2 | Shellfishing | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | ● | | | | ● | | | |
| 1.1.2.2.3 | Aquiculture | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | | | |
| 1.1.2.3.1 | Navigation improvements | | | | | | | | | | | | ● | ● | ● | ● | ● | ● | ● | | | ● | | ● | | | | | | ● | | | ● | | | | | | | |
| 1.1.2.3.2 | Coast facility improvements | ● | ● | ● | | | | | | | | | ● | | | | | | | | | | | | | | | | | ● | | | | | | | ● | | | |
| 1.1.2.4.1 | Food processing | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | |
| 1.1.2.4.2 | Oil refining | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.1.2.4.3 | Metals and related fabrication | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.1.2.5.1 | Sand and gravel mining | ● | ● | ● | ● | | | | | | ● | | ● | ● | ● | ● | ● | ● | ● | | | ● | ● | ● | | | | | | ● | | | | | | | ● | | | |
| 1.1.2.5.2 | Other mineral extraction | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | | | | | | | | | | | |
| 1.1.2.6.1 | Drinking and other personal uses | | | | ● | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.1.2.6.2 | Municipal uses | | | | | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.1.2.6.3 | Irrigation | | | | ● | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.1.2.6.4 | Manufacturing and processing | | | | | | ● | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | | | |
| 1.1.2.7.1 | Road building | ● | ● | ● | ● | | | | | | ● | | | | ● | | | | ● | | | ● | ● | ● | | | | | | ● | | | ● | | | | ● | | | |
| 1.1.2.7.2 | Facility construction | | | | | | | | | | | | | | ● | | | | | | | | | | | | | | | | | | ● | | | | ● | | | |
| 1.1.2.7.3 | Land filling and draining | ● | ● | ● | | | ● | | | | ● | | ● | | ● | | ● | | ● | | | ● | ● | ● | | | | | | ● | | | ● | | | | ● | | | |
| 1.1.2.8.1 | Domestic disposal | ● | ● | ● | | | | ● | ● | ● | ● | ● | | | | | | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | |
| 1.1.2.8.2 | Industrial disposal | ● | ● | ● | | | | ● | ● | ● | ● | ● | | | | | | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● |
| 1.1.2.8.3 | Agricultural waste disposal | | | | | | | | ● | ● | ● | | ● | ● | | | ● | ● | ● | ● | ● | ● | ● | ● | | ● | ● | ● | ● | ● | ● | ● | ● | | | | ● | | | |
| 1.1.2.8.4 | Dredging spoil disposal | | | | | | | | | | | | ● | ● | ● | | ● | ● | ● | ● | | | ● | ● | | | | | | ● | ● | | | | | | | | | |
| 1.1.2.9.1 | Boating | | | | | | | | | | | | | | | | | | | | | | | ● | | ● | | | ● | | | | | | | | ● | | | |
| 1.1.2.9.2 | Swimming and other water contact activities | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.1.2.9.3 | Fishing | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | ● | | | | | | | |
| 1.1.2.9.4 | Passive recreational activities | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1.1.2.10.1 | Pest control spraying | | | | | | | | ● | ● | | | | | | | | | | ● | | ● | | | | ● | | ● | | | ● | | ● | | | | | | | |

**Fig. III-3. Causal factors affecting environmental conditions.**

| Group | CHANGED ENVIRONMENTAL CONDITION | | 1.2.1.1.1 Surface elevation change | 1.2.1.1.2 Surface area change | 1.2.1.1.3 Surface shape change | 1.2.1.1.4 Surface hydrology change | 1.2.1.1.5 Subsurface geology | 1.2.1.1.6 Subsurface hydrology change | 1.2.1.1.7 Surface cluttering - surface materials | 1.2.1.2.1 Surface chemical composition change | 1.2.1.2.2 Subsurface chemical composition change | 1.2.1.3.1 Surface biological organism change | 1.2.1.3.2 Subsurface biological organism change | 1.2.2.1.1.1 Floor bottom topography change | 1.2.2.1.1.2 Channel depth and/or width change | 1.2.2.1.1.3 Shoaling (natural) | 1.2.2.1.1.4 Pitting | 1.2.2.1.1.5 Change in depth | 1.2.2.1.1.6 Floor bottom shape change | 1.2.2.1.1.7 Floor bottom material composition change | 1.2.2.1.2.1 Change in chemicals on floor | 1.2.2.1.2.2 Change in chemicals under floor | 1.2.2.1.3.1 Change in biological organisms on floor | 1.2.2.2.1.1 Solid material content change | 1.2.2.2.1.2 Settleable, floating and suspended solids | 1.2.2.2.1.3 Water temperature change | 1.2.2.2.2.1 Surface water chemical changes | 1.2.2.2.2.2 Subsurface water chemical changes | 1.2.2.2.3.1 Surface water biological changes | 1.2.2.2.3.2 Subsurface water biological changes | 1.2.3.1.1 Surface area change | 1.2.3.2.1 Surface chemical composition change | 1.2.3.2.2 Subsurface chemical composition change | 1.2.3.3.1 Biological composition change | 1.2.4.1.1 Air particulate content change | 1.2.4.1.2 Air clarity change | 1.2.4.2.1 Airborne chemical agent content change | Change in visual appearance | Change in noise level | Generation of obnoxious odors | Change in level of radio activity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ENVIRONMENTAL CONDITION AFFECTED | | ONSHORE | | | | | | | | | | | OFFSHORE | | | | | | | | | | | | | | | | WET-LAND | | | | AIR | | | | | | |
| ONSHORE | Surface elevation change | 1.2.1.1.1 | | ● | ● | ● | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | |
| ONSHORE | Surface area change | 1.2.1.1.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | ● | | | |
| ONSHORE | Surface shape change | 1.2.1.1.3 | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | |
| ONSHORE | Surface hydrology change | 1.2.1.1.4 | ● | | ● | | | ● | | ● | ● | ● | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | |
| ONSHORE | Subsurface geology | 1.2.1.1.5 | | | | | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ONSHORE | Subsurface hydrology change | 1.2.1.1.6 | | | | | | | | ● | ● | | | | | | | | | | | ● | | | | | ● | ● | | | | ● | ● | | | | | | | | |
| ONSHORE | Surface cluttering - surface materials | 1.2.1.1.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | |
| ONSHORE | Surface chemical composition change | 1.2.1.2.1 | | | | | | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | |
| ONSHORE | Subsurface chemical composition change | 1.2.1.2.2 | | | | | | ● | | | | | | | | | | | | | | | | | | | ● | ● | | | | ● | | | | | | | | ● | |
| ONSHORE | Surface biological organism change | 1.2.1.3.1 | | | | | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | ● | | | | | | ● | | | |
| ONSHORE | Subsurface biological organism change | 1.2.1.3.2 | | | | | | | | | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OFFSHORE | Floor bottom topography change | 1.2.2.1.1.1 | | ● | | | | | | | | | | | ● | | | | ● | | | | ● | | | ● | | | | | | ● | | ● | | | | | | | |
| OFFSHORE | Channel depth and/or width change | 1.2.2.1.1.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | ● | | | | | | | | | |
| OFFSHORE | Shoaling (natural) | 1.2.2.1.1.3 | | | | | | | | | | | | ● | ● | | | | ● | ● | | | | | | | | | | | ● | ● | | ● | | | | | | | |
| OFFSHORE | Pitting | 1.2.2.1.1.4 | | | | | | | | | | | | ● | ● | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | |
| OFFSHORE | Change in depth | 1.2.2.1.1.5 | | ● | | | | | | | | | | ● | ● | | | | | | | | | | | ● | | | | | ● | | | | | | | | | | |
| OFFSHORE | Floor bottom shape change | 1.2.2.1.1.6 | | | | | | | | | | | | ● | ● | ● | | | | | | | ● | | | | | | | | ● | | | | | | | | | | |
| OFFSHORE | Floor bottom material composition change | 1.2.2.1.1.7 | | | | | | | | | | | | | | ● | | | | | | | ● | | | | | | | | | | | ● | | | | | | | |
| OFFSHORE | Change in chemicals on floor | 1.2.2.1.2.1 | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | | ● | | | | | | ● | |
| OFFSHORE | Change in chemicals under floor | 1.2.2.1.2.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OFFSHORE | Change in biological organisms on floor | 1.2.2.1.3.1 | | | | | | | | | | | | | ● | ● | | ● | | ● | | | | | | | | | | | | | | | | | | | | ● | |
| OFFSHORE | Solid material content change | 1.2.2.2.1.1 | | | | | | | | | | | | | ● | ● | | ● | | | | | | | ● | | | | | | | | | | | | | | | | |
| OFFSHORE | Settleable, floating and suspended solids | 1.2.2.2.1.2 | | | | | | | ● | | | | | ● | ● | ● | | ● | ● | ● | ● | | ● | ● | | | | | ● | | | | | ● | | | | ● | | | |
| OFFSHORE | Water temperature change | 1.2.2.2.1.3 | | | | | | | | | | | | | | | | | | | | | ● | | | | ● | | ● | | | ● | | ● | | | | | | ● | |
| OFFSHORE | Surface water chemical changes | 1.2.2.2.2.1 | | | | | | | | | | | | | | | | | | | | | ● | | | | | | ● | | | | | | | | | | | ● | |
| OFFSHORE | Subsurface water chemical changes | 1.2.2.2.2.2 | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | | | | ● | |
| OFFSHORE | Surface water biological changes | 1.2.2.2.3.1 | | | | | | | | | | | | | | | | | | | | | ● | ● | ● | | | | | | | | | ● | | | | ● | | ● | |
| OFFSHORE | Subsurface water biological changes | 1.2.2.2.3.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WET-LAND | Surface area change | 1.2.3.1.1 | ● | | | | | | | | | | | | | | | | | | | | ● | | | ● | | | | | | | | | | | | ● | | | |
| WET-LAND | Surface chemical composition change | 1.2.3.2.1 | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | ● | | | | | | ● | |
| WET-LAND | Subsurface chemical composition change | 1.2.3.2.2 | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | | | | | | | | | | | |
| WET-LAND | Biological composition change | 1.2.3.3.1 | | | | | | | | | | | | | ● | | | | | | | | | ● | ● | | | ● | ● | | | ● | | | | | | ● | | ● | |
| AIR | Air particulate content change | 1.2.4.1.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | ● | | | |
| AIR | Air clarity change | 1.2.4.1.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | |
| AIR | Airborne chemical agent content change | 1.2.4.2.1 | | | | | | | | ● | | ● | | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | |
| | Change in visual appearance | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Change in noise level | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Generation of obnoxious odors | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Change in level of radio activity | | | | | | | | | ● | ● | ● | | | | | | | | | | ● | ● | | | | ● | ● | ● | | | ● | ● | ● | | | ● | | | | |

Fig. III-4. Interaction among environmental conditions.

| | CHANGED ENVIRONMENTAL CONDITION | | Crop production 1.3.1.1 | Livestock production 1.3.1.2 | Pesticide and fertilizer application 1.3.1.3 | Finfishing 1.3.2.1 | Shellfishing 1.3.2.2 | Aquiculture 1.3.2.3 | Navigation improvements 1.3.3.1 | Coast facility improvements 1.3.3.2 | Food processing 1.3.4.1 | Oil refining 1.3.4.2 | Metals and related fabrication 1.3.4.3 | Sand and gravel mining 1.3.5.1 | Other mineral extraction 1.3.5.2 | Drinking and other personal uses 1.3.6.1 | Municipal uses 1.3.6.2 | Irrigation 1.3.6.3 | Manufacturing and processing 1.3.6.4 | Road building 1.3.7.1 | Facility construction 1.3.7.2 | Land filling and draining 1.3.7.3 | Domestic disposal 1.3.8.1 | Industrial disposal 1.3.8.2 | Agricultural waste disposal 1.3.8.3 | Dredging spoil disposal 1.3.8.4 | Boating 1.3.9.1 | Swimming and other water-contact activities 1.3.9.2 | Fishing 1.3.9.3 | Hunting 1.3.9.4 | Passive recreational activities 1.3.9.5 | Pest control spraying 1.3.10.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ONSHORE | Surface elevation change | 1.2.1.1.1 | ● | ● | ● | | | | | ● | ● | | | | | | | | | ● | ● | ● | | | | | | | | | | |
| | Surface area change | 1.2.1.1.2 | | | | | | | | ● | | | | | | | | | | ● | ● | ● | | | | | | ● | | | ● | |
| | Surface shape change | 1.2.1.1.3 | | | | | | | | ● | | | | | | | | | | ● | ● | ● | | | | | | | | | | |
| | Surface hydrology change | 1.2.1.1.4 | ● | ● | | | | | | | | | | | | ● | | ● | | | | | ● | ● | ● | | ● | | ● | | ● | |
| | Subsurface geology change | 1.2.1.1.5 | | | | | | | | | | | | | | ● | ● | ● | ● | | | | | | | | | | | | | |
| | Subsurface hydrology change | 1.2.1.1.6 | ● | | | | | | | | | | | | | ● | ● | ● | ● | | ● | ● | | | | | | | | | | |
| | Surface cluttering - surface materials | 1.2.1.1.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | |
| | Surface chemical composition change | 1.2.1.2.1 | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | ● | ● | ● | | |
| | Subsurface chemical composition change | 1.2.1.2.2 | | | | | | | | | | | | | | ● | ● | ● | ● | | | | | | | | | | | | | |
| | Surface biological organism change | 1.2.1.3.1 | ● | ● | | | | | | | | | | | | ● | | | | | | | | | | | | | | | | |
| | Subsurface biological organism change | 1.2.1.3.2 | | | | | | | | | | | | | | ● | | | | | | | | | | | | | | | | |
| OFFSHORE | Floor bottom topography change | 1.2.2.1.1.1 | | | | ● | ● | ● | ● | ● | | | | ● | | | | | | | | | | | | | ● | ● | ● | | | |
| | Channel depth and/or width change | 1.2.2.1.1.2 | | | | ● | ● | | ● | ● | | | | | | | | | | | | | | | | | ● | | | | | |
| | Shoaling (natural) | 1.2.2.1.1.3 | | | | ● | ● | | ● | ● | | | | ● | | | | | | | | | | | | | ● | ● | | | | |
| | Pitting | 1.2.2.1.1.4 | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Change in depth | 1.2.2.1.1.5 | | | | ● | ● | | ● | ● | | | | ● | | | | | | | | | | | | | ● | ● | ● | | | |
| | Floor bottom shape change | 1.2.2.1.1.6 | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | ● | ● | ● | | | |
| | Floor bottom material composition change | 1.2.2.1.1.7 | | | | ● | ● | ● | | | | | | ● | | | | | | | | | | | | | | ● | ● | | | |
| | Change in chemicals on floor | 1.2.2.1.2.1 | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | ● | ● | | | |
| | Change in chemicals under floor | 1.2.2.1.2.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Change in biological organisms on floor | 1.2.2.1.3.1 | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | | ● | ● | | | |
| | Solid material content change | 1.2.2.2.1.1 | | | | | | | | | | | | ● | | | | | | | | | | | | | | | | | | |
| | Settleable, floating and suspended solids | 1.2.2.2.1.2 | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | ● | ● | ● | | | |
| | Water temperature change | 1.2.2.2.1.3 | | | | ● | ● | ● | | | | | | | | | | | ● | | | | | | | | ● | ● | ● | | | |
| | Surface water chemical changes | 1.2.2.2.2.1 | | | | ● | ● | | | | | | | | | | | | ● | | | | | | | | | ● | ● | | | |
| | Subsurface water chemical changes | 1.2.2.2.2.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Surface water biological changes | 1.2.2.2.3.1 | | | | ● | ● | ● | | | | | | | | | | | ● | | | | | | | | | ● | ● | | | |
| | Subsurface water biological changes | 1.2.2.2.3.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WET-LAND | Surface area change | 1.2.3.1.1 | | | | ● | ● | | ● | | | | | | | | | | | | | | | | | | ● | ● | ● | ● | ● | |
| | Surface chemical composition change | 1.2.3.2.1 | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | | ● | ● | ● | | |
| | Subsurface chemical composition change | 1.2.3.2.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Biological composition change | 1.2.3.3.1 | | | | ● | ● | ● | ● | | | | | | | | | | ● | | | | | | | | ● | ● | ● | ● | | |
| AIR | Air particulate content change | 1.2.4.1.1 | ● | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | ● | |
| | Air clarity change | 1.2.4.1.2 | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | ● | |
| | Airborne chemical agent content change | 1.2.4.2.1 | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Change in visual appearance | | | | | | | | ● | | | | | | | | | | | ● | ● | ● | | | | | ● | ● | | | ● | |
| | Change in noise level | | | ● | | | | | | | | | | | | | | | | | ● | | | | | | ● | ● | ● | ● | ● | |
| | Generation of obnoxious odors | | | | | | | | | | | | | | | | | | | | ● | | | | | | | ● | ● | ● | ● | |
| | Change in level of radio activity | | ● | ● | | ● | ● | ● | | | ● | | | | | ● | ● | ● | ● | | | | | | | | | ● | | | ● | |

HUMAN ACTIVITY AFFECTED

Fig. III-5. Environmental conditions affecting human activities.

edge develops to include conditions or use requirements which are presently not specified but which might be significant for the conduct of specific activities.

Appendix B describes this component in greater detail.

D. Analytical Design

The objective of this component of the MIS is to provide guidance about approaches for analyzing specific problems. This component must eventually contain information about specific analytical techniques, data requirements, and sequences of steps to be carried out in the analysis of the different classes of problems. The kinds of information needed and consequently, the kinds of output required from the MIS, vary considerably from use to use. It ranges from a simple presentation of data describing an existing situation, through a complex analysis for predicting the consequences of a proposed action, to broad approaches for total environmental planning. We have specified, for design purposes, four basic classes of uses. They are:

> 1—Response to specific data requests—This is the most straightforward use for the MIS. Such requests could range from a specific item of data at a particular grid location at given times to an extensive search of the data base to identify all locations for which a certain parameter falls within a specified value or range of values. For example, one could request the levels of salinity measured at a point in Great South Bay over a period of time. This information could be used to indicate how the salinity level is changing over time, and what, if any, cyclical patterns appear. This could conceivably be useful to the shellfish grower in the area.
>
> Another example of this class of MIS use is a request for a bibliography of literature available on a particular subject. For instance, a person could request a list of available publications dealing with the problem of beach maintenance on the Fire Island Seashore.
>
> A third type of use which falls into this class can be very important to the person who needs to evaluate a specific course of action, but who has little knowledge of how to go about it. In this case the MIS could be used to provide the relevant networks of cause-environmental conditions-effects relationships including the suggested procedure for conducting the specific analysis.
>
> 2—Analysis of proposed actions—There are many proposed activities which could have a potentially significant impact upon marine resources and the environment, and consequently, upon other uses of these resources. The analysis of these proposed activities to

predict their potential impacts prior to actual implementation will be an important use of the MIS. The MIS will provide the tools for evaluating such proposed activities. This will provide an agency with a means for evaluating and permitting or disallowing a proposed action.

Dredging request is one class of proposed actions which is continually under evaluation. Other class examples of proposals which do come up for review and which could be more adequately evaluated using the MIS are projects pertaining to sewer outfall locations, power plant construction and beach stabilization structures. Any proposed action which will change one or more environmental conditions can be considered appropriate for evaluation utilizing the MIS. In the context of the cause-environmental condition-effect concept, the analysis of proposed actions places the proposal into a framework of a causal activity and proceeds through to attempt to predict the changes and resultant effects. Figure III-6 illustrates the MIS approach sequence which would be followed in an analysis of a proposed action and depicts the relationship of the analytical design component to the other MIS components.

3—Analysis of problems—A problem, as previously defined, is a dissatisfaction is caused by the fact that the existing environmental condition(s) precludes the use of the environment (and its resources) for a given purpose at a satisfactory level. In this class the use the MIS will provide information to help analyze the situation by applying the cause-environmental condition-effect concept in the "opposite" direction. That is, starting with the stated dissatisfaction as the effect and tracing back to identify the environmental conditions which constrain the use and in turn the causal factors which have an impact on those environmental conditions. Examples of problems for which this class of use would apply include the loss of income in commercial fishing to specific pollution incidents, recreational beach congestion, loss of wetlands, and channel siltation.

4—Background analyses for planning—This use of the MIS is the broadest and most comprehensive. Still focusing upon the cause-environmental condition-effect concept the MIS can be used to provide an iterative evaluation of objectives (in terms of resources uses and/or specific standards), the environmental conditions which are necessary to meet the objectives and the changes in causal factors to bring about those conditions. The use is iterative because the desired changes may also affect other activities in a way that other problems, or conflicts, will arise. In comprehensive planning for society's needs the various components, such as housing, transportation, industry and recreation compete for a share of the limited natural resources. The use of the MIS throughout the planning process will help to guide it toward a more balanced use of resources.

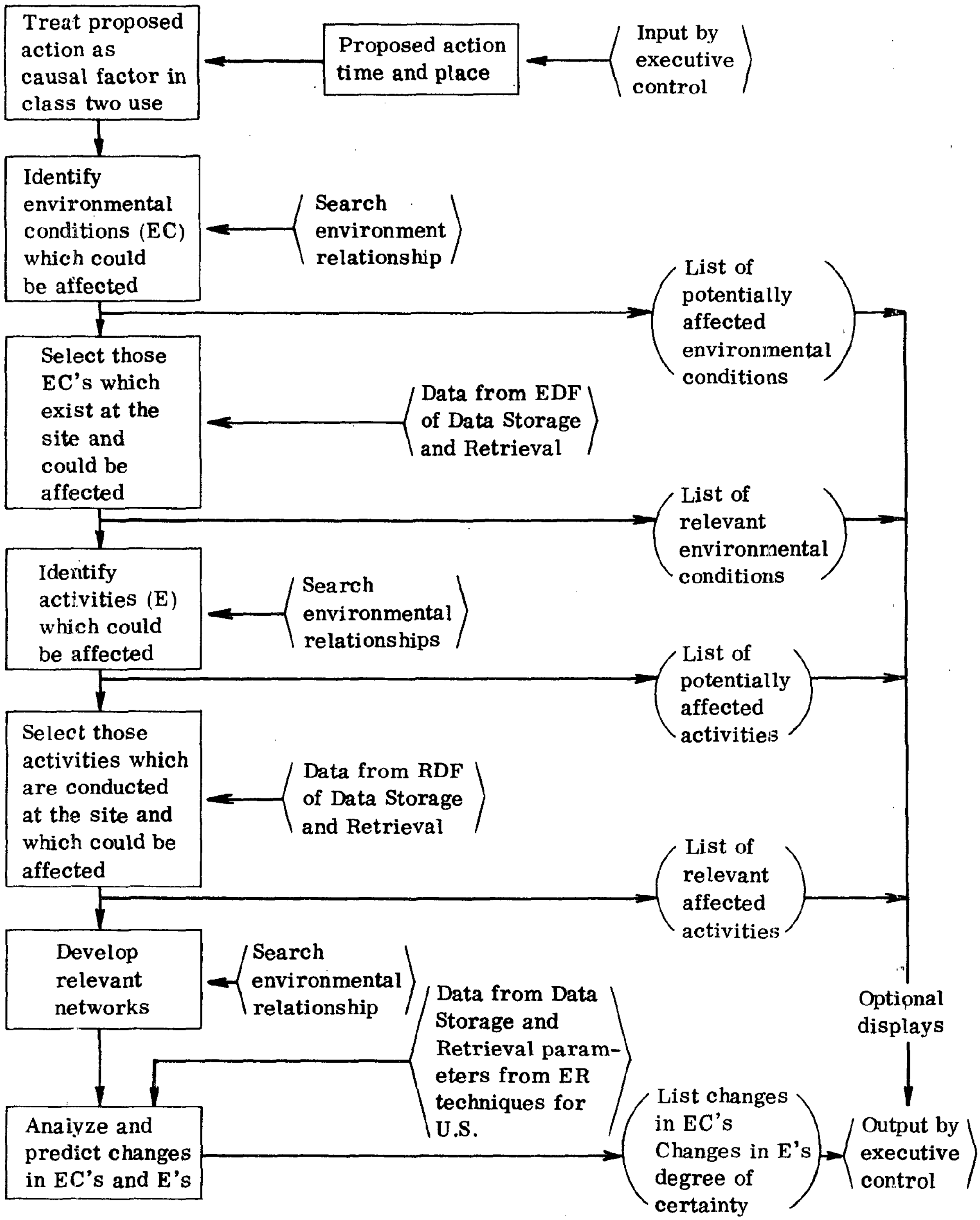



Fig. III-6. Example flow of approach for analysis of proposed action.

Figure III-7 illustrates the major steps in which the MIS would be utilized in a broad planning activity to evaluate the implications of the plan and to help identify and select alternatives or changes which may improve the plan's impact on the marine environment and related activities.

The analytical design component of the MIS will contain instructions for handling each of those classes of uses which require more than a simple straightforward data response.

Appendix C provides further discussion about this component.

## E. Analysis and Synthesis

The objective of the analysis and synthesis component of the MIS is to provide the capability for "pulling together" and selectively "operating" on existing quantitative data to provide information of use to the manager and planner.

Quantitative data, by itself has limited usefulness. Its value is greatly enhanced by combining it in ways that describe characteristics which are not readily apparent from observation.

The methods for analyzing data to derive significant characteristics and for synthesizing groups of data into meaningful information range from simple techniques to complex mathematical computations. The techniques which will be contained in this component are categorized into four classes: geographic analysis, statistical analysis, computer modeling and cost benefit and effectiveness analysis.

Data analysis on a geographic basis—Given observations of a selected parameter (such as water temperature or dissolved oxygen) taken at irregularly spaced sites, an analysis technique could be applied to derive values at uniformly spaced grid points to "fill in" blank areas and provide a picture of the areal distribution of the parameter. Given grid point data for a particular parameter another computational technique can be used to develop isopleth (or lines of equal value) maps for selected variables. A sequence of such maps is of particular value in showing how the distribution of values of a parameter is changing over time. Techniques of this sort are available and, in fact, in common use in the field of meteorology. They can be transferred into this context with little or no adaptation.

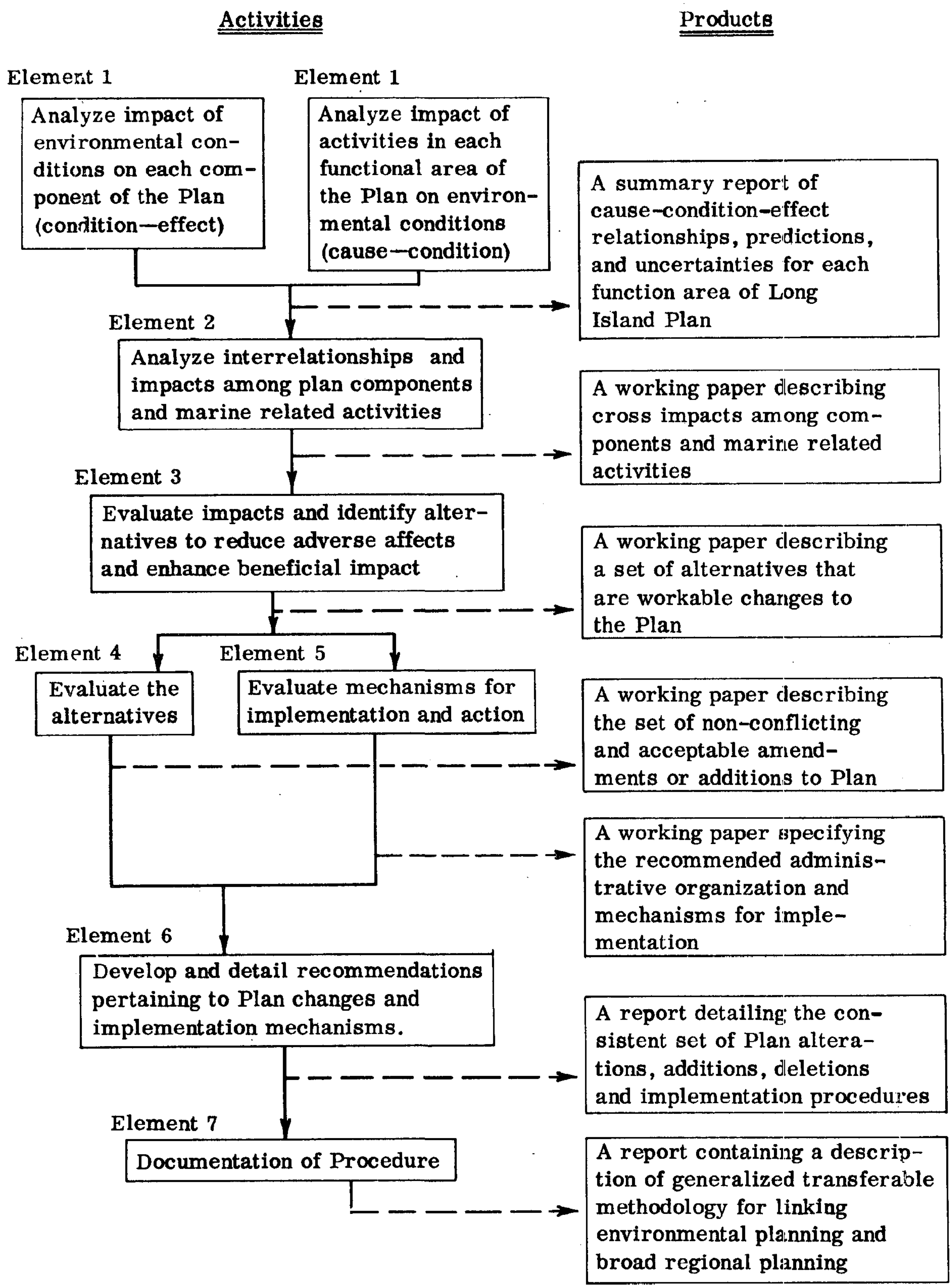



Fig. III-7. Example flow of approach for background analysis for planning.

Statistical analysis—There will be occasions when one or more statistical analysis techniques would provide information of value to the manager. Such techniques will assist the manager in dealing with the stochastic, or probabilistic nature of the data we are dealing with. Because the state of knowledge is not perfect, decisions frequently have to be made on the basis of an expected result and a range within which the result will fall. In cases where historical data are available the use of statistical techniques to develop means and variances of distribution of variables, to identify cycles and trends, and to develop correlations and regressions for the purposes of estimating expected results can provide the manager with a sounder base of information with which to make decisions under uncertainty. A large number of techniques is available from the simple to the very complex. Some are amenable to calculation using desk equipment while others require a tremendous amount of computation and matrix manipulation and therefore are only of use with a computer. There is no intent to have all conceivably useful techniques "on-line," but to have an adequate description of their uses, data and hardware requirements and a source for the programs if called for.

Computer simulation—A third kind of synthesis and analysis tool which is useful in the analysis of environmental problems is the computer simulation model used to represent the physical, chemical and/or biological behavior of the system. A model is useful in hypothesizing a change in system behavior through simulation without actually perturbing the real system.

While there are a number of different kinds of models ranging from physical scale models of existing systems to analogs, the mathematical computer model is most useful for repeated use under a variety of conditions and hypothesized changes. With an adequate base of knowledge a series of such models could be constructed for general use. Ideally, a generalized simulation model for water circulation and material transport could be presented with the boundary conditions of a particular water body (that is, the bottom topography, depths, inflow-outflow, etc.) and be then used to predict the consequences of a change in one boundary condition on the circulation of water and movement of material. Simplified models do exist and are frequently used for answering questions related to material transport, especially in conjunction with sewage outfall placement studies. The MIS should have existing general models available and on call for use; and, as the state of the art in modeling improves, the models should be replaced with improved versions. No original modeling is proposed for the initial MIS development.

Cost benefit and effectiveness—The manager and planner are constantly confronted with decisions having serious economic as well as environmental ramifications. Two types of questions which face the manager are:

- What are the costs and effectiveness in meeting data requirements of alternative systems (methods) of collecting data?
- What are the costs of alternative uses of marine resources and how do the benefits vary?

For example, cost effectiveness methodology has been developed[1/] than can account for extensive amounts of quantified expert judgment in the form of continuous and discontinuous Relative Worth Curves relating data worth to the meeting of data collection requirement characteristics. The model enables the manager to conduct trade-off and sensitivity analyses to answer a series of "what if" questions concerning the cost and effectiveness of alternative data in meeting planning and decision requirements. The methodology and the model is particularly valuable because:

(a) an analysis can be accomplished where data from past experience are lacking by using best estimates and opinions available from experts, and

(b) the impact of performance or results that are somewhat less than desirable are evaluated through the use of Relative Worth Curves.

Existing cost-effectiveness and cost-benefit techniques should be made available where appropriate for use by the MIS. Again, as in the cases of statistical techniques and computer simulation model, incorporation into the MIS will be based on need for the tool.

Appendix D provides additional discussion about this component.

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1/Northrop, G. M., E. L. Davis, E. R. Sweeton and F. L. Bartholomew, 1970: A Cost Effectiveness Methodology for Environmental Data Collection Systems. CEM Report 4053-430, The Center for the Environment and Man, Inc., Hartford, Conn.

## F. Executive Control

The purpose of the executive control component is to serve as the interface between man and machine. The MIS will offer the analyst a number of choices of use for analyzing a problem or topic of interest. These will range from a simple listing of data to a sophisticated analysis with a somewhat elaborate display of results. The use of the MIS which the analyst chooses will have to be interpreted from input controls by the executive control component and the correst action initiated.

The executive control must also be the custodian of the data base by being able to enlarge and update data files as new factors are discovered and more data is collected. It also must be flexible enough to accommodate additional components and related interfaces with other components as new knowledge permits. For instance, as new physical models are developed and system dynamics are further understood, new analytical approaches may be desired which require new component modules and the associated new analysis procedures in the Analytical Design Component.

In order to accomplish these tasks, the executive component will be able to translate input language to direct action by the system. Appendix E presents a detailed discussion of the function of the executive control component.

## IV. APPLICATION OF THE MANAGEMENT INFORMATION SYSTEM

### A. Summary of Applications

As described in Section III-D the MIS can and will be applied to a wide range of purposes all focusing upon natural resources and the physical environment. In review the classes of uses are:

1) Response to specific data requests;
2) Analysis of proposed actions;
3) Analysis of problems; and
4) Background analyses for planning.

In the application of the MIS to a request for any of these uses one or more of the components of the system will be required to perform its function. There is great variation in the actual application depending upon the request, the data available, the nature of the geographical area and resources involved, and the level of knowledge available for application. The following discussion contains examples of applications in each use class. Flow diagrams are also presented for each use. The diagrams detail the sequence as it would be in an automated system. When any or all of the components are manual the sequence will be much more variable, and the steps will be carried out in a much less formalized fashion.

### B. Response to Specific Data Requests—Category 1

A request for a specific item or items of data could be as simple as one item or measured environmental parameter for a given place and time, such as the salinity at a known observation point in Great South Bay on a particular date. However, the requests more likely will be for a series of such measurements over time for the given location or for a group of measurements for a given time. Figures IV-1, IV-2 and IV-3 depict the sequence of steps which would be used and show the optional paths followed, depending upon the specific request.

A request must be initiated by someone and must include the specifics such as data requested and output desired. With the specified request the executive control will access the data storage and retrieval system (Fig. IV-2). If the request is for a literature search the literature reference file (LRF) will be searched for combinations of the key words listed in the input. All those located will be listed and returned to the

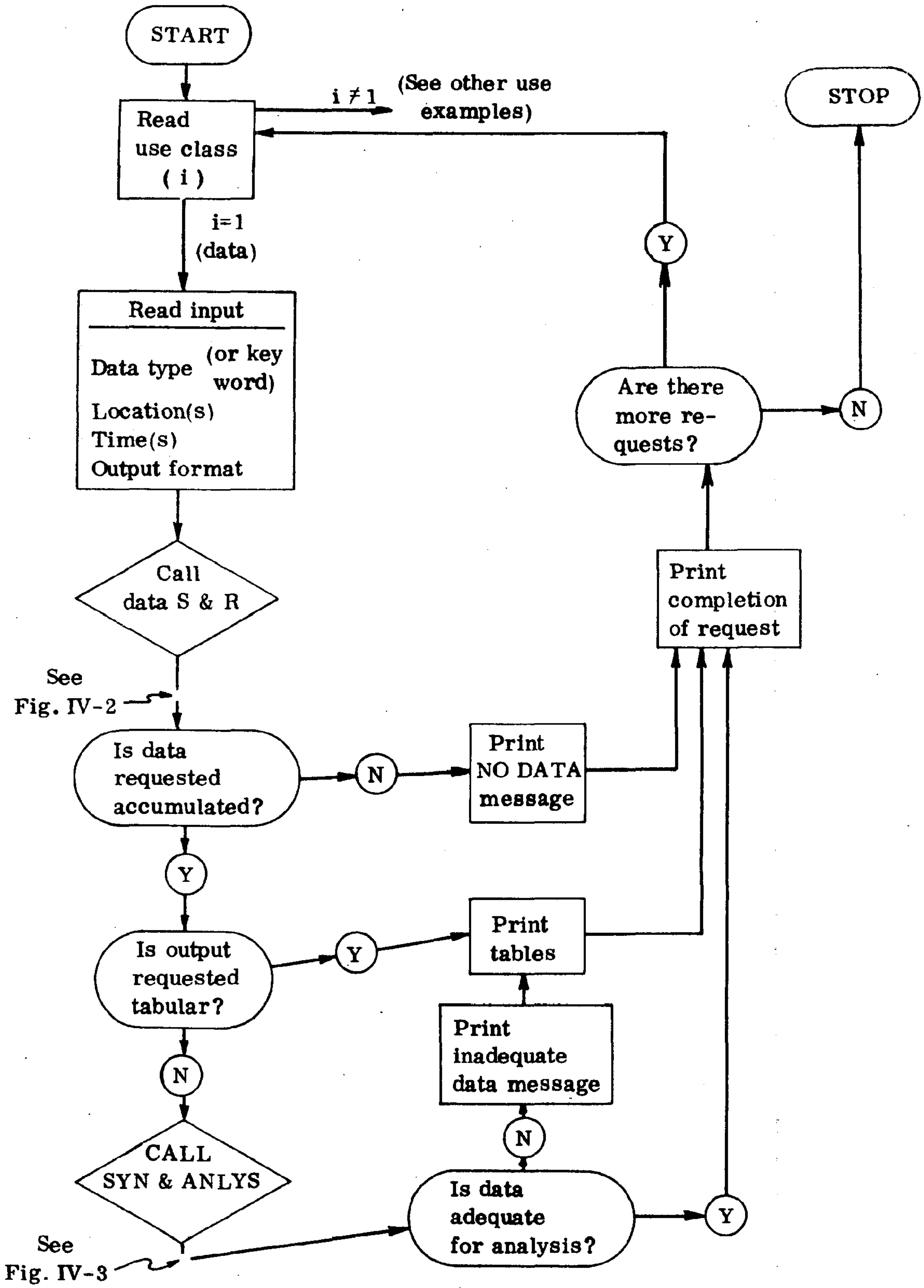


Fig. IV-1. Illustration of Class 1 use—EXCON component.

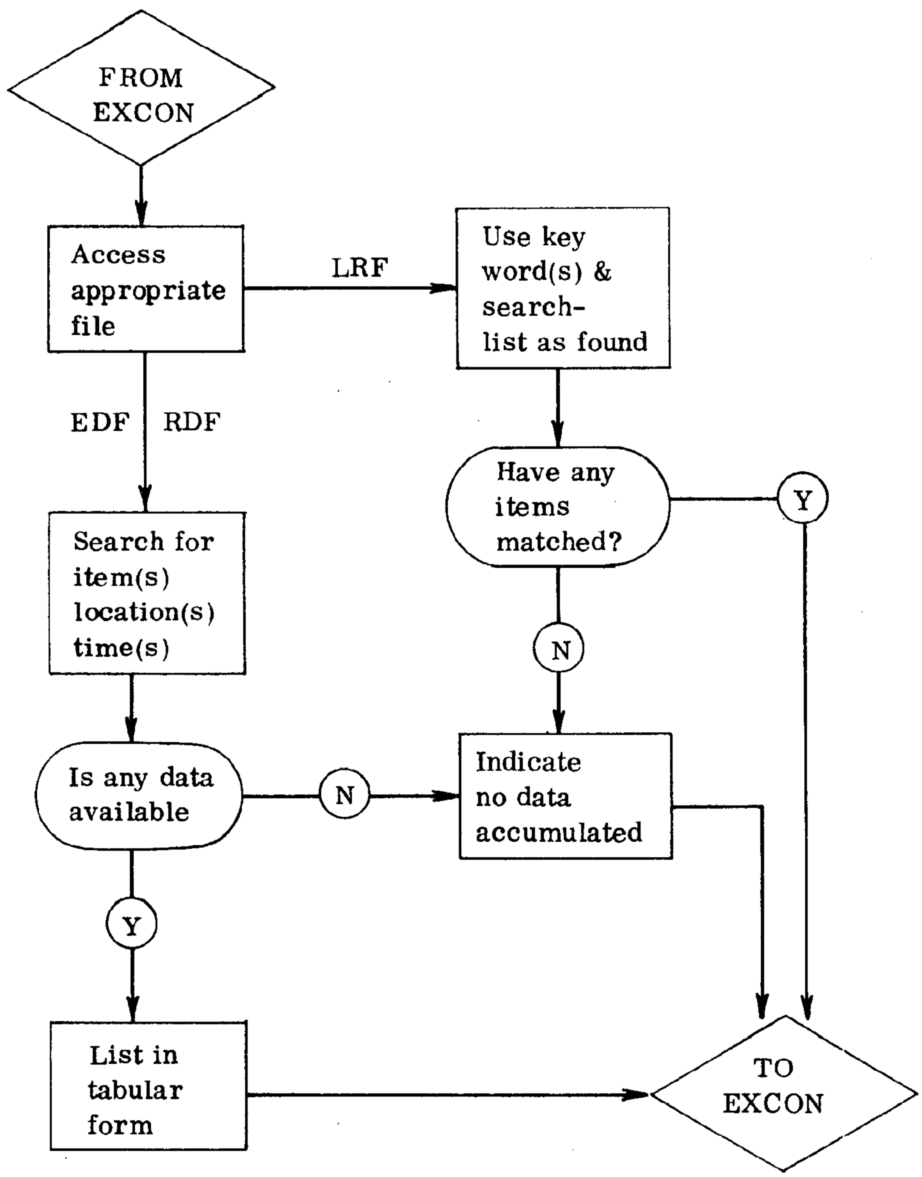


Fig. IV-2. Illustration of Class 1 use—DS & R component.

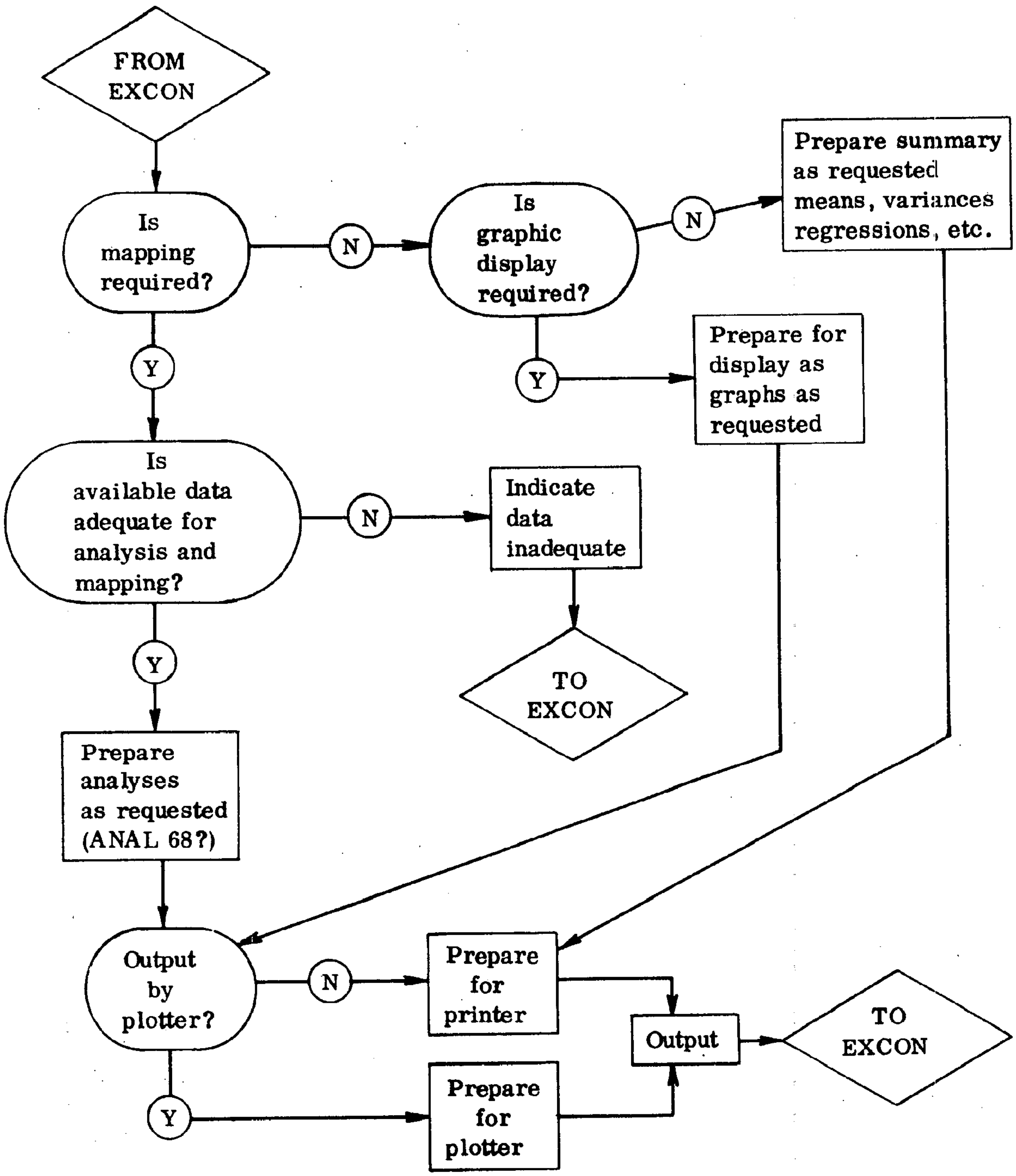


Fig. IV-3. Illustration of Class 1 use—SYN & ANLYS component.

executive control for printing a final output list. If none are found a message indicating that no such data exist within the system will be returned and the request will not be satisfied.

If the request is for data pertaining to the value of environmental or resource use data those files will be searched (EDF and/or RDF). All data which correspond to the request will be listed with its identifiers and returned to the executive control. If none is found the "no data" message will be returned.

Once the data has been returned to executive control it will be printed out according to requested format, if the request was for a straight tabular presentation of the data. The executive control will then go on to the next request, if any.

There may be requests for presenting the data in other than tabular form. These request may be for the analysis of a parameter over a geographic area to be presented in map form. Also there may be requests for graphic presentations, or for a statistical analysis such as a regression or simple means and variances of a particular parameter. When such outputs are requested the synthesis and analysis component will be called into action (Fig. IV-3) to perform the necessary functions and prepare the information for output on either the printer or a curve plotter if available; and return to the executive control to complete the output.

C. Analysis of Proposed Action—Category 2

One of the most significant uses of the MIS in terms of its contribution to resource and environmental management will be in the analysis of proposed projects or actions which will alter environmental conditions. This use, in essence, calls for the development of an environmental impact statement which will provide information to the decision maker.

There are many kinds of proposed actions which are potentially significant such as: the development of a sewer system; disposal of sewage into a bay; dredging; filling of a wetland; application of a pesticide; development of a shoreline housing facility. To illustrate the use of the MIS in this category a hypothetical application for a dredging proposal is depicted in Figs. IV-4 through IV-9. The procedures and guidelines followed for making selected analyses are based upon the information and guidelines developed in the previous report on dredging.[1/]

The procedure followed will draw upon data from the data storage and retrieval component, networks from the environmental relationships component, an approach from the analytical design component and a circulation and water quality model (if available) from the synthesis and analysis component.

While the procedure is put forth in flow diagram form similar to computer program logic diagrams the intent is to show the steps even if they all manually are completed. There is no intent to imply an automated system is required to perform the analysis.

Given a proposal or request to undertake a dredging project with a description of location of dredging, location of disposal of material, amount to be moved, time, duration and purpose of the project and technology to be used in dredging, the analyst would retrieve from the analytical design component the approach to be used in analyzing any dredging proposal. (This approach is listed as a series of steps in Fig. IV-5A.) (If no approach has been formalized for the particular action the analyst will seek additional information. Ultimately he will seek the best judgment of selected experts on potential environmental impacts for which no approach has been developed.)

Given the steps of the approach the analyst will follow their guidance using the components of the MIS in whatever state they are in; he will make special note of gaps in information and data; and prepare a statement of the potential environmental changes and affected activities including a judgment of the uncertainty involved in all predictions due to either a lack of knowledge, a lack of data or a low significance of the project which precludes the resource input required for a detailed, accurate analysis. (It would be impractical, for example, to conduct a $100 analysis if the worst that might happen could be translated into a $5 loss.)

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[1/] Dowd, Richard M., Dredging on Long Island, Regional Marine Resources Council, Nassau-Suffolk Planning Board. The Center for the Environment and Man, Inc., Hartford, Conn., February 1972.

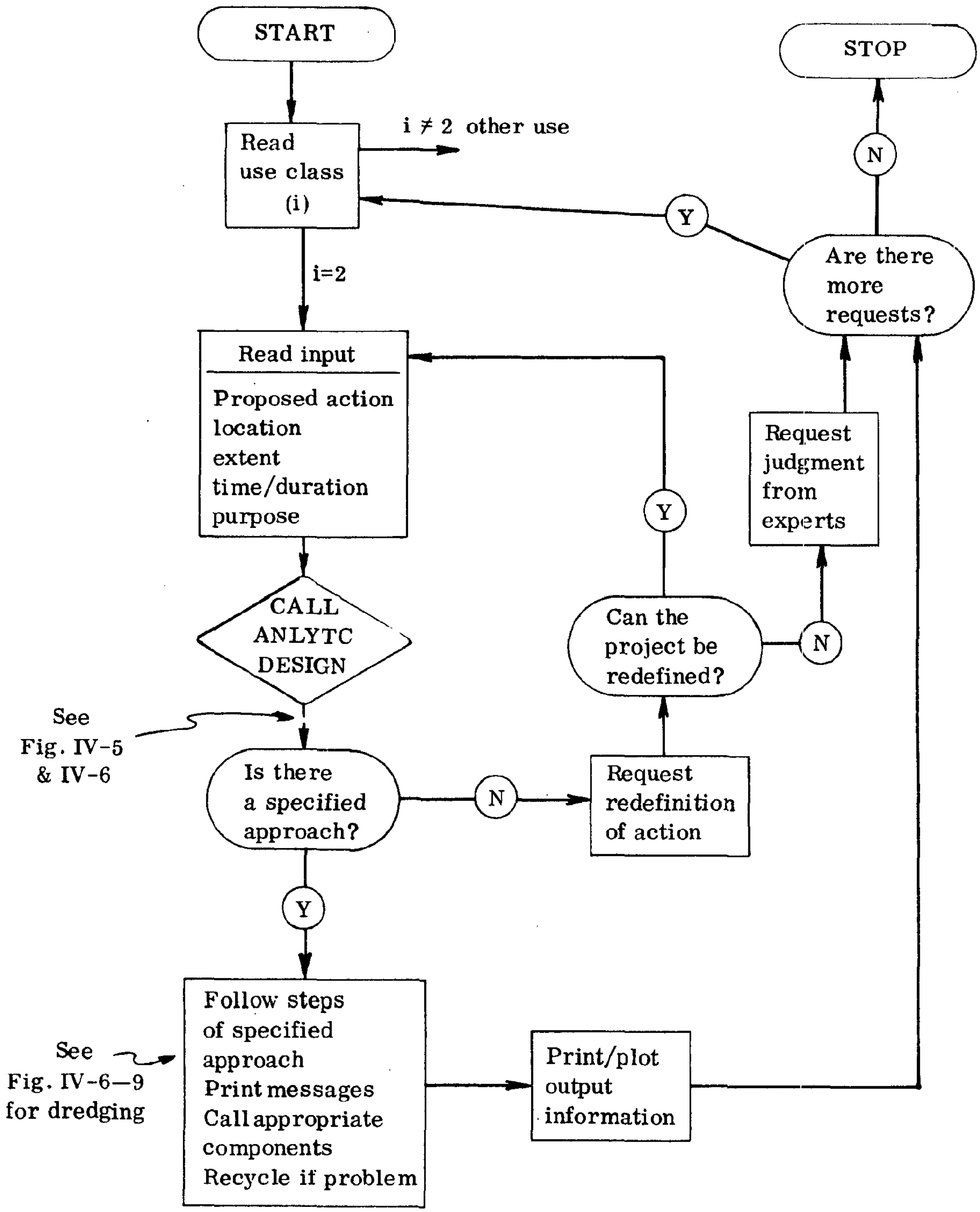



Fig. IV-4. Illustration of Class 2 use—EXCON component.

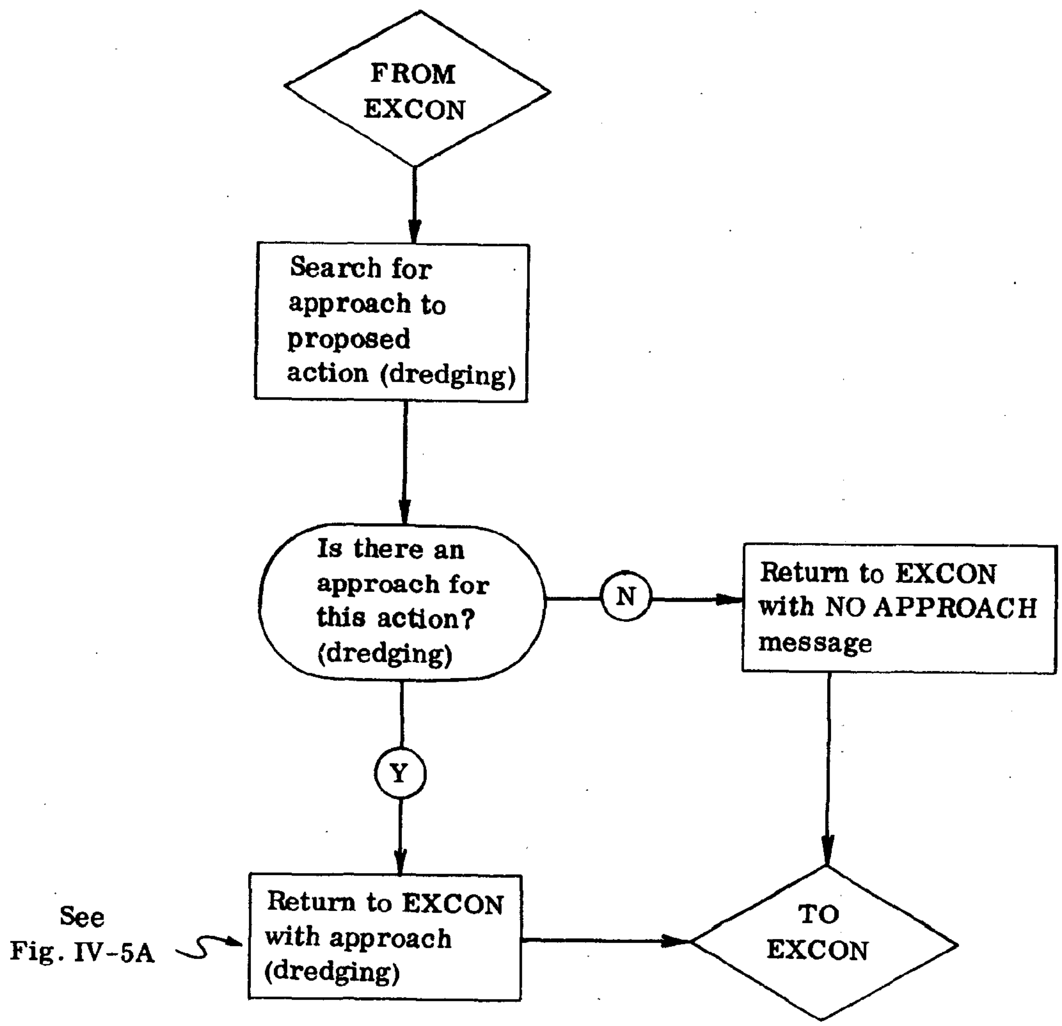



Fig. IV-5. Illustration of Class 2 use—ANALYTC DES component.

Fig. IV-5A. Illustration of class 2—USE—analytical design steps for dredging.

1. For area to be dredged retrieve data (from DS & R)

    - describing general character (wetland, bay, deep water, inlet, etc.)

    - describing benthic organisms (primarily shellfish) king and population density

2. For area to be used for spoil disposal retrieve data (from DS & R)

    - describing general character (as above)

    - describing benthic organisms (as above)

3. Check and note if dredging and/or disposal is proposed in a wetland area. Note value of that wetland if available.

4. Check and note if dredging and/or disposal will disturb an existing shellfish area. Note productivity of the area and harvest volumes if available.

5. Print out the above (3 and/or 4) if they will occur. (If judged important enough the project may be stopped or changed.)

6. If proposed project is less than 100,000 cubic years stop here. If equal or greater than 100,000 cubic yards retrieve the analytical network for dredging (from (Environmental Relationships) and so on (Fig. III-2).

7. For area to be dredged and area to be used for spoil disposal retrieve data (from DS & R).

    - benthic materials
    - water depths
    - water quality
    - bottom topography
    - marine organisms
    - currents/circulation
    - uses—existing and planned

8. Select the subnetwork relevant to this project for the disposal activity (Fig. IV-7).

9. Select the subnetwork relevant to this project for the dredging activity (Fig. IV-8).

10. Print out these subnetworks.

11. Print out the data gaps found to exist (see Fig. III-2).

12. Evaluate or judge the significance of each link in the subnetworks with information on the project, on the existing environment, and on the environmental relationships (from ER).

Fig. IV-5A (Cont.)

13. For each significantly changed environmental condition check the matrix (in ER) which identifies relationship of activities to conditions. Note those activities (existing or planned) which likely will be significantly affected.

14. If a model and adequate data are available develop prediction of (in Syn & An)

    - changes in circulation and flushing
    - changes in salinity
    - material transport and deposition

15. Develop report on predicted environmental changes, predicted impacts on uses and uncertainties including data gaps.

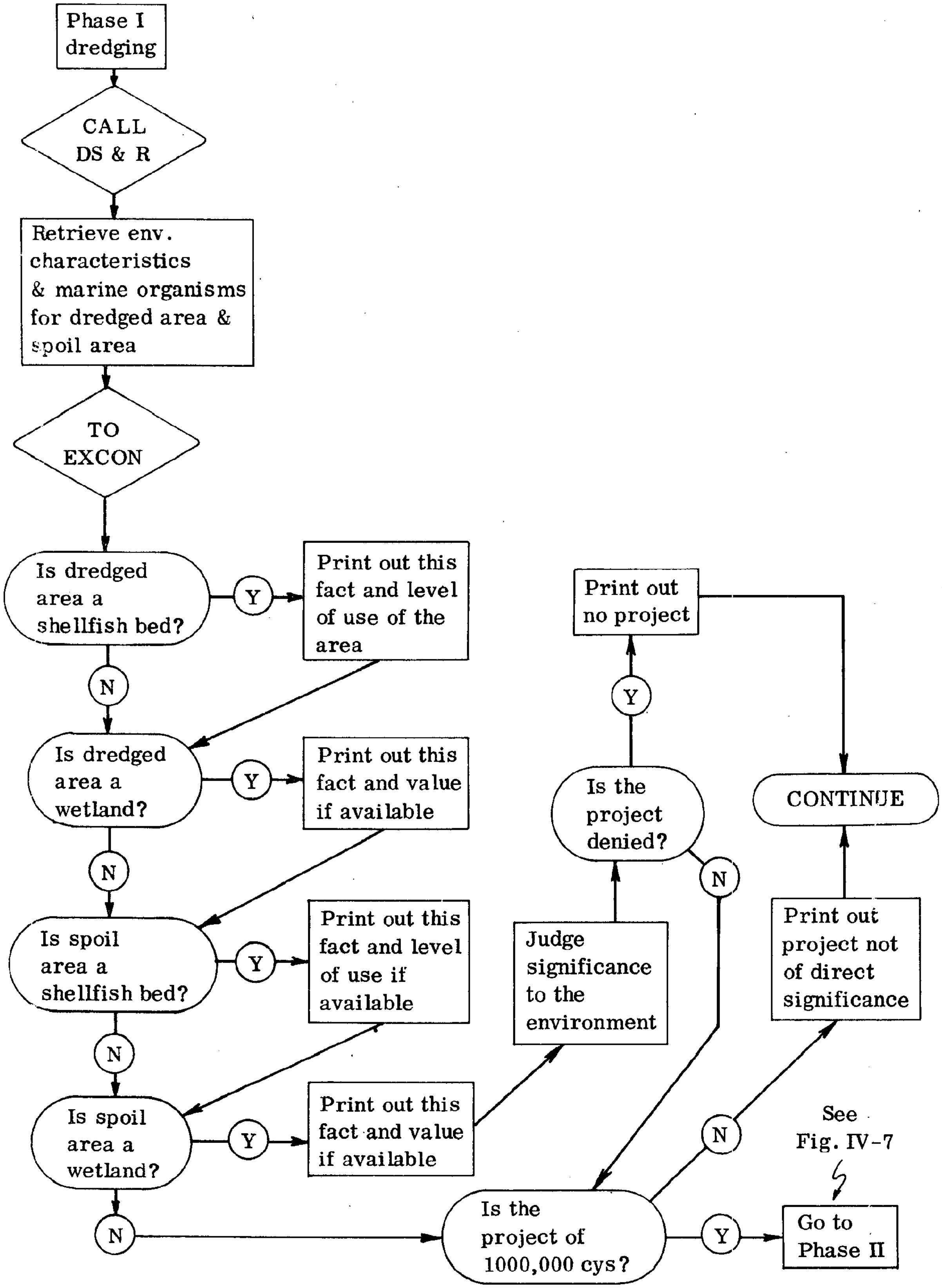



Fig. IV-6. Illustration of Class 2 use—Phase I dredging analysis.

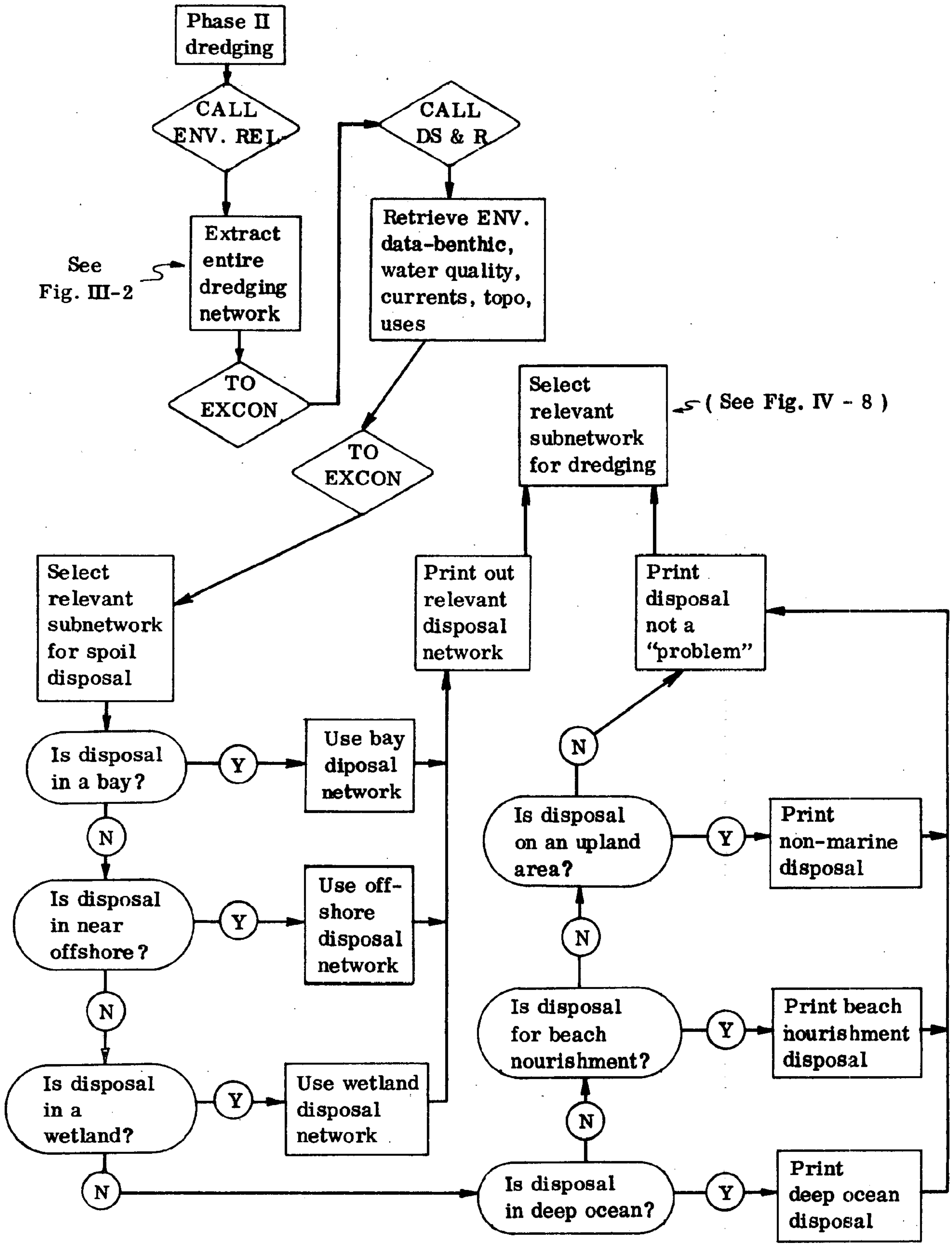



Fig. IV-7. Illustration of Class 2 use—Phase II dredging (network development disposal).

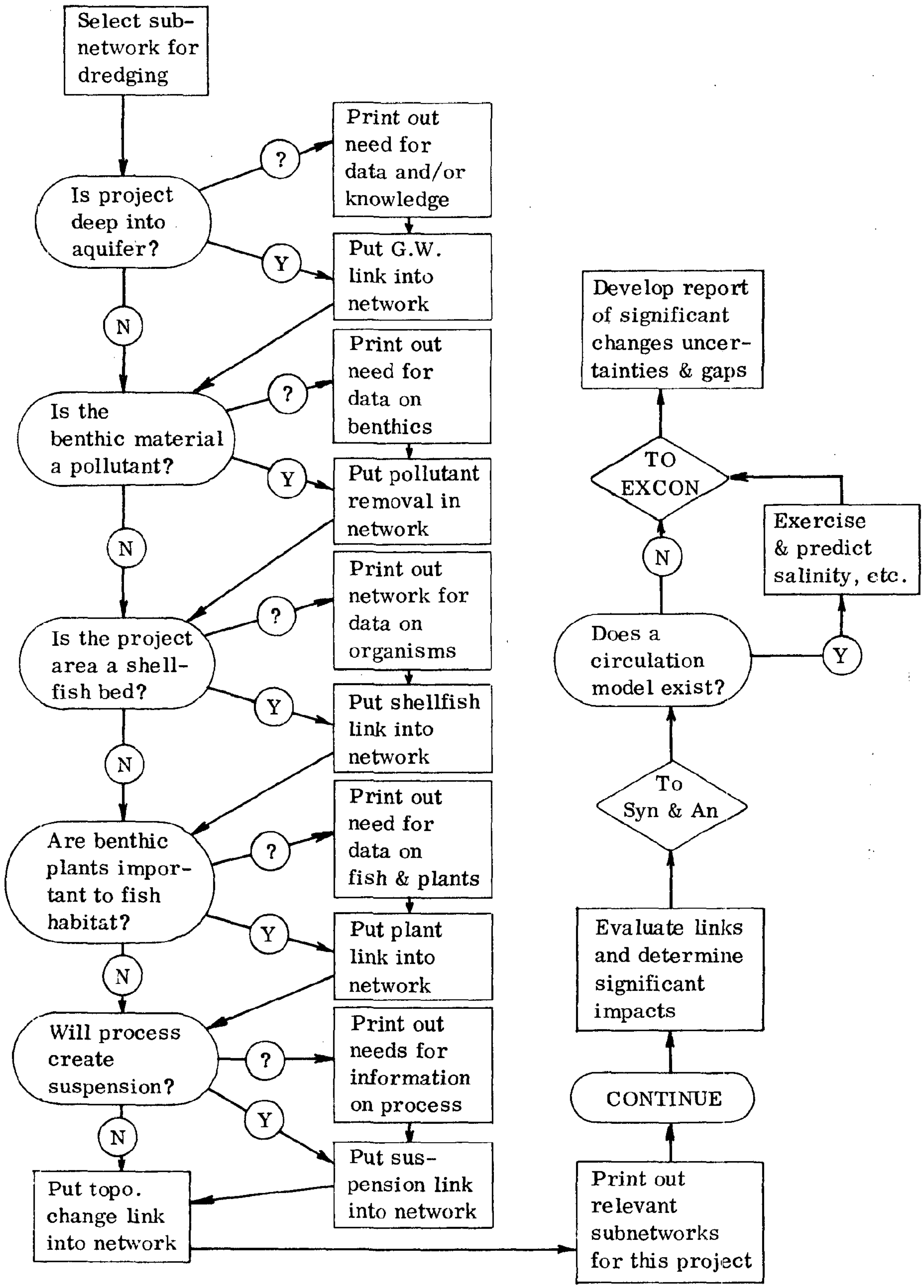



Fig. IV-8. Illustration of Class 2 use—Phase II dredging (network development dredging).

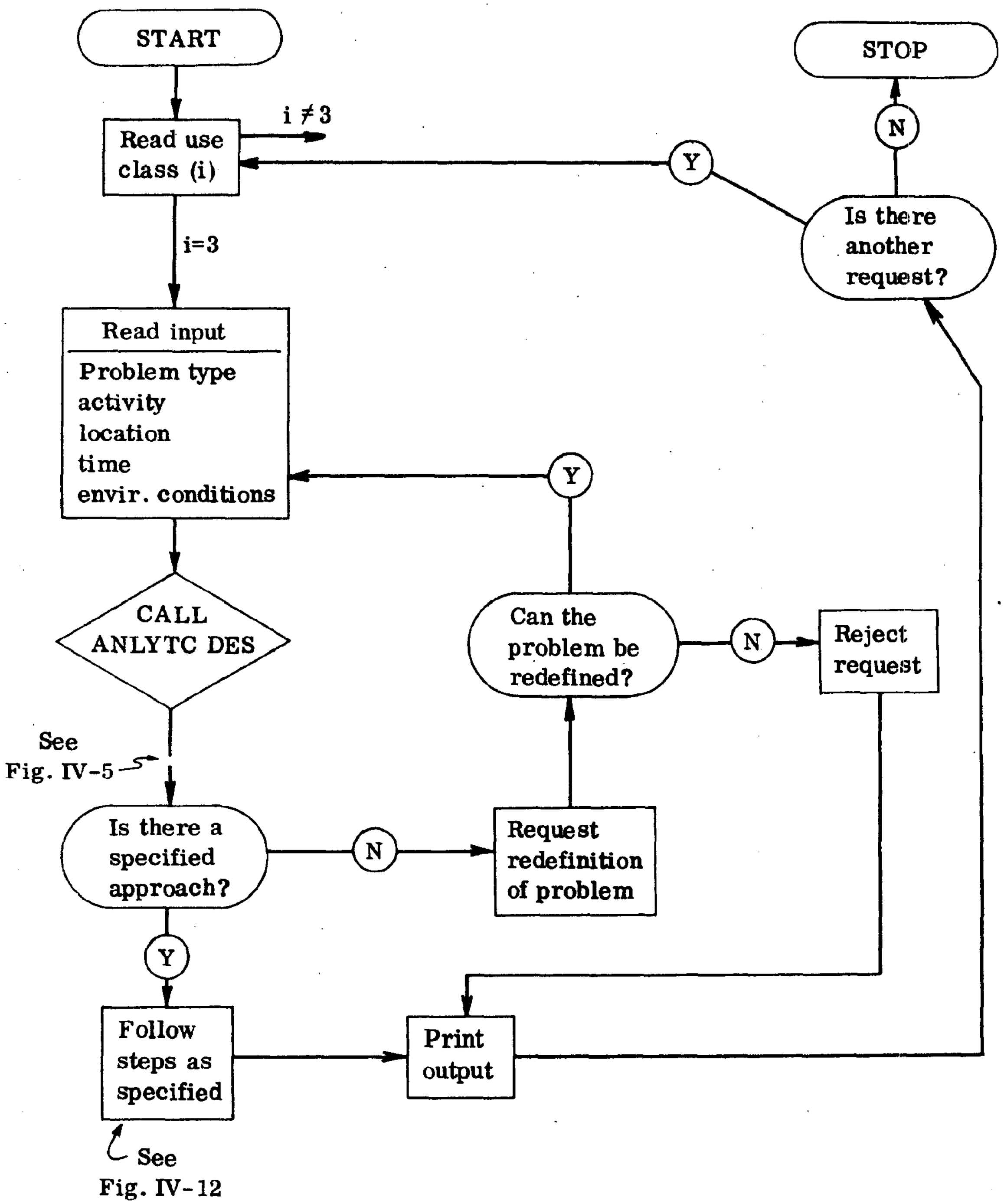



Fig. IV-9. Illustration of Class 3 use—executive control.

In the example case of a proposed dredging project, the steps of the analytical approach as specified by the analytical design (Fig. IV-5A) will itemize the data which should be retrieved from the data storage and retrieval component for the area to be dredged and the area to be used for spoil disposal.

The nature of both areas is then checked to see if either is a wetland or a shellfish area (see Fig. IV-6). If one or both are, this information will be made explicitly available along with any additional information that could contribute to an evaluation of the importance or value of the area.

At this point the project may be evaluated by decision body and judged important enough to be stopped in its present form. If so, the analysis will proceed no further.

If such is not the case (either because the areas are not wetlands or shellfish beds or because they are not considered important enough to stop the project) the next step is to check the size of the project (at present based upon the volume of material to be moved). If the project is less than 100,000 cubic yards the analysis based on guidelines related to spoil volume will not proceed further. If the project is 100,000 cubic yards or greater the analysis will enter a "Phase II" for more detailed project evaluation (see Figs. IV-7—IV-8). The total network diagram dredging as shown in Fig. III-2 will be used along with the specification of the proposed project and the description of the area to derive the "subnetwork" for both spoil disposal and dredging which is relevant to this particular project.

At this time it is impossible to systematically specify the remainder of the analysis except in a very general way. Within the present state of the art in computer systems and the present state of knowledge in the subject area (to say nothing of the practical usefulness of an automated evaluation procedure) the balance of the analysis will require primarily the judgment of the analyst and the decision maker.

Steps 12 and 13 (Fig. IV-5A) in the analytical approach require the analyst to follow through each link in the relevant submatrix and to judge its significance both to changes in environmental condition and to other activities which use the affected resources.

A further step can be taken if the project is judged significant enough to warrant the use of additional resources. Should the analyst judge that the potential changes in circulation, flushing and associated environmental conditions be likely to cause significant effects he may check the synthesis and analysis component to see if a model exists to predict these changes with a reasonable degree of certainty and, if data is adequate to exercise the model. In cases where the data and model exist and are easily manipulated he may perform such an analysis as a matter of course. Where it is not so easily done without a large commitment of resources he will likely not conduct such an analysis except in special cases.

Because of the variability in procedures which may be followed the flow through the steps in Fig. IV-8 indicate only only briefly the steps to be followed after the networks are developed.

D. Analysis of a Specific Problem—Category 3

A dissatisfaction with a given environmental condition or set of conditions is what is meant here by a problem. The main purpose of the MIS in the analysis and solution of a problem will be to help seek out and verify the reasons or causes of the condition(s) and to help analyze the effects of various potential solutions.

The initiation of this type of analysis should come from the person or group who is experiencing the dissatisfaction. He or they should be able to state quite concisely what condition or conditions are causing the dissatisfaction, or, at least, the specific activity which he wishes to pursue and is concerned about because of environmental conditions. Some of the problem statements will lead directly into an analysis which entails the development of planning activity for solutions. Such problems as beach erosion, congestion of recreation areas, and lack of beach access fall into this class. As such, they will be treated as a Category 4 (planning) use of the MIS and follow the procedures discussed in the next section. Other problems can be analyzed on a case by case basis and may be the cause for management action to correct the problem. Such problems as specific water pollution conditions, changes in fin fish or shellfish populations, and shoaling of a channel fall into this class.

Upon specification of a problem by, or in conjunction with, the initiator, or the affected party, the first step in the MIS processes is to check the compatibility of that activity with planned uses and specified standards, then to verify that the problem exists, based upon the environmental data describing the specific area and parameters. If the data exists and does not substantiate the complaint and, if its reliability is not question-able, the analysis stops, and the initiator can either attempt a redefinition of the problem or reevaluate the situation. If the data substantiates the problem—that is, that the existing environmental conditions are not adequate for the desired activity, an attempt will be made to investigate the historical changes in the data to see if and how the unfavorable conditions have been changing over time. At this point, if adequate data exists, a judgment will be made as to whether the analysis should be stopped or whether it warrants further investigation.

Assuming the judgment is in favor of further analysis, because the environmental conditions have shown a marked deterioration, the next step will to to attempt to determine the cause of the changes. In some cases there may be only one possible cause; but more likely, there will be multiple potential causes. Some changes may be the result of natural processes, such as the shoaling of a channel after a severe storm. Others may be indirectly caused by the solution of other problems. For example, water quality may be adversely affected by changing the flushing action in a bay through reconfiguration of an inlet.

Given a reasonable assurance that the cause has been found, the next step is to judge if some action should be taken. If action is not judged to be justified then the results of the analysis will be finalized, and no further action will be taken.

If action is judged to be warranted then the alternatives must be identified. Each alternative must be analyzed as to the effects it will have on other activities so that its feasibility can be evaluated. If a feasible solution is found then information on it will be prepared for the decision body. If more than one solution exists the output prepared will include information on all so that expert judgment or quantitative analysis, if available, can be exercised in making a decision.

At any time during this process there may be a point at which data does not exist. When such a point is reached a judgment must be made as to whether the problem warrants the resources necessary to acquire new data. Also, there may be points where the state of knowledge is just not adequate to provide answers. At such points there are usually three alternatives. First, the analyst can seek expert opinion to obtain a "best guess" to fill the knowledge gap. When this is done it should be made clear that is is an expert opinion and it should be accompanied by a judgment by the expert as to its reliability. Second, the analysis can be temporarily stopped while a research project is undertaken to develop the necessary knowledge. And third, the analysis may be stopped completely if the problem is not judged to be significant enough to warrant the time and cost.

Figures IV-9 through IV-11 depict the sequence which would be followed through the standardized MIS procedure, calling upon the system's components to provide the capability to conduct the analysis of a specific problem.

Fig. IV-10. Illustration of Class 3 use—analytical design

1. For location of the problem retrieve information on acceptable activities (from planning data, standards) (from DS & R).
2. If the activity desired is not compatible with those acceptable reject the problem and inform initiator that his activity is not a "conform" use. Stop the analysis.
3. If the activity is compatible retrieve data for the location on the particular environmental conditions (from DS & R).
4. If current data does not exist determine if the problem warrants data collection. If not notify the initiator and stop the analysis. If it does, get action started and postpone further analysis until data is available.
5. If there is current data compare its values with the limits and range within which the desired activity can be conducted (from E R).
6. If the observed data values fall within the acceptable range so notify the initiator and stop the analysis.
7. If the observed data values are outside the acceptable range check the past data against the current data to ascertain the trend in condition. If it is constant on decreasing in severity inform the initiator and stop the analysis.
8. If the conditions have deteriorated search for potential causes of the change. Identify the network links which lead to changes in this particular condition (from E R)
9. Using data on activities (from DS & R) and the relationships in the links (from ER0 attempt to identify an existing activity which is likely to be the cause. Use data (from DS & R) as necessary to perform the analysis. (For example, water circulation patterns, direction and velocity will help to identify sources of a particular water pollution incident.)
10. If data or knowledge are not adequate to reach a reliable conclusion seek expert judgment outside the system and stop the analysis or collect data and do research, model studies ( S & A)
11. If a cause is established identify and evaluate possible solutions. Such solutions may include:
    - do nothing
    - stop the causal activity
    - alter the causal activity
12. Present the data and information for the decision body to act upon. Cause-effect relationships, alternative actions, values and impacts of each alternative. Stop the analysis.

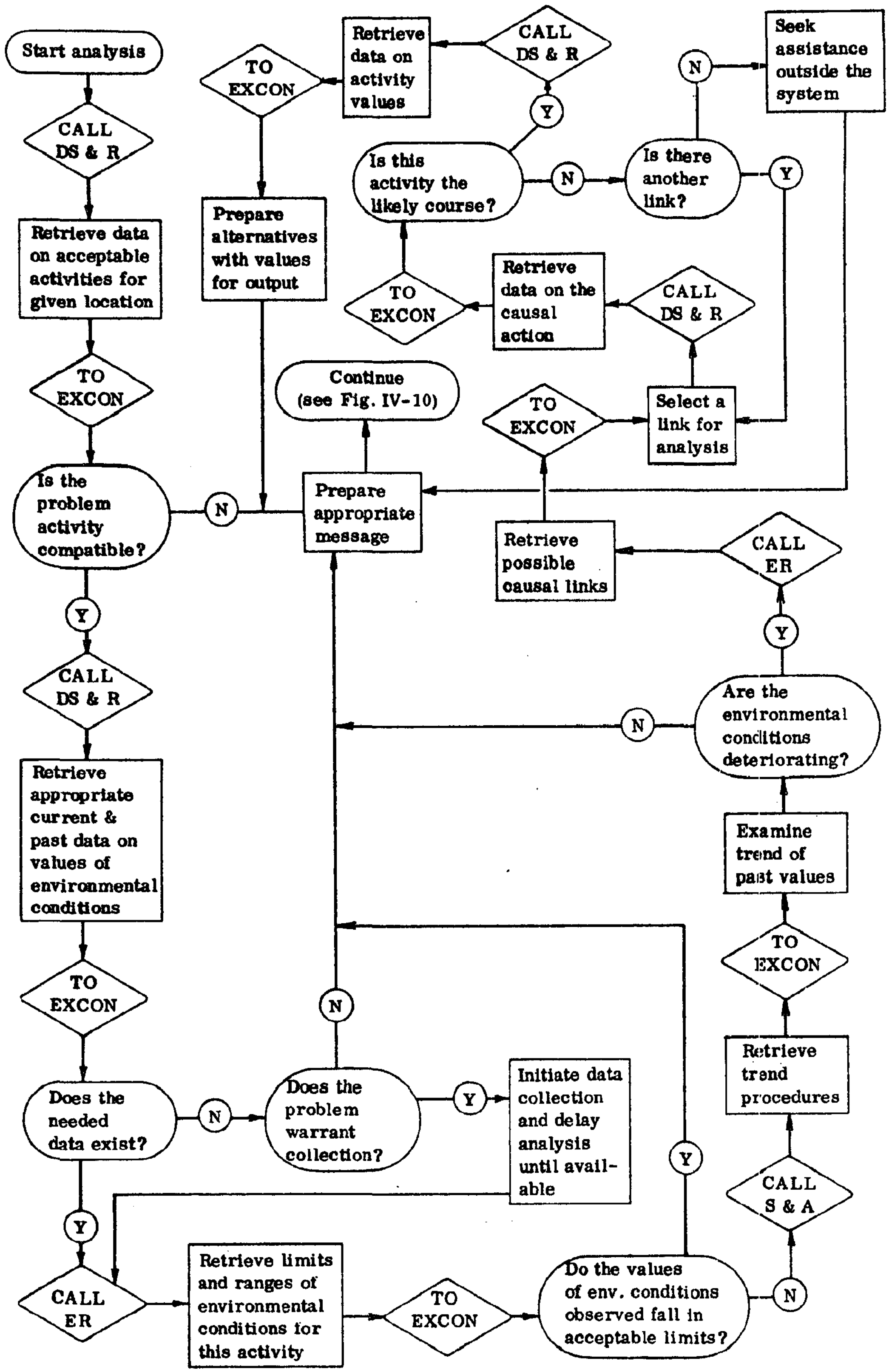



Fig. IV-11. Illustration of Class 3 use—based on analytical design.

## E. Analysis for Planning—Category 4

The fourth and final use of the MIS is its application in developing background analyses related to planning for environmental quality and resource use. In this use the planning may be for a specific activity, such as planning to accommodate demands for beach recreation, or for broad overall comprehensive planning for the multiple use of the available natural resources. Thus, there is a great deal of variability in the kinds of approaches which may be applied. This variability is further aggravated by the various levels of detail which may be required depending upon the purpose of the planning activity. Feasibility planning just to ascertain if a specific goal can be met requires little analysis. Planning which leads to the selection of the course of action to be followed will require substantially more detailed analysis to reliably present the pros and cons, or the benefits and costs.

Given the objective of the planning, stated as a desired level of a particular activity, there is a series of questions which if answered will provide the needed information to the planner. The MIS procedures will assist in providing the answers:

1) What environmental conditions will meet the needs for this activity?

2) Where does this combination of environmental conditions exist? (Or, what environmental conditions exist at the specified area?)

3) If the environmental conditions are not adequate can they be altered to meet the need?

4) What impacts on other activities will occur if this activity is developed or if the environmental conditions are altered?

Figures IV-12 through IV-14 depict the sequence and flow of steps in the MIS procedure for preparing background analyses for planning.

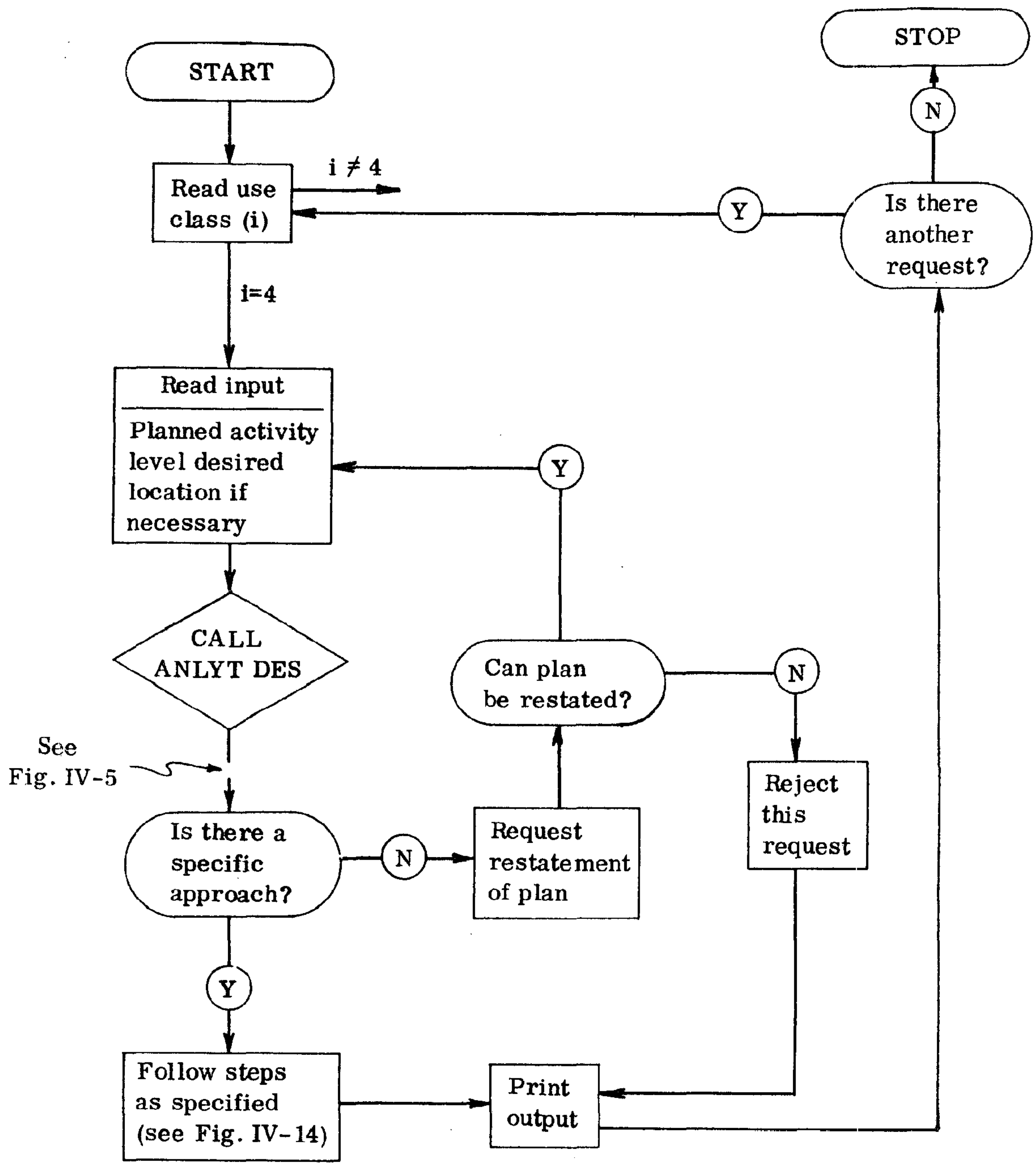



Fig. IV-12. Illustration of Class 4 use—executive control.

Fig. IV-13. Illustration of Class 4 use—analytical design.

1. For the desired activity retrieve necessary environmental conditions and their acceptable ranges or limits (from ER).
2. If the location of the desired activity is specified retrieve the data describing the relevant environmental conditions at that location (from DS & R). If the conditions satisfy go to 5; if not, go to r.
3. If the location is not specified search the environmental data file and identify areas which have the necessary conditions (from DS & R). If more than one area is found itemized and print out their location together with information about other activities which are conducted in the areas for the planner's selection (from DS & R). (The analyst, or planner would then select specific sites and the process would continue and go to 5.) If one area which meets the requirements is found go to 5. If no area is found with the required combination of environmental conditions print out a message to that effect and stop. (The analyst could then restart the process by specifying a particular area if desired.
4. If the desired site does not have the right combination of environmental conditions print out this fact and identify which conditions are outside the allowable range or limits. The analyst would then judge whether to drop the plan or find ways to alter the conditions. (Expanding beach by adding sand, dredging a deeper channel are examples of such changes.) (The hypothesized changes can be analyzed as a Class 2 use of the MIS.
5. Given that the area (or areas) is found or made to have the right environmental conditions, retrieve the data about other activities in that area (from DS & R). Investigate the effects of instituting the desired (planned) activity on other activities (from ER).
6. From the data on the level and value of these activities (from DS & R) calculate the costs and benefits associated with the planned change in use (from S & A).
7. Print out the list of effected activities, the level of effect, the estimated costs and benefits for use by the planner.

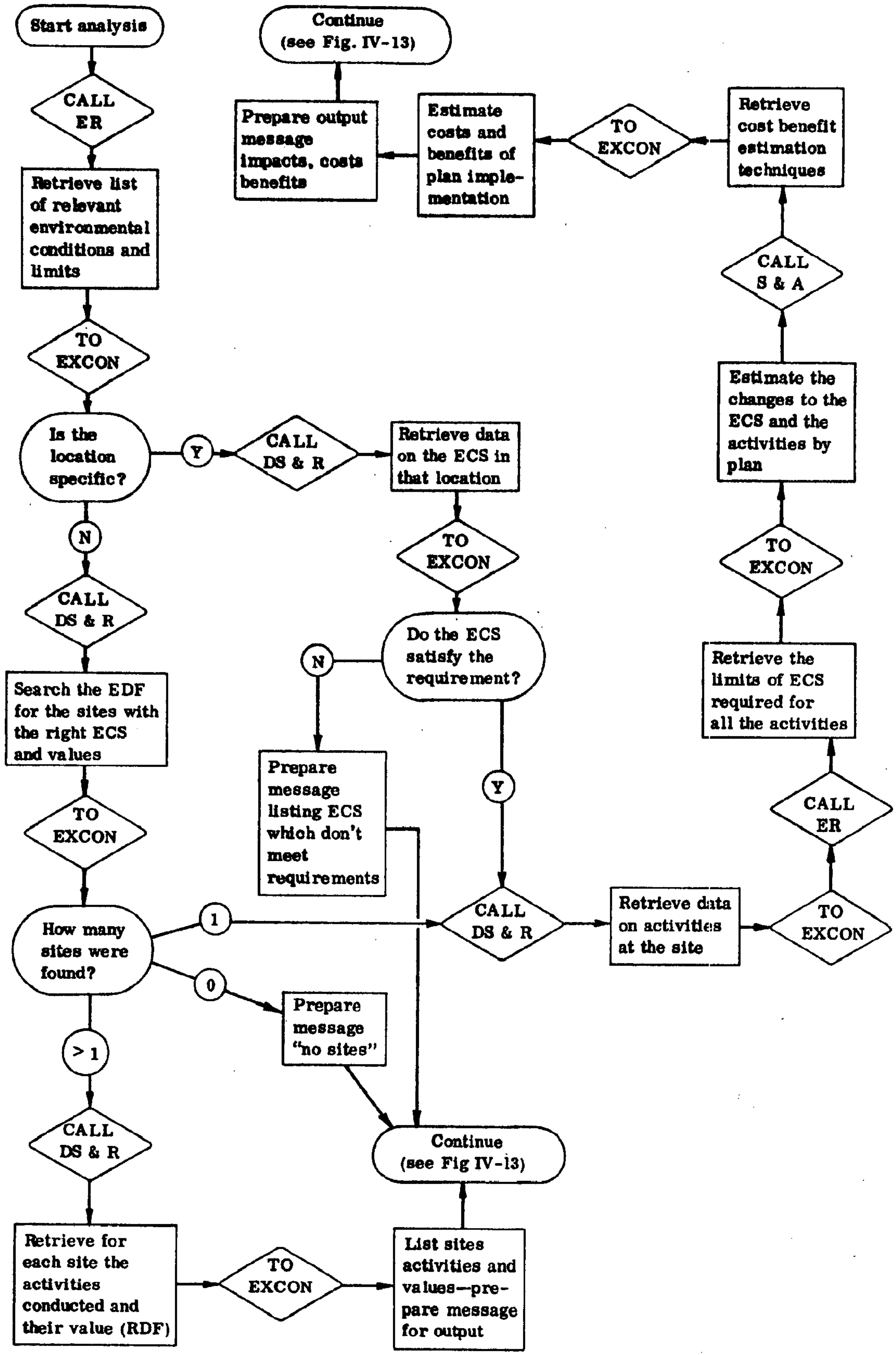



Fig. IV-14. Illustration of Class 4 use—based on analytical design.

## V. DEVELOPMENT AND IMPLEMENTATION OF MANAGEMENT INFORMATION SYSTEM

In planning the development and implementation of a Management Information System for coastal zone planning and resource management on Long Island we must clearly differentiate between two aspects of the effort required. These are:

- the design and early implementation of a structured MIS, and
- the acquisition and incorporation into the MIS of the requisite information, documents, data, analytical techniques, and models.

Managers and planners need information immediately to solve current, pressing problems of marine resource use. What is needed then in the design of a MIS development plan is a recognition of this immediate need balanced with an awareness of what is required for an orderly, efficient development of the system for future needs. To achieve this proper balance, it is essential that the use of the computer begin at an early data, while the necessary information, data, documents, etc. are being acquired. The initial computerized version of a given system component may not be identical with a more complex form which evolves at a subsequent date. For example, initially the causal matrices in the environmental relationships component may indicate only the existence or not be of a relationship while subsequent matrices may be expanded both in form and content to describe the nature of the relationship in a probabilistic or mathematical expression.

The development of each of the individual components of the MIS will follow the general steps outlined below. This sequence of steps is particularly applicable to the development and implementation of the data storage and retrieval component, environmental relationships component and the synthesis and analysis component. Steps one and two are carried out during the first year of the development program. The sequence of steps is:

1. Acquisition of information, documents, data, techniques, etc. to
   (a) serve as "handbook" information during system development, and
   (b) use for system component checkout.
2. Development and checkout of MIS component on a computer. This

requires

(a) detailed specification of component elements including content, format, interrelationships, etc.,

(b) coding and checkout of component computer program, and

(c) testing with real or simulated data and checkout with other MIS components as they are implemented on the computer.

3. Establish on the basis of availability, need, complexity, cost, etc., the relative order of incorporating knowledge, data and techniques into the MIS component.

4. Develop and carry out the coding, modifications, and preprocessing required to incorporate a given set of data or a technique into the appropriate MIS component.

5. Evaluate, revise, update, and expand the MIS components as part of a system that evolves with changing needs, increasing knowledge and information, and practical experience in use.

The detailed steps required for the development and implementation of each of the MIS components is given in Table V-1. A schedule for the first year of activities for the development of each component is shown in Fig. V-1. The overall manpower requirements and computer time needed to achieve the objective of an initial computerization of the MIS after one year are estimated to be two man-years, and 10 hours of machine CPU time on an IBM 360/65 computer. Other manpower requirements for non-computer portions of the project during the first year are estimated to be be two man-years. The non-computer portions of the project are indicated by asterisks in Table V-1. The Marine Resources Council research program has addressed itself to many of the activities indicated by asterisks in Table V-1. Consequently, this has significantly reduced the level of effort to the above estimate on the non-computer portions of the project during the first year. Without prior work we estimate that 10 man-years or more would be required the first year for non-computer work.

An important part of the description of the development and implementation of the MIS is a discussion of its evolving functional status. A brief description of what can be expected from each MIS component after six months and one year of system development follows Table V-1 and Fig. V-1.

TABLE V-1
STEPS FOR DEVELOPMENT AND IMPLEMENTATION OF THE MIS

1. Data Storage and Retrieval Component Development

    *(a) Identify and acquire documents and data.
    *(b) Evaluate literature reference systems and select one for adoption.
    (c) Write detailed specifications for EDF, RDF, and LRF and retrieval routine.
    (d) Code and checkout programs.
    (e) Test with data and with other MIS components.
    (f) Revise, update, and expand data base (after first year)

2. Environmental Relationships Component

    *(a) Develop a manual containing and describing the three causal matrices and the standards matrix.
    *(b) Develop most critical network linkage diagrams.
    (c) Write detailed computer specifications for three causal matrices and standards matrix.
    (d) Code and checkout programs.
    (e) Test with data and with other MIS components.
    (f) Expand matrix information content by including quantitative relationships (after first year).
    (g) Revise, update, and expand causal matrices and standards matrix (after first year).

3. Analytical Design Component

    *(a) Establish priority identification of problems and activities.
    *(b) List problem solving sequences of instructions for dredging, coastal erosion, wetlands, etc.
    *(c) Develop complete flow diagrams for above problems.
    *(d) List problem solving sequences of instructions for specific planning activities.
    *(e) Develop complete flow diagrams for above activities.
    (f) Develop, apply, evaluate and revise additional problem solving approaches (after first year); and computerize these approaches where appropriate.

4. Synthesis and Analysis Component

    *(a) Compile information on objective analysis techniques, statistical analysis techniques, environmental simulation models, and cost-effectiveness/cost-benefit models.
    *(b) Determine the usefulness of the techniques and models and the form of inclusion in the MIS.

TABLE V-1 (Cont.)

(c) Write detailed computer specifications for the overall synthesis and analysis component and include selected "on-line' techniques and selected descriptions of "of-line' techniques.
(d) Code and checkout programs.
(e) Test with data and with other MIS components.
(f) Selectively adopt a large number of relevant "off-line' techniques and models for use within the MIS (after first year).

5. Executive Control Component

(a) Design (general) all elements of Executive Control Component.
(b) Develop data base management capability.
(c) Develop prototype analytical approach.
(d) Test and verify Executive Control and MIS operation.

MIS System Development and Implementation—First year

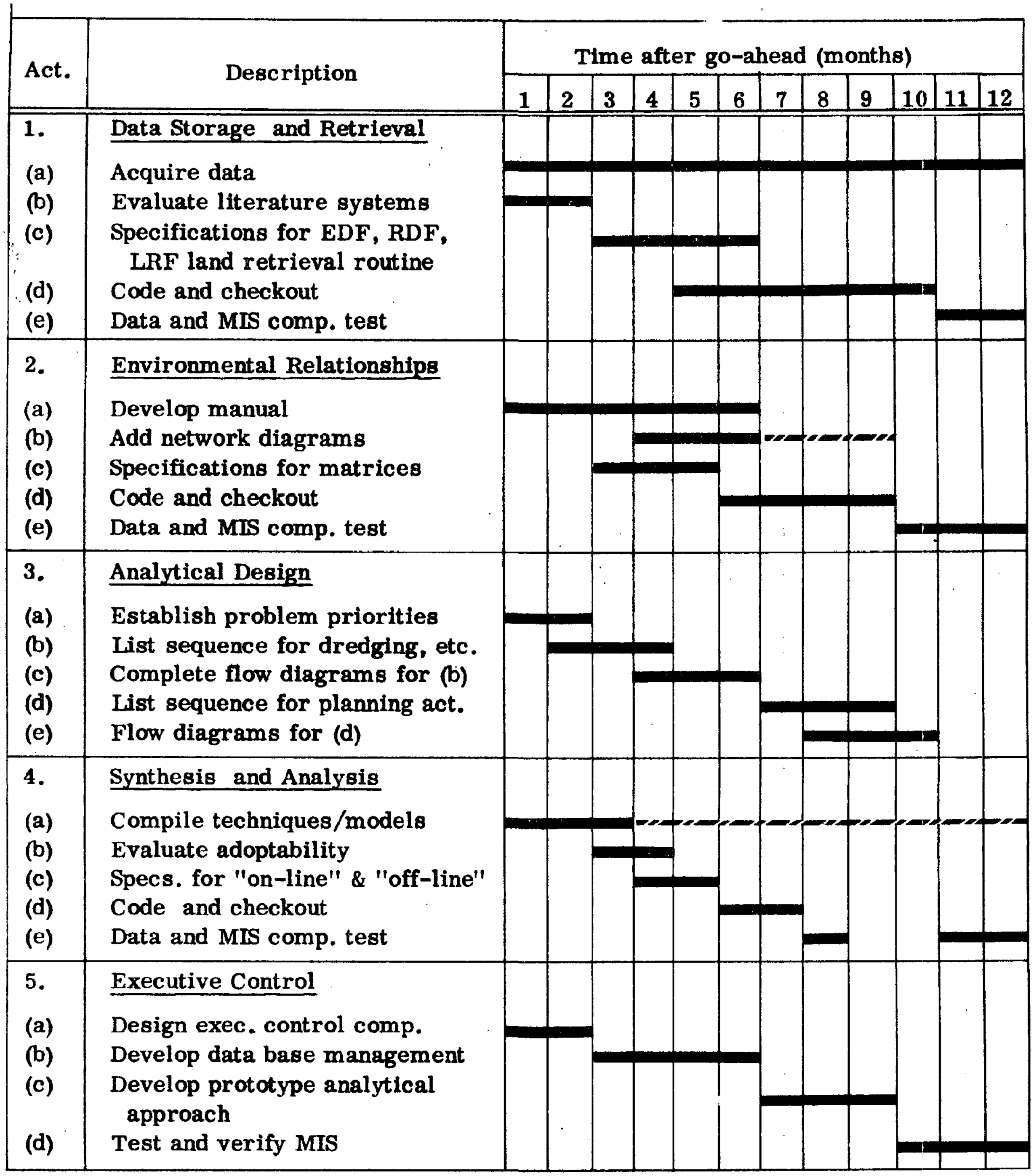



Fig. V-1. Component activity schedule.

After six months of developmental work, the functional status of each MIS component is as follows:

- Data Storage and Retrieval—Considerable data, documents and information will have been compiled, organized and available in a variety of forms (reports, punched cards, magnetic tape, etc.). The LRF will be checked out on the computer with limited information available.

- Environmental Relationships—A manual will be available containing and describing the three causal matrices, the standards matrix and critical network diagrams.

- Analytical Design—Complete and detailed flow diagrams together with instructions for their use will have been developed for problem solving sequences for dredging, coastal erosion, wetlands, and water supply and waste water management.

- Synthesis and Analysis—Information on objective analysis techniques, statistical techniques, environmental simulation models, and cost-effectiveness models will have been compiled and organized. Those techniques and models that can reasonably be utilized without a computer will be available for use.

- Executive Control—The functions of the executive control will be performed manually.

After one year of MIS development, the functional status of each system component is as follows:

- Data Storage and Retrieval—The EDF, RDF, LRF and required retrieval routines will be available on the computer. Most of the required data for the EDF and RDF, however, will be available only off-line.

- Environmental Relationships—The three causal matrices (depicting "zero-one" relationships) and the standards matrix will be available on the computer. The Environmental Relationships Manual is, of course, available for immediate reference.

- Analytical Design—Complete and detailed flow diagrams together with instructions for their use will have been developed for specific planning activities in addition to those available after the first six months of developmental work.

- Synthesis and Analysis—A limited number of techniques or models will be available for use or described on-line on the computer. Others are available for manual use only.

- Executive Control—A preliminary computerized executive control for data base management and analytical approaches will be available. Many of the functions of an executive controll will be performed by the analyst (i.e., manually).

After the first year, increasingly more extensive and effective use of the computer could be made within a MIS, given that sufficient resources are allocated for system development. This would encompass greatly expanding the data base in the EDF and RDF, including qualitative and quantitative relationships in the causal matrices, developing generalized analytical problem solving sequences for the computer, adapting off-line analytical techniques and models for selective computer use within the MIS, and expanding the functions of the executive control that can be accomplished (on option) within the computer.

## APPENDIX A. DATA STORAGE AND RETRIEVAL COMPONENT

### I. Introduction

The data storage and retrieval component of the management information system (MIS) provides the physical, economic and social data required by planners and managers for the identification, formulation and solution of problems involving marine resources. The data can be retrieved selectively according to classification criteria of subject, time or geographical location. The form, content and volume of data required may vary significantly depending on use. Data may be required for

- direct output without any additional processing,
- verifying that a problem exists and specifying the type of analytical approach required and
- use in numerical or statistical analyses.

This appendix discusses, in some detail, the principal elements of the data storage and retrieval component—the Environmental Data File (EDF), the Resource Use Data File (RDF) and the Literature Reference File (LRF). The grid systems for depicting the areal distribution of marine resource parameters in the Long Island area are reviewed and finally, consideration is given to steps required for the development and implementation of the data storage and retrieval component of the MIS.

The design of the data storage and retrieval component clearly reflects the problem dimensions and knowledge requirements previously identified.

The eight dimensions are:

- Cause-environmental condition-effect relationships
- Natural environmental characteristics
- Reasons for dissatisfaction
- Incidence of costs, damage or dissatisfactions
- Intensity or severity of the problem
- Geographic location of the problem
- Time description of the problem
- Governmental-administrative jurisdictions.

The actual method of organizing and storing information in the file for selective retrieval will make liberal use of the standard characteristic-item matrix. Columns will represent characteristics such as key words necessary to describe the item or may represent geographical subregions of the total area. Rows will represent items such as physical descriptors, conditions or problems and reference documents. The elements of the matrix may be a binary yes-no indication of applicability or an identification of yet another matrix needed for a finer, more detailed search. The method is well suited to electronic computer application and may even be adapted to physical systems such as McBee edge punched cards. Specific details of each application are included in the individual discussions of the three files in the component.

The knowledge requirements can be expressed in categories which are:

I—Information about current human actions and natural forces affecting the environment.

II—Information about the current physical and chemical states of the environment.

III—Information about the current state of the marine related biota.

IV—Information about desired uses of the coastal resources.

V—Knowledge of processes by which actions and forces affect the physical and chemical characteristics of the environment.

VI—Knowledge of the effects of actions and forces, and physical and chemical conditions on the marine biota.

VII—Knowledge of the impact of physical, chemical and biological environmental characteristics on uses of the coastal resources.

VIII—Knowledge of objective methods and procedures.

## II. Environmental Data File (EDF)

The EDF is designed to provide specific quantitative data describing the physical, chemical and biological characteristics of the Long Island coastal waters and adjacent shores on a geographical basis. The data yield the information needed to satisfy Categores II and III of the knowledge requirements. The EDF will be developed to include data on the information given below.

Physical Characteristics of Coastal and Estuarine Areas

- location and volume of stream flows into coastal waters
- location and volume of ground water flows into coastal waters
- water surface area in bays, harbors, etc.
- water depth by location
- physiography of benthic areas by location
- composition of benthic areas
- physiography of shoreline areas by location
- size and location of salt marshes, salt meadows and other wetlands including their relative importance from fish to wildlife point of view
- location and extent of offshore sandbars
- location and size of inlets to bays and other estuarine areas
- location, size, type and number of structures such as docks and erosion control structures which may affect circulation, tides, storm surges, etc.

Chemical and Physical Conditions of Coastal and Estuarine Waters

(by time and location for bays, harbors, streams, estuarine areas and coastal waters)

- water temperature
- pH
- salinity
- dissolved oxygen
- turbidity
- water color
- plant nutrients (primarily compounds of nitrogen and phosphorus) levels and ratios
- coliform bacteria
- floating and setteable materal
- toxic materials such as radionuclides, pesticides, and heavy metals
- oil

Information About the Current State of the Marine Related Biota

Population characteristics of important shellfish species (oyster, lobster, sea scallop, bay scallop, surf clam and hard clam) by time and location

- numbers of individuals

- size distribution
- age distribution
- growth rates of individuals
- growth rates of biomass
- population trend

Population characteristics of important finfish species (Bluefish, Cod, Fluke, Menhaden, Scop, Sea Bass, Striped Bass, Whiting, Yellowtail Flounder, Butterfish, Blackback Flounder) by time and location

- numbers of individual
- size distribution
- age distribution
- growth rates of individuals
- growth rates of biomass
- population trends

Population characteristics of other important marine fauna including marine predators and pests (e.g., oyster drills, starfish)

- numbers of individuals
- size distribution
- age distribution
- growth rates of individuals
- growth rates of biomass
- population trends

Population characteristics of important marine plant species (eelgrass, marshgrass, phytoplankton, algae)

- population density
- size of individuals
- growth rates of individuals
- growth rates of biomass
- population trends

Population characteristics of important migratory birds and other wildlife species:

- numbers of individuals
- size and age distributions

- growth rates of individuals
- population trends.

Because of the volume of data and the varieties of use for which the data are required, it is essential that

- the data be identified with specific locations on a grid system (discussed in Section 5 of this appendix), and
- variable length records for any particular location or region be employed.

A manager or planner may desire to obtain all known measurements and observations of physical, chemical and biological characteristics of the marine environment at a particular location or he may require the areal distribution of one or more of these descriptors throughout the entire Long Island coastal region. The variable length data records must be constructed to reflect the great variation in detail of information on environmental parameters from one location to another. For many parameters, the data are collected at several locations in the vertical (z) at a given horizontal location (x, y). Frequently, considerable supportive information such as the period of measurement ($\Delta t$), date and the time of day, the month or season of the year, etc. are required to adequately understand and interpret the observation. The proper design and development of a variable length record EDF requires both a thorough knowledge of the important descriptors of the marine environment and a clear understanding of the planned uses of the data within the MIS. A detailed concrete example of the concept of the variable length record and its creation is given in the next section of this appendix.

The efficient retrieval of information from the EDF will be accomplished through the use of search matrices. Since most of the data in this file must be identified by subject, time and geographical location, more than one matrix will usually be required. As an example, in order to simplify geographical location, the entire Long Island coastal region might be divided into meaningful sub-areas according to some criterion such as population, municipal boundaries, or simply large blocks of points in a grid system selected for some characteristics such as economic state. These areas would be represented by the columns of the search matrix. The items of interest in the EDF would be informational type of data describing the area such as physical or chemical characteristics, marine biota, etc. These would be represented by the rows. Since time is the third identifying characteristic of the data, the matrix element, or intersection of row and column, would indicate a second search matrix whose columns are time measures such as months, season, etc. If no further detail were required in the item of interest from the first matrix, this second one would be only one dimensional and would give a direct identification of the data record of interest. However, should another level of detail be required to adequately identify the item, the second matrix would again be two dimensional and have as rows the extended detail description. The matrix elements would then identify the data record of interest. This extension of detail description can be carried to any level simply by cascading the matrices as many times as necessary.

As noted above, the records must of necessity be variable length due to the variety in types of data and available knowledge of the subject. In an electronic computer this can be automated simply by creating a standardized descriptive record ahead of the actual data record. This descriptor would then contain all information necessary for the computer to "know" what the data record contains and where to locate it.

Figure A-1 shows a typical example of the use of search matrices in the EDF. In the case of water temperature, the second search matrix is one dimensional since no further detail is required. If key words were used, they would be, "AREA B, WATER TEMP, SPRING." In the case of fish at least one more level of detail may be required so the appropriate element of the first matrix identifies the second whose elements then locate the data record. Key words in this case would be, AREA C, FISH, MACKEREL, SUMMER.

## III. Resource Use Data File (RDF)

The RDF is one of the three basic data files which comprise the data storage and retrieval component of the MIS. Its purpose is to describe, as completely as possible, the series of problems of concern to marine resource planners throughout Long Island. To meet this objective, a series of variable length data records will be developed for computer processing and storage. Each record will contain all the information avail able for a particilar problem in a specific, contiguous geographical area, i.e., shell-

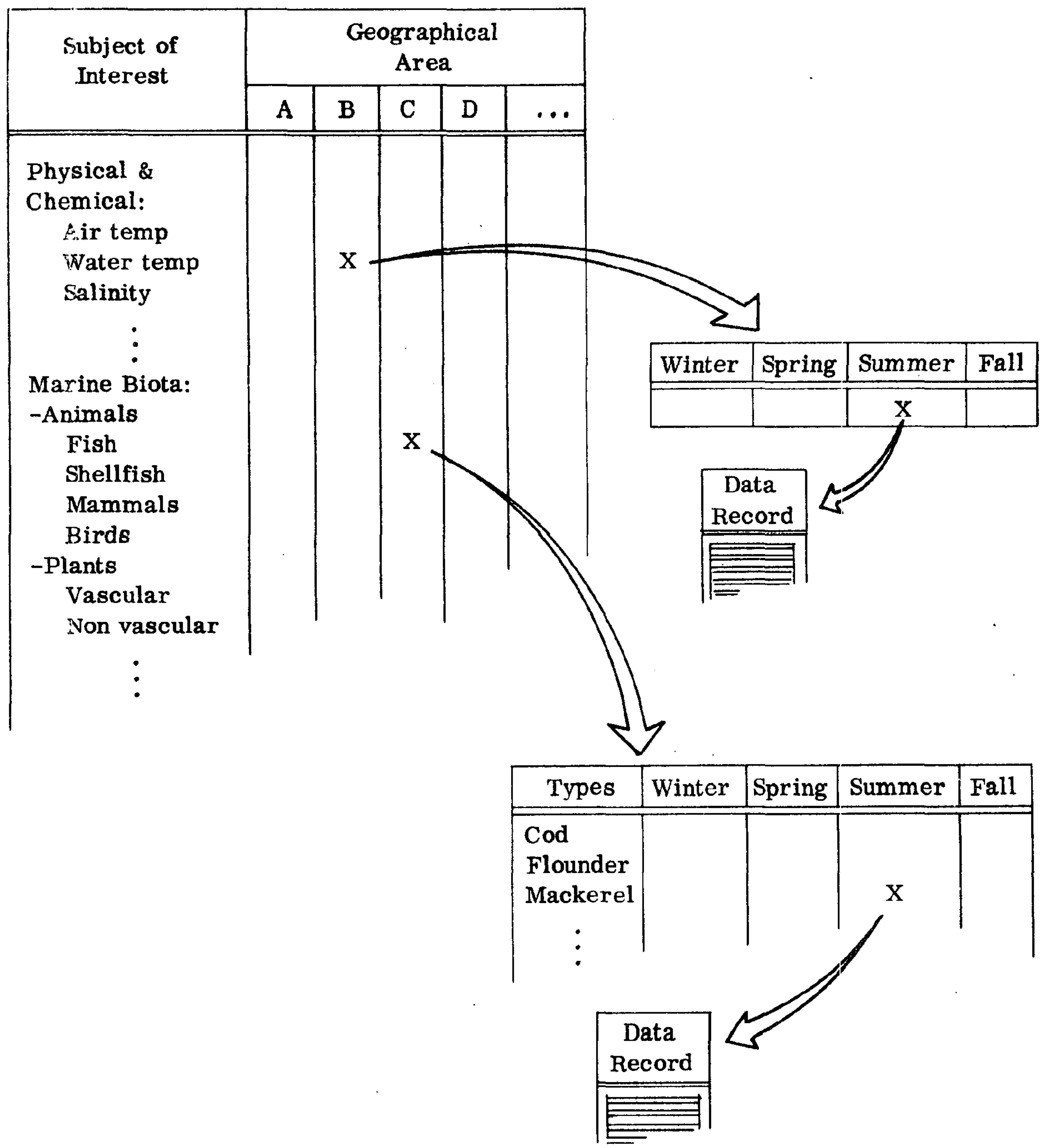



Fig. A-1. An example of the use of search matrices in the EDF.

fishing off the coast of West Sayville. The information contained in this record can be broken down into three categories:

- affected activity data;
- dissatisfied groups data; and
- causal activity data.

The variability in the data record length will reflect not only the complexity of the indicated problem, but also the extent of information available in each of these data categories.

In order that the information contained in the problem data file be consistent and, therefore, meaningful as a base for further analysis, it is necessary that the meaning of variables and their associated codes be explicitly defined. Section A of the following discussion directs itself toward this end as well as describing some of the constraints of the system. Samples of each of the five types of data input sheets are shown in Section B. Section C contains the set of coding instructions corresponding to the input format in Section B. A Master List has been developed in association with this section but is not included in this appendix because of its length. The list includes a coding procedure for categories of

- Affected and Causal Activities,
- Environmental Conditions,
- Name Location of Affected/Causal Activities,
- Type of person or agency experiencing dissatisfaction,
- Reason for dissatisfaction,
- Agencies and
- Agency Functions.

A. RDF Variables

Affected activity data:

1. Record Identification

A 1—6 digit number will be assigned sequentially to all records. This record identification code will be entered on all cards pertaining to this record.

2. Card Identification

Columns 10 and 11 of this code denote the card type, and the appropriate numbers are preprinted on the coding sheets. Columns 8 and 9 denote the causal activity being considered and will therefore, contain zeros on card types 1 and 2. Additional information concerning these coluns can be found in the coding instructions for the causal activity data #1 form.

3. Affected Activity

Since this item of information is the focal point of the entire record, it must contain an entry for the record to be accepted. The code for this variable is selected from the Master List.

4. Pattern of Occurrence of the Affected Activity

A one digit code will be entered for each of the seasonal categories to describe the pattern of occurrence of the affected activity during that season. For example, if finfishing is a problem activity throughout the years, a code of 1 would be entered in columns 17—20. Also, if boating was found to be a problem activity during the summer, a code of 1 would be entered in column 18, and a code of 8 in columns 17, 19, and 20. Thus the meaning of the code is that the problem doesn't occur in the other three seasons, not that the activity doesn't take place.

5. Trend of the Affected Activity

This item of information will be coded to reflect the trend of the activity as a problem. Thus in the boating problem cited above, the trend would be coded as slowly increasing (2) only if this were the case during the summer.

6. Name Location of the Affected Activity

The code for the common-name area in which the affected activity is taking place is selected from the master list. When a specific name for the area in question is not available, the name of the smallest geographical or political entity containing the activity area will be names. For example, a finfishing problem off the north shore of Long Island would have a name location of Long Island Sound (320). This field must contain an entry for the record to be valid.

7. Number of Grid Points

Up to 4 grid points are allowed to define the area in which the affected activity occurs. An area demarcation using one grid point is allowed if the area can be effectually defined as a point source, i.e., the launching of boats at a particular site. If no grid points have been determined, an unknown code is used (9). A zero code is not allowed.

8. X and Y Coordinates of the Grid Location

The coordinates used are those corresponding to the Universal Transverse Mercator system. If no grid points have been determined, all fields will contain the "unknown" code (999999). If, for example, 3 grid points are determined, the fields for the entry of the X and Y coordinates of the fourth point will contain the "not applicable" code (888888). An all zero entry for any point is not allowed.

Dissatisfied groups data:

9. Number of Categories of Persons or Agencies Experiencing Dissatisfaction

Up to 8 categories are allowed for each problem data record. If more than this number occur, a new data record will be developed. At least 1 category must exist for the record to be valid.

10. Category of People or Agency

The code for each category will be obtained from the master list.

11. Number of People in this Category

This code will be straight count. An unknown code (99999999) will be used if the category in question is a public agency.

12. Economic Value of Affected Activity to those in this Category

This code will be a straight dollar amount and is assumed to be a loss. This loss may be a reduction in profit or a measure of potential gain.

13. Time Frame of Economic Value

This code displays the economic gain or loss (item 12) in a time framework.

14. Reason for Dissatisfaction

The code for this item is obtained from the master list. If a particular category of individuals has more than one reason for their expressed dissatisfaction, 2 dissatisfied group sections must be filled out to accommodate these dual reasons.

15. Pattern of occurence of Dissatisfaction

- see item 4 -

16. Trend of Dissatisfaction

- see item 5 -

Causal activity data:

17. Number of Causal Activities

This is a straight count. In the instance where no causal activities have been identified, a "99" will be inserted in columns 8 and 9 of the card identification code as in this item.

18. Causal Activity

The code for this activity will be obtained from the master list.

19. Validity of the Information

The validity encoded here refers to the validity of this causal activity as a cause. Thus a real link between the causal activity and the affected activity needs to be shown.

20. Name Location of Activity

- see item 6 -

21. Number of Grid Points

- see item 7 -

22. X and Y Coordinates of Grid Location

- see item 8 -

23. Number of People Contributing to the Cause

An actual number is encoded.

24. Economic Value of this Activity

- see item 12 -

25. Time Frame of Economic Value

- see item 13 -

26. Extent of Contribution to the Affected Activity

This encoded percentage will reflect a subjective judgment concerning the contribution of this cause to the total effect.

27. Pattern of Occurrence of Causal Activity

- see item 4 -

28. Trend of Causal Activity

- see item 5 -

29. Number of Environmental Conditions Affected

This is a straight count, with up to 7 allowed.

30. Environmental Conditions

The codes for these conditions are obtained from the master list. These conditions function as the direct link between the causal and the affected activities. The order of listing of the environmental conditions assume no corresponding ranking of importance.

31. Number of Agencies Having Decision Making Authority Concerning this Causal Activity

This is a straight count with up to 7 allowed.

32. Name of Agency

This code is obtained from the master list.

33. Level of Agency

This code is enumerated in the coding instructions.

34. Function of Agency

This code is obtained from the master list.

B. Data Input Sheets

Each of the following data sheets corresponds to one input punch card. A problem data record may contain from 3 to a maximum of 35 cards.

## Affected Activity Data

1. Record Identification (columns 1–6): | | | | | | |

2. Card Identification (columns 8–11): | 0 | 0 | 0 | 1 |

| | | | |
|---|---|---|---|
| 3. | Affected activity | | (12—16) |
| 4. | Pattern of occurrence: | spring | (17) |
| | | summer | (18) |
| | | fall | (19) |
| | | winter | (20) |
| 5. | Trend of activity | | (21) |
| 6. | Name location of activity | | (22—24) |
| 7. | Number of grid points | | (25) |
| 8. | First point—X coordinate | | (26—31) |
| | —Y coordinate | | (32—37) |
| | Second point—X coordinate | | (38—43) |
| | —Y coordinate | | (44—49) |
| | Third point—X coordinate | | (50—55) |
| | —Y coordinate | | (56—61) |
| | Fourth point—X coordinate | | (62—67) |
| | —Y coordinate | | (68—73) |

## Dissatisfied Groups Data

1. Record Identification (columns 1–6)

2. Card Identification: 0 0 0 2 (columns 8–11)

| | | | |
|---|---|---|---|
| 9. | Number of categories | | (12) |
| 10. | Category | | (13—16) |
| 11. | Number of people | | (17—24) |
| 12. | Economic values | | (25—35) |
| 13. | Time frame of value | | (36—37) |
| 14. | Reason for dissatisfaction | | (38—40) |
| 15. | Pattern of dissatisfaction: | spring | (41) |
| | | summer | (42) |
| | | fall | (43) |
| | | winter | (44) |
| 16. | Trend of dissatisfaction | | (45) |
| 10 a. | Category | | (46—49) |
| 11 a. | Number of people | | (50—57) |
| 12 a. | Economic value | | (58—68) |
| 13 a. | Time frame of value | | (69—70) |
| 14 a. | Reason for dissatisfaction | | (71—73) |
| 15 a. | Pattern of dissatisfaction: | spring | (74) |
| | | summer | (75) |
| | | fall | (76) |
| | | winter | (77) |
| 16 a. | Trend of dissatisfaction | | (78) |

## Causal Activity Data #1

1\. Record Identification (columns 1–6)

2\. Card Identification (columns 7–11): _ _ 0 3

| | | |
|---|---|---|
| 17. | Number of causal activities | (12–13) |
| 18. | Causal activity | (14–18) |
| 19. | Validity of information | (19) |
| 20. | Name location of activity | (20–22) |
| 21. | Number of grid points | (23) |
| 22. | First point—X coordinate | (24–29) |
| | Y coordinate | (30–35) |
| | Second point—Y coordinate | (36–41) |
| | —Y coordinate | (42–47) |
| | Third point—X coordinate | (48–53) |
| | —Y coordinate | (54–59) |
| | Fourth point—X coordinate | (60–65) |
| | —Y coordinate | (66–71) |

## Causal Activity Data #2

| 1. Record Identification | 2. Card Identification |
|---|---|
| (1–6) | (7–11) 4 |

| | | |
|---|---|---|
| 23. Number of people | (12–19) | |
| 24. Economic value | (20–30) | |
| 25. Time frame of value | (31–32) | |
| 26. Extent of contribution to problem | (33–35) | |
| 27. Pattern of occurrence: spring | (36) | |
| summer | (37) | |
| fall | (38) | |
| winter | (39) | |
| 28. Trend of activity | (40) | |
| 29. Number of environmental conditions | (41) | |
| 30. First environmental condition | (42–46) | |
| Second environmental condition | (47–51) | |
| Third environmental condition | (52–56) | |
| Fourth environmental condition | (57–61) | |
| Fifth environmental condition | (62–66) | |
| Sixth environmental condition | (67–71) | |
| Seventh environmental condition | (72–76) | |

## Causal Activity Data #3

1. Record Identification: [ | | | | | ] (columns 1–6)

2. Card Identification: [ | | 0 | 5 ] (column 11)

| | | | |
|---|---|---|---|
| 31. | Number of agencies | (12) | ☐ |
| 32. | Name of first agency | (13—16) | ☐☐☐☐ |
| 33. | Level of first agency | (17) | ☐ |
| 34. | Function of first agency | (18—19) | ☐☐ |
| 32a. | Name of second agency | (30—23) | ☐☐☐☐ |
| 33a. | Level of second agency | (24) | ☐ |
| 34a. | Function of second agency | (25—26) | ☐☐ |
| 32b. | Name of third agency | (27—30) | ☐☐☐☐ |
| 33b. | Level of third agency | (31) | ☐ |
| 34b. | Function of third agency | (32—33) | ☐☐ |
| 32c. | Name of fourth agency | (34—37) | ☐☐☐☐ |
| 33c. | Level of fourth agency | (38) | ☐ |
| 34c. | Function of fourth agency | (39—40) | ☐☐ |
| 32d. | Name of fifth agency | (41—44) | ☐☐☐☐ |
| 33d. | Level of fifth agency | (45) | ☐ |
| 34d. | Function of fifth agency | (46—47) | ☐☐ |
| 323. | Name of sixth agency | (48—51) | ☐☐☐☐ |
| 33e. | Level of sixth agency | (52) | ☐ |
| 34e. | Function of sixth agency | (53—54) | ☐☐ |
| 32f. | Name of seventh agency | (55—58) | ☐☐☐☐ |
| 33f. | Level of seventh agency | (59) | ☐ |
| 34f. | Function of seventh agency | (60—61) | ☐☐ |

## C. Coding Instructions for RDF Input Sheets

### General Coding Instructions

All coding is right adjusted within its field and the field is filled with leading zeros. When a card contains an item of information, all fields on that card must contain an entry. A complete field of 9's indicates "unknown." No all zero fields are allowed.

### Affected Activity Data

There will be one affected activity data card for each problem data record. This card must contain a valid code for item 3 (affected activity) and item 6 (name location) for the record to be accepted.

| Item | Columns | Code |
|---|---|---|
| 1. Record identification | 1—6 | - as assigned - |
| 2. Card identification | 8—11 | - as given - |
| 3. Affected activity | 12—16 | - see Master List - This field must contain an entry for the record to be valid. |
| 4. Pattern of occurrence of activity | 17—20 | - a one digit code will be entered for each of the four seasonal categories.<br>1 = constant<br>2 = random<br>3 = other<br>8 = not applicable, doesn't occur<br>9 = unknown |
| 5. Trend of affected activity | 21 | 1 = constant<br>2 = slowly increasing<br>3 = moderately increasing<br>4 = rapidly increasing<br>5 = slowly decreasing<br>6 = moderately decreasing<br>7 = rapidly decreasing<br>9 = unknown |

| Item | Columns | Code |
|---|---|---|
| 6. Name location of affected activity | 22—24 | - see Master List - This field must contain an entry for the record to be valid. |
| 7. Number of grid points | 25 | - straight count (up to 4 allowed)<br>9 = unknown |
| 8. X and Y coordinates of grid location | 26—31<br>32—37<br>38—43<br>44—49<br>50—55<br>56—61<br>62—67<br>68—73 | - code as given in selected grid system -<br>888888 = not applicable, field not needed<br>999999 = unknown |

## Dissatisfied Groups Data

Since at least one category of dissatisfied individuals must be described for the data record to be accepted, there will be at least one dissatisfied groups data card for each problem data record. Up to 4 cards are allowed to accommodate the maximum of 8 dissatisfied groups. Only those cards containing information need be filled out.

| Item | Columns | Code |
|---|---|---|
| 1. Record identification | 1—6 | - as assigned - |
| 2. Card identification | 8—11 | - as given - |
| 9. Number of categories of persons or agencies experiencing dissatisfaction | 12 | - straight count (up to 8 allowed). There must be at least one category for the record to be valid. |
| 10. Category of persons or agency | 13—16 | - see Master List -<br>8888 = not applicable, field not needed |
| 11. Number of people in this category | 17—24 | - straight count<br>1 - 9,999,999 allowed<br>88888888 = not applicable, field not needed<br>99999999 = unknown |
| 12. Economic value to those in this category | 25—35 | - straight amount<br>$1. - $9,999,999,999 allowed<br>88888888888 = not applicable no economic consideration involved<br>99999999999 = unknown |
| 13. Time frame of economic value | 36—37 | 1 = daily<br>2 = weekly<br>3 = monthly<br>4 = yearly<br>5 = in the past 2 years<br>6 = in the past 5 years<br>7 = in the past 10 years<br>8 = other<br>88 = not applicable, no economic consideration involved<br>99 = unknown |

| Item | Columns | Code |
|---|---|---|
| **14. Reason for dissatisfaction** | 38–40 | - see Master List - |
| **15. Pattern of occurrence of dissatisfaction** | 41–44 | - a one digit code will be entered for each of the 4 seasonal categories -<br>1 = constant<br>2 = random<br>3 = other<br>8 = not applicable, doesn't occur<br>9 = unknown |
| **16. Trend of dissatisfaction** | 45 | 1 = constant<br>2 = slowly increasing<br>3 = moderately increasing<br>4 = rapidly increasing<br>5 = slowly decreasing<br>6 = moderately increasing<br>7 = rapidly decreasing<br>9 = unknown |

**This series of information is repeated for each dissatisfied group, i.e., 10a–16a.**

## Causal Activity Data #1

One causal activity data #1 form is encoded for each causal activity enumerated. The causal activity referred to by each card is specified in Columns 8—9 of the card identification. If no causal activities are enumerated, a "99" is inserted in Columns 8—9 and all fields in card type 3 are filled with 9's. Thus there will always be at least one card type 3 for each problem data record. In the latter case, card types 4 and 5 are not coded.

| Item | Columns | Code |
|---|---|---|
| 1. Record identification | 1—6 | - as assigned - |
| 2. Card identification | 8—11 | - as given - |
| 17. Number of causal activities | 12—13 | - straight count up to 10 allowed) - |
| 18. Causal activity | 14—18 | - see Master List - |
| 19. Validity of information concerning causal activity | 19 | 1 = documented<br>2 = partially documented<br>3 = not documented<br>9 = unknown |
| 20. Name location of causal activity | 20—22 | - see Master List - |
| 21. Number of gris points recorded | 23 | - straight count up to 4 allowed)<br>9 = unknown |
| 22. X and Y coordinates of grid location | 24—29<br>30—35<br>36—41<br>42—47<br>48—53<br>54—59<br>60—65<br>66—71 | - code as given in selected grid system<br>888888 = not applicable, field not needed<br>999999 = unknown |

Causal Activity Data #2

One causal activity data #2 form is encoded for each causal activity enumerated.

| Item | Columns | Code |
|---|---|---|
| 1. Record identification | 1—6 | - as assigned - |
| 2. Card identification | 8—11 | - as given - |
| 23. Number of people contributing to the causal activity | 12—19 | - straight count -<br>1 - 9,999,999 allowed<br>99999999 = unknown |
| 24. Economic value of the causal activity | 20—30 | - straight amount -<br>$1. - $9,999,999,999 allowed<br>88888888888 = not applicable no economic consideration involved<br>99999999999 = unknown |
| 25. Time frame of economic value | 31—32 | 1 = daily<br>2 = weekly<br>3 = monthly<br>4 = yearly<br>5 = in the past 2 years<br>6 = in the past 5 years<br>7 = in the past 10 years<br>8 = other<br>88 = not applicable, no economic consideration involved<br>99 = unknown |
| 26. Extent of contribution to affected activity | 33—35 | - straight estimate of percent<br>999 = unknown |
| 27. Pattern of occurrence of causal activity | 36—39 | - a one digit code is entered for each of the 4 seasonal categories<br>1 = constant<br>2 = random<br>3 = other<br>8 = not applicable, doesn't occur<br>9 = unknown |

| Item | Columns | Code |
|---|---|---|
| 28. **Trend of causal activity** | **40** | 1 = constant<br>2 = slowly increasing<br>3 = moderately increasing<br>4 = rapidly increasing<br>5 = slowly decreasing<br>6 = moderately decreasing<br>7 = rapidly decreasing<br>9 = unknown |
| 29. **Number of environmental conditions affected by causal activity** | **41** | - straight count (up to 7 allowed)<br>9 = unknown |
| 30. **Environmental condition** | **42—46**<br>**47—51**<br>**52—56**<br>**57—61**<br>**62—66**<br>**67—71**<br>**72—76** | - see Master List -<br>88888 = not applicable, field not needed<br>99999 = unknown |

## Causal Activity Data #3

One causal activity data #3 form is encoded for each causal activity enumerated.

| Item | Columns | Code |
|---|---|---|
| 1. Record identification | 1—6 | - as assigned - |
| 2. Card identification | 8—11 | - as given - |
| 31. Number of agencies having decision making authority | 12 | - straight count (up to 7 allowed) -<br>9 = unknown<br>If the number of agencies is unknown, all other fields will be filled with 9's |
| 32. Name of agency | 13—16 | - see Master List -<br>8888 = not applicable, field not needed<br>9999 = unknown |
| 33. Level of agency | 17 | 1 = federal<br>2 = state<br>3 = regional<br>4 = county<br>5 = bicounty<br>6 = municipal<br>7 = other<br>8 = not applicable, field not needed<br>9 = unknown |
| 34. Function of agency | 18—19 | - see Master List -<br>88 = not applicable, field not needed<br>99 = unknown |

The latter three categories of information (32—34) are repeated for each agency involved, i.e., 32a—34a.

D. RDF Tape Record

The following is a description of the words (items of information) contained in each problem data tape record. The vertical dots indicate the variable length segments of the record. A maximum of 564 words are allowed in any record.

| Word # | | Content |
|---|---|---|
| 1 | - | Word count |
| 2 | - | Record identification code |
| 3 | - | Date of entry or update |
| 4 | - | Affected activity |
| 5 | - | Pattern of occurrence of affected activity |
| 6 | - | Trend of activity |
| 7 | - | Name location of activity |
| 8 | - | Number of grid points (up to 4 allowed) |
| 9 | - | Grid point 1 - X coordinate |
| 10 | - | Grid point 1 - Y coordinate |
| ⋮ | | ⋮ |
| 16 | - | Grid point 4 - Y coordinate |
| 17 | - | Number of categories of persons or agencies experiencing dissatisfaction or affected (up to 8 allowed) |
| 18 | - | First category |
| 19 | - | Number of people in this category |
| 20 | - | Economic loss to those in this category |
| 21 | - | Time frame of economic loss |
| 22 | - | Reason for dissatisfaction |
| 23 | - | Pattern of dissatisfaction |
| 24 | - | Trend of dissatisfaction |
| 25 | - | Second category |
| ⋮ | | ⋮ |
| 73 | - | Trend of dissatisfaction of eighth category |

| Word # | | Content |
|---|---|---|
| 74 | - | Number of causal activities (up to 10 allowed) |
| 75 | - | First causal activity |
| 76 | - | Validity of information concerning this causal activity |
| 77 | - | Name location of causal activity |
| 78 | - | Number of grid points (up to 4 allowed) |
| 79 | - | Grid point 1 - X coordinate |
| 80 | - | Grid point 1 - Y coordinate |
| ⋮ | | ⋮ |
| 86 | - | Grid point 4 - Y coordinate |
| 87 | - | Number of people contributing to this cause |
| 88 | - | Economic worth of causal activity |
| 89 | - | Time frame of economic worth |
| 90 | - | Extent of contribution to affected activity |
| 91 | - | Pattern of occurrence of causal activity |
| 92 | - | Trend of causal activity |
| 93 | - | Number of environmental conditions altered by causal activity (up to 7 allowed) |
| 94 | - | First environmental condition |
| ⋮ | | ⋮ |
| 100 | - | Seventh environmental condition |
| 101 | - | Number of agencies having decision making authority (up to 7 allowed) |
| 102 | - | Name of first agency |
| 103 | - | Level of first agency |
| 104 | - | Pertinent function of first agency |
| ⋮ | | ⋮ |
| 123 | - | Pertinent function of seventh agency |

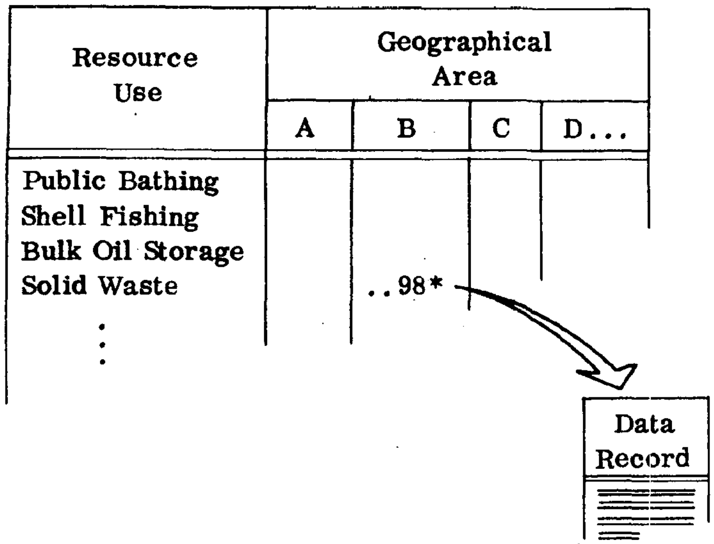
| Word # | | Content |
|---|---|---|
| 124 | - | Second causal activity |
| ⋮ | | ⋮ |
| 564 | - | Pertinent function of seventh agency pertaining to tenth causal activity |

A 564 word record would occur only if all data classification categories were completely utilized. Specifically this would result if all of the following occur:

- All locations require 4 grid point coordinates for specification.
- Eight categories of persons or agencies experience dissatisfaction or are affected
- Ten causal activities are involved, each causal activity altering seven environmental conditions, and each altered environmental condition involving seven agencies having decision-making authority.

The storage and retrieval of data from the RDF will be accomplished through the use of search matrices similar to those used in the EDF. Here again, columns may represent geographical sub-areas and rows, resource uses and problems. Time categories and level of detail of available information may be identified by cascading the matrices. The variable length records may be automated on an electronic computer simply by including a standard descriptive record preceding the data record which tells the computer what data is available and where it is located in the data record.

Figure A-2 shows a typical use of search matrices for retrieving data from the RDF. In this case there is only a single level of detail and time is not a factor. However, the elements of the first matrix can be coded to include information in addition to indicating where the data record is. For instance, a zero code indicates no resource use of problems at a location. A decimal number from 1 to 9 may indicate a relative level of usage with no problem but a digit in the tens place from 1 to 9 could be used to code the presence and severity of a problem created by a resource usage in the area. Another two digits may identify the planned usage of the area. This type of coding could be extended to include a great deal of information in the one matrix element in addition to indicating where the data record is located. This would enable extracting information a number of ways without




*..98 indicates a very high activity of solid waste disposal which is creating a severe problem.

Fig. A-2. An example of the use of coded search matrices in the RDF.

referring to the data record. For instance, all problems of a given severity or higher in an area could be identified by searching down the columns of the area. Also, all areas with a given problem of specified severity or higher could be identified by searching the row for that resource usage. The same could be done for planned usage.

## IV. Literature Reference File (LRF)

The LRF provides a listing of pertinent source documents that may be required for marine resource problem formulation, understanding or solution. A description of the document (author, title, abstract, type of publication, publisher, etc.) is given together with information regarding its availability. Such a listing of pertinent source material can be referenced according to the following categories of information:

- subject(s)
- author(s)
- date of publication
- region of study.

A number of literature referencing systems have been developed such as the KWIK Index developed by IBM. Initially, existing systems should be compared and evaluated in terms of their applicability to the literature reference system required for the marine environment.

Retrieval of data from the LRF will again make use of search matrices. Where there might be no geographical locations involved in this file, the columns could represent characteristics describing the available literature documents which the rows would represent. A binary yes-no code could be used as matrix elements to indicate the presence or absence of information pertaining to a characteristic for each document. Where the characteristic was applicable, the element would also locate the data file which would include reference information describing the document and where it can be obtained. Normally each document would have one data file and characteristics would be indicated by key words.

In many cases more than one characteristic may be required in a given document. In these cases it may be desirable to construct a search vector with binary elements corresponding to each characteristic or column. By using a one for each characteristic desired and a zero for those not wanted, the result of multiplying each document row with this vector gives an indication of how many of the desired characteristics are included in each document. An acceptable threshold could be specified so that only those documents equal to or greater than this would be considered. Simple sorting methods would then list these documents in descending order for further investigation. Where certain of the desired characteristics are more important than others, the vector elements could be weighted to a value greater than one, thus causing the results to be biased towards these characteristics.

Figure A-3 shows a typical use of a search vector for retrieving information from the LRF. This example is a case where water pollution laws are of primary concern with slight interest in biological studies having been conducted. Document 3 is clearly most applicable, with Document 4 a close second.

## V. A Review of Coordinate Grid Systems Available for Long Island.

### A. A Criteria for Selecting a Coordinate Grid System for Marine Resource Management

A grid system is needed for the purpose of organizing data pertinent to the

| Document | Characteristics | | |
|---|---|---|---|
| | Biol. Studies | Air Poll. Laws | Water Poll. Laws |
| 1 | 1 | 1 | 0 |
| 2 | 0 | 1 | 0 |
| 3 | 1 | 0 | 1 |
| 4 | 0 | 0 | 0 |
| . | | | |
| . | | | |
| . | | | |

$$\begin{array}{c} \underline{\text{Search}} \\ \underline{\text{Vector}} \end{array} \qquad \qquad \underline{\text{Doc}} \quad \underline{\text{Result}}$$

$$\begin{array}{c} A \\ B \\ C \end{array} \begin{bmatrix} 1 \\ 0 \\ 4 \end{bmatrix} \times \text{ Matrix } = \begin{array}{cc} 1 & 1 \\ 2 & 0 \\ 3 & 5 \\ 4 & 4 \end{array}$$

Fig. A-3. An example of the use of a weighted search vector in the LRF.

management of the marine resources of Nassau and Suffolk counties on Long Island. The system will perform at least three functions:

1. The grid will provide a system of x, y and z coordinates to locate the position of points in the marine environment.
2. The grid cells will serve as units of area and volume for aggregating data.
3. The grid system will serve as a framework for presenting data directly as output from a computer in the form of maps.

In comparing the merits of various grid systems, the following list of criteria may assist in arriving at the system that best suits the needs of the Nassau-Suffolk marine resources study. The following features would be desirable:

1. The grid system should conveniently fit Long Island, the outlying islands and the territorial waters of New York State.
2. The grid system should be capable of incorporating data organized by other grid systems. If mathematical formulas are available the conversions could be done automatically. by computer.

3. The grid system should be flexible enough to provide several scales or sizes of grid cells. Some problems will be dealt with in the context of a harbor, or bay, others may encompass all of the coastal waters of Long Island. The grid, then, must be flexible enough to aggregate data at various scales appropriate to the extent of the area and the nature of the problem under consideration.

4. The grid system should facilitate the collection of new data, and the reporting of phenomena, either by allowing automated conversion of data from other grid systems or by providing a simple, standard means of determining location by observers at any point in the marine environment, above, or below the surface of land and water.

## B. Grid Systems Available for Long Island Tri-State Transportation Commission Grid

The equal area grid system devised by the Tri-State Transportation Commission is adequate for locating points and aggregating land use data that can be identified on the aerial photographs used in their survey of the Tri-State region. There are several inherent disadvantages of the system. It is not yet possible to automatically convert the Tri-State grid coordinates into any other grid system, although the mathematical formulation is said to be conceptually possible. The Tri-State grid system is not geographically precise; distances measured by grid coordinates to not correspond to actual geographic distances because of cumulative errors inherent in the grid system.

Data of land use, population and transportation have been stored on computer tapes according to the grid system. The smallest areal unit by which land use data is aggregated is $\frac{1}{4}$ of a square mile. Most of the data applies to the urbanized region of Long Island that extends to about Riverhead in Suffolk County and excludes the two eastern forks.

None of the planning boards in Nassau or Suffolk County have adopted the grid system, nor do they use the data stored on tape, the reason being that the $\frac{1}{4}$ square mile grid is too coarse for local and county planning needs.

### Latitude and Longitude

The spherical coordinates of the earth's surface measured in degrees, minutes, and seconds of latitude and longitude comprise a grid system of angular rather than linear measurement. The shape of the grid cell is not square, and does not facilitate computer graphic displays. The arc of a second of longitude in the vicinity of Long Island represents a distance of about 75 feet; a second of latitude represents about 100 feet. Positions on Long Island can be expressed in 6 digits of latitude and longitude representing a tenth of a second to within $\pm$ 10 feet. The arc distance represented by a unit of latitude diminishes in moving northward. However, since the north-south dimension of Long Island is only about 35 minutes, the variation in arc distance is slight.

The Nassau-Suffolk Regional Planning Board and the Bureau of the Census are exploring the possibility of having 1970 census data recorded using the address coding guide prepared by the planning board. Node dots assigned to each block would be located by latitude and longitude using two whole numbers and four decimals for each coordinate. This system, if it proves feasible, would for the present only apply to the Towns of Nassau County and the four western towns of Suffolk County for which the address coding guide has been prepared.

State Plane Coordinate System

State plane coordinate systems were set up during the 1930's by the U.S. Coast and Geodetic Survey for each state in order to tie together all cadastral surveys of property boundaries into a standard, pricise network. One grid was established expressly for Long Island, using a cartographic projection and baseline alignment that minimized distortion. Positions may be expressed as distances in feet from the false origin located south and west of Long Island. United States Geodetic Survey quadrangles provide tick marks along the margins at intervals of 10,000 feet. The United States Geodetic Survey makes available tables giving the plane coordinates for 2-1/2 minute intersections of meridians and parallels within the limits of Long Island.

The State of New York does not require that legal descriptions of property boundaries be defined in terms of state plane coordinates. Only occasionally will large development tracts include state plane coordinates, according to the Nassau County Clerk.

Universal Transverse Mercator (UTM) Grid System

The Universal Transverse Mercator grid system was devised for military mapping purposes, and has been included on all recently revised United States

Geodetic Survey topographic maps. The grid system is called "universal" because each of the 1,000-meter grid squares is of the same size and shape. Under this system, the earth's surface has been divided into zones of 6° longitude; each zone is divided into 8° of latitude. This area is then further divided into 100 km squares and numbered from the southwest corner.

Several features of the UTM grid recommend it for use in the Nassau-Suffolk study. Locations in UTM coordinates may be translated into spherical coordinates of latitude and longitude and into state plane coordinates. Tables for converting from one system to another are available from the United States Geological Survey in Arlington, Virginia. Another advantage for the UTM grid system is its geographical precision; points are defined to within 100 meters. Also, the UTM grid is marked on the margins of United States Geodetic Survey top sheets at 1 km intervals.

The New York State Office of Planning Coordination (OPC) has adopted the UTM grid for storing data in its statewide inventory of land use and natural resources (LUNR). Aerial photos from which data is taken are at the same scale of USGS 7-1/2-minute quadrangles (1:2, 400). Since most of the state fits within a single UTM zone, the UTM grid of equal area and shape was a logical choice. Long Island has not yet been inventoried by OPC, but the work should be completed in the near future, according to the OPC staff.

The New York Department of Commerce is locating industrial sites by UTM grids for the portions of the LUNR survey as they are completed by OPC.

## C. Conclusion

The Tri-State grid aside from its geographical imprecision might become feasible if methods are devised to translate other grid systems into it automatically.

The other three systems have the advantage of converting coordinates of one system into another system, using tables and formulas provided by the U. S. Geological Survey. These three other systems—the UTM grid, New York State Coordinate grid, and the latitude—longitude grid—appear on USGS 7-1/2-minute quadrangles. (The UTM grid is only included on Long Island quadrangles revised since 1954.) None of these three systems have yet been used to organize data about Long Island. When the Office of Planning Coordination completes its statewide survey of Long Island,

land use and natural resource data will be available in $\frac{1}{4}$ square kilometer units of the UTM grid system. Any of these three systems would satisfy the criteria as stated above.

The Nassau-Suffolk Regional Planning Board does not presently use any of the grid systems considered above. The Board is considering the possibility of tying land use and transportation data to the census data origanized by block and located by latitude and longitude. The Tri-State and UTM grids have been discounted by the regional planning board because it is felt that land use data aggregated by grids of 1/4 square kilometer is in too coarse a form for local or county planning purposes. There seems to be no reason why the grid coordinates in either the state plan coordinate system or the UTM system could not be used instead of latitude and longitude. However, all three systems are translatable.

After reviewing the four coordinate grid systems available for Long Island, the Universal Transverse Mercator grid system is recommended for the Nassau-Suffolk marine resource management program. the UTM grid satisfies the criteria stated above. As the UTM coordinate grid system is compatible with most other grid systems, it could well become the basis for organizing and compiling all planning data for Long Island, not only marine resource data, but land use, upland natural resource, and population data as well.

## VI Development and Implementation of Data Storage and Retrieval Component

The development and implementation of the data storage and retrieval component of the MIS involves the following principal steps:

1. Identify and begin acquisition of all significant documents and data describing marine resources and the marine environment of Long Island and related social and economic information.

2. Evaluate literature reference systems and select system of greatest usefulness for the MIS. Write detailed specifications describing the content and format of the EDF and LRF and the methods to be employed in processing data and information into these formats. Section III of this appendix provides an example for the RDF. Error checking and quality control procedures must be specified. Techniques for updating and maintaining the files must also be included.

3. Establish initial guidelines which will be employed to determine the form in which data and information will be placed within the data storage and retrieval component. The EDF and RDF will be developed over a period of years as more complete and detailed environmental data and knowledge become available. The data and information are initially available from documents and in a variety of formats on punched cards and magnetic tapes. Guidelines must be determined to establish, on a priority basis, the order of incorporating the data into the standardized EDF and RDF elements of the data storage and retrieval component. The guidelines must reflect the need, use and potential benefits of the data to coastal zone planning and management. Obviously, the resources required to process the data must be evaluated. In effect, then, the guidelines must reflect cost effectiveness and cost benefit considerations. It should be noted that cost benefit and cost effectiveness models are included in the synthesis and analysis component of the MIS and these might be utilized in planning the development of the data storage and retrieval component of the system.

4. During the development period, the design of the data storage and retrieval component must be evaluated in terms of its efficiency of response to other components of the MIS. Specifically, the adequacy of responses to

- provide direct unprocessed output data to the executive control,
- provide data for problem verification and definition and for specifying an analytical approach in the analytical design component, and
- provide data for analysis in the synthesis and analysis component

must be reviewed and revised where problems are encountered.

## APPENDIX B. ENVIRONMENTAL RELATIONSHIPS COMPONENT

### I. Introduction

The environmental relationships component of the MIS specifies cause-condition-effect relationships which underlie problems associated with the marine environment. The matrices are required to organize the established "cause-condition-effect" relationships. These relationships in turn can be presented by computerization in the form of a network structure depicting the links. The matrix and networks concepts are described in the next section of this appendix. The construction and use of an environmental standard matrix is described in the third section. In the fourth section the important factors affecting the development of the environmental relationships component are discussed.

### II. Environmental Relationship Matrices and Derived Networks

The three basic matrices required to describe the cause-environmental condition-effects relationships are:

1. Causal factors x environmental conditions affected—describes the influence of specific causal factors (natural or man-controlled) on the level (or change in the level) of specific environmental conditions.

2. Changed environmental condition x environmental condition affected—describes the influence of a change in a specific environmental condition on other environmental conditions.

3. Changed environmental condition x human activity affected—describes the influence of the level (or change in level) of a specific environmental condition on specific marine related human activity.

An initial representation of these three matrices, Figs. B-1—B-3, is included for convenient reference in this appendix. As depicted here, a dot in a cell of the matrix does not indicate the quantitative or even necessarily qualitative nature of the relationship. Initially each cell of the matrices simply contains a "one" if a relationship exists, or potentially exists, and a "zero" if there is no relationship between the elements.

The design of the matrix and the procedure for obtaining derived networks depicting cause-environmental condition-effect relationships must account for the

|  |  | ONSHORE |  |  |  |  |  |  |  |  |  |  | OFFSHORE |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | WETLAND |  |  |  | AIR |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CAUSAL FACTORS |  | Surface elevation change | Surface area change | Surface shape change | Surface hydrology change | Subsurface geology change | Subsurface hydrology change | Surface cluttering - surface materials | Surface chemical composition change | Subsurface chemical composition change | Surface biological organism change | Subsurface biological organism change | Floor bottom topography change | Channel depth and/or width change | Shoaling (natural) | Pitting | Change in depth | Floor bottom shape change | Floor bottom material composition change | Change in chemicals on floor | Change in chemicals under floor | Change in biological organisms on floor | Solid material content change | Settleable, floating and suspended solids | Water temperature change | Surface water chemical changes | Subsurface water chemical changes | Surface water biological changes | Subsurface water biological changes | Surface area change | Surface chemical composition change | Subsurface chemical composition change | Biological composition change | Air particulate content change | Air clarity change | Airborne chemical agent content change | Change in visual appearance | Change in noise level | Generation of obnoxious odors | Change in level of radio activity |
| [illegible] | Air circulation | ● | ● | ● |  |  |  | ● |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  | ● | ● | ● |  |  |  | ● |
| [illegible] | Moisture-amount and distribution |  |  |  |  |  |  |  | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| [illegible] | Solar radiation |  |  |  |  |  |  |  |  |  | o |  |  |  |  |  |  |  |  |  |  | ● |  |  | ● |  |  | ● |  |  |  |  | ● |  |  |  |  |  |  |  |
| [illegible] | Water circulation | ● | ● | ● | ● | ● | ● |  | ● | ● | ● | ● | ● | ● | ● |  | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |  |  |  |  |  |  | ● |
| [illegible] | Erosion | ● | ● | ● | ● |  |  |  |  |  |  |  | ● | ● |  |  | ● | ● | ● |  |  |  |  | ● |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |
| [illegible] | Sedimentation | ● | ● | ● | ● |  |  |  |  |  |  |  | ● | ● | ● |  | ● | ● | ● | ● |  |  | ● |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |
| [illegible] | Crop production |  |  |  |  |  |  |  | ● | ● | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |
| [illegible] | Livestock production |  |  |  |  |  |  |  | ● |  | ● |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  | ● |  | ● |  |
| [illegible] | Pesticide and fertilizer application |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  | ● |  | ● |  |  |  | ● |  | ● |  |  | ● | ● | ● | ● |  | ● |  |  | ● |  |
| [illegible] | Finfishing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  | ● |  |  |  | ● |  | ● |  |
| [illegible] | Shellfishing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  | ● |  |  |  | ● |  |  |  |
| [illegible] | Aquiculture |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1.2.3.1 | Navigation improvements |  |  |  |  |  |  |  |  |  |  |  | ● | ● | ● | ● | ● | ● | ● |  |  | ● |  | ● |  |  |  |  |  | ● |  |  | ● |  |  |  |  |  |  |  |
| 1.1.2.3.2 | Coast facility improvements | ● | ● | ● |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  | ● |  |  |  |
| 1.1.2.4.1 | Food processing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |
| 1.1.2.4.2 | Oil refining |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1.2.4.3 | Metals and related fabrication |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1.2.5.1 | Sand and gravel mining | ● | ● | ● | ● |  |  |  |  |  | ● |  | ● | ● | ● | ● | ● | ● | ● |  |  | ● | ● | ● |  |  |  |  |  | ● |  |  |  |  |  |  | ● |  |  |  |
| 1.1.2.5.2 | Other mineral extraction |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1.2.6.1 | Drinking and other personal uses |  |  |  | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1.2.6.2 | Municipal uses |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1.2.6.3 | Irrigation |  |  |  | ● |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1.2.6.4 | Manufacturing and processing |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1.2.7.1 | Road building | ● | ● | ● | ● |  |  |  |  |  | ● |  |  |  | ● |  |  |  | ● |  |  | ● | ● | ● |  |  |  |  |  | ● |  |  | ● |  |  |  | ● |  |  |  |
| 1.1.2.7.2 | Facility construction |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  | ● |  |  |  |
| 1.1.2.7.3 | Land filling and draining | ● | ● | ● |  |  | ● |  |  |  | ● |  | ● |  | ● |  | ● |  | ● |  |  | ● | ● | ● |  |  |  |  |  | ● |  |  | ● |  |  |  | ● |  |  |  |
| 1.1.2.8.1 | Domestic disposal | ● | ● | ● |  |  |  | ● | ● | ● | ● | ● |  |  |  |  |  | ● | ● | ● | ● | ● | ● | ● |  | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |  | ● |  |
| 1.1.2.8.2 | Industrial disposal | ● | ● | ● |  |  |  | ● | ● | ● | ● | ● |  |  |  |  |  | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● | ● |  | ● | ● |
| 1.1.2.8.3 | Agricultural waste disposal |  |  |  |  |  |  |  | ● | ● | ● |  | ● | ● |  |  | ● | ● | ● | ● | ● | ● | ● | ● |  | ● | ● | ● | ● | ● | ● | ● | ● |  |  |  | ● |  |  |  |
| 1.1.2.8.4 | Dredging spoil disposal |  |  |  |  |  |  |  |  |  |  |  | ● | ● | ● |  | ● | ● | ● | ● |  |  | ● | ● |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  |
| 1.1.2.9.1 | Boating |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  | ● |  |  | ● |  |  |  |  |  |  |  | ● |  |  |  |
| 1.1.2.9.2 | Swimming and other water contact activities |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1.2.9.3 | Fishing |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ● |  |  |  |  | ● |  |  |  |  |  |  |  |
| 1.1.2.9.4 | Passive recreational activities |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 1.1.2.10.1 | Pest control spraying |  |  |  |  |  |  |  | ● | ● |  |  |  |  |  |  |  |  |  | ● |  | ● |  |  |  | ● |  | ● |  |  | ● |  | ● |  |  |  |  |  |  |  |

Fig. B-1. Causal factors affecting environmental conditions.

| | | ENVIRONMENTAL CONDITION AFFECTED | ONSHORE | | | | | | | | | | | OFFSHORE | | | | | | | | | | | | | | | | | WET-LAND | | | | AIR | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CHANGED ENVIRONMENTAL CONDITION | | Surface elevation change 1.2.1.1.1 | Surface area change 1.2.1.1.2 | Surface shape change 1.2.1.1.3 | Surface hydrology change 1.2.1.1.4 | Subsurface geology 1.2.1.1.5 | Subsurface hydrology change 1.2.1.1.6 | Surface cluttering - surface materials 1.2.1.1.7 | Surface chemical composition change 1.2.1.2.1 | Subsurface chemical composition change 1.2.1.2.2 | Surface biological organism change 1.2.1.3.1 | Subsurface biological organism change 1.2.1.3.2 | Floor bottom topography change 1.2.2.1.1.1 | Channel depth and/or width change 1.2.2.1.1.2 | Shoaling (natural) 1.2.2.1.1.3 | Pitting 1.2.2.1.1.4 | Change in depth 1.2.2.1.1.5 | Floor bottom shape change 1.2.2.1.1.6 | Floor bottom material composition change 1.2.2.1.1.7 | Change in chemicals on floor 1.2.2.1.2.1 | Change in chemicals under floor 1.2.2.1.2.2 | Change in biological organisms on floor 1.2.2.1.3.1 | Solid material content change 1.2.2.2.1.1 | Settleable, floating and suspended solids 1.2.2.2.1.2 | Water temperature change 1.2.2.2.1.3 | Surface water chemical changes 1.2.2.2.2.1 | Subsurface water chemical changes 1.2.2.2.2.2 | Surface water biological changes 1.2.2.2.3.1 | Subsurface water biological changes 1.2.2.2.3.2 | Surface area change 1.2.3.1.1 | Surface chemical composition change 1.2.3.2.1 | Subsurface chemical composition change 1.2.3.2.2 | Biological composition change 1.2.3.3.1 | Air particulate content change 1.2.4.1.1 | Air clarity change 1.2.4.1.2 | Airborne chemical agent content change 1.2.4.2.1 | Change in visual appearance | Change in noise level | Generation of obnoxious odors | Change in level of radio activity |
| ONSHORE | Surface elevation change | 1.2.1.1.1 | |●|●|●| |●| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |●| | | |
| ONSHORE | Surface area change | 1.2.1.1.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | |●| | | | | | |●| | | |
| ONSHORE | Surface shape change | 1.2.1.1.3 |●| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |●| | | |
| ONSHORE | Surface hydrology change | 1.2.1.1.4 |●| |●| | |●| |●|●|●| | | | | | | | | | | | | | | | | | | |●| | | | | | | | | |
| ONSHORE | Subsurface geology | 1.2.1.1.5 | | | | | |●| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ONSHORE | Subsurface hydrology change | 1.2.1.1.6 | | | | | | | |●|●| | | | | | | | | | | |●| | | | |●|●| | | |●|●| | | | | | | | |
| ONSHORE | Surface cluttering - surface materials | 1.2.1.1.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |●| | | |
| ONSHORE | Surface chemical composition change | 1.2.1.2.1 | | | | | | | | |●|●| | | | | | | | | | | | | | |●| | | | |●| | | | | | | |●| |
| ONSHORE | Subsurface chemical composition change | 1.2.1.2.2 | | | | | |●| | | | | | | | | | | | | | | | | | |●|●| | | |●| | | | | | | |●| |
| ONSHORE | Surface biological organism change | 1.2.1.3.1 | | | | | | | |●|●| | | | | | | | | | | | | | | | | | | | | | | | | | |●| | | |
| ONSHORE | Subsurface biological organism change | 1.2.1.3.2 | | | | | | | | | |●| | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OFFSHORE | Floor bottom topography change | 1.2.2.1.1.1 | |●| | | | | | | | | | |●| | | |●| | | |●| | |●| | | | | |●| |●| | | | | | | |
| OFFSHORE | Channel depth and/or width change | 1.2.2.1.1.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | |●|●| | | | | | | | | |
| OFFSHORE | Shoaling (natural) | 1.2.2.1.1.3 | | | | | | | | | | |●|●| | | |●|●| | | | | | | | | | |●|●| |●| | | | | | | |
| OFFSHORE | Pitting | 1.2.2.1.1.4 | | | | | | | | | | |●|●| | | |●|●| | | | | | | | | | | | | | | | | | | | | | |
| OFFSHORE | Change in depth | 1.2.2.1.1.5 | |●| | | | | | | | | |●|●| | | | | | | | | | |●| | | | |●| | | | | | | | | | |
| OFFSHORE | Floor bottom shape change | 1.2.2.1.1.6 | | | | | | | | | | |●|●|●| | | | | | |●| | | | | | | |●| | | | | | | | | | |
| OFFSHORE | Floor bottom material composition change | 1.2.2.1.1.7 | | | | | | | | | | | | |●| | | | | | |●| | | | | | | | | | |●| | | | | | | |
| OFFSHORE | Change in chemicals on floor | 1.2.2.1.2.1 | | | | | | | | | | | | | | | | | | | |●| | | | | | | | | | |●| | | | | |●| |
| OFFSHORE | Change in chemicals under floor | 1.2.2.1.2.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| OFFSHORE | Change in biological organisms on floor | 1.2.2.1.3.1 | | | | | | | | | | | |●|●| |●| |●| | | | | | | | | | | | | | | | | | | | |●| |
| OFFSHORE | Solid material content change | 1.2.2.2.1.1 | | | | | | | | | | | |●|●| |●| | | | | | |●| | | | | | | | | | | | | | | | |
| OFFSHORE | Settleable, floating and suspended solids | 1.2.2.2.1.2 | | | | | |●| | | | |●|●|●| |●|●|●|●| |●|●| | | | |●| | | | |●| | | |●| | | |
| OFFSHORE | Water temperature change | 1.2.2.2.1.3 | | | | | | | | | | | | | | | | | | | |●| | | |●| |●| | |●| |●| | | | | | |●| |
| OFFSHORE | Surface water chemical changes | 1.2.2.2.2.1 | | | | | | | | | | | | | | | | | | | |●| | | | | |●| | | | | | | | | | | |●| |
| OFFSHORE | Subsurface water chemical changes | 1.2.2.2.2.2 | | | | | | | | | | | | | | | | | | | | | | | |●| | | | | | | | | | | | | |●| |
| OFFSHORE | Surface water biological changes | 1.2.2.2.3.1 | | | | | | | | | | | | | | | | | | | |●|●|●| | | | | | | | |●| | | |●| |●| |
| OFFSHORE | Subsurface water biological changes | 1.2.2.2.3.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WET-LAND | Surface area change | 1.2.3.1.1 |●| | | | | | | | | | | | | | | | | | | |●| | |●| | | | | | | | | | | |●| | | |
| WET-LAND | Surface chemical composition change | 1.2.3.2.1 | | | | | | | | | | | | | | | | | | | | | | | |●| | | | | | |●| | | | | |●| |
| WET-LAND | Subsurface chemical composition change | 1.2.3.2.2 | | | | | | | | | | | | | | | | | | | | | | | |●| | | | | | | | | | | | | | |
| WET-LAND | Biological composition change | 1.2.3.3.1 | | | | | | | | | | | |●| | | | | | | | |●|●| | |●|●| | |●| | | | | |●| |●| |
| AIR | Air particulate content change | 1.2.4.1.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |●| |●| | | |
| AIR | Air clarity change | 1.2.4.1.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |●| | | |
| AIR | Airborne chemical agent content change | 1.2.4.2.1 | | | | | | | |●| |●| | | | | | | | | | | | | | | | | | | | | | | | | |●| | | |
| | Change in visual appearance | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Change in noise level | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Generation of obnoxious odors | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Change in level of radio activity | | | | | | | | |●|●|●| | | | | | | | | |●|●| | | |●|●|●| | |●|●|●| | |●| | | | |

Fig. B-2. Interaction among environmental conditions.

| | | HUMAN ACTIVITY AFFECTED<br>Crop production 1.3.1.1 | Livestock production 1.3.1.2 | Pesticide and fertilizer application 1.3.1.3 | Finfishing 1.3.2.1 | Shellfishing 1.3.2.2 | Aquiculture 1.3.2.3 | Navigation improvements 1.3.3.1 | Coast facility improvements 1.3.3.2 | Food processing 1.3.4.1 | Oil refining 1.3.4.2 | Metals and related fabrication 1.3.4.3 | Sand and gravel mining 1.3.5.1 | Other mineral extraction 1.3.5.2 | Drinking and other personal uses 1.3.6.1 | Municipal uses 1.3.6.2 | Irrigation 1.3.6.3 | Manufacturing and processing 1.3.6.4 | Road building 1.3.7.1 | Facility construction 1.3.7.2 | Land filling and draining 1.3.7.3 | Domestic disposal 1.3.8.1 | Industrial disposal 1.3.8.2 | Agricultural waste disposal 1.3.8.3 | Dredging spoil disposal 1.3.8.4 | Boating 1.3.9.1 | Swimming and other water-contact activities 1.3.9.2 | Fishing 1.3.9.3 | Hunting 1.3.9.4 | Passive recreational activities 1.3.9.5 | Pest control spraying 1.3.10.1 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CHANGED ENVIRONMENTAL CONDITION** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ONSHORE — Surface elevation change | 1.2.1.1.1 | ● | ● | ● | | | | | ● | ● | | | | | | | | | ● | ● | ● | | | | | | | | | | |
| Surface area change | 1.2.1.1.2 | | | | | | | | ● | | | | | | | | | | ● | ● | ● | | | | | | ● | | | ● | |
| Surface shape change | 1.2.1.1.3 | | | | | | | | ● | | | | | | | | | | ● | ● | ● | | | | | | | | | | |
| Surface hydrology change | 1.2.1.1.4 | ● | ● | | | | | | | | | | | | ● | | ● | | | | | ● | ● | ● | | ● | | ● | | ● | |
| Subsurface geology change | 1.2.1.1.5 | | | | | | | | | | | | | | ● | ● | ● | ● | | | | | | | | | | | | | |
| Subsurface hydrology change | 1.2.1.1.6 | ● | | | | | | | | | | | | | ● | ● | ● | ● | | ● | ● | | | | | | | | | | |
| Surface cluttering - surface materials | 1.2.1.1.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | ● | |
| Surface chemical composition change | 1.2.1.2.1 | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | ● | ● | ● | | |
| Subsurface chemical composition change | 1.2.1.2.2 | | | | | | | | | | | | | | ● | ● | ● | ● | | | | | | | | | | | | | |
| Surface biological organism change | 1.2.1.3.1 | ● | ● | | | | | | | | | | | | ● | | | | | | | | | | | | | | | | |
| Subsurface biological organism change | 1.2.1.3.2 | | | | | | | | | | | | | | ● | | | | | | | | | | | | | | | | |
| OFFSHORE — Floor bottom topography change | 1.2.2.1.1.1 | | | | ● | ● | ● | ● | ● | | | | ● | | | | | | | | | | | | | ● | ● | ● | | | |
| Channel depth and/or width change | 1.2.2.1.1.2 | | | | ● | ● | | ● | ● | | | | | | | | | | | | | | | | | ● | | | | | |
| Shoaling (natural) | 1.2.2.1.1.3 | | | | ● | ● | | ● | ● | | | | ● | | | | | | | | | | | | | ● | ● | | | | |
| Pitting | 1.2.2.1.1.4 | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | | |
| Change in depth | 1.2.2.1.1.5 | | | | ● | ● | | ● | ● | | | | ● | | | | | | | | | | | | | ● | ● | ● | | | |
| Floor bottom shape change | 1.2.2.1.1.6 | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | ● | ● | ● | | | |
| Floor bottom material composition change | 1.2.2.1.1.7 | | | | ● | ● | ● | | | | | | ● | | | | | | | | | | | | | | ● | ● | | | |
| Change in chemicals on floor | 1.2.2.1.2.1 | | | | ● | ● | | | | | | | | | | | | | | | | | | | | | ● | ● | | | |
| Change in chemicals under floor | 1.2.2.1.2.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Change in biological organisms on floor | 1.2.2.1.3.1 | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | | ● | ● | | | |
| Solid material content change | 1.2.2.2.1.1 | | | | | | | | | | | | ● | | | | | | | | | | | | | | | | | | |
| Settleable, floating and suspended solids | 1.2.2.2.1.2 | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | ● | ● | ● | | | |
| Water temperature change | 1.2.2.2.1.3 | | | | ● | ● | ● | | | | | | | | | | | ● | | | | | | | | ● | ● | ● | | | |
| Surface water chemical changes | 1.2.2.2.2.1 | | | | ● | ● | | | | | | | | | | | | ● | | | | | | | | | ● | ● | | | |
| Subsurface water chemical changes | 1.2.2.2.2.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Surface water biological changes | 1.2.2.2.3.1 | | | | ● | ● | ● | | | | | | | | | | | ● | | | | | | | | | ● | ● | | | |
| Subsurface water biological changes | 1.2.2.2.3.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| WET-LAND — Surface area change | 1.2.3.1.1 | | | | ● | ● | | ● | | | | | | | | | | | | | | | | | | ● | ● | ● | ● | ● | |
| Surface chemical composition change | 1.2.3.2.1 | | | | ● | ● | ● | | | | | | | | | | | | | | | | | | | | ● | ● | ● | | |
| Subsurface chemical composition change | 1.2.3.2.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Biological composition change | 1.2.3.3.1 | | | | ● | ● | ● | ● | | | | | | | | | | ● | | | | | | | | ● | ● | ● | ● | | |
| AIR — Air particulate content change | 1.2.4.1.1 | ● | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | ● | |
| Air clarity change | 1.2.4.1.2 | | | | | | | | | | | | | | | | | | | | | | | | | ● | | | | ● | |
| Airborne chemical agent content change | 1.2.4.2.1 | ● | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Change in visual appearance | | | | | | | | ● | | | | | | | | | | | ● | ● | ● | | | | | ● | ● | | | ● | |
| Change in noise level | | | ● | | | | | | | | | | | | | | | | | ● | | | | | | ● | ● | ● | ● | ● | |
| Generation of obnoxious odors | | | | | | | | | | | | | | | | | | | | ● | | | | | | | ● | ● | ● | ● | |
| Change in level of radio activity | | ● | ● | | ● | ● | ● | | | ● | | | | | ● | ● | ● | ● | | | | | | | | | ● | | | ● | |

Fig. B-3. Environmental conditions affecting human activities.

following:

1. Depending on the manner in which a problem is defined, a manager or planner may wish to examine the problem starting with either a causal factor or an affected human activity. Thus, the matrices must be capable of yielding networks derived from either starting point.

2. Initially the cells of the matrix may contain only a "zero" or "one" indicating the presence or absence of a relationship between the elements defining the cell. However, as further research is conducted and information collected it will be possible, based on expert judgment, to specify the nature of the relationship in more objective but still qualitative terms (e.g., the degree of interaction on a 0—9 scale). Finally as additional knowledge is acquired it will be possible to specify the relationship in either an exact (mathematical) or in probabilistic (statistical) form. The matrices will, in effect, provide a mechanism for organizing and catloging research results; and hence must be flexibly designed with efficient accessing procedures for periodic expansion and updating of content. This comment applies both to the content of the individual cells and the dimensions of the matrices (number of elements included on either axis).

Figure B-4 illustrates conceptually the relationship between the three causal matrices. Starting with a given causal factor, two network diagrams are derived. In the first diagram all relationships are accounted for. This would be the only possible derived network from a set of "zero-one" or "yes-no" matrices defining only whether a relationship exists between the elements of the matrix. It is envisioned, however, that the matrices will be updated to describe the nature or strength of the relationships by using a coded value (e.g., 0—9, or another appropriate scale of numbers). This can be accomplished without having a complete quantitative description of the relationship between two elements of a matrix. It will, in fact, be necessary for the identification and solution of many problems. When all possible relationships are accounted for, and stored in the MIS in the matrix framework including those which are weak, they can be displayed in output format as networks or "decision tree" diagrams (see Figs. III-2 and B-4). We recognize that extremely complex networks will result in many instances, and it may be difficult to identify critical information. A simplified network can be derived from some problems, however, if only the very strong, critical relationships are included. For many pro-

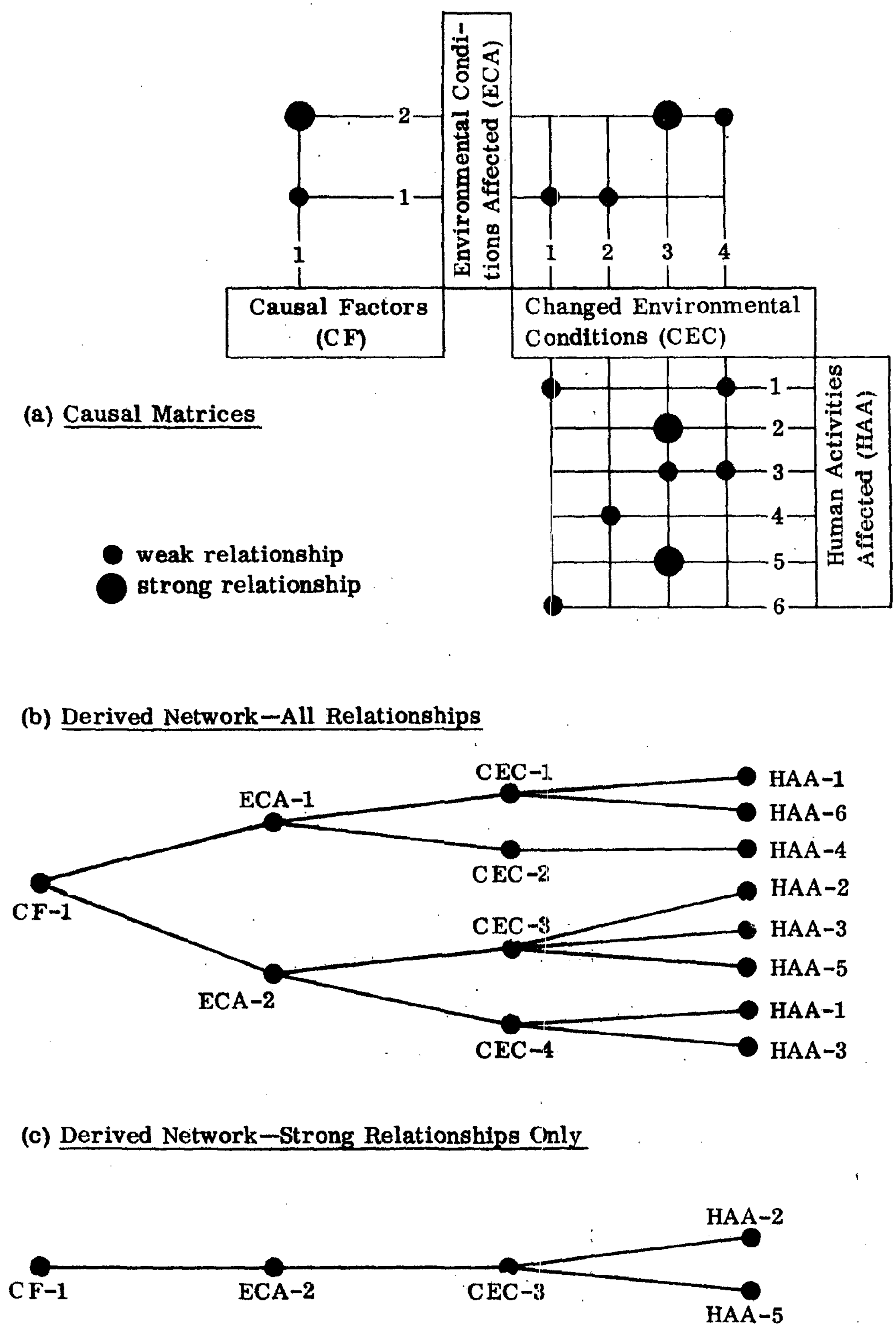



Fig. B-4. Conceptual example of network derived from the causal matrices.

blems and activities it will undoubtedly be desirable to consider both a network depicting all relationships and one showing only the critical relationships. The potential complexity of the derived networks can be verified simply by starting with a given causal factor, e.g., erosion, road building and tracing through the three causal matrices to determine the environmental conditions affected directly (ECA), Fig. B-1 and those changed (CEC), Fig. B-2, and the corresponding human activities affected (HAA), Fig. B-3. It is clear that a manual, problem by problem, development of the required networks will consume considerable time and effort. The development schedule for the MIS, given in Section V of the report, was prepared with the recognition that it would be desirable to begin employing the computer for this purpose during or by the end of the first year if possible.

The causal matrices and the networks derived from them allow a great deal of flexibility in approaching problems dealing with uses of the marine environment. The structure permits problems to be approached in the following three ways:

- Given a causal factor, one can determine the affected environmental conditions and changes in these conditions and hence the human activities that are affected.
- Given a human activity, one can determine the changes in environmental conditions that are important and the causal factors that can affect these changes.
- Given a changing environmental condition, one can determine the human activities affected and the causal factors related to the changing environmental conditions.

Thus, the planner and manager will be able to establish causal relationships starting with any of the following:

- a causal factor, e.g., sand and gravel mining,
- a changed environmental condition, e.g., surface water chemical changes, or
- a human activity affected, e.g., fishing.

Thus far, we have discussed the evolution of the causal matrices through two stages of development. In their initial form, the matrices define whether a relationship exists and in the second stage of development the matrices depict qualitative estimates of the strength of the relationship. In the third stage of development, a quantitative description of the relationship will be utilized when available.

In the third stage, each cell of the causal matrix will be coded to indicate both the strength of the relationship and whether a quantitative (mathematical or statistical) description of the relationship exists. The information required to locate the quantitative relationship within the MIS will be stored in a separate matrix in the environmental relationships component. The quantitative relationships will be obtained in three ways.

- Environmental relationships component—An environmental relationships file (ERF) will be established to contain simple or compact mathematical and probabalistic relationships.
- Synthesis and analysis component—Many of the relationships will be quantified through the use of environmental simulation models that are either on-line or off-line elements of this system component.
- Data storage and retrieval—Some of the more complex quantitative relationships will be available in documents described in the LRF.

In this third stage of development of the causal matrices, the importance of a flexibly designed MIS and the value of increased computerization of the system become very evident.

## III. Environmental Standards Matrix

A fourth matrix included in the environmental relationships component of the MIS will describe Environmental Conditions Standards × Human Acitivity This matrix will contain quantitative data limits as specified by standards or requirements for various descriptors of the marine environment in relation to categories of human activities. It is clear that the comments in Section II regarding computer design apply here also, as this matrix will be frequently updated and expanded to reflect changing and more comprehensive marine environmental standards. The MIS should have the capability to provide standards information automatically, on option, along with relationships established by the Changing Environmental Condition × Human Activity Affected matrix discussed in the preceding section.

## IV. Development and Implementation of Environmental Relationships Component

Initially the matrices described in the preceding sections will be contained in a handbook along with a number of derived networks that have been developed in response to the most frequent planning and management requirements. An evolution toward computerization of the environmental relationships component of the MIS, however, will be required as:

1. an increased number of qualitative relationships are developed along with a judgment as to strength of the relationships,
2. quantitative relationships replace qualitative relationships to describe the relation between elements of the matrices,
3. the complexity of planning and management decisions requires a large volume of derived network linkages, and
4. the number and complexity of defined environmental standards increases.

## APPENDIX C. ANALYTICAL DESIGN COMPONENT

### I. Introduction

The analytical design component of the MIS provides the mechanism for identifying steps required to conduct the analysis of a particular problem or planning objective. Given a request, the appropriate approach for that request will be extracted from this component and used to provide the information that will best suit the needs of the decision making body.

Approaches are needed for each of the significant problem types or classes which come up frequently enough to warrant the development of standardized procedures.

### II. Content and Format of the Analytical Design

The analytical design for a particular problem can be formulated in the form of a list of sequential steps to be taken and the decision points and "branches" or paths which will be followed, depending upon interim results, as the analysis progresses. The approach can also be depicted in the form of a flow diagram containing the same decision points and alternative paths. The approach will specify:

- data needed for analysis
- questions to be answered
- procedures for acquiring answers
- alternative steps to be followed depending upon adequacy of data
- alternative steps to be followed depending upon results
- criteria to be used in determining which path to follow
- guidelines for evaluating and selecting alternatives to be presented for the decision maker
- output information and format required for presentation.

Figures IV-11 and IV-12 (extracted from the main body of the report) illustrate the initial formats which the analytical design for a particular problem will take.

### III. Development and Implementation of Analytical Design Component

The analytical design component will be developed in a problem by problem sequence with a priority established by the importance of the problem.

Fig. IV-10. Illustration of Class 3 use—analytical design.

1. For location of the problem retrieve information on acceptable activities (Data Storage and Retrieval Component).
2. If the activity desired is not compatible with those acceptable reject the problem and inform initiator that his activity is not a "conforming" use. Stop the analysis.
3. If the activity is compatible retrieve data for the location on the particular environmental conditions (from DS & R).
4. If current data does not exist determine if the problem warrants data collection. If not notify the initiator and stop the analysis. If it does, get action started and postpone further analysis until data is available.
5. If there is current data compare its values with the limits and range within which the desired activity can be conducted from Environmental Relationships Components).
6. If the observed data values fall within the acceptable range so notify the initiator and stop the analysis.
7. If the observed data values are outside the acceptable range check the past data against the current data to ascertain the trend in condition. If it is constant on decreasing in severity inform the initiator and stop the analysis (from D & SR).
8. If the conditions have deteriorated search for potential causes of the change. Identify the network links which lead to changes in this particular condition (from ER).
9. Using data on activities (from DS & R) and the relationships in the links (from ER) attempt to identify an existing activity which is likely to be the cause. Use data (from DS & R) as necessary to perform the analysis. (For example, water circulation patterns, direction and velocity will help to identify sources of a particular water pollution incident.)
10. If data or knowledge are not adequate to reach a reliable conclusion seek expert judgment outside the system and stop the analysis or collect data and do research, model studies (S & A).
11. If a cause is established identify and evaluate possible solutions. Such solutions may include:
    - do nothing
    - stop the causal activity
    - alter the causal activity
12. Present the data and information for the decision body to act upon. Cause-effect relationships, alternative actions, values and impacts of each alternative. Stop the analysis.

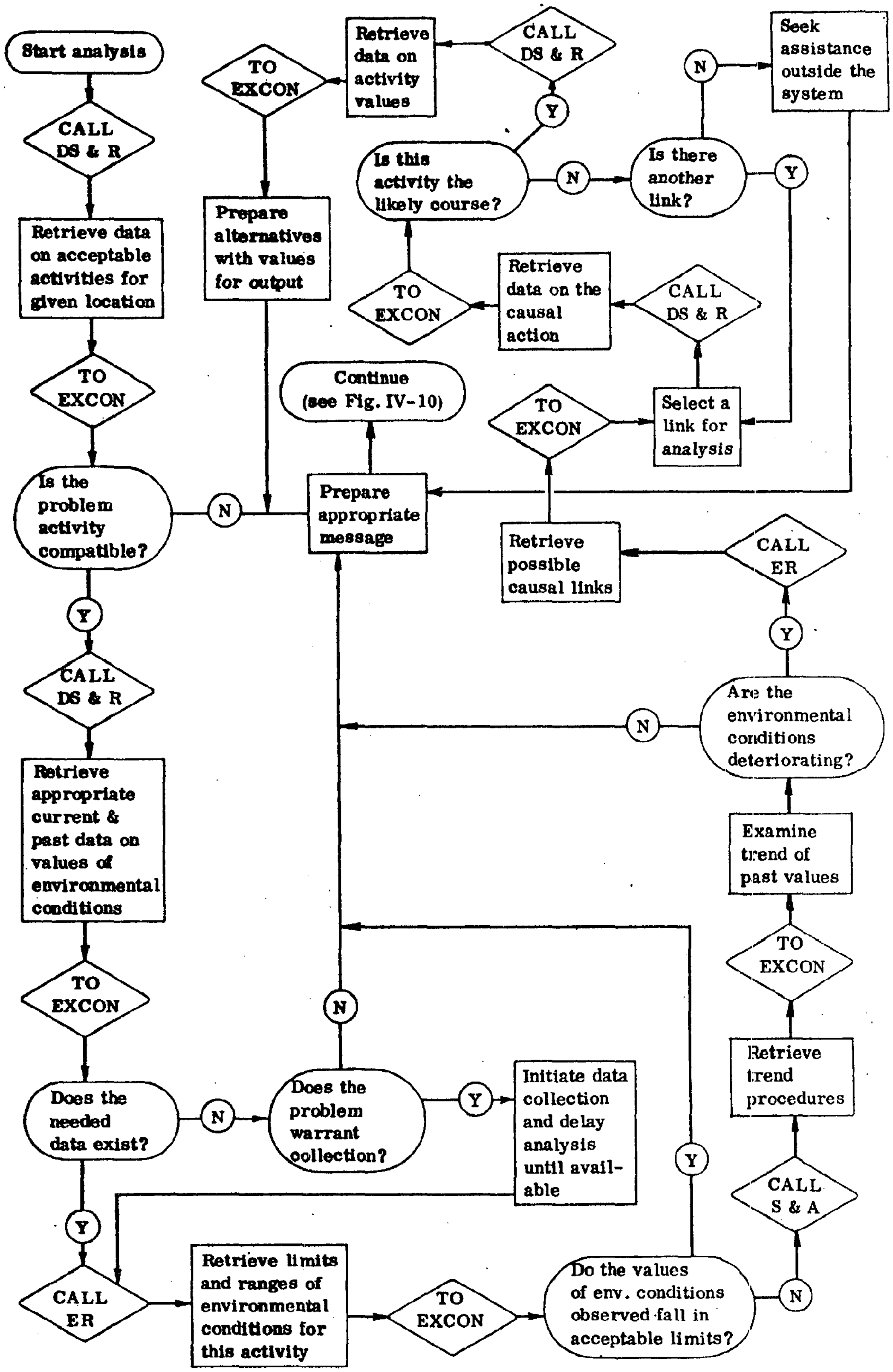



Fig. IV-11. Illustration of Class 3 use—based on analytical design.

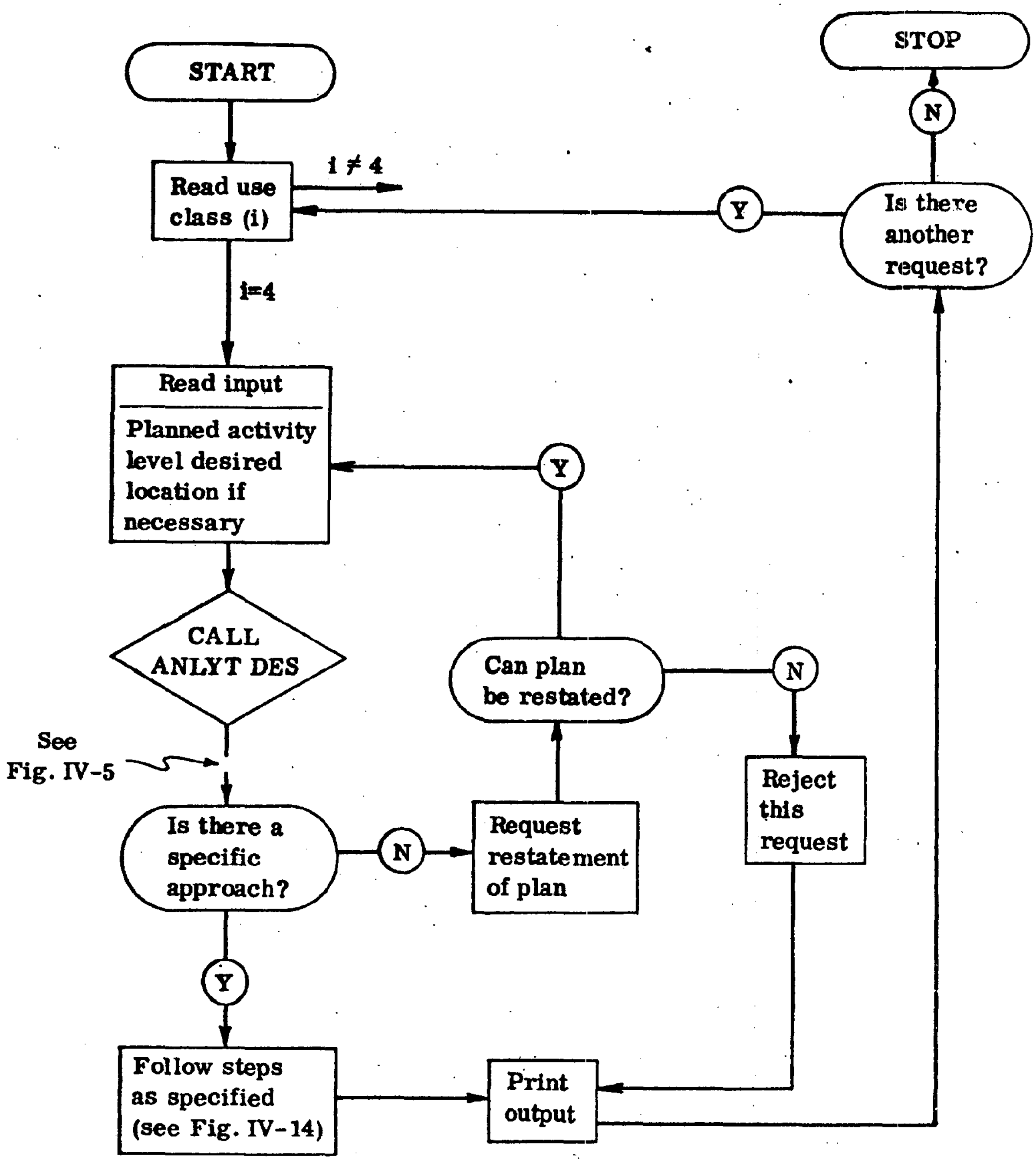



Fig. IV-12. Illustration of Class 4 use—executive control.

The initial format of an approach will be as a list of instructions to be sequentially followed by the analyst. As the system evolved into a more sophisticated form the lists will be converted into complete flow diagrams which will then not only guide the analyst, but will also serve as a guide for programming the approach for computer applications.

The special studies for water supply and waste water management, dredging, coastal erosion and wetlands form the background information for the first four approaches to be formally specified.

Following these, the development will be concentrated on the different approaches for specific planning activities. These should be available by the end of the first development year.

Beyond the first year additional approaches will be developed and, those that have been developed will be applied, evaluated and altered as necessary to make them truly operational.

Computerization of the analytical design component will not be practical under the present state of knowledge because of the tremendous variability in the possible results and different paths which can be followed. There will be a number of places in an analysis where the judgment of the analyst will necessarily supersede any formalized approach. This condition will hold for the forseeable future.

When computerization is undertaken the initial form will require a constant monitoring by the analyst who will still perform the major decision function in an analysis.

## APPENDIX D. SYNTHESIS AND ANALYSIS COMPONENT

### I. Introduction

The synthesis and analysis component of the MIS provides the function of combining and analyzing quantitative data to yield specific and interpretable information to the manager and planner. The analytical techniques available can be grouped into four general categories:

(a) objective analysis on a geographical basis
(b) statistical analysis,
(c) environmental simulation models and
(d) cost benefit/cost effectiveness models.

This appendix lists some available analytical methods that would be considered for inclusion in the synthesis and analysis component. Most of the analytical methods and models would not be an integral part of the computerized synthesis and analysis component of the MIS, but will be available on call for use as required.

### II. Objective Analysis on a Geographical Basis

A variety of objective analysis techniques exist for obtaining values of a variable at regularly spaced intervals (grid points) from values observed at irregularly spaced observation points. Some of these techniques (for example the first one described below) have been used operationally in the field of meteorology for over a decade. They can be applied with little or no adaptation to the needs of the MIS. The three techniques cited below are typical examples of those which are available.

- Successive Approximation Technique (SAT)[1/]—Interpolated values of the variable are obtained at each grid point by means of a series of corrections made to the initial value at the grid point (initial guess). Each observation within a given radius of the grid point is used in the correction and is weighted according to its distance from the grid point.

[1/] Cressman, G. P., 1959: An Operational Objective Analysis System. Monthly Weather Review, 87, 10, pp. 367—374.

- Conditional Relaxation Analysis Method (CRAM)[2/]—CRAM is a procedure for interpolating between observations. It requires that the grid point values satisfy Poisson's equation, subject to constraints imposed by the observations and boundary values.

- Numerical Variational Analysis[3/]—This analysis approach uses diagnostic and prognostic equations to supplement observations.

## III. Statistical Analysis

A large number of "standard" statistical analysis techniques are available for developing, describing and evaluating the significance of relationships. These statistical methods are described in many comprehensive texts on statistical analysis and for this reason most techniques are simply listed below without further comment.

- Computation of "simple" statistical measures: mean, mode, median,standard deviation, variance, etc.

- Simple data tabulations: histograms, contingency tables, scatter diagrams, etc.

- Random number generation; Monte Carlo Analysis

- Bivariate Correlation Analysis; Partial Correlation

- Multiple Regression Analysis

- Regression Estimation of Event Probabilities[4/]—This technique provides separate regression equations for predicting the probability of occurrence of each category of a predictand.

- Analysis of variance

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[2/] Thomasell, A. and J. G. Welsh, 1963: Studies of Techniques for the Analysis and Prediction of Temperature in the Ocean. Report 7046-70, The Travelers Research Center, Inc., Hartford, Conn.

[3/] Sasaki, Y., 1970: Some Basic Formalisms in Numerical Variational Analysis. Monthly Weather Review, 98, 12, pp. 875—898.

[4/] Miller, R. G., 1964: Regression Estimation of Event Probabilities, Report 7411-121, The Travelers Research Center, Inc., Hartford, Conn.

- Factor Analysis—An analysis of variance technique used to examine two—or higher order dimensional arrays to determine significant relationship patterns and data groupings.

- Power Spectral Analysis—Spectral analysis is used extensively in the field of meteorology to determine the statistical mean energy that is found at various scales of motion.

- Statistical Significance Tests—A variety of tests exist to examine the significance of a distribution or relationship, i.e., the probability that the distribution or relationship was not due to chance. These include the Chi-square test, F-test, Students t-test, and tests of the fit of a sample to the normal or Poisson distributions.

## IV. Environmental Simulation Models

Three classes of models were described in CEM Report 4047-411[5/] as being potentially applicable to the Long Island coastal environment and are summarized below.

- Hydraulic models are small-scale three dimensional replicas of rivers and harbors. They are typically constructed at scales in the order of 1:1000 in the horizontal and 1:100 in the vertical. These models might be expected to explain aspects of tidal circulation, and salinity patterns as they are influenced by shoaling, wind and storm actions, dredging, freshwater flow and tidal action. The Corps of Engineers has constructed hydraulic models for Fire Island Inlet and Moriches Inlet on the south shore of Long Island.

- Hydrodynamic models based on the equations of motion and continuity for a fluid particle are used to examine circulation patterns. The computations require the use of high speed computing facilities and yield the velocity field and the water height field for a given body of water. The models are employed to study storm surge, shoaling, flow through inlets, and salinity patterns. A two dimensional hydrodynamic model of Jamaica Bay is currently being investigated. A second model appropriate for bays, is available in a general form with a complete listing of the requisite computer program and instructions for its use.

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[5/] Ortolano, L. and P. S. Brown, 1970: The Movement and Quality of Coastal Waters: A Review of Models Relevant to Long Island, New York. CEM 4047-411, The Center for the Environment and Man, Inc., Hartford, Conn.

- Water Quality models are mathematical representations designed to assess the mixing, transport and reactions of substances contained in wastewater discharges. They are useful for predicting the concentration of wastewater constituents in coastal waters as a function both of time and space. A two dimensional form of the advection-diffusion equation is being used to model water quality in Jamaica Bay.

## V. Cost Effectiveness/Cost Benefit Methods

A large number of cost effectiveness/cost benefit methodologies have been developed to compare costs of carrying out a series of activities, determine the relative effectiveness of alternative activities and estimate the various benefits that would be derived from each activity. The cost effectiveness method discussed below is one example of the methodologies that have been developed.

A cost effectiveness methodology has been developed recently[6/] which considers

- data collection requirements,
- data collection platforms, and
- quantified expert judgment.

The model is designed for evaluation of marine environmental data collection systems. The model incorporates quantified expert judgment concerning data users' requirements and estimates of system performance and costs. This requirements information is obtained in the form of non-linear Relative Worth Curves relating worth of data and the capability to meet stated requirement characteristics, and also in the form of relative weights (or, priorities) for parameters, layers, sites and regions. Computer programs and instructions for their use have been prepared for each of the three components:

- Capability Model,
- Reliability Model, and
- Regional Effectiveness Model.

[6/] Northrop, G. M., E. L. Davis, E. R. Sweeton and F. L. Bartholomew, 1970: A Cost Effectiveness Methodology for Environmental Data Collection System. CEM Report 4053-430, The Center for the Environment and Man, Inc., Hartford, Conn.

In addition to the above analyses, the benefits to be derived from alternative systems can be compared to system costs in Cost-Benefit analysis. The methodology described above could also be adopted to evaluate the economic impacts of alternative uses of marine resources.

## VI. Development and Implementation of Synthesis and Analysis Components

The development and implementation of the synthesis and analysis component of the MIS can logically be described by the steps outlined below.

1. Assemble information on the analytical methods and models listed above. The information should include

   - a complete description of the technique, its complexity and the type of applications for which the technique is most appropriate,
   - a discussion of the input data required, computations involved and output data and information obtained, and
   - a description of the computational hardware requirements (desk calculator, small computer, large computer, etc.) and the source for the technique and model (text book, binary deck, magnetic tape, etc.)

2. Considering the knowledge requirements of managers and planners, select those techniques and models that are most valuable for inclusion in the synthesis and analysis component.

3. Determine those techniques and models, which because of their simplicity or high rate of use, should be included directly "on-line" within the synthesis and analysis component. This might include for example the computation of simple statistical measures (mean, variance) and capability for simple statistical data tabulations (histogram or frequency tabulations and contingency tables).

4. Develop a complete "on-line" description of all other techniques and models. This will include a discussion of the analysis technique, its input data requirements, its location and form, and how the technique is input to the MIS system.

## APPENDIX E. EXECUTIVE CONTROL COMPONENT

### I. Introduction

The purpose of the Executive Control Component is primarily to serve as the interface between man and machine in that the input language used by the analyst must be translated to direct action by the system. It must also be the custodian of the data base by being able to enlarge and update data files as new information becomes available, and it must be flexible enough to accommodate new components and related interfaces to other components as new knowledgeand analysis procedures are developed.

### II. Use of the MIS

The purpose of the MIS is to provide information to the analyst which is relevant and useful towards making decisions concerning a topic under study. The relevancy and usefulness of the information produced by the system is determined by two different methods. It may be judged by the analyst who requests specific data and how it will be analyzed and displayed, or it may be determined by the system itself using stored approaches previously developed.

1. Data Requests. Where the analyst requests specific information, the Executive Control (EXC) will determine this by key word input and then turn control over to the Data Storage and Retrieval (DS & R) component which will then identify the data from the input as to type, geographical location, time, etc. Using this information the DS & R will locate the appropriate data file if it exists, confirm that the requested data are available, extract the data and then return control to the EXC. Should the DS & R not be able to locate the data, this indication would be displayed in the output and EXC informed which would then terminate this request and turn towards the next input. If the data were successfully retrieved, EXC would then check the input request for special processing or display instructions. Again, these would be in the form of key words relating to the processing routine in the Synthesis and Analysis component to which the EXC would identify and pass control along with the data. The processing routine would then complete the request and return control to EXC which would again check the input and repeat the procedure until all processing requests were fulfilled at which time the request would be terminated and the next input identified.

2. Stored Approaches. Where the analyst prefers to work on a higher level and accepts the relevancy and usefulness of data as determined by previously developed

approaches, this would again be indicated in the input and recognized by EXC. Each analytical approach will be in the form of a complete autonomous sub-program for each general topic and will be stored in the analytical design component. Upon discovery by EXC that a stored approach is requested, the topic to be analyzed will be identified from the input and control will be turned over to the appropriate sub-program.

Each sub-program will be unique in that its analysis approach will have been designed and structured by persons knowledgable in the field or topic being analyzed. In many instances, one may call upon another to perform a specific analysis necessary for evaluation of a larger, more comprehensive area of interest. For instance, the analysis of a dredging proposal may require an analysis of loss of a wetland due to spoil disposal. If this wetland contributed to the shellfish industry, an analysis of the economic impact due to the loss of this contribution to the industry may be necessary.

Thus, although the sub-programs may be used for independent, separate analysis themselves, they may also be combined to form other more comprehensive analyses simply by structuring other sub-programs to include them. This not only affords the analyst a choice of level of investigation but also facilitates new analytical approaches to be added to the MIS as better understanding of the relationships between factors becomes known. Each analytical approach will use other components as tools and materials to build and present to the manager a collection of meaningful information which is essential or useful to him in arriving at managerial decisions. The level of sophistication of these approaches will vary widely and may range from initially a simple listing of all available data which is pertenent to a topic to sophisticated analytical techniques which come closer to automatically making many decisions faced by the manager. They will be evolutionary and will be determined by the knowledge and data available and the understanding and expertise of whoever structures them. Figure E-1 shows the basic general flow of the MIS.

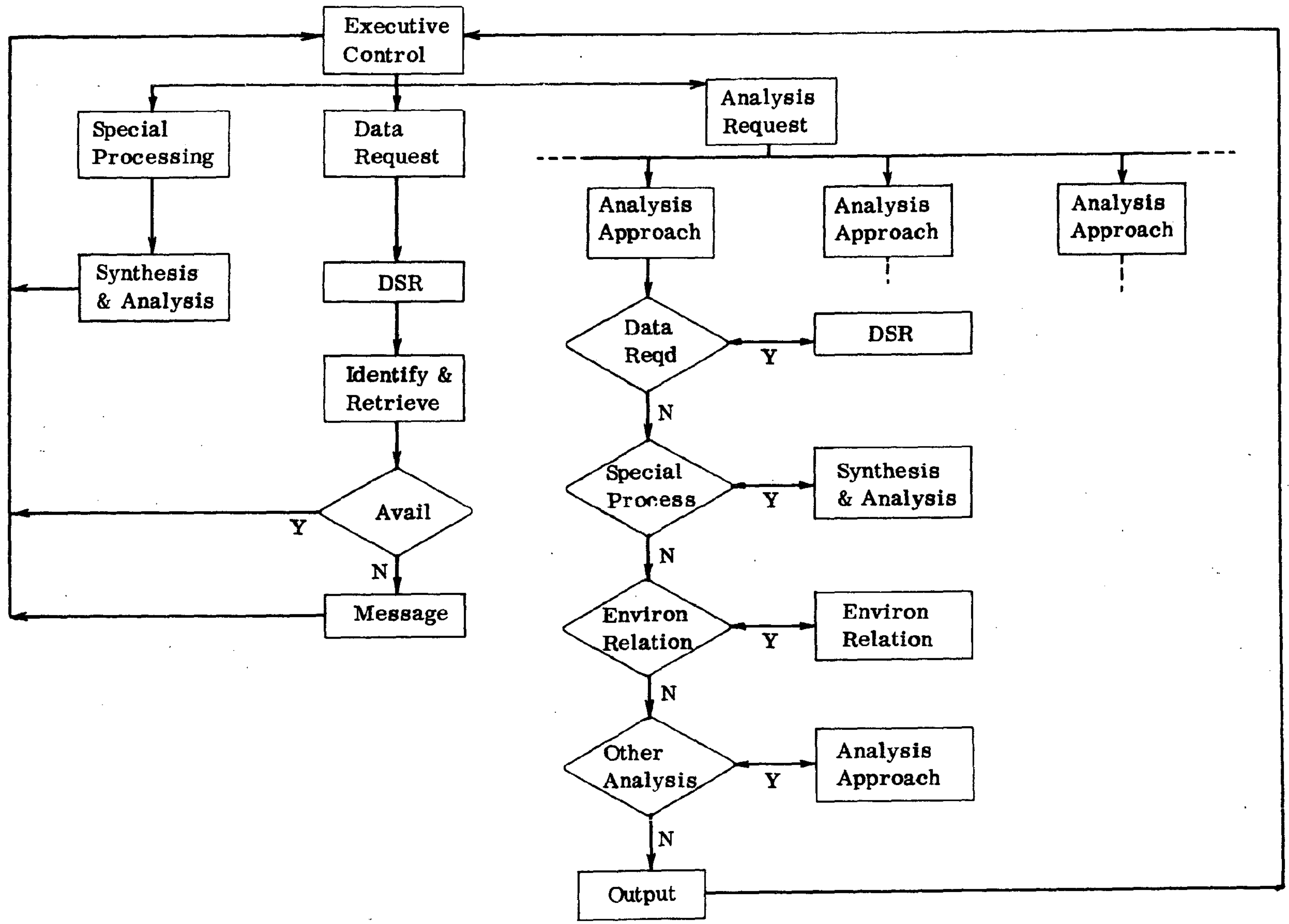


Fig. E-1. Organizational Flow through the MIS.