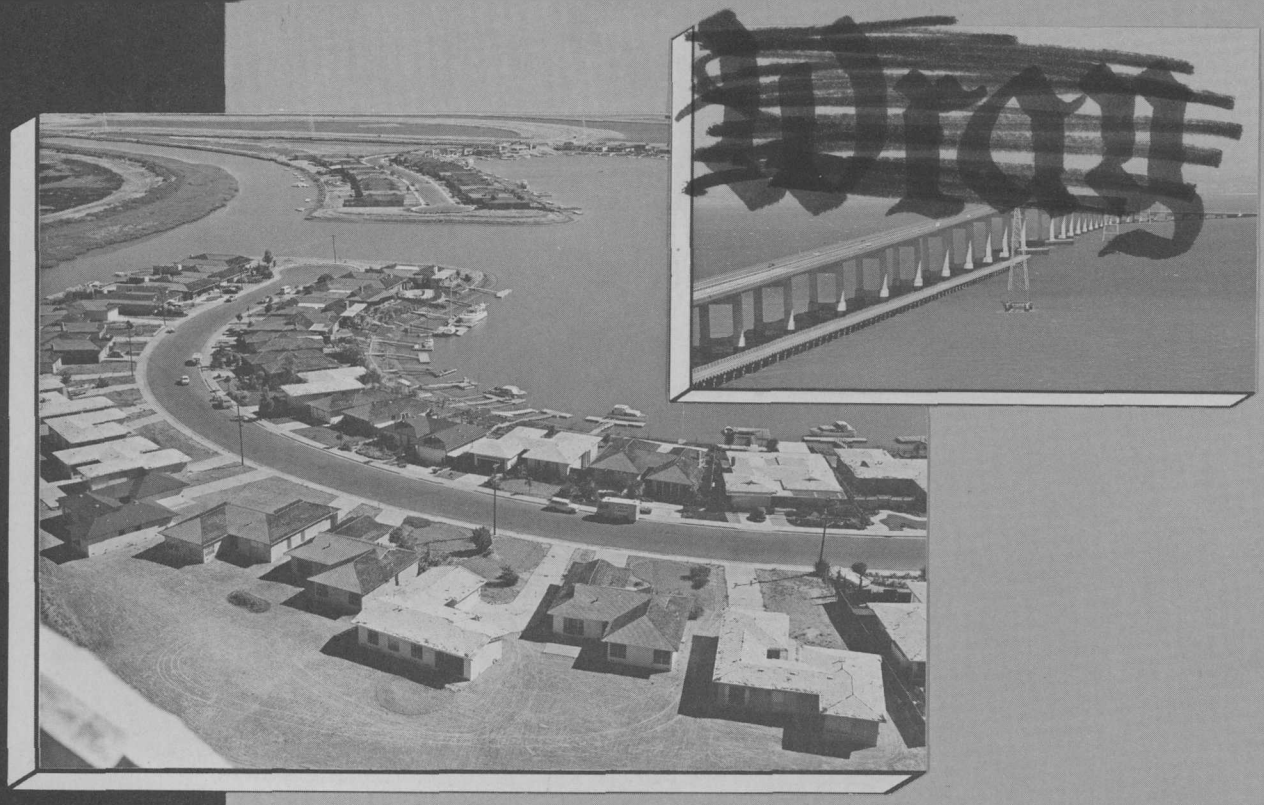

# PROGRAM DESIGN
1971



# SAN FRANCISCO BAY REGION ENVIRONMENT AND RESOURCES PLANNING STUDY

U. S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
U. S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
OFFICE OF THE ASSISTANT SECRETARY FOR RESEARCH AND TECHNOLOGY

# PROGRAM DESIGN

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# PROGRAM DESIGN

# FOR

# SAN FRANCISCO BAY REGION

# ENVIRONMENT AND RESOURCES PLANNING STUDY

U.S. DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

AND

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

RESEARCH AND TECHNOLOGY

Menlo Park, California

October 1971

Frontispiece.--HUD Urban Planner Dale James and USGS Deputy Project Director Andy Spieker inspect relief model of the San Francisco Bay region

United States Department of the Interior

GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

OFFICE OF THE ASSISTANT SECRETARY
FOR RESEARCH AND TECHNOLOGY
WASHINGTON, D. C. 20410

Dear Reader:

We are pleased to transmit the Program Design for the San Francisco Bay Region Environment and Resources Planning Study being jointly carried out by the U.S. Geological Survey and the Department of Housing and Urban Development. This program, which has been developed by the two participating agencies, represents what we believe to be a well-rounded and broadly based approach to relating physical environmental factors, particularly geologic hazards, to regional and urban planning and development. While this study focuses on the nine-county San Francisco Bay Region, the geologic factors considered are found in many other parts of our country and the world. In that light, the findings are of direct and immediate value to other metropolitan areas and to pertinent Federal, State, and local programs.

The Program Design is an evolving document rather than a fixed statement of our work plans. We are continually modifying our concepts and refining our ideas on the basis of experience gained and suggestions from users of our products. For these reasons, we are distributing this Program Design to a large audience throughout the Nation, encompassing a wide range of interests and disciplines. We would welcome your comments on our intended approach to facilitate the use of earth-science concepts in regional planning and decision making.

W. A. Radlinski

W.A. Radlinski
Acting Director
U.S. Geological Survey

Harold B. Finger

Harold B. Finger
Assistant Secretary
Department of Housing and
Urban Development

Enclosure

# PREFACE

The "Program Design" for the San Francisco Bay Region Environment and Resources Planning Study represents a refinement, elaboration, and extension of the plans which formed the basis for the cooperative program between the Department of the Interior, Geological Survey, and the Department of Housing and Urban Development, Office of Research and Technology, formally recognized in the Letter of Agreement of October 24, 1969, and begun January 1, 1970. From the first, the study was recognized as an experimental pilot study, and new developments in the state-of-the-art in the earth sciences and in urban and regional planning were recognized as necessary. Indeed, the development of a suitable structure for such a program was considered one of the important parts of the experiment. Consequently, one of the stated goals of the Letter of Agreement was to produce a Program Design.

At the start, the readiness and capabilities of the cooperating agencies to conceive and carry out, or even to weigh the relative importance of, individual program elements ranged from poor to excellent. The design evolved as additional individuals, talents, and organizations were melded into the program during the first year. Proposed additional program elements and different approaches to recognized problems already have grown far beyond the visible level of support. But everything cannot be done at once, and this volume expresses but one step in the evolution of an ideal environmental and planning study.

This edition of the Program Design represents a synthesis of ideas of more than 50 people from various parts of U.S. Geological Survey, Department of Housing and Urban Development, and Association of Bay Area Governments, who collectively contributed more than 3 man years of effort to deliberations, writing, and preparation of the volume. We believe the volume presents a well-rounded plan for relating physical environmental factors to urban and regional planning and development. The reader of this volume, however, should recognize some of the limitations and constraints within which the program developed.

Among the major considerations which shaped the program were: (1) the interests of the U.S. Geological Survey (USGS) in environmental geology and the scope of its ongoing program, (2) the interests of the Department of Housing and Urban Development (HUD) and the original lack of urban and regional planning capability at study level, and (3) the financial support level available.

The scope of the ongoing program of the USGS provided a broad base for attacking an array of physical environmental problems, but because of the past histories of some ongoing programs, not all program elements and projects of importance to urban and regional development and planning were of equal strength at the start of the

study. Indeed, a perfect balance is unlikely even within the 3 years of the study, nor will all agree on what constitutes a proper balance.

The lack of urban and regional planning capability at study level was remedied only after the project was well under way. In June of 1970, a professional planner from HUD was assigned to the study and in October 1970, a professional planner from the Association of Bay Area Governments (ABAG) was assigned part time. Only after these men became available on a continuing basis did it become possible to generate effective discussions between planners and earth scientists and to include the results of such discussions in the Program Design.

The original funding projection was based on estimates of a minimum effort in each of about 30 earth-science program elements. Additional program elements, for example in the area of urban land-use planning, were deemed necessary as study plans progressed. Additional funding was made available by the USGS for some of these program elements. By July 1971 additional HUD funds were made available for studies related to urban planning. This Program Design thus represents a combination of what is actually being carried out, what is planned but not yet formally funded, and some proposed efforts which should be included and, it is hoped, will be in the future.

Several of the program elements are of such importance and complexity that the entire funding might be fully justified if spent entirely on only one of them. The program thus represents a compromise in an effort to provide a broad approach to environmental problems.

Some program elements of the study are of particular significance only to the San Francisco Bay region or to similar environments in the Western United States, but the very diversity of environmental considerations treated in the study should develop many principles applicable to other urban regions.

This study is one of the first major efforts directed toward learning how man can better accommodate his activities to the physical environment of the earth. It is an effort long overdue.

*Robert E. Wallace*
Project Director,
San Francisco Bay Region Study
October 1971

U.S. DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

AND

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

RESEARCH AND TECHNOLOGY

PROGRAM DESIGN

FOR

SAN FRANCISCO BAY REGION

ENVIRONMENT AND RESOURCES PLANNING STUDY

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ILLUSTRATIONS

# BACKGROUND, SCOPE, AND ORGANIZATION

## THE PROBLEMS

The uncontrolled urban sprawl that has engulfed the landscape since the end of World War II has been created with little regard for the assets of the landscape, or for the hazards that attend its misuse. Urban planners, administrators, and legislators as well as earth scientists have become increasingly aware of the need for information concerning the environment and resources of our urbanizing areas. Furthermore, it has become painfully apparent that such information is not always available, and the information that is available is presented in forms virtually unintelligible to the planner or to those not trained in earth science.

Neither have the assets and liabilities of the land and water resources been adequately inventoried, nor have satisfactory methods been established for adequately considering the physical environment in urban planning. Homes are being built on landslides, over active fault zones, and on flood plains. Land which should be retained as open space or for ground-water recharge is being built upon. Public access to shorelines along bays, rivers, and the ocean is largely being denied, as these scarce land-water interfaces are being used for such purposes as solid-waste disposal and industrial development.

Land-use decisions made on a local basis may be fragmented and are often inappropriate when considered on a regional scale. In the San Francisco Bay area a great many land-use problems are inherently regional in scope and are incapable of satisfactory solution on a local basis. For example, San Francisco Bay is important to the entire region, indeed to the entire nation, for its uses range from port facilities to climate control and recreation. Minimization of the earthquake hazard in the Bay area cannot be solved in a local context. The behavior of an earthquake fault cannot be understood by studying it under a single town or county. The fault pattern of the entire region must be analyzed. Recovery of locally concentrated mineral resources, including cement lime, and sand and gravel essential for building and construction in the entire region, should be coordinated through regional planning and meshed with other demands for the sites where these materials happen to occur.

The need for a regional approach to urban planning in the San Francisco Bay region has been recognized in the creation of the Association of Bay Area Governments (ABAG) and the San Francisco Bay Conservation and Development Commission (BCDC). Such existing organizations, and the agencies that may develop in the future, can affect urban and regional planning and decision making only to the extent that basic data exist and are in a suitable form, and to the extent that methods are available or can be evolved to make, and then implement, the decisions.

## GENERAL SCOPE

The San Francisco Bay Region Environment and Resources Planning Study includes consideration of both the physical environment and the resources of the region and of their significance to urban and regional development and planning. The study is being conducted cooperatively by the U.S. Department of the Interior, Geological Survey and the U.S. Department of Housing and Urban Development, Office of Research and Technology. The study emphasizes the disciplines of topography, geology, geophysics, and hydrology--disciplines which represent the core expertise of the U.S. Geological Survey--and applies to improving regional urban development, planning, and decision making.

This pilot study is highly experimental in nature. The experimental aspects include the type of physical data collected, the way in which the data are synthesized, the formats in which the data are presented, and the lines and methods of communication that will ultimately help society gain the optimum benefit from the physical environment, landscape, and resources.

The U.S. Geological Survey (USGS) has certain ongoing programs which are producing basic data pertinent to the study, and the Department of Housing and Urban Development (HUD) is providing funds to augment such ongoing programs so that the pilot study can be completed within the time planned. The goal is to develop earth-science concepts, products, and procedures which can significantly improve regional planning and development. Additional critical data are to be gathered and basic geologic, geophysical, hydrologic, and topographic data are to be translated into documents that will be useful in the planning and decision-making process. The avenues of communication and coordination in the planning process are to be explored and evaluated to find the most appropriate channels and methods for effectively applying the data, and experimental demonstrations programs are planned to test the products and methods evolved.

The project is designed to meet major national as well as regional needs. By focusing this pilot study on the Bay region, the Geological Survey hopes to identify those earth-science parameters most important to urban development, to evaluate the priorities of those parameters, and thereby guide the nation in seeking optimum use of earth resources.

## CONCEPTS AND METHODS OF STUDY

### The National Interest

As an experimental pilot study, the program will serve the national interest in several ways. In general, it represents one attempt by society to learn to live in harmony with a natural physical environment, taking advantage of countless beneficial factors while not overstressing complex natural interrelationships.

More specifically, relative to the responsibility of the USGS, the study hopes to improve the overall capability of the earth sciences in solving the environmental problems of urban and regional development. The study should be of great help in reevaluating national earth-science research priorities and educational programs, and it should provide guidance and new background data and techniques to the scientific and engineering professions dealing in earth science and natural resources as applied to urban development.

Relative to the responsibilities of HUD, the study hopes to learn and to demonstrate the significance of physical environmental factors, particularly geologic hazards, in the regional urban planning and development process. The information gathered will provide a basis for the formulation and improvement of policies and guidelines on physical environmental factors as they relate to the Department's planning, housing production, and community development programs. The study will provide benefits of national significance because of the widespread occurrence throughout the country of geologic hazards and problems such as flooding, mudslides, unstable housing foundations and earthquakes. Improved urban planning techniques will be developed and demonstrated in a real-life situation and will become vital tools for urban decision makers facing similar environmental hazards and problems throughout the nation.

These are long-term goals that will not be achieved overnight, but to the degree that progress is made, everyone in the nation will benefit; thus, the Federal Government will be providing a valuable service.

## The Regional Approach

The regional approach to meshing physical environmental factors with the planning process was chosen for the pilot project for three main reasons: (1) the urban regional planning process needs to be strengthened, it needs to become more comprehensive, and it needs to become more sensitive to natural environmental factors; (2) many physical environmental factors are regional in nature and can be addressed through generalized data which can be gathered, evaluated, and interpreted during a short 3-year study; and (3) the type of data considered in a regional study is well adapted to providing the broad guidelines needed for application to the national level.

Regionalized data, although satisfying some needs at the local level, cannot satisfy all. For example, data needed in detailed planning and execution of a residential subdivision cannot be provided. Such local problems require a measure of detail in geologic mapping, soils analyses, drainage plans, etc., that, for the entire region, would require hundreds of times the effort to be expended in the present study and should be the responsibility of local public agencies and the private sector rather than Federal agencies. The regional approach, however, does provide a "first-cut" or background for

approaching even these detailed needs and can provide an alert that physical problems may exist that should be evaluated and considered.

## Response to Urban Planning and Development Needs

The need for interaction of the earth scientists with members of the urban planning and development community was recognized from the start. This need is being filled in three ways:

1. *Staff Interaction.*--Urban planners from the staffs of HUD and ABAG maintain a close day-to-day relationship with the scientific staff of the Bay Region Study group for the mutual exchange of ideas and concepts.

2. *Communication Outside the Study Staffs.*--A Consultative Panel provides a vehicle for communication and exchange of ideas with members of the planning community and other potential users of Bay Region Study products. In addition, periodic meetings are held with county planning staffs and other users for exchange of information and ideas.

3. *Formal Contracts and Cooperation.*--Contracts or cooperative agreements are maintained with several States and county agencies (for example, the California Division of Mines and Geology and the San Mateo County Planning Department) for specific work elements related to the project objectives. Additional contracts will be let in connection with the Planning Work Element "Application and Demonstration Studies." Contracts will also be let to private planning consultants in connection with the Planning Work Elements "State-of-the-Art" and "Planning Technical Report Studies."

## Why the San Francisco Bay Region

The San Francisco Bay region was selected for this pilot study for a variety of reasons. Few regions must contend with a greater variety of environmental factors. Here are land and water assets including the Bay itself which are of great economic, aesthetic, and climatic importance. Here are encountered such natural hazards as earthquakes, flooding, and landslides. The region is large, has a present population of about 5 million people (see table of statistics below), and is being urbanized rapidly. The political and public attitudes in the region are more receptive than in many other areas to the proposition that environmental considerations are important to the quality of life. The Association of Bay Area Governments and the Bay Conservation and Development Commission are regional agencies in existence that, among others, can channel environmental data into the planning and decision-making process.

SAN FRANCISCO BAY REGION

(nine counties)

STATISTICS

| | |
|---|---|
| Population (1970) | 5,083,549 |
| Dwelling units (1965) | 1,404,146 units |
| Area (land) | 6,952 sq mi |
| San Francisco Bay, original area (1835) | 680 sq mi |
| Filled or diked area | 280 sq mi |
| Remaining area | 400 sq mi |
| Linear shoreline | 276 miles |
| Shoreline, public access | 5 miles |

| Comparisons | Area | Population (1960) |
|---|---|---|
| San Francisco Bay region | 7,416 sq mi | 3,667,962 |
| Israel | 7,993 | 2,643,000 |
| Connecticut | 5,009 | 2,535,234 |
| Maryland | 10,577 | 3,100,689 |
| Delaware | 2,057 | 446,292 |
| Rhode Island | 1,214 | 859,488 |

A practical consideration is that the presence in the Bay area of one of the main centers of the U.S. Geological Survey makes it possible to carry out a study such as this at a fraction of the cost and time that would be needed in many other parts of the country.

## Bridging Gaps Between Specialties

One of the main problems of the present study is to find ways to bridge the gaps between scientific, engineering, planning, political and administrative specialties. For example, a geochemist who may be best qualified to determine the quality of San Francisco Bay water, very likely will have neither the inclination nor the talent to enter the political arena to see that full use is made of his knowledge. Or a planner, although aware of the interrelation of many urban problems, may not be personally attuned to the engineering and construction fields in which development takes place.

Many steps must be taken in progressing from the collection of raw data about earth sciences to its final use in urban development. Such steps include acquisition of data, interpretation of data, presentation of interpretations, land-use planning and design, implementation of plans, and finally development. Each step may involve an interdisciplinary team with a wide range of talents and backgrounds. Furthermore, the earth sciences themselves include specialties as diverse as geologic mapping and studies of mineral resources, soil mechanics, geophysics, seismology, hydrology, geochemistry, and cartography, each of which requires career specialization.

The solution to the problem of bridging gaps between specialties will depend upon the extent to which individuals can reach beyond their usual fields of specialization, the extent to which new interdisciplinary capabilities evolve, and the extent to which new communication procedures can be developed.

## Focus and Methods

The San Francisco Bay Region Study is designed around the disciplines that represent the core expertise of the U.S. Geological Survey, namely geology, geophysics, geochemistry, hydrology, and topographic engineering, and the planning expertise of HUD and ABAG.

The attempt will be made to develop, within 3 years, earth-science concepts and products, expressed in forms which can be readily utilized, which address regional land-use problems, and to use and demonstrate these concepts and products in real-life situations. During the study a continuing appraisal of the products will be made through working-level discussions with potential users.

Publications will be distributed to various existing user groups and to new user groups which develop during the course of the study.

The basic design of some of the end products of the study was relatively clear before the project was started. For example, a 1:125,000-scale topographic map of the region was needed. Other end products are less definite and will depend upon individuals and their capabilities. For example, the quantification of seismic ground motion depends on research skill and effort and cannot be specifically scheduled. Thus, the projects or elements within the study range from simple execution of specific tasks to fundamental research which is recognized as critical, but the course of which will always remain indeterminate.

An important concept of the study is represented by the publication scheme (see section on Publication and Dissemination of Information). Three series of publications are planned. As the project progresses, there will be an evolution from the more basic maps and reports to progressively more interpretive reports.

1. The *Basic Data Contributions* represent output from the first data-gathering phase of the study. This type of product will be derived both from ongoing and special programs. Such data are useful to limited audiences, primarily technical. For example, the consulting engineering geologist can immediately put such data to use in improving the quality of advice given clients, thus applying earth-science factors to action steps.

2. The *Technical Series* represents products to be derived from basic data by a progression through several stages of generalization, interpretation, and presentation. The results will be directed toward a second type of audience, also technically oriented, but more specifically involved with development and planning. The user might be on the technical staff of a county planning group in ABAG or BCDC or might be a city, county, or consulting engineer. Consultants who are asked to prepare planning programs for any of the local or regional agencies or for the private sector would base decisions on this type of report. They could carry out their assignments more efficiently and competently because of the availability of the Technical Series material.

3. The *Interpretive Report Series* (provisional title) represents the final distillation of the foregoing basic data, technical information, and analyses. This series is addressed primarily to the policy makers and staff in government at all levels and to those in the private sector who are not technically oriented. Urban planners, zoning officials and boards, elected officials, city managers, city and county public works officials, public utility officials,

and officers of insurance and financial institutions are examples of the intended users of these reports. The reports should also be of considerable interest to civic-minded citizens and organizations, such as the League of Women Voters.

The term "interpretive report series" is not wholly satisfactory in defining the purpose and scope of these reports. Other terms which have been suggested include "manuals," "handbooks," "planning reports," and "primers." The format of these reports will be varied, depending on their content. Some will consist primarily of maps with marginal explanatory text. Others will consist primarily of text and will be prepared in a book format. Some may be published as informal pamphlets. It has been suggested that some might consist largely of illustrations, containing the types of graphics and visuals frequently used in newspapers, magazines, or television programs to simplify story concepts. They will be written in non-technical language avoiding in large measure theoretical discussions of how the conclusions were reached.

We intend these reports to be innovative and expect them to have a significant impact on urban-comprehensive planning and functional planning, and on the urban development process in general. Their success, however, will depend upon the extent to which earth scientists are able to communicate with members of the urban planning and political communities. In addition to the urban planners on the staff, it is expected that other specialists, such as structural engineers, lawyers, political scientists, and economists, will co-author some of the interpretive reports. The Consultative Panel should also be helpful in guiding the preparation of this series.

Some of the interpretive report series probably will cover urban development problems or topical areas rather than work program elements. For example, one interpretive report might deal with the problems faced in hillside development, such as slope stability, active faults, and seismicity. Another might deal with the problems of developments in the flatlands, such as flooding, drainage, subsidence, and earthquake hazards. Another may focus directly on the urban planning function of local government and the problems associated with the use of earth-science data in general.

Where feasible, earth-science factors (such as slope stability, flooding, and earthquake risk potential) will be expressed in terms of land-use capability. Potential hazards, problems, and opportunities will be discussed. The impact of alternative development plans will be discussed. If possible, comparative costs and benefits of alternative land uses will be analyzed.

The proposed content of interpretive reports is described in more detailed terms under many of the individual program elements.

## Status of Earth Sciences Relative to Planning

Although the earth sciences are relatively old and have had a tremendous impact on the search for and development of mineral, water, and fuel resources, they have been applied relatively little to urban planning and development. Only within the past few decades have the geological sciences begun to be used in engineering development. For example, the Association of Engineering Geologists was created as recently as 1963. Within the geologic profession, however, it has long been recognized that many techniques and talents are available that could greatly benefit mankind in ways not yet realized. The present study is of interest to the profession since it is an experiment in realistically relating the earth sciences to social needs. It is hoped that the value of this relation will become more generally recognized.

## Evaluation Stage

An evaluation stage has been planned to follow the 3-year study. The products will be judged over a period of a few years to determine their strengths and weaknesses. A modest effort early in the study will be concerned with appraising the present state-of-the-art (earth-science data available for planning) as a basis for evaluating the contributions developed by the study.

## Organization

The San Francisco Bay Region Study is being carried out by a Task Force within the U.S. Geological Survey and the Department of Housing and Urban Development under a Project Director headquartered in Menlo Park, Calif. The Project Director acts on policy matters in consultation with an Executive Committee consisting of key officers from three operational Divisions of the Survey (Topographic, Geologic, and Water Resources) and the San Francisco Regional Office of the Department of Housing and Urban Development. A Survey-HUD-ABAG Operations Committee consisting of the individuals responsible for directing the study in four Survey Divisions and in the Planning Program serves to coordinate working-level actions.

The Assistant Director for Research of the Geological Survey provides bureau-level coordination and Washington liaison with the Department of Housing and Urban Development.

An officer in HUD's Washington Office of Research and Technology is the technical representative for HUD. Field-level coordination and direction of the Planning Program is provided by an urban planner in the HUD San Francisco Regional Office.

Firm working relations have been established with the Association of Bay Area Governments. An ABAG regional planner provides coordination between the Bay Region Study and regional planning programs and is a key participant in the study.

## Organization and Coordination Diagram

Figure 1 is an organization chart showing distribution of funds, coordination, staff interaction, and interagency relations. The left part of the diagram represents the organization of the ongoing program of the USGS which is the foundation on which the San Francisco Bay Region Environment and Resources Planning Study is built. This program is financed both by direct appropriations and by transfer funds from a variety of other agencies. The Geologic Division, Topographic Division, and Water Resources Division are the principal operating units responsible for carrying out the San Francisco Bay Region Study. The Computer Center Division provides important support. In addition, the Earth Resources Observation Systems Program and the Geographic Applications Program under the Office of Geography have adjusted their programs in such a way as to supplement and support the study even though not formally a part of the study. Similarly cooperative programs, some of which provide funds to the USGS, indirectly support the San Francisco Bay Region Study. The Bay Region Study management does not have direct administrative control over the ongoing program, but nevertheless does influence it.

The right-hand part of the diagram represents the organization of the study management and coordination. To assist in carrying out the program, both USGS and HUD provide augmentation funds. USGS augmentation funds are from direct appropriations. The major dollar contribution by HUD is from the Office of the Assistant Secretary for Research and Technology and these monies are transferred to the USGS. In addition, funds are provided by the HUD Region IX Office in the form of salary for the HUD urban planner assigned to the project. A similar funding arrangement exists with HUD's San Francisco Area Office, which provides two-thirds of the salary of the Association of Bay Area Governments' staff planner assigned to the study. The planning project is under the direction of the HUD urban planner and consists of supporting planning research and demonstration studies. Dashed lines connecting the right-hand and left-hand parts indicate that the study draws very heavily on the data output of the USGS ongoing program.

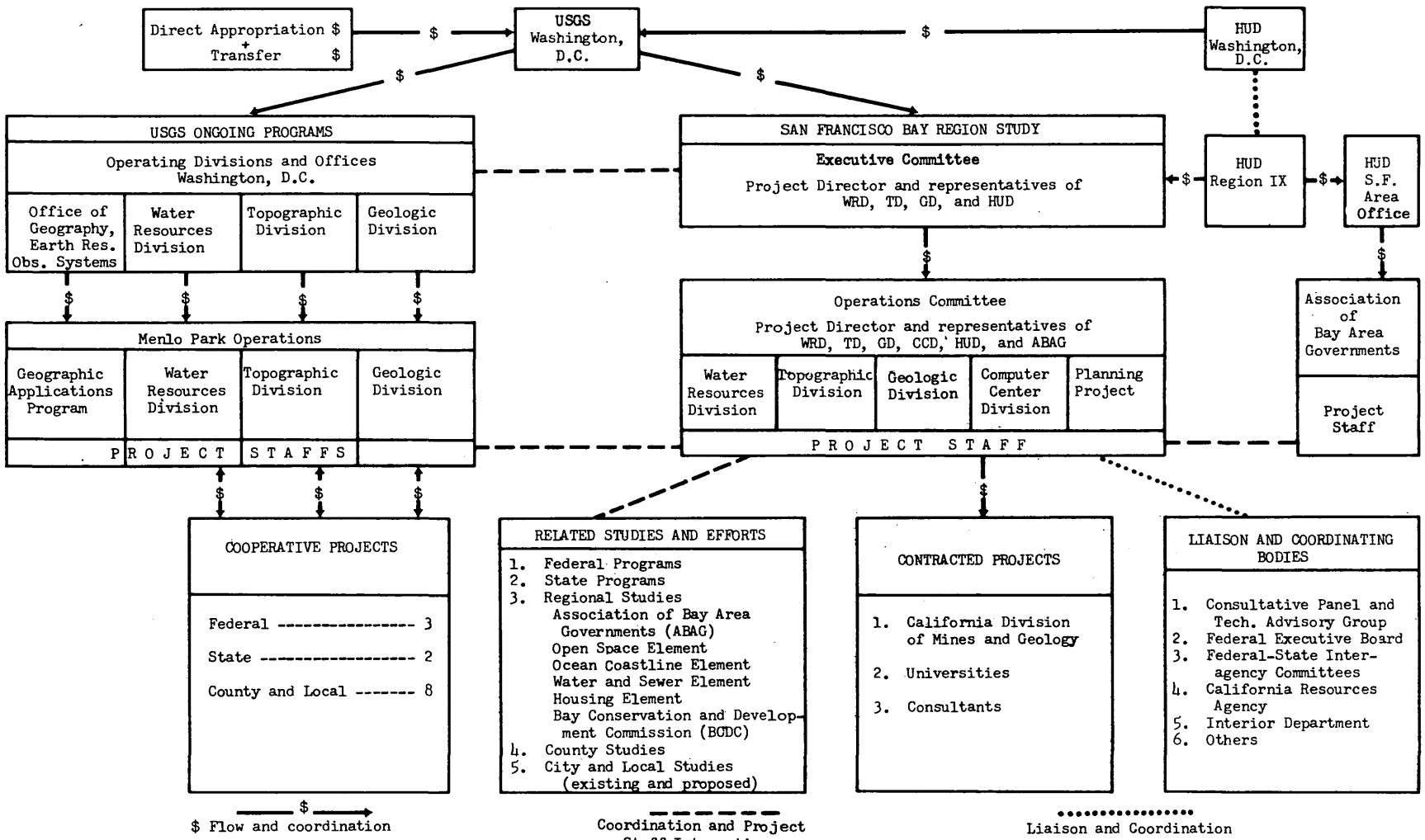



Figure 1. -- Organization and coordination - San Francisco Bay Region Study

## The Role of the Association of Bay Area Governments

The Association of Bay Area Governments, as the comprehensive regional planning agency, has as one of its primary objectives the coordination of the various regional planning efforts taking place in the nine-county San Francisco Bay area, whether they are conducted by other regional agencies, or by agencies of the State and Federal Governments.

Coordination of planning efforts is needed, because the many regional planning programs conducted by separate, special-purpose agencies lead wholly or partly to the preparation of special-element plans. Unless these plan elements include thorough consideration of all related elements of regional development and conservation, they may be uneconomical, shortsighted, or even counterproductive. They may not relate to other special-element plans in preparation or already approved, or, through lack of coordination of such basic planning inputs as population, economics, and land-use forecasts, they may lead to opposing strategies. Because of lack of communication and coordination, each separate planning program finds itself in an unstable planning environment. This results in the need to prepare expensive, frequent, short-range plans that must remain flexible in the face of shifts in planning by others as they respond to the inequilibrium. The separate planning programs cannot lock in on common comprehensive goals unless each program is better related to the other through communication and coordination. The Association's role in the San Francisco Bay Region Study is twofold: first, to provide communication, liaison, and coordination and to relate the final products of the program to the member communities, to regional agencies, and to the Association's regional planning program; and second, to provide a continual participating staff effort as a member of the study group, through a full-time staff member assigned to the study, and to aid in: (1) determining the physical environmental knowledge and data most useful for comprehensive regional urban planning and decision making; (2) determining the most effective ways of interpreting and presenting this information; (3) providing a comprehensive regional framework as an input for the study; and (4) assisting in insuring that the products of the study are useable by the planners and policy makers in the Bay region.

## COORDINATION AND COOPERATIVE PROGRAMS

### Consultative Panel

A Consultative Panel will provide the Study with representation from those agencies and professions which directly and significantly influence the processes of urban physical development.

Composition of the Consultative Panel

1. Association of Bay Area Governments (Chairman of Panel)
2. Alameda County, Planning Director
3. Contra Costa County, Planning Director
4. Marin County, Planning Director
5. Napa County, Planning Director
6. San Francisco County, Planning Director
7. San Mateo County, Planning Director
8. Santa Clara County, Planning Director
9. Solano County, Planning Director
10. Sonoma County, Planning Director
11. Metropolitan Transportation Commission
12. Bay Conservation and Development Commission
13. Regional Water Quality Control Board
14. California Council on Intergovernmental Relations
15. California State Office of Planning and Research
16. Federal Executive Board, Environment Committee
17. USDA - Soil Conservation Service
18. Association of Bay Area Planning Directors
19. Conservationist
20. Consulting Engineer
21. Urban Planning Consultant

Purposes of the Consultative Panel

1. To provide direct liaison between the Study and key urban physical development decision makers.

2. To provide the representative agency or profession with an opportunity to creatively apply the findings of the Study to its own special areas of responsibility.

3. To provide a forum for the exchange of ideas and information.

4. To provide guidance to the Study team and its consultants.

Functions of the Consultative Panel

1. Review and evaluation of the overall Program Design.

2. Review and evaluation of individual work element designs prepared by Study staff, consultants, and Application and Demonstration studies staff.

3. Provide advice and counsel during the actual carrying out of the work elements.

4. Identify special information needs and problem areas.

Technical Advisory Groups

From time to time the interests of the Panel will be focused on particular topical areas of the Study. Small ad hoc groups technically oriented to specific program elements will be formed. These Technical Advisory Groups will be composed of certain of the Panel members who can contribute special expertise, occasional consultants, or perhaps temporary additions to the Panel membership. For example, in the fields of land-use law or geologic engineering, advice and counsel will be needed from the practitioner who can introduce needed pragmatism.

## Liaison with Other Agencies

The office of the Director of the State Resources Agency has been designated by the Governor of California to provide liaison with related efforts of the State. A cooperative program with the California Division of Mines and Geology is planned to provide data on mineral resources for the study. Cooperative programs with agencies listed below provide data pertinent to the San Francisco Bay region, but are not formally a part of the study:

1. Atomic Energy Commission
2. Advanced Research Projects Agency, Department of Defense
3. Corps of Engineers
4. Alameda County Flood Control and Water Control District
5. Alameda County Water District
6. Marine County
7. California Department of Water Resources
8. Contra Costa County Flood Control and Water Control District
9. East Bay Municipal Utility District
10. San Mateo County
11. Santa Clara County Flood Control and Water District

Existing formal coordinating committees and groups are used to provide coordination with other State and Federal agencies. Examples of these are:

1. Federal Executive Board, Main Board, and Environment Committee
2. Federal-State Interagency Committees
3. Interagency Coordinating Committee, California Regional Water Quality Control Board
4. U.S. Department of the Interior - Pacific Southwest Field Committee

Continuing working-level contacts are maintained with other Federal and State agencies that have pertinent information or related programs.

Working relations with universities are being established both to coordinate research efforts and to employ the research capabilities of the universities directly, possibly through contract arrangements or through coordination with National Science Foundation grants. Involvement of private industry is expected, both on a consultative basis and in correlative but independent efforts.

A program to use and evaluate remote-sensing techniques is being conducted by the National Aeronautics and Space Administration (NASA). Sequential flights over the Bay region will be made and will include black and white, multiband, and infrared photography. Other projects, including one under the Geographic Applications Program, in connection with the Earth Resources Technology Satellite programs, are also under consideration and, if funded, will be coordinated with the San Francisco Bay Region Study through the Project Director's office.

## FLOW DIAGRAM

The inception, development, and execution of the program can be pictured from the accompanying flow diagram (fig. 2). The start of the program was the recognition of the basic need to upgrade the state of both earth-science and urban-planning techniques in order to improve urban planning and development. The project flow generally follows two parallel paths with interfaces at all steps--first, the development of improved earth-science products and techniques; and second, the development of improved planning methods and techniques. The two paths coalesce with the generation of a Joint Preliminary Program Design.

From the Joint Preliminary Program Design will evolve a Joint Program Design and a Joint Operational Plan. The rationale for separating these concepts is alluded to in the Preface. The Joint Program Design sets forth an "ideal" program, the development of which is experimental and continuously evolving. The Operational Plan represents what is actually being carried out at a given moment within

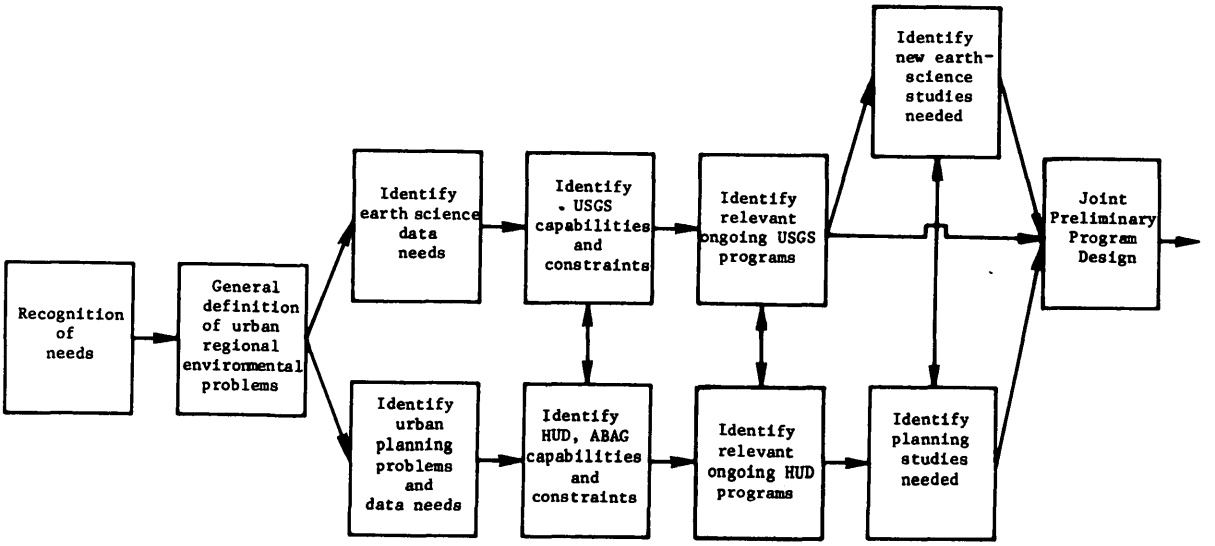
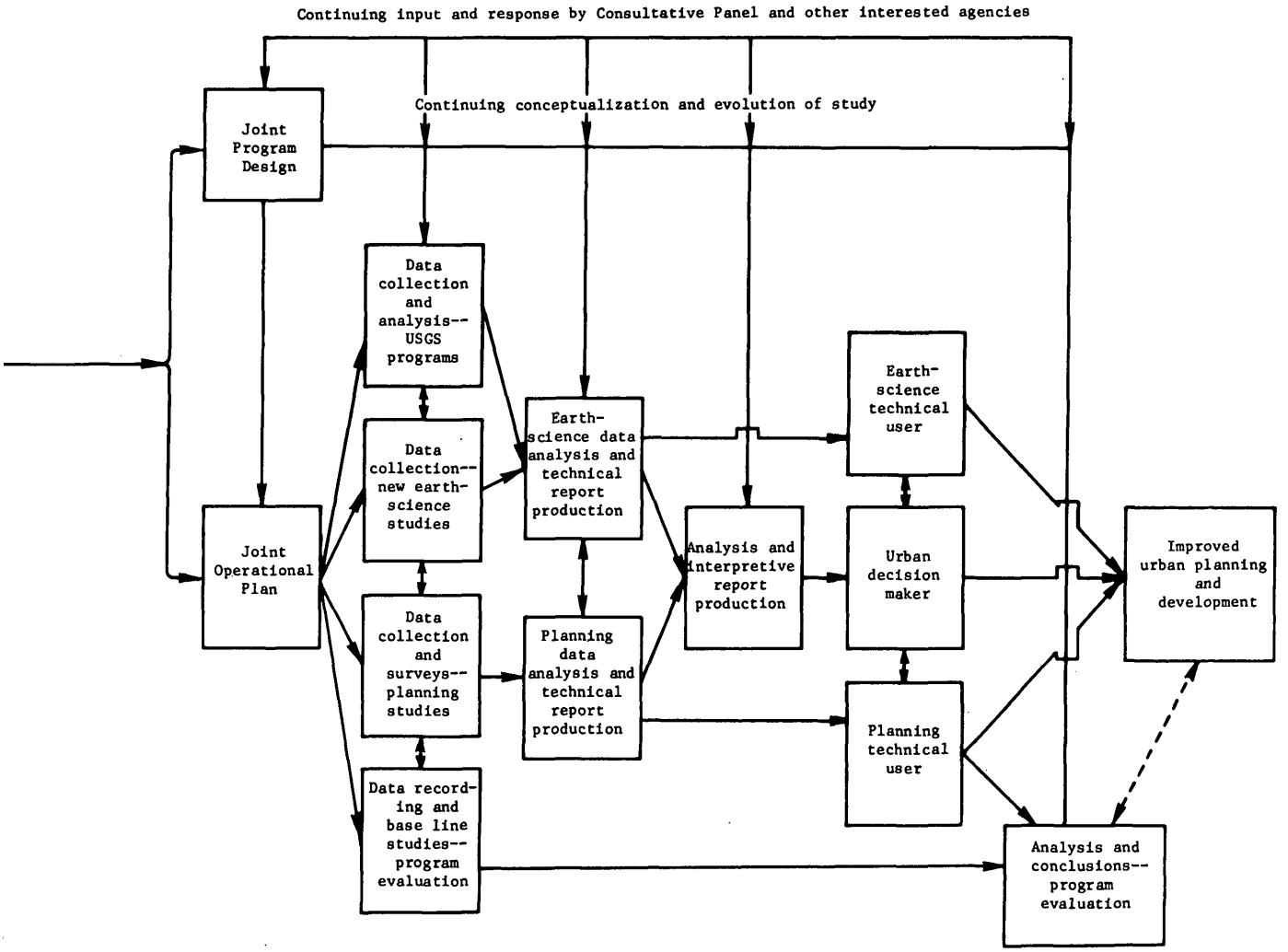



Figure 2.--Flow diagram showing evolution and development of the program. This diagram is intended only as a visual portrayal of the project and not as a guide for day-to-day activities.

existing constraints of funding, time, and available manpower. The gap between these plans may not be large, but concepts within the "ideal" program will always tend to lead by many months, or even years, the actual implementation of any one idea.

Throughout the project, advice and interchange of ideas will be provided by the Consultative Panel and other interested agencies, and the program will change to reflect this advice and interchange.

From the Joint Operational Plan the two parallel paths continue, through data collection and analysis, to the production of the three types of reports. The ultimate target of improved urban planning and development is approached from three directions: (1) through the urban decision maker, (2) through earth-science users (for example, consulting geologists and engineers), and (3) through urban planners via the appropriate report series.



High-altitude air photograph of the San Francisco Bay region, showing much of the central urbanized area. Photograph taken July 17, 1968 from an altitude of 70,000 feet. The San Andreas fault lineament shows up dramatically along the San Francisco Peninsula (upper left of photo)

PROGRAM ELEMENTS

## PLAN OF PRESENTATION

Program elements, or types of studies, to be carried out in the San Francisco Bay Region Study are presented in the following section of the report. Each description includes the problem addressed, the method of attack, and the types of publications, maps, or other products to be developed. Following the description of the Program Elements is a Matrix showing their application to urban planning and development; this in turn is followed by a Work Schedule indicating the completion date for each element and subelement.

## TOPOGRAPHIC ELEMENTS

### Topographic Map (Scale 1:125,000)

No topographic maps at the scale of 1:125,000 (approximately 1 inch = 2 miles) are presently available for the Bay area. The Association of Bay Area Governments (ABAG) requested the Survey to compile such a map several years ago, but cost and production time caused it to be set aside. However, 196 U.S. Geological Survey maps covering 7.5-minute quadrangle areas at a scale of 1:24,000 (1 inch = 2,000 feet) have been completed and are available to the public. Most of these maps were revised in 1968 from aerial photographs flown that year and thus provide recent information on the extent of urbanization of the Bay area. These maps have contour intervals ranging from 5 feet to 40 feet, and provide all the necessary topographic information (except some new freeways) required for making a satisfactory new regional base map at a scale of 1:125,000--the scale considered the most useful for regional planning. Older U.S. Geological Survey maps covering 15-minute quadrangle areas at a scale of 1:62,500 (1 inch = about 1 mile) are available for most of the area but have not been recently revised. In addition a special map at a scale of 1:250,000 (1 inch = about 4 miles) for the entire Bay area was produced by the USGS in 1970 for ABAG as a substitute for the 1:125,000 they had hoped to finance.

*Work Proposed*

We propose to compile, update, color-separate, edit, and print a Bay area base map suitable for plotting regional information from all the various studies in the San Francisco Bay region environmental study. The map will be prepared from the U.S. Geological Survey 7.5-minute quadrangle maps augmented by revision material from the new orthophotomosaic described below.

*Products*

A three-sheet topographic base map, at a scale of 1:125,000, printed in approximately ten colors and covering the nine Bay area

counties, Santa Cruz County, and parts of ten adjacent counties, will be the primary product. It will show highways, city streets, railways, major utilities, airports, public land lines, urban areas, landmark buildings, streams, rivers, lakes, tidal flats, shorelines, underwater topography of San Francisco Bay and the adjacent Pacific Ocean (by means of depth curves), 200-foot contours with supplementary 40-foot contours in flat areas, woodland cover, and political boundaries. Many special-purpose maps will be made from this base map by selecting the types of information and the scale required. This can be done easily because each type of information will be placed on a separate sheet. To make a map showing only drainage features, for example, will only require separating the particular sheets containing these features and making a map of them. Thus, the base map will have great flexibility and be adaptable to many potential uses.

### Orthophotomosaic (Scale 1:125,000)

An orthophotomosaic shows what the land surface looks like by placing together a series of vertical aerial photographs from which position distortion related to differences in elevation have been removed. The photographs are joined so that there is no distortion, and a photoprint of great accuracy is produced. This type of mosaic shows much detail and provides up-to-date geographic information. No orthophotomosaic of the Bay area exists at the present time. Individual aerial photographs at a scale of 1:30,000 covering the entire Bay area were flown in 1968 in connection with the revision of the U.S. Geological Survey 7.5-minute quadrangle maps (1:24,000 scale). However, the scale of these photographs is too large to permit efficient use of them to produce an orthophotomosaic at 1:125,000. New photographs at a smaller scale will be required for this purpose. These new photographs would provide negatives from which the orthophotomosaic could be produced at a lower overall cost, and also would provide more up-to-date information.

*Work Proposed*

We propose to obtain new quadrangle-centered 1:80,000-scale vertical aerial photographs of the Bay area, and from these photographs prepare a regional orthophotomosaic at a scale of 1:125,000.

*Products*

A 1:125,000-scale orthophotomosaic providing an up-to-date photographic image of the entire Bay area, at the same scale and coverage as the base map, will be the primary product. The scale of this mosaic will be uniformly very accurate. Contact prints or

enlargements of the individual 9 x 9-inch aerial negatives and special 1:24,000-scale enlargements of orthonegatives, each covering a 7.5-minute quadrangle, will constitute secondary products of great usefulness to regional planners and developers.

### Urban Orthophotomap (Scale 1:7,200)

An orthophotomap combines the wealth of ground imagery on aerial photographs with the utility of a topographic map into a single versatile map form. It consists of a mosaic of aerial photographs on which map information (such as names of rivers, highways, lakes, and localities) is overprinted. As such, it has a wide range of uses. At the present time, no orthophotomaps in the nine Bay area counties are available from government sources.

*Work Proposed*

We propose to obtain new 1:12,000-scale vertical aerial photographs of one 7.5-minute quadrangle of the Bay area, and from these photographs prepare orthophotomaps of six sheets on an experimental basis at a scale of 1:7,200. The orthophotos will be joined together to produce a mosaic; other photography and existing topographic maps will be used to accurately position the orthophotos. Thus the area of one U.S. Geological Survey 7.5-minute quadrangle map (scale 1:24,000) would be covered by six orthophotomaps, each bordered by 2.5-minute x 3.75-minute geographic projections.

*Products*

Six experimental colored orthophotomaps each printed in six colors at a scale of 1:7,200 will be the primary product. Six of these orthophotomaps will comprise a single U.S. Geological Survey 7.5-minute quadrangle map. The orthophotomap will show the toned imagery of aerial photographs, with the names of major highways, streets, buildings, and other urban features printed over the photoimagery. No contour lines will be included. The maps will be very accurate and useful in urban planning because of their large scale and their detailed and up-to-date photoimage.

### Slope Map (Scale 1:125,000)

The 196 U.S. Geological Survey 7.5-minute topographic maps covering the Bay area at a scale of 1:24,000 have contour intervals ranging from 5 to 40 feet--the intervals being greater in areas of steep terrain.

Although these maps show landforms and elevations with great precision, they do not graphically categorize the terrain in ranges of percent of slope, and such ranges are critical in many studies of environmental geology and urban planning. No reliable slope maps covering large parts of the Bay area are presently available, despite the great need. However, the existence of the detailed topographic quadrangle maps makes it possible to produce complete slope-map coverage of the area.

*Work Proposed*

We propose to compile, color-separate, edit, and print a slope map for the Bay area at a scale of 1:125,000. This map will serve as a regional reference for determining slope percentages; it will be derived photomechanically from the 1:24,000-scale maps and printed on a base from the proposed topographic base map, which will be at the same scale.

*Products*

A three-sheet tinted slope map of the Bay area at a scale of 1:125,000 will be the primary product. Each of the five or six slope categories will have a unique color or tint and will be divided on the basis of percentage of slope. The shoreline and drainage network as well as major transportation routes will be contained on the map. Slope maps at scales larger than 1:125,000 may be produced as secondary products for special studies.

## Dimensional Topographic Relief Model (Scale 1:125,000)

A three-dimensional reproducible relief model of the entire Bay area would provide an excellent means of analyzing and studying the terrain and topography for a variety of purposes. Plastic relief maps produced by Army Map Service at a scale of 1:250,000 of the Bay area have been extensively used in the past by many different groups. No relief models of the Bay area exist at the scale of 1:125,000 at the present time.

*Work Proposed*

We propose to construct a three-dimensional relief model of the land and submarine topographic surface of the Bay area at a scale of 1:125,000. This model will be constructed in one piece, and a mold make available for producing an unlimited number of models for use by various interested agencies. The models will be molded of 1/8-inch-thick fiberglass-plastic and will be approximately 6 feet long by 6 feet wide, and total relief will be about 1 foot. The vertical scale will be seven times greater than the horizontal scale. From the original model constructed of veneer and asbestos sheeting, a large number of models can be produced.

*Products*

A three-dimensional reproducible topographic model of the Bay area at a scale of 1:125,000 will be the primary product; a variety of information can be plotted on the surface of the models, depending upon the interest of the user. The scale and coverage of the model will permit direct comparison of the model to the topographic base map and orthophotomosaic.

## Urban Growth Map (Scale 1:125,000)

A knowledge of historical patterns of urban growth is helpful in planning for future orderly development. However, no graphic display is available to provide this information for the Bay area. The U.S. Geological Survey has photorevised, from 1968 photography, all the 7.5-minute quadrangle maps that cover urban and suburban development in the area. These offer a uniform starting point. It is likely that the revised quadrangle maps, historical copies of previous maps, and census reports can be correlated, supplemented by additional research, and used to compile an urban-growth map based on regular time intervals.

*Work Proposed*

We propose to compile, color separate, and edit a historic growth-pattern map showing progress of the urbanization of the nine Bay area counties from 1900-1968. It is hoped that this growth pattern can be developed in 10-year increments, but further research is required before such a product can be assured.

*Products*

A three-sheet map at a scale of 1:125,000 showing the historical growth of urban areas will be the primary product. Selected information from the 1:125,000 topographic base map will be incorporated into this map.

## GEOLOGIC AND GEOPHYSICAL ELEMENTS

### Active Faults

The San Francisco Bay region is traversed by three major earthquake-generating fault zones that have been active in historic time and by several smaller active or possibly active faults. The location and anticipated activity of these faults are two of the dominating environmental restraints on the location of buildings and structures and on land use in the Bay region.

The primary hazards of active faults are:

1. Slip along the active faults periodically displaces the earth's surface and disrupts overlying structures. This slip may occur as large sudden displacements or as small semicontinuous displacements called fault creep.

2. Fault movement is commonly, although not always and everywhere, a sudden event that generates earthquakes.

The secondary hazards of active fault zones result from the patches of boggy ground that they typically contain, and their particular susceptibility to landslides.

The magnitude of the active fault problem in the Bay region may be gaged from the fact that active zones a few tens of feet to 1½ miles wide traverse 285 miles of Bay region terrain. In addition, destructive earthquakes (Modified Mercalli intensity VII and above) have struck the region 36 times since the first earthquake was recorded in 1800.

*Proposed Investigations*

The location and the historical and recent geologic history of the active faults in the Bay region will be determined by surface and subsurface geologic techniques, distribution of microearthquakes, and measurement of crustal strain. It is hoped that from these data the location of most future disruptions of the earth's surface along active faults in the Bay region can be predicted, and an estimate of the frequency of future episodes of fault slip and destructive earthquakes can be made. The width of the active fault zones that should be considered hazardous because of branching faults or subordinate geologic structures and the location of sag ponds, boggy ground, and landslides in the active fault zones will also be determined. The last phase of the project will be the practical application of the data on active faults to land-use planning and decision-making in the Bay region. In this phase Geological Survey personnel, a structural engineer, and planners will collaborate.

The San Andreas fault and the Hayward fault will have the highest priority for the current investigations. Both have moved in historic time, and both have produced major earthquakes and major surface rupture in the San Francisco Bay area. The Calaveras, Rodgers Creek, Healdsburg, and Sargent faults exhibit convincing evidence of current or historic activity, but surface geologic evidence indicates a lower rate of movement than on the San Andreas and Hayward faults. Nevertheless, data are needed to evaluate these features. A number of faults, including the Pilarcitos, San Gregorio, and Franklin faults, are not known to be active but will be evaluated geologically, because they cut very young deposits or because they are potentially active.

Specific investigations designed to provide the essential data are:

1. The preparation of strip maps based on areal geologic and geomorphic investigations of suspected active faults and of sedimentary deposits and geologic structures in active fault zones that are potentially hazardous to buildings and structures. Data are to be based on geologic interpretation of aerial photographs, field investigations, and possibly geophysical studies of selected areas. Goals are to identify and map active faults, and to collect geologic and geomorphic evidence bearing on movement rates and level of risk.

2. Studies of microearthquakes based on a broadly distributed telemetered seismic net in the nine Bay counties to provide seismic data on known and suspected active faults. Goals are to determine the distribution of microearthquakes in space and time, to identify and map sections of faults that are currently moving, and to monitor sections that are known to be geologically active but appear to be presently aseismic.

3. Physical exploration of active fault zones. Data are to be derived from trenches, auger drill holes, and possibly rotary drill holes (shallow shot-hole rig) located so as to provide data for detailed stratigraphic and structural studies. Goals are to obtain data on fault zone widths, frequency of historical and geologically young fault movements, and, where possible, the age and amount of displacement of those fault movements.

4. Strain measurements and monitoring of known active fault zones. Data are obtained from such relatively low cost nonrecording devices as quadrilaterals and alinement arrays. Minimum new installations are needed in the Point Reyes segment of the San Andreas fault; the Point Arena - Fort Ross segment of the San Andreas fault; and the Healdsburg - Rodgers Creek fault. Goals are to compare local surface strain on known active faults with regional strain as determined from Coast and Geodetic triangulation nets, geodimeter lines, and other precise survey data; also to detect changes from established long-term patterns of strain.

5. Interpretation of marine geophysical surveys in order to locate active faults, and to obtain stratigraphic data pertaining to the age of the last movement. Highest priority is to determine the northern extent of the Hayward fault in San Pablo Bay. Marine surveys will also help locate and date movements on the offshore parts of the San Andreas and San Gregorio faults between Montara Mountain and Point Reyes. Goals are to identify and map submarine segments of active faults, and to collect marine geologic and geophysical evidence bearing on movement rates and level of risk.

*Products*

Basic Data Contributions

1. Strip maps showing active fault breaks:[1]

   a. The San Andreas fault from Paicines to San Francisco. Scale 1:24,000; open filed mid-1971, to be published later as Miscellaneous Geologic Investigation (MGI).

   b. The San Andreas fault from Bolinas Lagoon to Point Delgada. Scale 1:24,000; open filed mid-1970, to be published later as MGI.

   c. The Healdsburg-Rodgers Creek fault (to be prepared only if field and photo interpretive data identify these faults as potentially major sources of earthquake risk).

   d. The Hayward fault northwest of Pinole Point (contingent on availability of geophysical and geologic evidence needed to locate fault in San Pablo Bay and to the north).

   e. Other active faults that may be identified during the course of the investigation.

2. Fault-plane geometry and history of geologically recent faulting in the Bay region as exposed in trenches and drill holes.

3. Distribution and character of microearthquakes in the Bay region from 1968 to 1973.

4. Crustal strain along the active faults of the Bay region from 1968 to 1973.

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[1]Strip maps showing active breaks along the southern Hayward and southern Calaveras faults have already been prepared.

5. Brief reports summarizing environmentally significant findings with time value, obtained from physical exploration program, field investigations, seismology program, or other parts of the active-fault program.

6. Scientific and technical reports for journal or U.S. Geological Survey publication summarizing or describing important research findings. Where such research data are important in planning and decision-making they will be released first under Item 5.

Technical Reports

Tectonic synthesis and evaluation of the known and suspected active faults of San Francisco Bay region, accompanied by a discussion of the relative level of risk and an estimate of future activity, as judged from geologic and geophysical evidence and from historic records. To be accompanied by an active-fault map of the Bay region, scale 1:125,000.

Interpretive Reports

In the various interpretive reports to be prepared (see section on Focus and Methods) the risk of the region's various active faults will be rated in terms of the probable recurrence of major earthquakes and the nature and amount of displacement to be expected. Guidelines for land use in and near fault zones will be provided; for example, set-back limits will be suggested, model ordinance language will be developed, and suggestions of regulatory procedures for public agencies will be prepared.

Slope Stability and Engineering Behavior of Bedrock Areas

The behavior of the ground from an engineering standpoint places varying constraints on man's use of the land, and the possibility of landslides, particularly, will become an increasingly dominant constraint as the need for housing sites extends into the hillside areas. Earth materials in the Bay region range from hard solid rock to swelling clays and various unconsolidated sediments. This range, together with varying geologic structures, topography, and other factors, leads to great differences in the behavior of the ground from place to place. If these differences are ignored, building foundations may collapse, and such public facilities as roads, sewer lines, water and gas pipelines, and bridges may be severely damaged.

Landslides constitute the greatest problem in the region. Large to small masses of earth move downhill at varying rates of speed, removing support for structures above them, impinging on land and structures below them, and multiplying sediment loads in adjacent

streams. Fast-moving landslides can destroy life as well as property.

Bearing strength, swelling potential, ease of excavation, and other characteristics of earth materials are of lesser importance but cannot be ignored. These characteristics can cause excessive construction and maintenance costs and structural failures.

In order to make the best and most economical use of the land, unstable slopes must be identified, grading design must be accommodated to the local materials and slopes, foundation and building design must be fitted to local foundation conditions, and other physical aspects of the ground must be anticipated and planned for. One measure of the significance of these factors is the cost to the State highway system as a result of landslides. Landslides are common in the Bay region and in some places constitute as much as one-quarter of the land area. The cost of emergency cleanup alone of landslides on the 1,115 miles of State highway throughout California averaged almost $3,000,000 per year between 1946 and 1967, and the total direct costs of landslides in State Highway District 5 in the Coast Ranges amount to about $18,000,000, or 10 percent of annual construction costs, in fiscal year 1966-1967.

*Proposed Investigations*

The distribution and general physical characteristics of the various earth materials in the region will be established through literature study, interviews, and field and laboratory observations and testing. From this information, the most critical engineering factors, such as bearing strength, ease of excavation, and erodibility, will be predicted for the region.

The distribution and character of existing landslides in the region will be determined by study of aerial photographs and by limited field investigations. The occurrence of the landslides will be related to the natural and artificial processes which cause them, including lithology, geologic structure, amount and height of slope, rainfall, and land-use practices. The results will be used to predict slope stability over the whole region.

The critical geologic and hydrologic processes and land-use practices that produce landslides and other slope failures are not fully known. Accordingly, selection of the specific physical characteristics to be studied and the procedural details of the slope-stability study will depend on the early results of the investigation.

The last phase of the project will be to apply the information gathered concerning the physical characteristics of earth materials and the slope stability to land-use planning and decision-making in

the Bay region. This phase will involve collaboration between the planners and the geologists, hydrologists, and engineers of the Geological Survey. It is hoped that the results of the project will provide a basis for planning and land-use decisions on a regional and subregional scale, and will provide useful guidance to more detailed studies. However, the results are not intended for site planning and design, or for other local planning decisions.

Specific investigations designed to provide basic data and geologic interpretation are:

1. Existing landslides will be identified and mapped through interpretation of aerial photographs, supplemented by field investigations in selected areas. The factors responsible for the landslides will be determined, and the occurrence of small landslides in the control areas will be established.

2. Maps will be prepared to show the kinds of earth materials present in the Bay region, and their spatial relations, structural character, and areal distribution. The maps will be based on compilation of published and unpublished studies, supplemented by new field investigations. In addition to providing the basic information needed in the landslide and engineering behavior studies, the geologic mapping will provide the essential framework for the active fault, resource, seismic, and hydrologic studies.

3. The physical properties of the earth materials in the Bay region that have critical engineering and land-use significance will be determined and tabulated. Sources of information include the technical literature, selected unpublished files, and field and laboratory testing. The engineering behavior of the earth materials will be predicted, based on the physical properties and methods determined during the investigation.

4. Analysis of the relative stability of hillsides in the Bay region will be based on the occurrence and character of existing landslides and on the geologic, hydrologic, and topographic features and physical processes that cause them. These features and processes include the character, properties, and geologic structure of the earth materials, the height, steepness, and exposure of slopes, ground-water conditions and rainfall, and seismic shaking.

*Products*

Basic Data Contributions

1. Landslide inventory.

    a. Preliminary maps at a scale of 1:62,500 will show

identifiable landslides in selected parts of the Bay region larger than about 300 feet across. These maps will be released to open file according to the tentative schedule shown on the index map (fig. 3).

b. A final map at a scale of 1:125,000 will show landslide occurrence and type, and distribution of those physical factors that appear to control landslides in the Bay region.

2. Geologic maps.

a. Preliminary geologic maps of the Bay region at a scale of 1:62,500 will be compiled from the literature and a minimum amount of field investigation. These maps will be released to open file according to the same tentative schedule as the preliminary landslide maps.

b. A final geologic map at a scale of 1:125,000 will show the distribution and character of earth materials, faults, and the general orientation of bedding.

3. Engineering geologic map.

A map at a scale of 1:125,000 will interpret map units according to their physical properties and engineering behavior and will also show faults and generalized structural characteristics. A tabular text listing the physical properties and engineering behavior of the map units will accompany the map.

Technical Reports

1. Landslides and other slope instabilities in the San Francisco Bay region will be described together with their occurrence, formation, and relation to physical properties and geologic processes.

2. A map, at a scale of 1:125,000, will give a prediction of the future stability of slopes in the San Francisco Bay region, and will be accompanied by a discussion of the map and the data and methods used in its preparation.

Interpretive Reports

In the various interpretive reports to be prepared (see section on Focus and Methods), guidelines will be formulated for developments in areas having slope-stability problems. Maps will be prepared on a regional scale to show the relative stability of various terrains. Factors such as density of development, alternative land uses, and other methods of minimizing the slope-stability problem will be discussed.

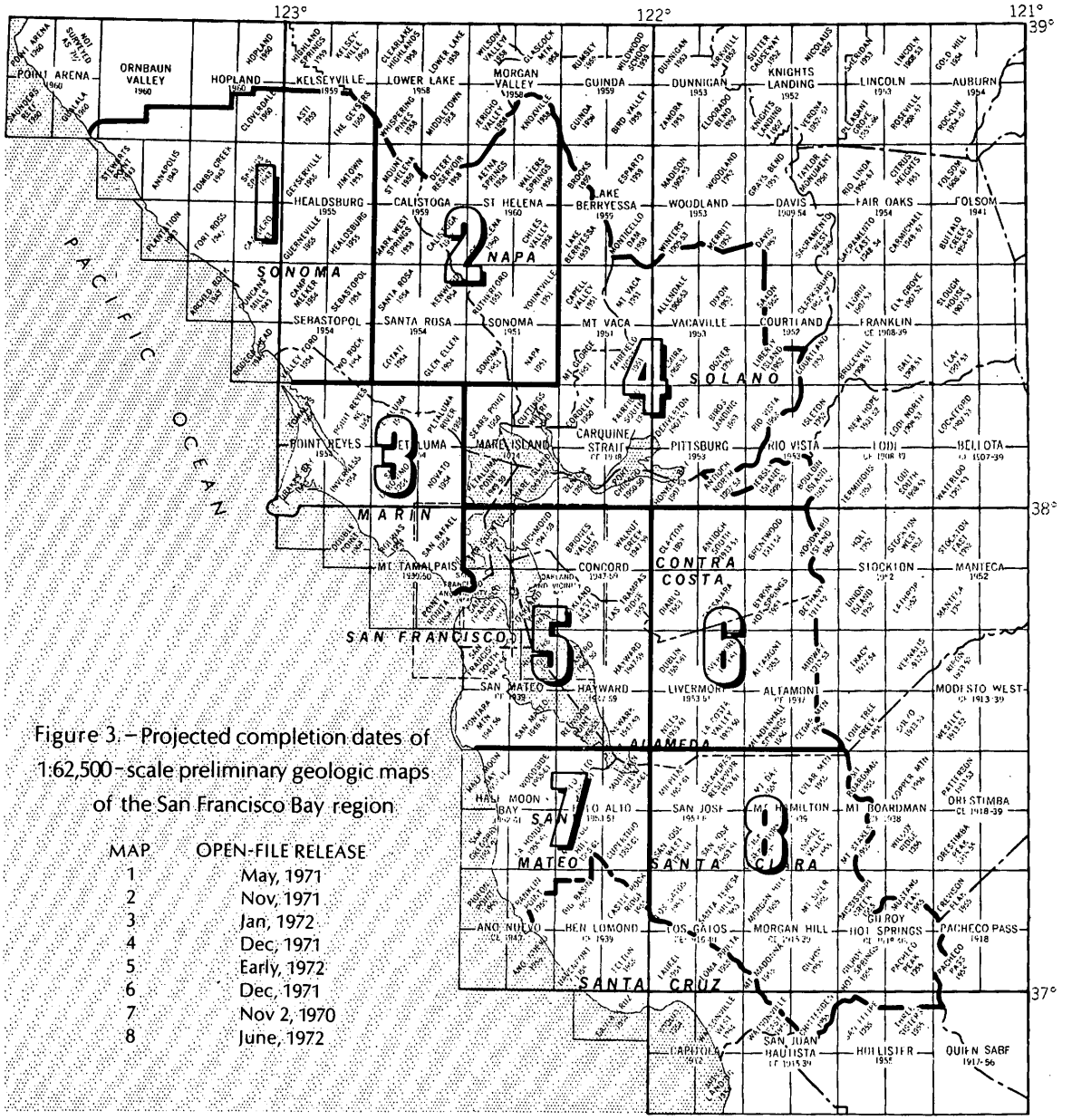



Figure 3.—Projected completion dates of 1:62,500-scale preliminary geologic maps of the San Francisco Bay region

| MAP | OPEN-FILE RELEASE |
|---|---|
| 1 | May, 1971 |
| 2 | Nov, 1971 |
| 3 | Jan, 1972 |
| 4 | Dec, 1971 |
| 5 | Early, 1972 |
| 6 | Dec, 1971 |
| 7 | Nov 2, 1970 |
| 8 | June, 1972 |

## Physical Properties of Unconsolidated Deposits

Most of the population in the San Francisco Bay region is concentrated in lowland areas underlain by unconsolidated sedimentary deposits. As population increases and greater demands are made on these areas for residential, agricultural, industrial, and recreational use, it is imperative that various geological conditions be considered. Pertinent geological data should be incorporated into regional and local plans to avoid or minimize the adverse affects of natural processes, to prevent the artificial intensification of any natural problems, and to avoid creating new problems. Several of the most important geologic conditions affecting land use in lowland areas are summarized below.

Ground motion resulting from earthquakes may be amplified as a result of the low shear strength of unconsolidated materials. Consequently, earthquakes pose a more serious problem in areas underlain by sediments than in areas underlain by consolidated bedrock. Because the San Francisco Bay region is traversed by three major earthquake-generating fault zones that have been active in historic time, this problem is of particular significance. The 1906 San Francisco earthquake clearly illustrates the actual hazards, and the 1964 Alaska earthquake, in which property damage was much more severe on unconsolidated ground than on bedrock, illustrates the potential hazard.

Poor foundation conditions such as liquefaction and compressibility (low bearing strength) may be associated with certain sedimentary deposits such as the Bay mud. Expansive soil is a common problem in the lowland areas, though it is not restricted to this particular geologic or geographic setting. When ignored these properties may cause safety hazards, excessive maintenance costs, or even condemnation as a result of structural failures.

The unconsolidated deposits in lowland areas form the natural reservoirs supplying most of the locally derived water for domestic, agricultural, and industrial uses. The quantity and quality of this water is both directly and indirectly related to the physical characteristics (such as porosity, permeability, bedding, and lateral extent) and the structural features (such as faults and folds) of the sedimentary deposits. To protect this valuable water resource, land use and operational practices should be carefully evaluated. Pumping rates, if too high, could deplete reservoirs and cause regional subsidence as in San Jose (as much as 8 feet in a 30-year period) or allow encroachment of saline water into fresh-water aquifers. Solid- and liquid-waste disposal, if not properly effected, could contaminate ground water or clog natural aquifers. Inadequately designed or improperly situated percolation ponds would inhibit recharge of ground water reservoirs.

Areas susceptible to the various problems outlined above must be identified in order to make the best and most economical use of the lowland regions. The thickness and the gross physical characteristics of the sedimentary prism are among the most important parameters required for a seismic-intensity (ground-motion amplification) map of the Bay region. Contour maps of the bedrock surface and isopach maps of the sedimentary deposits will provide essential data for identifying areas of high seismic intensity. Areal geologic maps and cross sections of the sedimentary deposits will provide data for identifying areas with potential foundation and ground-water problems. With these important data readily available, land use and building design can be better adapted to local geological conditions.

*Proposed Investigations*

The gross physical aspects of the sedimentary deposits--lateral extent, thickness, bedding characteristics, structural features, compaction, grain size, etc.--will be determined as completely as possible by surface and subsurface geologic methods. Compilations of published and unpublished maps and well logs will be checked and augmented by limited field mapping, geophysical investigations, drilling, and laboratory tests, such as age dating and fossil identification. These basic data will be synthesized to provide an insight into the late Cenozoic geologic history of the Bay region. A knowledge of the geology as recorded in the sedimentary deposits is essential not only to the problems previously outlined but also to many other aspects of the program.

The initial phase of the project will involve collecting and synthesizing available geologic data. The second phase will focus on selected topics or strategic areas with particular problems or inadequate information. Therefore, the detailed execution of the second phase will depend on the first. The final phase will involve interpretation of the basic data with the focus on applying the results to land-use planning. This phase will involve collaboration between planners and engineers from local and regional governments, and earth scientists of the Geological Survey.

It is hoped that the proposed maps and reports will provide adequate information for regional and subregional planning. They probably will not provide adequate information for local planning or specific site appraisal, but should provide useful guidance for detailed studies.

Specific investigations designed to provide the basic data and geologic interpretations are:

1. Data will be derived from well logs, geophysical surveys, and field mapping, the goals being to define the depth and configura-

tion of the upper bedrock surface primarily as an aid to the prediction of variations of ground-motion intensity during earthquakes.

2. A study of the thickness and lithology of unconsolidated sedimentary units will be based on surface and subsurface mapping and geophysical surveys. These data are needed to predict the seismic and engineering behavior of the unconsolidated deposits. They are basic to understanding the past movements and predicting the future activity of earthquake faults. They are also essential for understanding present ground-water problems (supply as well as resulting subsidence) and predicting future problems. They also provide information for construction-material inventories.

3. The characteristics of the unconsolidated deposits that determine their engineering behavior will be studied and tabulated. Data will be derived from field and laboratory engineering tests and geologic maps compiled from the literature, augmented by field mapping. From a knowledge of the lateral distribution at or near the ground surface, potential engineering problem areas will be delineated.

*Products*

Basic Data Contributions

1. Contour map of bedrock surface; scale 1:62,500 or larger.

2. Isopach map of unconsolidated deposits; scale 1:62,500 or larger.

3. Map of historic limits of San Francisco Bay marshlands; scale 1:62,500 or larger.

4. Geologic maps and cross sections by counties; scale 1:62,500.

5. Engineering geologic map; scale probably 1:62,500 or larger; with tabular data listing physical properties and engineering behavior.

6. Miscellaneous maps; scale probably 1:62,500 or larger. Maps show distribution of specific characteristics or problems (such as land subsidence). Topics to be determined as project progresses.

Interpretive Reports

The results of this program element will be incorporated into general interpretive reports or manuals (see section on Focus and Methods), and will serve as background for a more meaningful appraisal of such factors as land subsidence, seismic damage potential,

availability of sand and gravel, foundation conditions for construction, and tunneling excavation and drainage problems. These data will be fundamental to the land-use guidelines which will be developed in the interpretive reports.

## Seismicity and Ground Motion

The rapidly expanding urban region surrounding San Francisco Bay lies on one of the earth's most active tectonic features--the San Andreas fault system. Along this fault system the crustal plate that floors the Pacific Ocean is sliding northwestward past the crustal plate supporting the North American continent at a rate of several centimeters per year. The opposing plates slide past each other quite smoothly in some regions where their relative motion is accommodated by aseismic creep and frequent small-to-moderate earthquakes. In other regions, including the Bay area, they are more firmly locked together and slip suddenly, after long but irregular intervals of time, when stresses across the fault induced by slowly accumulating elastic strains along the plate edges build up to levels that exceed the "strength" of the fault. The great earthquakes that can result from this process, such as the 1906 San Francisco earthquake, constitute a major hazard to life and property. The historical record suggests that the Bay area should expect at least one great earthquake ($M \geq 8$), several major ones ($M \geq 7$), and many destructive ones ($M \geq 5.5$) per century.

The San Andreas fault system is quite complex in the Bay area. It splits southeast of San Francisco Bay and major branches run along both sides of the Bay. The principal "San Andreas" branch, which produced the 1906 quake, runs up the peninsula west of the Bay and continues northwestward to Cape Mendocino. The subsidiary Calaveras and Hayward branches can be traced up the east side of the Bay to Carquinez Strait but their relationship to major faults in the Coast Ranges north of the strait is not clear. Although a major earthquake occurred on the Hayward fault in 1868, both the Hayward and Calaveras faults appear to be creeping sporadically at the present time.

Most of the destruction caused by earthquakes results from damage to, or collapse of, structures built by man--destruction caused either directly by ground shaking produced by seismic waves spreading outward from the generating fault, or indirectly by failures in the underlying materials (foundation failures, landslides, etc.) induced by ground shaking. Measures to lessen or avoid earthquake damage usually are directed toward preventing damage to structures. The success of these measures is dependent upon the accuracy of the estimates of the character and intensity of ground shaking in

specific regions (or even at specific sites) that will be produced by earthquakes originating on the major faults.

Traditional methods of arriving at such estimates are mostly empirical. They involve examination and analysis of damage produced by specific earthquakes on the terrain and on the structures that were by chance subjected to them. Progress by these methods has been slow, and the results that they have produced have been semiquantitative at best. Even a great historical earthquake, such as the 1906 earthquake in the Bay area, fails to provide an adequate basis for sufficiently detailed, accurate predictions of the effects of a future great earthquake in the same region. Urbanized areas have expanded enormously, and much of the growth has been on ground of uncertain geologic stability. Moreover, far more sophisticated, reliable predictions of ground shaking are required to insure a safe design for a large structure than for the simpler frame structures against which the 1906 quake was measured.

In the search for a better understanding of how earthquakes are generated and for more reliable and direct methods of predicting their effects, the Geological Survey has undertaken a broad range of studies on the San Andreas fault system in central California. The long-range goal of this program is the prediction of the time, place, and magnitude of earthquakes in the region as well as the character, intensity, and duration of strong ground motion experienced at sites throughout the shaken area.

*Proposed Investigations*

Different instrument systems and methods of study are employed to attack various aspects of the problem, as outlined below.

1. The mechanics of earthquake generation are being investigated by:

   a. Detailed study of microearthquakes and aftershocks by the permanent telemetered seismic network and by special portable seismic networks to map faults in three dimensions and to determine the nature and time history of movement along the fault surface.

   b. Detailed measurements of strain along the San Andreas fault system. The measurements are designed to detect the elastic strain accumulating across a broad region containing the fault zone as well as to detect the concentrated, nonstored strain (or slip) associated with creep and microearthquakes.

   c. Analysis of the space-time history of microearthquakes and strain to define the outlines of local crustal "plates" and to develop methods for short-term earthquake prediction.

d. Laboratory studies of the mechanical properties and behavior of crustal rocks under the conditions of temperature and stress encountered in the crust.

e. Model studies of the mechanics of "faulting" in a heterogeneous strained elastic medium.

2. Seismic wave propagation in the crust is being investigated by:

a. Explosion-refraction studies of gross crustal structures and of geometrical spreading and dissipative attenuation along various paths.

b. Same as above, but with precisely located microearthquake sources at depth within the crust instead of surface explosions.

c. "Mapping" of seismically sensitive sedimentary deposits in basins by seismic refraction and reflection techniques. Determination of in situ elastic constants by the same methods.

3. Influence of local geologic conditions on the character, intensity, and duration of strong ground shaking are being investigated through:

a. Studies of the relative amplification and spectral ratios ("site" to "bedrock") of seismic waves from distant sources as a function of the geology of the recording site. These are "small-motion" measurements.

b. Analysis of telemeter and portable seismograph station magnitude residuals to determine variations in average amplitude response for local earthquakes as a function of recording-site geology.

c. Multilevel down-hole seismograph installations to record waves from moderate local earthquakes to provide data for detailed studies of the amplification of seismic waves by weak near-surface materials. On occasion, the down-hole installation will be augmented by a surface tripartite array of three-component portable stations to establish the identity of the wave types associated with large amplitudes and particle velocities at the surface of a sedimentary section.

d. Theoretical studies of the interaction of seismic waves emerging from the "basement" with localized basins of low-velocity sediments.

e. Strong-motion versus weak-motion amplification ratio studies in the vicinity of nuclear tests to establish the range of applicability of "small-motion" studies.

Most of these studies are being made along the San Andreas fault between San Francisco and Cholame, where the opportunity to study the widest variety of conditions with a minimum of effort presented itself. For the purposes of the San Francisco Bay Region Study, the telemetered seismic net should be strengthened north of the Bay and strain-monitoring networks should be established there to extend the work now carried on in the southern counties to the rest of the nine-county pilot program area.

Seismic studies to be added to answer specific questions pertinent to the San Francisco Bay Region Study include:

1. Ground-motion studies; primarily install and operate downhole seismograph at edge of Bay.

2. Extension of microearthquake and strain networks into the area north of Carquinez Strait.

3. Special seismic reflection/refraction studies of sedimentary basins.

4. Preparation of seismic intensity estimate maps.

*Products*

Although the primary USGS earthquake study program is open ended and largely financed under programs other than the cooperative program with HUD, substantial results of great importance to the San Francisco Bay Region Study are anticipated during the next 3 years.

Basic Data Contributions

1. Precise delineation of microearthquake-generating active faults in the Bay area and detailed monitoring of quiet sections of known major active faults for signs of reactivation. Both the seismic and strain nets will contribute to this study. Seismic and strain observations will be analyzed and evaluated in the light of geologic evidence on active faulting developed under the Active Faults Project, and the results of the coordinated study will be presented in the reports described under that project. Supporting lists of earthquakes, giving locations, occurrence times, and magnitudes, will be provided in addition to the epicenter maps.

2. Development and field evaluation of active seismic techniques for mapping the distribution and thickness of low-velocity sediments

in basins and of estimating the elastic constants of the sediments. This work will be closely coordinated with the Unconsolidated Deposits Project, and many of the results will be published as refinements and extensions to maps presenting the work of that project. In addition, it is anticipated that cross-section profiles will be published for the major basins in the nine Bay area counties.

3. The relative ground amplification map of the margins of the Bay (originally published in a paper by Borcherdt) will be refined and extended as the availability of Nevada Test Site shots of suitable size permits.

Technical Reports

Technical papers will be published in scientific journals to report the major theoretical and experimental results of the earthquake study program.

Interpretive Reports

The seismic risk factor will be incorporated into various interpretive reports. A special interpretive report will include maps showing the extent of expected damage from earthquakes of various magnitudes originating on the major active faults of the region. The expected damage will be expressed in terms of intensity measured by the Modified Mercalli scale--an arbitrary scale that extends from I (shock generally not felt by anyone) to XII (total destruction of manmade structures). These intensities will be estimated from their relation to: (1) observed historic damage as a function of distance from the earthquake epicenter and (2) variations in damage intensity with variations in rock and soil types. The expected ground-motion data will be generated by computer and can be updated as new information is accumulated. In collaboration with structural engineers, an attempt will be made to develop model code requirements in different earthquake risk zones.

## Mineral Commodity Utilization

Continued industrial growth and urbanization in the Bay region will require the utilization of large quantities of mineral commodities. Many of these commodities are available within the Bay region itself. It is advantageous, especially for construction materials, to utilize local resources where this can be done without degrading the environment, because proximity to markets is a large part of their intrinsic value. A few of the commodities, in particular the metallic resources, are in short supply nationally. Both types of commodities form the basis for the livelihood of many people and some communities in the Bay region. The utilization of these resources, however, will

require planning mechanisms to insure that development is (a) compatible with urbanization, (b) does not degrade the natural environment, and (c) serves the public need for these commodities at an economically realistic cost and with the least congestion of public highways and streets and degradation of the environment along them.

The major problems are:

1. Long-range plans are necessary for mining operations.

2. The pressure of urbanization is strong and immediate, and such pressure has a general history of overriding the promise of long-term gains from the development of local mineral commodity resources.

3. Mineral commodity deposits are geographically fixed and must, therefore, be utilized where they occur.

4. Urbanization has made large areas that would have been potentially valuable for construction materials unavailable for development.

5. Future worth depends on supply, demand, and technological advances, all of which are difficult to predict.

The per capita consumption of metallic and nonmetallic resources increases exponentially with increases in population. The rapid expansion of population and associated urbanization in the Bay area will inevitably put ever greater demands on the area's construction material resources. Effective resolution of the conflict between urbanization and resource management and utilization is necessary to insure the continued economic health of many communities and industries in the Bay region.

*Proposed Investigation*

Three phases will be undertaken in this project, each of which requires extensive background data.

The first phase of the project will be to inventory and evaluate the mineral commodities of the Bay region. The major deposits, districts, and areas of economic potential of major commodities will then be delineated, classified, and ranked.

The second phase will be to determine the social and economic impact, and the environmental factors which attend the utilization or nonutilization of the various mineral (commodity) deposits of the Bay region.

The third phase will be to integrate all of the considerations into a strategy for making planning decisions on the development of Bay region mineral resources that are compatible with maintaining a quality environment. This last phase will be accomplished jointly by U.S. Geological Survey personnel, an urban planner, and a consultant in the field of nonmetallic minerals.

*Specific Investigations*

1. California Division of Mines and Geology will prepare a basic data report on the mineral commodities in the Bay region. Data will be a compilation of existing information. This report will provide basic information for guiding future work.

2. Updating information in the California Division of Mines and Geology will be performed primarily by incorporating Marine Geology data on commodities in the Bay, the delta, and the continental shelf. Recent data from field studies of the HUD program will also be incorporated. This will then be the most complete and most recent data available on Bay region mineral commodities.

3. Detailed mapping from aerial photographs and field investigations of carefully selected deposits, districts, or areas of economic potential will provide data on their extent, quality, and economic value. Such information is essential for economic decisions, classification, and ranking of the mineral deposits. These detailed investigations will be undertaken only to fill critical gaps in the extensive published literature and available private reports.

4. Classification and ranking of deposits, districts, or areas will be based on physical examinations and preexisting information. The areas will be classified on the basis of size, quality, accessibility, and amenability to utilization. The areas will then be ranked to provide a basis for decision-making.

5. A strategy will be developed for deciding upon the utilization or nonutilization of mineral commodity deposits in the urban environment, with particular reference to the San Francisco Bay region.

*Proposed Reports*

Basic Data Contributions

1. Commodity maps: Release will be by commodity for all nine counties. Scale 1:63,360.

2. Basic data report containing the California Division of Mines and Geology information after updating by U.S. Geological Survey.

3. Classification and ranking maps.

Interpretive Reports

Interpretive reports will deal with three major subjects:

1. Discussion of the impact of commodities on urban planning with emphasis on the economic results of nonutilization.

2. Development of decision-making criteria with regard to the utilization of local mineral commodity deposits based on considerations of geology, economics, conservation, and urbanization.

3. Presentation of dynamic programming techniques and a "decision tree" analysis to expedite the decision-making process. (The general development of a dynamic programming scheme would probably involve personnel of the Computer Division of the USGS.)

## Open-Space Study

Relatively little effort has been made to identify Bay region lands and waters that constitute a scientific, educational, historical, or recreational resource, and to determine the social and economic value of this resource. The certain prospect of continued increase in Bay region population, with a concomitant increase in urbanization, make it mandatory that such resources be identified, cataloged, and evaluated for permanent preservation quickly. These resources constitute the cultural and natural heritage, as well as the scenic and recreational amenities, that make the Bay region an enviable place to live. Once overwhelmed by urbanization, most of these resources are lost forever.

### *Proposed Investigations*

The investigation will catalog and map Bay area lands and waters that have significant scientific, educational, historical, and recreational values. Use and potential use of these lands will be analyzed with respect to geologic or hydrologic hazards, and mineral and (or) water resources. These factors will be related to open-space use and analyzed as an aid to making better land-use decisions. Examples of such resources are areas valuable for the recharge of ground water or for flood control; areas with recreational potential; wetlands which are fundamental to the food chain; areas of sanctuary for wildlife; areas of scientific importance (such as archaeological or fossil-collection sites and geologic, hydrologic, and biological models); prime agricultural lands, and areas that are culturally or esthetically outstanding, such as the prime vineyard areas of the Livermore, Napa, Santa Clara, and Sonoma Valleys.

*Products*

Basic Data Contribution

A catalog, with maps at a scale of 1:125,000, of open-space resources and of the current uses of the lands and waters which contain these resources.

Interpretive Report

An analysis of the various geologic, hydrologic, social, and economic factors that affect the ultimate value of land with significant open-space resources. This report will attempt to evaluate the true long-term social and economic worth of these lands to the Bay region community and to develop a strategy based on environmental criteria by which decisions on the ultimate use of these lands can be made on a regional basis.

## HYDROLOGIC ELEMENTS

The San Francisco Bay Region presents an extremely diverse hydrologic setting. The complexities of the flows in and through the Bay-Delta system and its circulation patterns far exceed the range of problems encountered in most estuaries. The increasing upstream utilization, along with greater loading from municipal, industrial, and agricultural wastes, aggravate the delicate ecological balance in the Bay. Exceedingly broad and lengthy studies, some of which have in part been undertaken by other agencies, would be necessary to provide a complete description and understanding of this intricate system. The hydrologic studies outlined here emphasize the hydrology of the land areas surrounding the Bay and considerations pertinent thereto. Analyses of the Bay itself are limited in scope and are intended to provide a generalized understanding of the estuary system.

The aim of this part of the program is to provide a framework for planning, based on sound hydrologic principles, whereby problems, constraints, and factors advantageous to development can be recognized early in the planning process. The primary input will be in the form of topical studies treating various facets with which the planner may be concerned. Results of the studies will be presented in a series of basic data contributions, technical reports, and interpretive studies showing practical applications of the findings.

### Public Water-Supply Services Areas

There are no up-to-date maps and compilations of data that show areas served by public water-supply systems in the nine Bay area counties, and that define, within reasonable limits, the present capacities of the several systems and the number of people served. The study considered here is primarily a service activity requested by ABAG and depending in considerable part on information to be supplied by that agency, and by the Public Utilities Commission.

*Proposed Investigations*

Information needed to define the service areas will be compiled and an appropriate map or maps prepared. Data on connections, number of people served, quantities of fluid handled, and ultimate capacities of the several systems will be obtained and tabulated. In addition to the information furnished by public agencies, it may be necessary to contact each of the private service companies to get information on ultimate capacities.

*Products*

Basic Data Contributions

1. A map (scale 1:250,000) showing service areas of municipal and private water-distribution agencies in the nine Bay region counties.

2. A tabulation to accompany the map showing the following information: (a) source of water, (b) population presently served, (c) number of service connections, (d) present water consumption, (e) future population projection, and (f) future water needs.

## The Ground-Water Resource

Of the two alternative sources of water--ground water and surface water--used in the Bay region, ground water, or water occurring in the subsurface and extracted by pumping from wells, represents the larger quantity native to the region. The surface water used so extensively in the region is largely imported from remote sources because the Mediterranean climate--winter rains and summer dry weather--causes low flows or intermittent flow in most Bay region streams.

Therefore, ground water is an important resource, and should be considered in a management context, like other resources. Although ground-water reservoirs are extensive and capacious, they are neither infinite nor--despite a shielding of clay, earth, and rock--impervious to contamination. And, although movement of water in a ground-water reservoir is infinitely slow in comparison to movement in surface-storage reservoirs, the ground water does move in response to physical laws; therefore, its quantity and behavior under various stresses can be determined and predicted within reasonable limits.

Management of a ground-water reservoir requires (1) definition of the boundaries (typically of impervious rock) that confine the permeable materials that constitute the reservoir; (2) determination of the water-storage and transmissive characteristics of the materials composing the reservoir; and (3) assessment of the rates at which water is added to and withdrawn from that subsurface reservoir.

With those factors determined, it becomes possible to evaluate the natural recharge (addition to) and discharge from (outflow from springs is an example), the potential for artificial recharge, and the rates of withdrawal from wells that can be sustained without causing undesired effects in the system. At the same time, the chemical and biological properties of the water can be determined, and the susceptibility of the reservoir to contamination from such things as sewage effluent from septic tanks, pollution from discharge of industrial wastes, or invasion of the reservoir by sea water, can be assessed. With those facts in hand, a program of ground-water reservoir management can be designed that will provide optimal use of the resource.

*Proposed Investigations*

Functional-planning maps will be prepared delineating the principal ground-water basins:

1. Maps showing areas underlain by aquifers capable of yielding large quantities of water to deep wells, small quantities of water to shallow wells, and areas underlain by virtually nonwater-bearing rocks. Tables showing estimated usable ground water in storage (1970) and estimated usable but unused ground-water storage capacity.

2. Maps showing depth to water supply.

3. Basin maps showing content of dissolved solids in water from wells, and water quality of aquifers containing deteriorated ground water.

4. Of special importance is a map showing areas where water levels were at or above land surface in deep wells during 1969, and (or) where levels were at or above land surface historically. Also important is a map showing the thickness of the unsaturated zone between land surface and water table. Of particular importance is a high degree of accuracy in mapping the water table.

5. A map showing the location of larger flowing wells and springs, and selected wells having pumps powered by internal-combustion engines which could be used for emergency domestic water supply. Also the map should show wells near populous areas principally used as a standby supply for emergency use (electrical power pumps).

Most of the data needed will be assembled from published sources of the Water Resources Division and the California Department of Water Resources or from files of county agencies, but some fieldwork and mapping will be required. Also, files of State and county highway departments will be consulted for some data, such as water levels in test borings for roads, bridges, and dikes.

*Products*

Basic Data Contributions

1. Map (scale 1:250,000) showing areas where the depth to the water table is 200 feet or less as of 1969 in each of the major ground-water basins.

2. Map (scale 1:250,000) showing areas where water levels of deep wells are or have been at or above the land surface.

3. Map (scale 1:125,000) showing locations of water sources that could be used to provide emergency domestic supplies in the event of failure of existing supplies.

4. Tabular report giving the estimated ground water in storage to a depth of 200 feet below the water table, and the estimated usable storage capacity in unsaturated aquifers to a depth of 200 feet below the land surface, for each major ground-water basin.

Technical Reports

1. Map (scale 1:250,000) showing potential yield of aquifers to wells in all land areas within the study area. Yields shown will be of four magnitudes, as follows:

a. Yield marginal for stock or single-family domestic use (average yield less than 10 gallons per minute).

b. Yield adequate for stock and single-family domestic use (average yield about 10 gallons per minute).

c. Yield suitable for light industry, but marginal for irrigation or heavy industry (average yield about 100 gallons per minute).

d. Yield adequate for irrigation and heavy industry (average yield about 1,000 gallons per minute).

2. Map (scale 1:125,000) showing the range of total dissolved solids in water from wells in each ground-water basin, areas where saline connate water is found, and areas where the ground water has been degraded by the intrusion of saline water.

Interpretive Report

An interpretive report on development of the ground-water resource and management of subsurface reservoirs in the Bay region will be prepared. It will include a discussion of the possible use of these subsurface reservoirs for the temporary storage of local storm runoff or imported waters, and strategies for controlling land subsidence, salt-water intrusion, and other problems resulting from large-scale development of the ground-water resource. Emphasis will be placed on the importance of maintaining recharge rates to the region's aquifers and the potential role of urban planning in attaining this objective. The alternative approaches of preserving natural recharge areas or replacing them with artificial recharge facilities (pits, ponds, spreading basins, injection wells) will be considered.

## Aquifer-Recharge Areas

The supply of ground water which can be pumped annually in the Bay area has been regarded by users, through long custom and legal precedent, as a renewable resource. That is, the supply is considered to be a more or less permanently fixed quantity which depends on natural phenomena--the average rainfall and runoff--without regard to development of the area. However, because the rain or runoff must first percolate from the surface to the ground-water body through permeable earth materials, development of the Bay area can change the available ground-water supply. Areas where recharge occurred under undeveloped conditions are changed by development, and are rendered unsuitable as recharge sites through paving or installing housing. Planners should take into consideration the utility of maintaining natural ground-water recharge sites. Their existence should be known and the consequence of their removal by paving or other development should be considered in the planning phases.

### *Proposed Investigations*

Existing areas of ground-water recharge will be identified, including areas of natural ground-water recharge along stream courses and on alluvial fans, and areas of artificial ground-water recharge such as water spreading in surface basins or ponds constructed for the purpose.

Additional areas where ground water is unconfined and which could be used for artificial ground-water recharge through spreading in surface ponds or basins, will be identified. The criteria for selection will include (1) depth to ground water greater than 100 feet; (2) permeable deposits that extend vertically from land surface to the water table; (3) saturated deposits underlying the site that exceed 100 feet in thickness; (4) estimated transmissibility prior to recharge that exceeds 25,000 gallons per day per foot; (5) wells of large yield that exist or could be constructed nearby; (6) available storage capacity not less than 20,000 acre-feet; (7) direction of flow of recharged water predictable and not likely to cause downgradient water logging, drainage problems, or losses into surface streams, lakes, swamps, or areas of evaporation from soils or phreatophytes.

Most of the data needed will be available after ground-water mapping for this study is completed but some additional well-data compilation and collection will be required. All available geophysical data (resistivity and seismic refraction) will be sought from local agencies, private companies, and universities. Available geologic maps will be consulted. Data from all local water agencies, purveyors, flood-control districts, and so forth, will be collected.

*Products*

Basic Data Contribution

Report with tabular material on the current status of artificial recharge including a discussion of the potential for additional artificial recharge.

Technical Reports

1. Map showing significant areas where natural and artificial recharge of aquifers is taking place.

2. Map showing areas where the potential exists for artificial recharge of aquifers.

Interpretive Report

The interpretive report on the ground-water resource will incorporate the findings of this program element.

## Wastewater Sources and Pollutional Loadings

The world-wide problem of disposal of sewered wastes is aggravated in the San Francisco Bay region by the following factors: (1) growing population; (2) areas, presently unsewered, that are receiving an influx of peoples; (3) sewage-treatment systems presently below acceptable standards of capacity and incapable of providing adequate treatment of wastes; (4) geography that has directed development toward disposal of sewage into the Bay, parts of which have weak circulation patterns; and (5) the likelihood that circulation in the Bay will be further diminished with time. In addition, there are over 50 major industrial facilities in the San Francisco Bay region, which may be significant from a water-pollution standpoint. These industries include factories for food and kindred products, paper, petroleum refining, and chemicals. Industries in the region are generally located near the periphery of San Francisco Bay and many have discrete industrial waste outfalls which discharge wastes directly to the Bay and its tributary waterways.

*Proposed Investigations*

Wastewater sources--both domestic and industrial--will be identified and pollutional loadings determined for San Francisco Bay, its principal tributaries, and the offshore coastal waters. The most significant domestic and industrial pollutants will be identified, as well as other significant sources such as agricultural wastes, storm-water runoff, and watercraft. A qualitative study will be undertaken to determine how land-development practices and varying levels of treatment appear to be affecting wastewater loading patterns.

*Products*

Basic Data Contributions

1. Map showing boundaries of Bay area sewerage districts.

2. Map showing location of municipal and industrial sewage outfalls, including descriptive data on municipal and industrial dischargers.

Technical Reports

1. Map, accompanied by tables and graphs, showing estimated pollution emissions within six subregions surrounding the Bay and compilation of per capita wastewater loading coefficients.

2. Report on alternatives in wastewater management and probable future trends in water-quality management practices. Among the alternatives being considered are several wastewater conveyance plans, higher degrees of treatment, recycling of wastewaters, and land-based disposal of wastewaters.

Interpretive Report

Material from this program element will be incorporated into the interpretive report on water quality.

## Water Quality

The influence that man has upon the water quality of streams, lakes, and ponds is well known. Yet, surprisingly little has been published on the subject. Long-term analyses of water-quality changes due to the activities of man are generally inadequate. Some limited data are available, and these will be analyzed.

In several Bay area streams, the USGS and the State of California have made periodic "major ion" determinations over a period of several years. These data are available and statistical comparisons at several sampling sites on several streams will be made. Significant changes with time will be noted and discussed in relation to changes brought about by the activities of man. Unfortunately, these comparisons are possible only with major ions at this time. Some nutrient data are available, but they are insufficient for long-term comparisons.

*Proposed Investigations*

A study will be made of the relationship of water quality to beneficial use in San Francisco Bay. The Regional Water Quality Control Board (RWQCB) has established eight water-quality zones in the Bay, and for each it has prescribed beneficial uses and water-quality criteria. Likewise, BCDC has identified existing and potential recreational areas, wildlife refuges, primary fish habitats, and hunting and fishing grounds, around the Bay. A series of maps showing past and present quality of water relative to these beneficial uses will be prepared. Future changes in water quality, based on population and land-use projections, will be estimated, the principal parameters to be considered being coliform bacteria, dissolved oxygen, biostimulants, and relative toxicity.

*Products*

Basic Data Contributions

1. Map showing present water-quality sampling sites on streams, rivers, lakes, and estuarine waters in the San Francisco Bay region. The parameters being analyzed will be shown.

2. Maps depicting present and past water-quality conditions in Bay area waters.

3. Selected tabular and graphical water-quality data for major Bay area streams, rivers, and estuarine water.

4. A series of maps showing relation of present water quality to beneficial uses and water-quality criteria designated by the RWQCB.

Interpretive Report

An interpretive report will be prepared on water quality in the streams, aquifers, San Francisco Bay, and offshore coastal waters. This will be a nontechnical report with emphasis on the impact of decisions regarding future urban development on the quality of waters in the Bay region. Present pollution loadings, waste disposal practices, and the existing quality of receiving waters will be described. A correlation will be attempted between alternative land-use practices and the resulting pollution loads. The effects of alternative proposals for wastewater management on the quality of the receiving waters will be discussed. Among the alternative proposals which might be considered are continuation of present practices, consolidation of treatment facilities and disposal into San Francisco Bay, ocean outfalls, recycling of wastewaters, and land-based wastewater disposal by sprinkler irrigation.

## Land Pollution Susceptibility

Solid-waste disposal sites and individual septic systems have a large potential for land pollution--pollution of the ground-water resource by leaching, and pollution of the land itself and the surface streams by overland runoff. A knowledge of the geologic environment is important in the location, planning, and design of these land-based waste-disposal facilities. The proposed study should provide, on a regional scale, information on the geologic environment which can be used by urban planners and others concerned with urban development to help locate the most favorable sites for these waste-disposal facilities.

The location and maintenance of solid-waste disposal sites is a constant problem facing government officials. In the San Francisco Bay region, solid waste has been placed in sanitary landfills, or has been used to fill parts of the Bay. However, little is known about the influence of solid-waste leachates from sanitary fills upon the quality of such receiving bodies as streams, ground-water bodies, and the Bay itself. This study will attempt to fill some of the gaps in our knowledge, and will also summarize the present status of sanitary fills in the region. It is emphasized that present disposal methods cannot be continued indefinitely and an investigation of alternative methods is needed to evolve a coordinated regional plan of solid-waste disposal.

Septic tanks are used for waste disposal in those areas of the San Francisco Bay region that are not serviced by sewers. Small future developments outside the boundaries of sanitary districts may start out by using septic tanks, because of the large capital cost of sewage systems. Efficient operation of septic tanks and drain fields depends, to a great degree, on the geology and soil of the area.

### *Proposed Investigations*

1. A regional-scale study will be made of the geologic and soils conditions of the Bay region, and guidelines will be presented for the definition of areas favorable and unfavorable for land-based waste-disposal systems.

2. A map will be prepared showing the 77 landfill sites in the region. These sites range in area from 1 or 2 acres to 500 acres, and occupy a total of 5,000 acres. The sites will be identified by number on the map and in a table that will give the exact location by coordinates, ownership (public or private), area and volume of the site, and probable date when the site will be filled. The map will also show the drainage path of the leachates, where known.

3. A few sample studies of leachate quality and its effect on the receiving water body will be made, and general guidelines for selecting sanitary-landfill sites will be presented. It will be emphasized that the selection of any future sites must be compatible with land-use plans to prevent deterioration of the environment.

4. A map showing sanitary-district boundaries will be prepared. Land areas outside these boundaries with a potential for use as septic tanks and drain fields for waste disposal will be delineated, based on an evaluation of soil and geologic factors.

*Products*

Basic Data Contributions

1. Location map (scale 1:125,000) of Bay area landfills with accompanying tabular data summarizing hydrogeologic conditions, leachate production, water-pollution potential, ownership, size, and probable date when site will be filled.

2. Map of the Bay region showing distribution and density of individual septic systems, based on data of housing from U.S. Census.

Interpretive Report

A report on the susceptibility of Bay region lands to water pollution will be prepared. A map showing land-pollution susceptibility will be based on hydrogeologic criteria such as soil permeability and porosity, depth to ground water, and different types of rock and earth materials. The report will indicate the suitability of various types of development for areas susceptible to pollution and should provide planners with a means to "red flag" areas potentially hazardous for sanitary-landfill locations and individual septic systems. Existing areas of subsurface pollution will be delineated.

## Eutrophication of Fresh-Water Bodies

Eutrophication is the enrichment of water with nutrients that promote excessive growth and production of plants and animals. The enrichment of waters is a naturally occurring event, but also one that is greatly hastened by the activities of man. In the Bay area, it is suspected that many inland (fresh) waters are undergoing accelerated enrichment. Several housing developments in the Bay area have excavated lakes which show the influence of accelerated enrichment within the span of 4 to 6 years. These accelerated-enrichment processes suggest that the affected lakes will have only short lives of usefulness unless remedial measures are adopted.

*Proposed Investigations*

Major lakes and ponds in the Bay area will be visited, and their status of enrichment will be estimated by making late-summer oxygen profiles, and by obtaining cores of their bottom materials. The cores will be analyzed for organic matter, and the rate of sediment deposition will be determined. Information collected in the field will be supplemented by that available from other agencies. The ultimate objective will be to identify, for planners, the lakes presently undergoing accelerated enrichment, and to acquaint the planners with methods that can be employed to reduce enrichment, as well as to provide information useful in the design and management of urban lakes so that eutrophication may be reduced.

*Products*

Basic Data Contribution

Map showing the location of Bay area lakes larger than 160 acres in surface area, and their drainage areas.

Technical Report

A technical report on status of enrichment of selected lakes in the study area, including data on water quality and physical characteristics of the selected lakes.

Interpretive Report

An interpretive report on lakes and reservoirs in the Bay region will be prepared. It will show the extent of enrichment of existing lakes and will provide guidelines for the prevention and remedy of eutrophication.

## Stream-Channel Aesthetics

An increasingly important facet of regional planning is the preservation or enhancement of the aesthetics of selected features of the environment. This study is not intended to treat the subject of aesthetics in depth, but to treat it to a degree that will ensure that it is not ignored. Only stream channels will be considered in this program.

Although aesthetics is largely a subjective consideration, the USGS has attempted, through the work of L. B. Leopold and C. T. Snyder, to apply objective criteria in the evaluation of stream-channel aesthetics. The principles they established will be used in this study.

*Proposed Investigations*

Principles established by Leopold and Snyder for objective evaluation of stream-channel aesthetics will be applied to the streams and their flood plains in the study area; reaches having high aesthetic values will be delineated. Planners will be consulted on desirable uses of such reaches.

*Products*

Basic Data Contribution

A map (scale 1:250,000) delineating those stream reaches having high aesthetic values.

Technical Report

A technical report summarizing criteria for selection of stream reaches of high aesthetic value with descriptions of such reaches and discussion of possible uses of the reaches.

Interpretive Report

The report on open space will incorporate the findings and recommendations of this program.

## Flood-Plain Inundation

The hazards to life and property, and the economic losses resulting from flooding are well known. Nevertheless, the flat flood plains of streams remain almost irresistibly attractive to builders of both industrial and residential properties, although optimal uses of areas subject to flooding might be for parks, playgrounds, farmlands, parking lots, and other facilities whose periodic inundation would result in no, or minimal, loss and danger to life. The Federal Flood Insurance Act of 1968 provides for insurance against flood damages, but also requires that plans for flood-plain management are prerequisite to insurability. Local governments can, by zoning and ordinance, control use of flood-prone areas to a much greater extent than they have to date. It is in the interest of all concerned to have in hand detailed information on areas subject to flooding.

*Proposed Investigations*

A "50-year flood"--that is, one calculated to have a statistical recurrence interval of 50 years--occurred in the region in 1955. As the "50-year flood" is a criterion commonly used in design and planning, the high water of 1955 becomes a convenient historic record from which to work. Data will be compiled from records of the Corps

of Engineers and county flood-control districts. Fieldwork, identifying high-water marks from 1955 and other evidence, will supplement information in agency files. The limits of areas inundated in 1955 will be mapped. As appropriate and feasible, other data such as depth and discharge of water, and monetary losses, will be recorded.

The extent of inundation from the "100-year flood" will also be mapped for streams in the area. This "100-year flood" is being mapped in conformance with the provisions of the Federal Flood Insurance Act of 1968.

*Products*

Basic Data Contribution

A map (scale 1:125,000) showing areas inundated by a flood having a recurrence interval of 100 years, with accompanying tabulations showing water stage, discharge, and stage-frequency curves at selected sites for notable floods. The "100-year flood" was selected to conform with the Federal Flood Insurance Act of 1968.

Interpretive Report

A report on the usefulness and limitations of flood-plain information in flood-plain management will be prepared. This report will be, in a sense, a "manual" on the interpretation and use of the 100-year flood maps. Examples, both actual and hypothetical, of the judicious use of lands subject to flooding will be cited. Structural (dams and levees) and nonstructural (flood-plain zoning and regulations and open space) alternatives will be discussed, with emphasis on the role of urban planning in achieving the desired results. The effects of urbanization on flood frequencies and patterns will be described in general terms. Specific undeveloped areas subject to flooding will be identified, and alternative uses and management strategies for these lands will be discussed. If feasible, a suggested flood-plain management ordinance will be drafted in collaboration with lawyers, planners, and civil engineers.

## Coastal Flooding

Coastal flooding--a hazard to coastal structures such as houses, highways, and harbors--may be caused by tsunamis, waves, exceptionally high tides, or a combination of these events. Delineation of possible flooded areas would provide a means of knowing what structures are in danger of being flooded and what access routes to and from inundated areas might be used during an emergency.

*Proposed Investigations*

Studies will include an analysis of historical coastal flooding. Agencies, such as the Corps of Engineers, U. S. Army, and the National Oceanic and Atmospheric Administration, will be contacted to obtain available maps of tsunami-prone areas. If such maps and data are available, determinations of coastal flooding will be estimated on the basis of theoretical conditions.

*Products*

Basic Data Contributions

1. Map (scale 1:62,500) showing areas that have been and that might be inundated as a result of high tides in combination with intense storms.

2. Map showing areas that might be flooded by tsunamis.

3. Tabular report listing towns, parks, and highways that might be damaged by coastal floods or tsunamis.

## Storm-Design Criteria

Precipitation depth-duration-frequency data are needed both for hydrologic design and for the slope stability studies that are to be made. Data for durations from 5 minutes to 6 hours are required for drainage design. They are also needed for the study of surface-erosion potential, using land slope and soil type as additional factors. Data for longer durations, to be used in conjunction with land slope and soil and geologic factors, are needed for the study of land-slippage potential.

*Proposed Investigations*

The data needed for analysis are (1) a detailed isohyetal map of mean annual precipitation, and (2) statistically arrayed precipitation data for climatological stations in and near the San Francisco Bay region. The isohyetal map is available from the Corps of Engineers; the statistically arrayed precipitation data for 80 stations are available from the California Department of Water Resources. The distinctly seasonal regimen of precipitation in the study region should make it possible to relate the depth of precipitation for a given duration period and a given recurrence interval to the mean annual precipitation. Once such relations are derived, one can obtain the depth of precipitation at any site in the region, corresponding to any desired duration and frequency, by first reading the mean annual precipitation for that site from the isohyetal map, and then applying the appropriate relation.

The durations to be studied will range from 5 minutes to 60 consecutive days, and the recurrence intervals will range from 2 to 100 years.

*Products*

Basic Data Contributions

1. A map showing mean annual precipitation (scale 1:250,000) at contour intervals of 2 inches for mean annual precipitation values less than 40 inches, and 4 inches for mean annual precipitation values greater than 40 inches.

2. Graphs, and their corresponding equations, relating precipitation for various durations to mean annual precipitation. A separate set of graphs will be presented for each duration; each set will include six graphs--one for each of the following recurrence intervals: 2, 5, 10, 25, 50, and 100 years.

3. A report describing the deviation of graphs shown in (2), the procedure for obtaining depth-duration-frequency information for storm drainage design.

## Design Criteria for Flood-Flow Facilities

In the design of drainage facilities it is necessary to consider the probability of occurrence of runoff events. An economic balance must be achieved between the cost of structures and the direct and indirect costs of possible property damage and inconvenience to the public during the life of the structures. The designer must compute discharges corresponding to various probabilities as a preliminary to his actual design. The methods currently used in the computation of discharge vary with the degree of hydrologic sophistication of the designer and with the funds available for design. This project will not attempt to establish a single method for use by all designers, but it will develop and recommend criteria for use with each of the methods that are currently popular in the San Francisco Bay region. At present there is no uniformity in the criteria used.

Design criteria are to be established for watersheds in their natural conditions and under varying conditions of urbanization, that is, variation in the percentage of impervious area and percentage of channels paved or lined. The designer can then select his criteria, in advance of development, on the basis of the type of the development planned.

*Proposed Investigations*

1. The first task will be to establish percentages of impervious area to be used in designing drainage systems for various types of urban development--commercial, industrial, light residential, apartments, and so on. Actually this is not a simple task, and there is little uniformity nationwide in selecting percentages of impervious area for design purposes. The difficulty is due to the many ways in which rainfall reaching an impervious surface may be disposed of. For example, rainfall on a roof in the Palo Alto area may leave in one or more of the following ways:

a. Depression storage and eventual evaporation (Eichler tracts).

b. Through a downspout and drain into the street gutter (Sharon Heights).

c. Through a downspout to a "spatter-block" and thence over a lawn, all or a part of which may infiltrate the lawn (Eichler tracts).

d. Through a downspout into a dry well and thence to the underlying ground-water body (USGS Center, Menlo Park).

2. Regional flood-frequency relations will be obtained by standard USGS methods, using 40 unregulated gaged streams in or just outside the region. Discharge corresponding to recurrence intervals ranging from 2 to 100 years will be related to size of drainage area, mean annual precipitation, and slope (if slope is shown to be statistically significant). On the basis of studies for an area near Sacramento and for areas elsewhere in the Nation, coefficients will be obtained to adjust peak discharges (corresponding to various frequencies) for the effect of various degrees of urbanization and channel improvement.

3. The Rational Method, despite its many shortcomings, is extremely simple to apply, and is easily the most popular method among designers of urban drainage for determining peak discharge. It is used for areas smaller than 5 square miles and preferably smaller than 0.5 square mile. This study will introduce easily applied refinements that should improve the reliability of the method.

4. The most popular complete-hydrograph method for determining peak discharge is the Soil Conservation Service Method. In the SCS Method a triangular unit hydrograph of standard dimension is used for any area in the United States, and the portion of precipitation that becomes surface runoff is independent of rainfall duration. An

attempt will be made to elaborate on the SCS Method using data for 6 basins (55 storms), whose areas range from 0.7 to 11.9 square miles, which are available for analysis. The analysis will be complicated, but once regionalized values are obtained, the application of the method should be fairly simple.

5. The most sophisticated of the various methods for measuring peak discharge is to use a basin model. This method was used by Santa Clara County in formulating its Master Drainage Plan. Several models are in existence butthe most advanced, and the one best adapted for urbanization studies, is the Stanford Watershed Model. There is no thought of offering modifications to that model in this study, and it will merely be described.

*Products*

Technical Reports

1. A report describing and appraising current procedures for computation of design flood flows.

2. A report evaluating the effects of urbanization on current procedures.

3. A report showing how the technical relationships developed can be used in the application of current procedures to computation of design flood flows in the Bay region.

These reports will be useful in the preparation of designs for region-wide storm-sewer facilities and in planning safe and economical structures such as highways and culverts in light of changes in run-off patterns caused by urban growth.

Interpretive Report

Possibly an interpretive report will be prepared on the role of planning in urban drainage design and development. The effects of urbanization on flood peaks will be described in nontechnical language, and ways in which the planner can help bring about the design of more effective and economical drainage systems will be discussed. The role of the urban planner in the preservation and maintenance of natural drainage ways, as opposed to construction of artificial channels and culverts, will be emphasized. If feasible, an economic analysis will be made of alternate drainage plans.

## Stream-Borne Sediment

The erosion, transportation, and deposition of sediment by streams constitute a natural hydrologic process which in an urbanized environment has numerous attendant problems of importance to man. Stream-borne sediment is a detriment to the function and maintenance of stream-associated constructions such as lined channels, bridges, culverts, reservoirs, and water-treatment plants. It is often a pollution hazard as it absorbs and entrains harmful materials and redistributes them throughout the stream system. Altered stream channels may respond to mechanisms of the sedimentation process with adjustments in slope capacity and form. Some effects of these adjustments are bank cutting, gullying, slumps, slides, and the loss of soil and usable land. These effects are not only expensive to contain, but also are aesthetically displeasing as the landscape appears deteriorated and the stream channels become turbid and laden with debris.

The U.S. Geological Survey in cooperation with other agencies, has maintained sediment-sampling programs on streams in the study area beginning as early as December 1956, and a few modest interpretive projects, utilizing the data, have been completed or are currently in progress. These and other studies, including especially aerial photography, will be extrapolated where applicable to help accomplish the following aims: (1) delineate areas where sediment deposition and bank erosion presently cause problems; (2) define the effect of urbanization on sediment yield of selected watersheds; (3) identify the effects of flood runoff in moving sediment, and determine the seasonal variations in sediment transport; (4) quantify the effect of sediment deposition on the life of reservoirs, ponds, and lakes; and (5) relate the size of sediment particles to their sources in various soil and rock types.

### *Proposed Investigations*

As sediment studies in the Bay region have been rather sparse, it will be necessary, once available information has been identified and compiled, to make periodic field studies of representative streams. Those studies will include observation of stream channels, mapping of areas of erosion and deposition, making water-discharge measurements, and taking samples for analysis of sediment content and size distribution, and--where possible--making intensive studies of areas where construction is modifying the natural sediment regimen. Insofar as possible, data gathered in sampled basins will be extrapolated to analogous areas throughout the region.

*Products*

Basic Data Contribution

A map prepared at a regional scale with explanatory text to show soil erodibility, values and areas of measured sediment yield, and special related parameters which are available for certain areas.

Technical Report

Selected maps with brief explanatory text to show (1) areas where erosion, transportation, and deposition of sediments constitute problems; and (2) the areas where the potential for sediment problems is large.

Interpretive Report

An interpretive report will be prepared to show the interrelations among urbanization and other activities of man (for example, logging) in the study area and the sedimentation process. The report will be conceptual in nature, drawing justification for concepts from various measured and observed aspects of sedimentation in the study area. The report will include discussion of the following topics:

1. The effect of urbanization in increasing sediment yields, and the deleterious effects of sediment on the urban environment.

2. Sources of sediment, including naturally high sediment-yielding geologic formations, mudflows and areas of gullying and streambank erosion, and areas where man's activities have exposed erodible material.

3. The relations among rates of erosion and precipitation duration and intensity, land slope, soil, vegetal cover, and other pertinent physical factors.

4. Characteristic relations between water discharge and sediment discharge in streams of the study area.

5. The effects of sediment deposition in reservoirs and the effects of the sedimentation process on other constructions.

6. The potential for stream-borne sediment to carry and deposit harmful bacteria, toxic materials, or other undesirable wastes.

7. Alternative approaches to the management of sedimentation in the study area.

8. The aesthetic aspects of sedimentation, and the natural sedimentation process, and its place in certain specific particular ecosystems in the study area.

## Local Drainage Problems

Local drainage problems are often discovered after costly development of an area has taken place. Proper zoning, based on foreknowledge of areas that would be subject to these problems, is desirable. These areas would be more suitable for recreation than for residential, commercial, or industrial development.

### *Proposed Investigations*

Areas having local drainage problems that are difficult or costly to solve, will be delineated on appropriate maps. These will include areas where natural runoff accumulates--in effect, drainage sumps with a high water table and(or) an impermeable land surface. Some data can be obtained from county flood-control districts, but in the main, aerial flights after storms will be required to delineate the poorly drained areas.

### *Products*

#### Basic Data Contributions

1. Maps (scale 1:24,000) of selected localities showing areas where natural runoff accumulates. Such areas of restricted drainage are clearly unsuited to some uses without expensive modification. Their recognition and delineation will allow planners to assign land-use patterns compatible with natural conditions.

## Land Subsidence

Land subsidence may result from ground-water withdrawal, application of water to the land, or the compaction and shrinkage of peatlands. In the Bay area, land subsidence has resulted from pumping ground water but not from applying water on the surface. Pumping from artesian aquifers causes slow compaction of fine-grained deposits as water is squeezed out in response to the changing hydraulic pressure due to pumping from interbedded coarse-grained deposits. This deep compaction is transmitted to the land surface, which subsides. Also lowering water levels in near-surface deposits which contain interbedded peat can result in exposing peat to air and oxidation, a process which causes shrinkage and also results in land subsidence. At the southern end of the Bay, where subsidence is caused by ground-water withdrawal, it has been necessary to construct an extensive

system of levees to prevent inundation by Bay waters. Continued subsidence can become a problem in the maintenance of sewers, aqueducts, bridges, harbors, and other structures. Extensive peaty deposits are interbedded with water-bearing materials in the Bay area lowlands. Extensive water-table lowering, if brought about by pumping or drainage of land, could result in widespread land subsidence in these lowland areas, with resulting damage to existing or planned structures and public facilities.

*Proposed Investigations*

The study will identify where land subsidence has occurred, how much subsidence has occurred, the potential areas where deep-seated subsidence could occur if artesian aquifers were heavily pumped, including estimates of the potential amount of subsidence, and areas of extensive peatlands where dewatering could result in oxidation and consequent subsidence. Because the phenomenon of land subsidence results from development, ameliorative measures are possible and will be discussed. Existing data will be used in the discussion of the subsidence areas at the southern end of the Bay and in the Delta peatlands. Data will be collected and analyzed for areas of potential subsidence.

*Products*

Basic Data Contribution

Map showing location and degree of subsidence in the study area.

Technical Report

Map showing areas of potential subsidence from heavy ground-water pumping or dewatering of peatlands.

Interpretive Report

An interpretive report will be prepared on the general relation of land subsidence to urban development. Causes of subsidence will be described in nontechnical language. Possible preventive and remedial measures will be discussed, citing the well-documented example of the Santa Clara valley. This report will be of a generalized, qualitative nature.

Physical and Chemical Hydrologic Properties of San Francisco Bay

The water within San Francisco Bay is used for water commerce, municipal and industrial sewage disposal, recreation, fishing, and as a source of aesthetic enjoyment. Pressure on the Bay water system

to accommodate some of these competitive uses will increase with population and industrial growth. For many of these uses it is desirable to understand (1) the rates at which undesirable materials are introduced into the Bay, the length of time they remain in the Bay, and the rates and mechanisms by which they are removed; (2) the sources and the ways by which organic and inorganic sediments are moved in the Bay and along the adjacent Pacific Ocean; (3) the time and the locations at which light-dependent organisms (phytoplankton) grow within the Bay; and (4) the source and consumption of nutrient materials required for organic growth.

San Francisco Bay has experienced considerable change in the past through filling, dredging, diking, and water diversion; and it can be expected that additional changes will occur. An understanding of the interrelations of these processes will assist in predicting the effects of artificial physical or chemical modification of the Bay or the adjacent Pacific Ocean.

*Proposed Investigations*

Physical and chemical properties of the water within the Bay and the adjacent Pacific Ocean will be measured monthly for a period of several years. Relations between biologic and nonbiologic agents that affect the water mass will be evaluated. Using these observations, conceptual models with predictive properties can be constructed to determine the effects of proposed modifications.

The physical circulation patterns of the water mass within the Bay and the exchange with the Pacific Ocean will be studied, and plastic markers, released periodically, will define the movement of deep-water bottom currents that are important in determining the movement of sediments and undesirable constituents.

Specific investigations designed to provide the necessary data are:

1. Identification and quantitative measurement of suspended organic and inorganic sediment in the Bay and adjacent ocean. The goal will be to separate these constituents and to identify where and when phytoplankton growth occurs within the Bay.

2. Analysis of selected water constituents and properties at stations occupied on a monthly basis throughout the Bay and adjacent ocean. The goal will be to define seasonal and annual variations in water chemistry, and to define times, rates, and amounts of removal or addition of nutrient materials by biologic and nonbiologic processes.

3. Changes in the amounts of organic and inorganic constituents in the water can be used to define the movement of water in the estuary

after effects of biologic and nonbiologic processes have been evaluated. The goal will be to characterize the movement of the mixing ocean and river water within the Bay in space and time, and for varying amounts of river inflow.

*Products*

Basic Data Contributions

1. A summary of basic chemical and physical data collected annually, released in February of each year.

2. A summary of the movement of bottom current drifters, released after the study is complete in June 1971.

Technical Reports

1. Analyses of the source, movement, and disposition of suspended sediment.

2. A report describing seasonal changes in chemical properties as they are related to biochemical and inorganic processes.

3. A report describing seasonal changes in water circulation patterns in the Bay and adjacent Pacific Ocean.

Interpretive Report

A discussion of the interrelation between physical and chemical processes that will be of assistance in evaluating proposed modifications in the configuration of the hydrography of the Bay and adjacent Pacific Ocean. These studies will have direct application to such fields as the disposal of sewage and dredge spoils, removal of deleterious constituents by organic and inorganic processes, and information relevant to recreational uses.

## Planning and Management Considerations

Water is a dynamic resource, highly variable in time and place. This variability is in contrast with the land which is a relatively fixed resource. Water in the Bay region occurs in a complex highly interwoven system which is subject to considerable modification by man. Any modification of one component of this hydrologic system will very likely cause modifications in other components. For example, the construction of a flood-control reservoir in the uplands, together with haphazard urban development on alluvial fans and flood plains below the reservoir may result in substantially reduced recharge to ground-water reservoirs. On the other hand, flood control

and drainage facilities planned in conjunction with urban development can be designed so as to preserve or even enhance ground-water recharge. Excessive pumping of ground water from unconsolidated deposits can result in land subsidence, while the provision of compensating artificial recharge can reduce or minimize such subsidence.

This, the last of the hydrologic elements, is essentially a synthesis of the foregoing hydrologic work elements with a focus on the broader aspects of planning and management. This synthesis will evolve from the technical and interpretive reports resulting from these work elements, and is expected to result in one or more interpretive reports. Part of this synthesis will involve the preparation of a "hydrologic framework" for the Bay region--a flow diagram showing the average amount of water that passes through the region in a year, where it comes from, when and how it is used, and where it goes.

*Products*

Interpretive Reports

One or more interpretive reports will be prepared to define the role of water in urban planning, with emphasis on the various uses of hydrologic data. The hydrologic implications of various types of urban development will be evaluated. Alternative plans for water management and their environmental implications will be discussed. Illustrative examples of coordinated land and water management will be presented, with emphasis on the interrelation among the many components of the urban water system. The report(s) will be prepared in collaboration with planners.

## PLANNING PROGRAM ELEMENTS

### State-of-the-Art Review and Analysis

In recent years, for some local governments and public agencies, the use of earth-science data has become increasingly important in the land-use planning and regulatory function. Considerable experience exists in the use of certain types of data, notably historic flood data. But by contrast certain other types of earth-science data such as seismicity and ground motion, the engineering behavior of bedrock, or the location and characteristics of aquifers have rarely been used by local governments as factors to be considered when planning for future urban development. Figure 4 illustrates the range of earth-science data that may be applied to typical governmental land-use planning and regulatory functions. Each intersection in the matrix suggests special problems, and if an agency used earth-science data, many questions could be asked: Was the data understandable: that is, could useful interpretations be made? Were special interpretive methods developed to translate earth-science data into land-use terms? Did the agency make effective use of that data: that is, was the data found to be an acceptable basis for influencing plans or actions? Were traditional decision-making procedures altered to include earth-sciences considerations: that is, what were the changes in review board functions and in administrative procedures, regulations, codes, and ordinances? What was the general significance of the interpretation and application of the data in terms of actually affecting the course of urban physical development?

By studying the experiences of the relatively few agencies which have begun to grapple with this interdisciplinary problem, this work element will provide a basis for understanding why an agency succeeded or failed. This study will enable both the Bay Region Study team and the potential user of earth-science information to benefit from and build on the experiences of others.

*Proposed Investigations*

A sampling of present uses by government of earth-science data will be carried out, and an attempt will be made to identify and categorize the different ways in which different governmental levels now use the data. The problems that the agencies have faced or the benefits that have accrued will be evaluated, and an examination will be made of the agency's degree of success or failure in applying the data.

| Earth-science data | Land-use policy planning | | | Public-facility planning | | | Land-development regulations | | |
|---|---|---|---|---|---|---|---|---|---|
| | County | Regional | State | County | Regional | State | County | Regional | State |
| Topographic map 1:125,000 scale | | | | | | | | | |
| Orthophotomosaic | | | | | | | | | |
| Slope map | | | | | | | | | |
| Active faults | | | | | | | | | |
| Slope stability | | | | | | | | | |
| Unconsolidated deposits | | | | | | | | | |
| Seismicity and ground motion | | | | | | | | | |
| Mineral commodity utilization | | | | | | | | | |
| Ground-water resource | | | | | | | | | |
| Aquifer recharge areas | | | | | | | | | |
| Water quality | | | | | | | | | |
| Land pollution susceptibility | | | | | | | | | |
| Eutrophication of lakes | | | | | | | | | |
| Flood-plain inundation | | | | | | | | | |
| Storm design criteria | | | | | | | | | |
| Stream-borne sediment | | | | | | | | | |
| Land subsidence | | | | | | | | | |

Figure 4.--Matrix showing possible range of applications of earth-science data to various levels of planning. Each earth-science element can be shown to have some application to each planning level.

The investigations will be analyzed in terms of:

1. The level of government or special-purpose agency, such as, state, regional, county, city; district function; and study emphasis.

2. The functional area of land-use planning and regulation, such as, policy formulation for an entire jurisdiction--preparation or revision of the general plan, district or more detailed land-use planning, short-range development planning, capital improvement programming; public facility planning; land-development control mechanisms.

3. The type of earth-science data used by the agency, such as, active faults, slope stability, unconsolidated deposits, seismicity and ground motion, water quality, ground water, subsurface pollution, eutrophication, flood-flow facility design criteria, flood-plain inundation, land subsidence, stream-borne sediments, or any combination of these.

The limitation of funding and the vastness of the subject matter suggest that this work element cannot be comprehensive. However, the fundings will be analyzed in terms of some or all of the following selective samplings of earth-science data.

1. The development of municipal and county land-use policies as expressed in the general plan, such as, facilities planning, transportation, open space, and housing.

2. The implementation of county and municipal land-use policies, such as,

a. Zoning ordinances--the identification and mapping of areas requiring the application of earth-science principles to zoning-district regulations, that is, geologic and soil investigations, agency review procedures as a part of conditional-use permits, and design-review criteria.

b. Land-development ordinances--requirements relating earth-science principles to subdivisions, minor land division, site-review criteria, etc.

c. Location of public facilities--inclusion of earth-science factors in official locational criteria for schools, hospitals, civic buildings, etc.

d. Building ordinances, codes, and grading ordinances--requirements that earth-science principles be considered.

3. Special districts, such as utilities--consideration of earth-science factors in site-selection criteria.

4. In regional (multi-county) government and agencies--land development policies that include geologic and seismic considerations in general planning activites, such as, regional land use, transportation, open space, and such implementation activities as review of local plans, shared jurisdiction over local land-use and zoning decisions, review of local plans, programs, and projects for Federal grant purposes.

5. In State agencies--general ways of including the earth sciences in State development plans and policies; State requirements which affect local land-use planning, such as, planning legislation, subdivision-map acts, assistance given to local and regional planning agencies; and the review of local agency plans, programs, and projects, including Federal grant applications.

*Products*

Technical and Interpretive Reports

Written reports will be prepared describing and analyzing the experiences of certain agencies and including conclusions and recommendations organized according to level of government, governmental function, and type of earth-science data.

## Urban Information Systems--Feasibility Study

In recent years the urban land-use planning process has increased in scope and complexity. Information requirements have dramatically expanded in quantity and diversity. Maps and personal field observations, once the urban planner's principal source of information, are today wholly inadequate. As information requirements grow, the problems of manipulating, storing, and managing data become formidable. Computer-based urban land-use information systems are being increasingly employed to help meet these problems.

Environmental factors should be consciously and systematically included in the urban land-use planning process. To accomplish this, earth-science data must be interrelated with other critical data--economic, social, and functional. Thus if earth-science factors are to become as fully useful as their significance warrants, the applications of computer technology must be explored. This study will identify the technical requirements and the costs attendant on the preparation of earth-science data for incorporation in computer-based urban land-use information systems. Because of the scale of the Bay Region Study, only regional and county-level systems will be considered.

*Proposed Investigations*

The general feasibility of preparing earth-science data for incorporation in computer-based urban information systems will be examined as follows:

1. Selected earth-science data will be tested to see how readily and at what cost the information can be put in machine-readable form.

2. The essential characteristics of urban land-use information systems will be identified. The system used by the Bay Area Transportation Study Commission (BATSC) and a selected county system will be used as study models.

3. Some modifications of data formats will be developed and tested to see if the data can be expressed in terms more compatible with urban information system requirements.

4. From these preliminary experiments, technical problems will be identified, costs estimated, and general recommendations developed to adapt various types of earth-science data to computer-based information systems.

During the investigations various operational requirements will be considered such as reformating, data retrieval, updating capabilities, reporting, and calculating. General costs of alternative procedures will be estimated. If this study demonstrates feasibility, an operational pilot study will be designed and carried out as a part of this work element.

*Products*

Technical Report

A report written primarily for planners and information-system specialists in order to bridge the gap between the utilization of geologic data and computer technology.

## Application and Demonstration Studies

Over the years, many systems of knowledge have been interpreted and adapted for use in shaping urban-development policy. Specific methods have been developed to translate specialized information into expressions useful to the functions of land-use planning and regulation. The study of economics, for example, did not originate for the purpose of guiding urban land-development policy. Today, however, the use of economic data in policy formulation has not only become

acceptable but has proved indispensable. A wide range of data--demographic, functional, physical--in addition to economic data, provide local government with a basis for managing the use of land. These data guide local government in establishing policy with regard to the general location and character of future private development; in designing control regulations to ensure the realization of that policy; and in the short- and long-range budgeting of revenue for the staging, design, and construction of public facilities. To what extent should and would local governmental policy regarding future urban development be affected if earth-science data were to supplement the more traditional data mentioned above?

The nine-county San Francisco Bay area contains over 100 local governmental jurisdictions and special districts which influence the urban use of land. Many of these agencies will begin new studies and programs during the life of the San Francisco Bay Region Study. Most of these studies will be conducted without adequate knowledge of the regional hydrologic, geologic, and geophysical systems. Substantial benefits would accrue to the potential user of earth-science information and to the Bay Region Study if actual earth-science data-application projects were initiated both during and following the completion of the program. The day-to-day experiences and regular reporting of a "demonstration" staff would contribute significantly to the development of earth-science information, to the refinement of recommendations contained in the Interpretive Report Series, and to the instructing of local governments in the effective use of earth-science data. A small number of earth-science data application-demonstration studies will be undertaken by appropriate public agencies in or directly related to the nine-county Bay area. The application studies will be included as part of the agency's larger but more typical studies and programs.

The selection of an application and demonstration study will be based on the nature of the agency and the agency's study or program, and on the type of available earth-science data. Although many public agencies are engaged in environmentally significant activities, not all are appropriate for the purposes of application and demonstration studies. An appropriate study or program being conducted by a public agency would be identified on the basis of the following considerations: Are the agency's activities related to questions of land-use planning? Is the geographic area of the agency's jurisdiction, the subject-matter focus, and the detail of the study appropriate to the scale and nature of the earth-science data? Would the experiences gained during the application of earth-science data be generally transferable and therefore have significance for other agencies: that is, will the agency's study effort focus on relatively typical land-use decision-making areas such as land-use policy planning, locational planning for public facilities or private-land development regulations? What are

the opportunities for developing land-use policy proposals with and without the use of earth-science data so that the full significance of the data can be assessed? Is the agency concerned with potential problem areas: that is, is the geographic jurisdiction subject to strong demand for urban development, and must land-use policy positions or controls be formulated in the near future? Does the agency staff have experience in the application of earth-science data, and to what degree have past policies and plans actually included earth-science factors? What is the scheduled beginning date of the agency's study? Figure 5 (presented for illustrative purposes only) demonstrates, for different governmental levels and functions, the range of actual programs with which Application and Demonstration Studies might be integrated.

The design of such studies will be guided by the essential characteristics of the earth-science data which are or can be developed during the life of the Bay Region Study. These might include the regional scale and nature of the data, the level or degree of interpretability of classes of data, the publication or release date of the products, and perhaps the quantity and type of data expected in specified geographic areas.

*Proposed Investigations*

During the application of earth-science data, the agency making the study would be expected to make general investigations in the following areas:

1. The significance of various types of earth-science data in terms of classes of urban land uses and facilities: for example, what would be the significance for residential-development policy of information bearing on the location of ground-water recharge areas and pollution-susceptible aquifer systems; or what would be the effect of locating on potentially unstable hillsides? What is the significance for industrial and commercial-development policy of information about the location of areas subject to frequent flooding or the location of loosely compacted sediments and the likely reaction of these materials to seismic shock? What is the significance of information about the location of active fault traces and of fault zones for transportation systems and public facilities?

2. Types of earth-science data which are particularly difficult to incorporate and those which are particularly adaptable to use in a local government's decision-making processes.

3. Modifications needed in administrative procedure, ordinances, regulations, codes, etc.

| PLANNING FUNCTIONS | COUNTY | REGIONAL | STATE |
|---|---|---|---|
| LAND-USE POLICY PLANNING | 1. General plan revision | 1. Regional-plan revision--open-space element<br>2. Regional-plan revision--housing element<br>3. BCDC shoreline land-use policy refinement<br>4. Flood-Control District recommendations<br>5. ABAG grant review function<br>6. Regional-planning information system | 1. State development plan<br>2. Special-element policy plan, i.e., ocean-area plan |
| PUBLIC-FACILITY PLANNING | 1. Public-works capital improvement programming | 1. Regional transportation planning<br>2. Regional airport studies<br>3. Water-quality-control planning<br>4. Community-shelter studies<br>5. ABAG grant review function<br>6. Water and sewer system planning<br>7. Environmental impact review function | 1. Highway planning<br>2. State hospitals, colleges<br>3. Environmental impact review function |
| LAND DEVELOPMENT REGULATION/ CONTROL/ADMINISTRATION | 1. Zoning-regulation refinement<br>2. Subdivision-ordinance refinement | 1. BCDC project-review procedure refinement<br>2. ABAG grant review function | 1. Subdivision Map Act<br>2. Public Utilities Commission requirements |

Figure 5.--Examples of public-agency studies, programs, or functions appropriate for consideration in application and demonstration studies.

4. Redefinition of the review and interpretive functions of boards and commissions.

5. Adapt the traditional and accepted analytic methods used in land-use planning studies to accommodate earth-science data.

*Product*

Technical or Interpretive Report

A written report from each agency making a study describing the actual use of earth-science data, analyzing problems, and presenting recommendations.

## Planning Studies Synthesis

This work element will bring together and present in summary form the findings of the Planning Program. General conclusions and concepts will be developed and presented. Special emphasis will be given to the development of general guidelines for the use of earth-science data by the urban land-use planner. Because of the scale of the earth-science data it is expected that the planning-applications section will emphasize regional and county-wide problems. However, brief consideration will be given to other related governmental functions which strongly influence the character of urban development.

Each earth-science work element or combination of elements will require a Technical or Interpretive Report. And each of these reports will contain an urban "planning-applications" section wherein the earth-science data are presented and discussed in terms which are useful to the urban land-use planning function. These will include general discussions of the following: constructional problems and risks; environmental consequences associated with selected classes of facilities, and the land-use implications of selected classes of earth materials and geographic areas. These sections will be developed in close collaboration between scientists, planners, application and demonstration study staffs, planning consultants, and members of the Consultative Panel.

Many of the users of the reports will be located within the nine-county San Francisco Bay area; however the objectives of the study require a national as well as a regional perspective. A very important product will be the general findings and conclusions of the study as they relate to the relatively formalized urban land-use planning process. Many of these findings and conclusions can be of use to those beyond the Bay area. Thus, a separate report will be prepared both as an accompaniment to earth-science data products and for those agencies and persons located outside the study area. This somewhat

more technical report will focus directly on the urban land-use planning process of local government as it relates to the use of earth-science considerations in general. It will be based on and be a synthesis of the findings and analyses of the preceding four Planning Program Elements. The planning staff and the planning consultants will be primarily responsible for the production of this report; however, close collaboration with the science staff is expected.

The following illustrates, in summary form, the approach of the proposed investigations and the structure of this report:

1. The Nature of the Problem: A discussion of the conflict between two systems--one manmade urban and one natural environmental. An outline of the relative significance of selected geologic, hydrologic, and geophysical systems to the urban-development process. Significance, whenever possible, will be expressed in terms of economic, social, functional, and aesthetic factors.

2. Developing the Plan: An outline of methods useful for the translation of selected earth-science data into standard expressions of land-use categories. An identification of the general requirements of data compatibility between environmental data and urban physical, functional, and economic data. An outline, if feasible, of approaches to the comparative analysis of urban data and environmental data required for the formulation of general land-use policy, such as, discussions of cost-benefit methods, indexes of risk, and measures of accumulative environmental deterioration.

3. Implementation of the Plan: A discussion of the implications of earth-science data for a range of new and traditional legal and procedural tools used in implementing land-use policies. Outlining, where feasible, model enabling legislation and State planning-act elements, zoning ordinances, subdivision regulations, grading ordinances, building codes, site-and design-review criteria, regular referral, capital improvement programming, and responsibilities of commissions and limited-function review boards.

## Continuing Activities of the Planning Staff

The planning staff for the San Francisco Bay Region Study will be composed of two senior-level urban planners, two part-time graduate students enrolled in programs in or related to urban physical planning, and one part-time general clerical assistant. During the final year, January 1973 - January 1974, the planning staff will be increased to include one additional senior-level urban planner and one additional part-time graduate student. This will be necessary to complete the activities outlined below. Approximately 35 percent of the planning staff's time will be devoted to duties other than for the Bay Region Study.

The anticipated activities of the planning staff can be described in terms of three functional areas:

1. Activities directly related to the Planning Program Elements of the Bay Region Study.

2. Other activities as needed but not directly referred to in the Planning Program Elements, such as, special short-term tasks and studies, and ongoing advice to the science staff of the Bay Region Study.

3. General communication and liaison activities.

*Proposed Investigations*

1. Activities directly related to the Planning Program Elements. These activities include: substantive participation in the preparation of the Technical and Interpretive Reports; preparation of general specifications for and the direction of the conduct of Planning Elements; selection of consultants and application and demonstration studies and agencies; preparation of scope-of-work contracts; direction, program review, and administration; product evaluation; presentations to Consultative Panel and Bay Region Study science staff as needed.

2. Activities not directly referred to in the Planning Program Elements include: (1) Well-defined tasks and studies which must be conducted relatively early in the Bay Region Study; (2) less well-defined short-term studies which initial experience strongly suggests may be valuable; and (3) activities which are considered to be ongoing.

The planning staff will undertake a brief analysis of the general requirements of selected data users. For the purpose of providing additional information to the science staff in their efforts to define priorities, a brief analysis will be undertaken of each category of earth-science information in terms of the particular needs of the formalized urban regional and county planning function.

Other activities and studies, somewhat less well defined but which initial experience strongly suggests may be valuable, include the following: Develop a list of major types of land uses and facilities which can be related to questions of geologic hazard and environmental deterioration. Develop land-use classification criteria which are environmentally meaningful--occupancy relative to potential loss of life; structural types relative to potential loss of property; activity type relative to potential environmental deterioration; functional type relative to post-disaster recovery, etc. Outline ways of modifying the land-use planning and regulatory process in order to incorporate, on a continuing basis, new and updated environmental information and new engineering considerations. Develop model land-use policies which can be adopted by governmental agencies responsible for land-use planning and regulation.

3. General communication and liaison activities include the following: Participate in and carry the major role in communications with agencies responsible for urban land-use planning at the State, regional, county, and municipal level, including the Consultative Panel; serve as spokesmen and lecturers as necessary; prepare quarterly progress reports to be incorporated in Bay Region Study quarterly reports; regular communication with parent organizations--HUD Central, Regional and Area Offices and ABAG Office.

## EVALUATION STUDY

Inasmuch as the San Francisco Bay Region Study is a complex interdisciplinary study composed of several different program elements and having several goals, a special effort is deemed necessary to evaluate the success of the overall program. An evaluation of the individual earth-science and planning documents is desirable, and a general appraisal of the real impact of the study on urban and regional development is of great interest.

Questions that should be asked include:

1. Is the format of technical maps and reports suitable and understandable by planning officials?

2. Are the interpretive reports useful to the nontechnically oriented public official?

3. Is the basic data gathered of true importance to urban development and planning?

4. Has the study produced better data and presented it better than formerly?

5. Have the model ordinances developed been put to use, and what effect have they had?

6. What has the actual flow of data been from the original gathering to the ultimate use?

7. Has the regional planning process become more responsive to environmental factors because of the existence of the study?

8. What examples can be cited of major impacts made by this study?

9. Have there been economic or sociologic dividends?

Such questions have been in the minds of the earth scientists and planners since the inception of the study, but a specific plan is necessary to formally document and answer the questions. For example, a base-line study is desirable for comparing the "before" and "after" situations. One environmental planning study conducted in 1968 and 1969 attempted to use earth-science data as it existed then, and an investigator from that study team has been contracted to provide an appraisal of the state-of-the-art in the earth sciences as he found it just prior to the San Francisco Bay Region Study.

Throughout the three-year study program records, such as newspaper clippings, letters from users, and diary-type summaries of meetings, should be kept to provide a history of the use of the study products.

Finally, after the study is completed, a follow-up will be instituted to summarize the impact of the effort and to provide constructive criticisms which will be helpful to succeeding generations of environmentalists and planners. Cost-benefit appraisals should be made or other means should be sought for quantitatively comparing the San Francisco Bay Region Study to other types of programs. A chapter titled "lessons learned" would be appropriate, and the lessons might range from specific details of map format to general philosophies of planning and administration. Earth scientists and planners, of necessity, will have to be involved, but the principal investigator may well be a historian, a sociologist, or an economist.

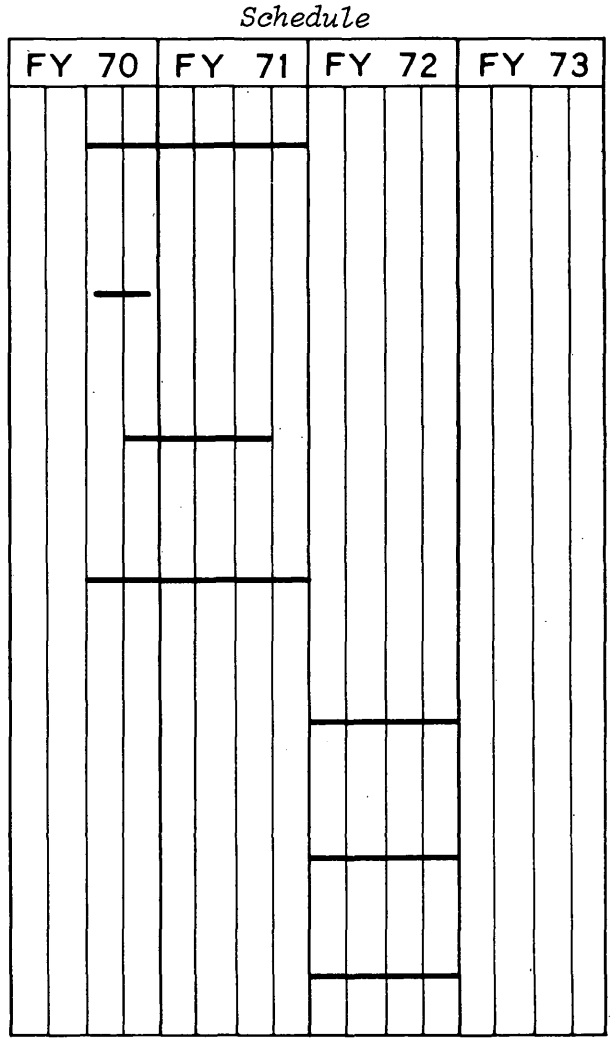
## MATRIX

On the following page is a matrix which indicates, for each of the earth-science program elements, a range of potential applications to representative problems of urban planning and development. Each box marked with an "X" indicates a potential application of the products resulting from a given program element to a specific urban problem. This matrix is not all-inclusive. It may not include all urban problems to which earth-science data might be applicable. Likewise, the omission of an "X" does not necessarily mean that this particular program element cannot be applied to this problem. Rather, the matrix represents the best collective judgment of the project staff at the time of writing as to the most important applications of the earth-science program elements.

RELATION OF PROGRAM ELEMENTS TO REPRESENTATIVE ENVIRONMENTAL PLANNING PROBLEMS

| Program Element and Subelement | Hillside development | Flatland development | Fault hazard zones | Subsidence potential (lowlands) | Seismic hazard | Water navigation | Water pollution | Utilization/pollution of San Francisco Bay | Availability of mineral commodities | Public safety | Recreation and education | Environmental aesthetics | Hydrologic hazards | Public facility design, local | Public facility design, regional | Sewage disposal | Solid waste disposal | Urban land use; general policy planning |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Topographic Elements** | | | | | | | | | | | | | | | | | | |
| 1. Topographic map 1:125,000 scale | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 2. Relief model-reproducible 1:125,000 scale | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 3. Orthophoto mosaic 1:125,000 scale | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 4. Slope map 1:125,000 scale | X | | X | | X | | | | X | X | X | X | X | X | X | X | X | X |
| 5. Urban orthophoto maps(6) 1:7,200 scale | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| 6. Patterns of urban growth | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X |
| **Geological and Geophysical Elements** | | | | | | | | | | | | | | | | | | |
| 1. Active faults | X | X | X | X | X | X | | | | X | X | | | X | X | | | X |
| 2. Slope stability | X | X | X | X | X | X | | | | | | X | | X | X | | | X |
| 3. Rock properties and engineering behavior | X | X | X | | X | X | | | X | X | X | X | | X | X | X | | X |
| 4. Soil properties and engineering behavior | X | X | X | | X | X | | | X | X | X | X | | X | X | X | X | X |
| 5. Seismicity and ground motion | X | X | X | X | X | X | | | | X | | | | X | X | | | X |
| 6. Mineral commodity utilization | X | X | | | | X | | X | X | X | X | | | | | | X | X |
| 7. Open-space study | X | X | X | X | X | X | | X | X | | X | X | | | | X | X | X |
| **Hydrologic Elements** | | | | | | | | | | | | | | | | | | |
| 1. Public water-supply service area | X | X | X | | X | X | X | | | | | | | X | X | | | X |
| 2. The ground-water resource | X | X | | X | X | | X | | | X | | | | X | | | X | X |
| 3. Aquifer-recharge areas | | X | | X | | | X | | | | | | | X | | X | X | X |
| 4. Waste-water sources and pollutional loadings | X | X | X | X | X | X | X | X | | X | X | X | | X | X | | X | X |
| 5. Quality of receiving waters | | | | | | | X | X | | | X | X | | X | X | X | X | X |
| 6. Land pollution susceptibility | X | X | | | | | X | | | | X | X | | X | X | | X | X |
| 7. Eutrophication of fresh-water bodies | | X | | | | X | X | | | | X | X | | | | | X | X |
| 8. Stream channel aesthetics | X | X | | | | | X | | | | X | X | | X | | | | |
| 9. Flood-plain inundation | | X | | X | X | | X | | X | X | X | X | X | X | X | X | X | X |
| 10. Coastal flooding | | X | | | | | | X | | X | X | | X | | X | | | X |
| 11. Storm design criteria | X | X | | | | | X | | | X | | | X | X | X | | X | X |
| 12. Design criteria for flood-flow facilities | X | X | | | | | X | | | X | | X | X | X | X | | X | X |
| 13. Stream-borne sediment | X | X | | | | X | X | X | | X | X | X | X | X | | | X | X |
| 14. Local drainage problems | | X | | | | | X | | | | | X | X | X | | | | X |
| 15. Land subsidence | | X | | X | | | | | | X | | X | X | X | | | X | X |
| 16. Physical and chemical hydrologic properties of San Francisco Bay | | | | | | X | | X | X | X | X | X | | X | X | X | | |
| 17. Planning and management considerations | | X | | X | | X | X | X | | | X | X | X | X | X | X | X | X |

## WORK SCHEDULE FOR TOPOGRAPHIC PRODUCTS




Topographic map
1:125,000 scale

Relief model--reproducible
1:125,000 scale

Orthophoto mosaic
1:125,000 scale

Slope map
1:125,000 scale

Urban orthophotomaps (6)
1:7,200 scale

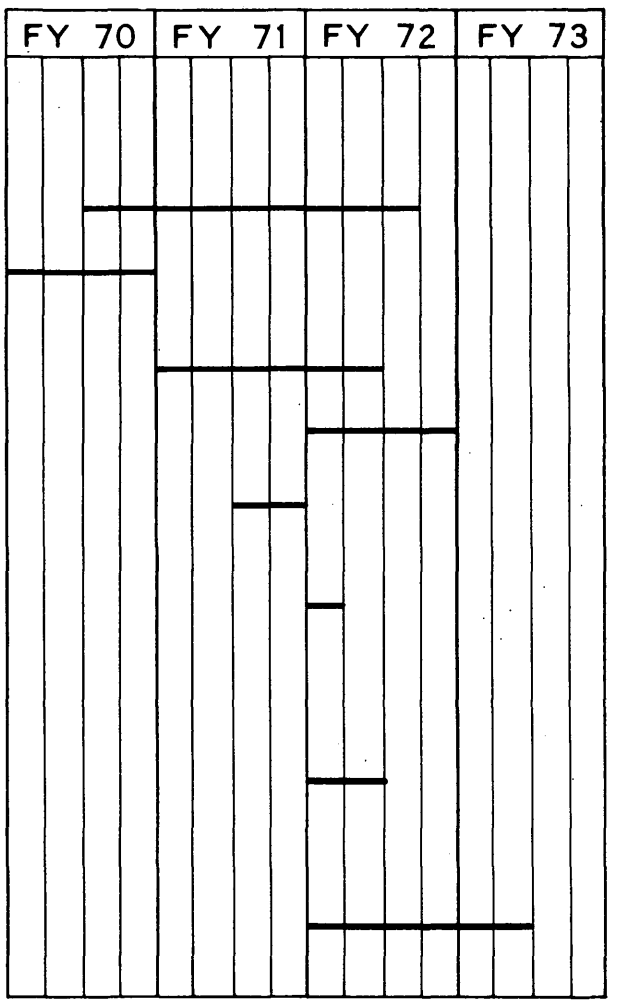
Patterns of urban growth

Publication

WORK SCHEDULE FOR GEOLOGICAL AND GEOPHYSICAL STUDIES

*Program element and subelement*

*Schedule*




Active faults

1. Strip maps showing active fault breaks (at scale 1:24,000)

   a. San Andreas fault from Paicines to San Francisco

   b. San Andreas fault from Bolinas Lagoon to Point Delgada

   c. Healdsburg - Rodgers Creek fault zone

   d. Green Valley fault

   e. Other active faults that may be identified during the study

2a. Summary map (1:250,000) showing location of active faults and their relation to crustal strain and microearthquakes (in conjunction with "Seismicity and ground motion"), South Bay area

2b. Summary map (1:250,000) showing location of active faults and their relation to crustal strain and microearthquakes (in conjunction with "Seismicity and ground motion"), North Bay area

3. Report describing geometry and history of geologically recent faulting as exposed by physical exploration

Active faults--Continued

4. Catalog and map showing distribution and character of microearthquakes and crustal strain (in conjunction with "Seismicity and ground motion")

5. Technical journal reports on tectonic synthesis and evaluation of active faults

6. Report discussing level of risk and estimate of the future activity of active fault zones

7. Interpretive report discussing application of data on active faults to problems of land use, urban decision-making, and evaluation of seismic risk

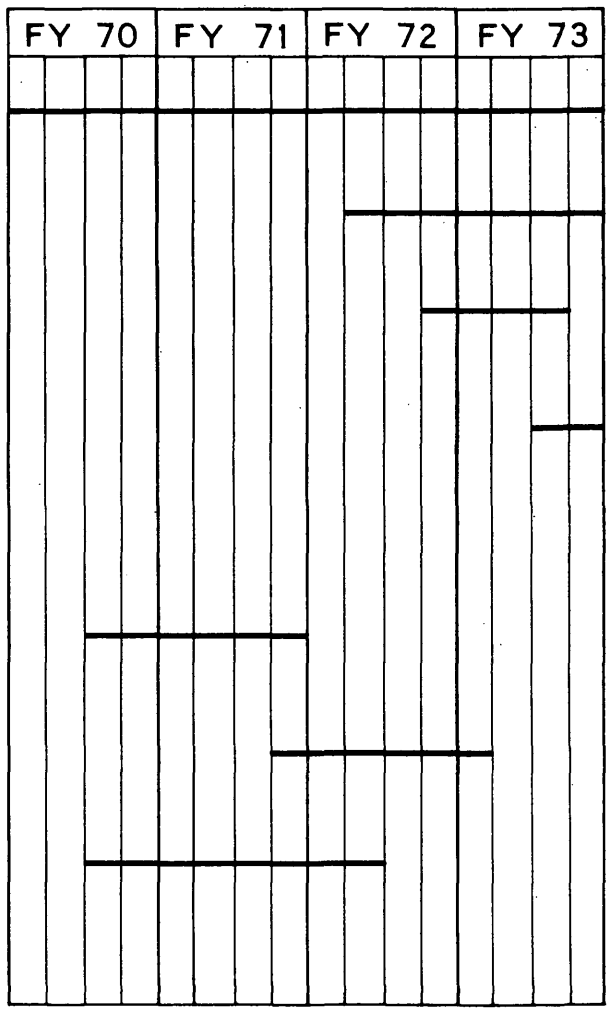
Slope stability and engineering behavior in bedrock formations

1. Preliminary maps (1:62,500) showing distribution of landslides and other slope failures

2. Map (1:125,000) based on preliminary landslide maps to show occurrence, type, and distribution as related to geologic controls for slope failures

3. Preliminary geologic maps (1:62,500) of bedrock units and structures

*Schedule*



Slope stability and engineering behavior in bedrock formations--Continued

4. Geologic map (1:125,000) of the nine Bay area counties showing the distribution, character, and structure of earth materials

5. Engineering geologic maps (1:125,000) showing map units interpreted for their physical properties and engineering behavior; includes tabular text listing physical properties and engineering behavior of map units

6. Technical report describing areas of landslides and other slope instabilities, and discussing their occurrence and formation with relation to physical properties and geologic processes

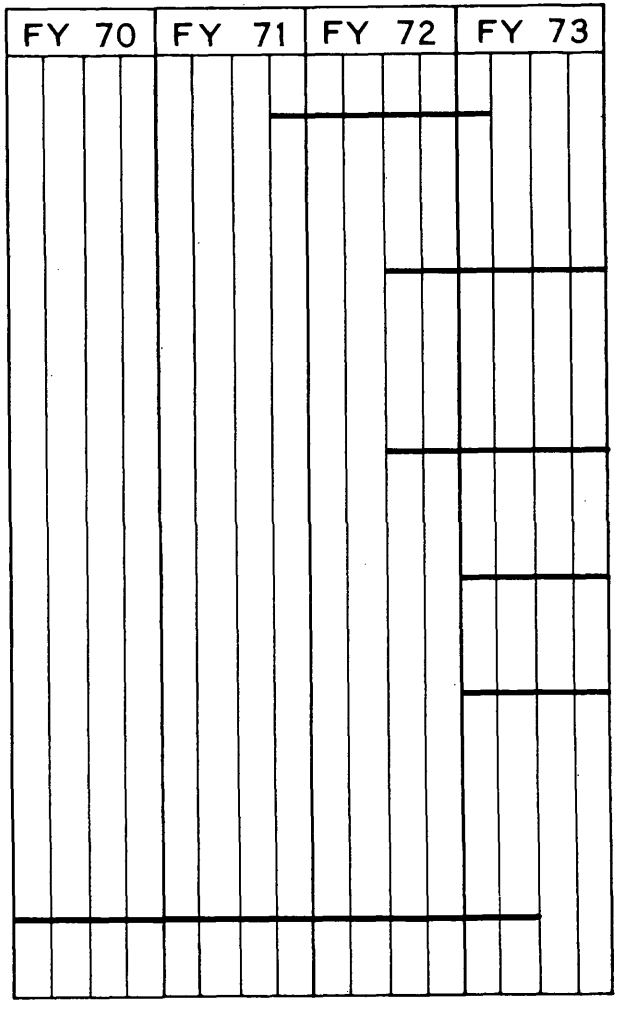
7. Map (1:125,000) showing prediction of future stability of slopes

8. Interpretive report discussing application of slope stability and related engineering geologic information to practical problems of land use

Physical properties and engineering behavior of unconsolidated formations

1. Contour map (1:62,500) of bedrock surface beneath unconsolidated deposits of Bay area including San Francisco Bay

*Schedule*



Physical properties and engineering behavior of unconsolidated formations--Continued

2. Map (1:62,500) showing variation in thickness of unconsolidated deposits of Bay area

3. Map (1:62,500) of historic limits of San Francisco Bay marshlands

4. Geologic maps (1:62,500) and cross sections showing distribution, and character of unconsolidated deposits of San Francisco Bay, the Coastal Margin, the Delta, and Interior Valleys in the Bay region

   Specific maps are:

   a. Santa Clara County

   b. San Mateo County

   c. Alameda County

   d. Sonoma County

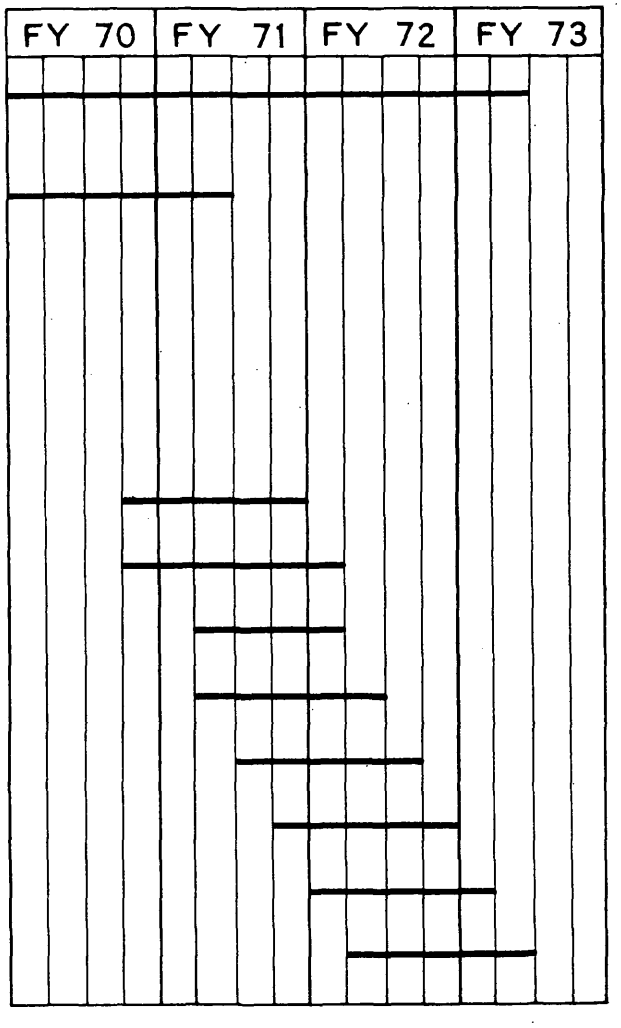
   e. Contra Costa County

   f. Napa County

   g. San Francisco and Marin Counties

   h. Solano County

*Schedule*



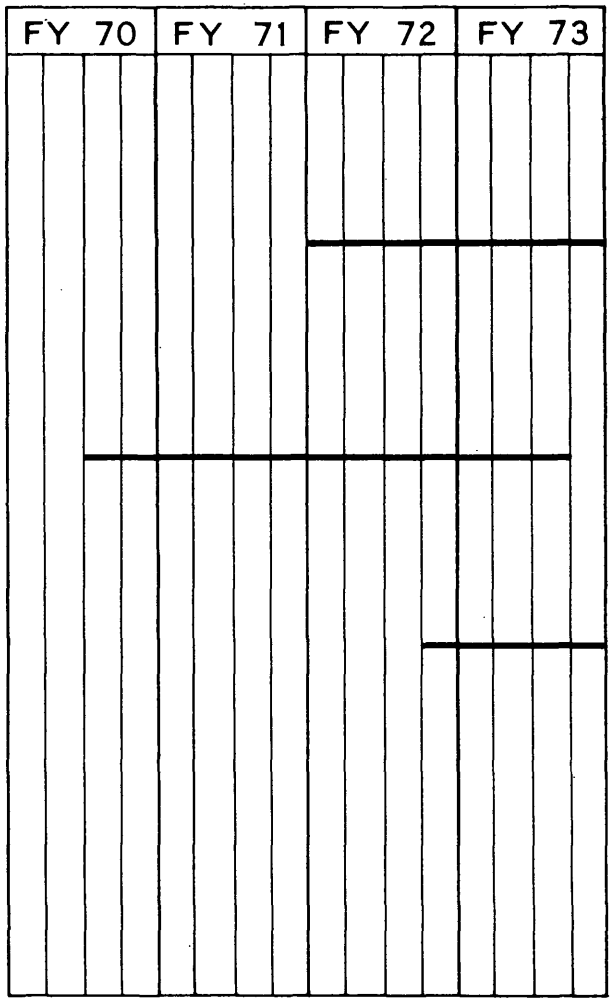
Physical properties and engineering behavior of unconsolidated formations--Continued

5. Engineering geologic maps (1:62,500) with accompanying tabular data listing physical properties and engineering behavior of unconsolidated deposits of the Bay region

6. Maps showing special characteristics or problems of specific areas. For example, land subsidence, swelling clay content of unconsolidated deposits, etc.

7. Interpretive report applying the data on character and distribution of unconsolidated deposits to land-use problems in the Bay region

*Schedule*



Seismicity and ground motion

1. Map showing microearthquake-generating active faults (in conjunction with "Active faults")

2. Report on results of monitoring quiet sections of known major active faults for signs of reactivation

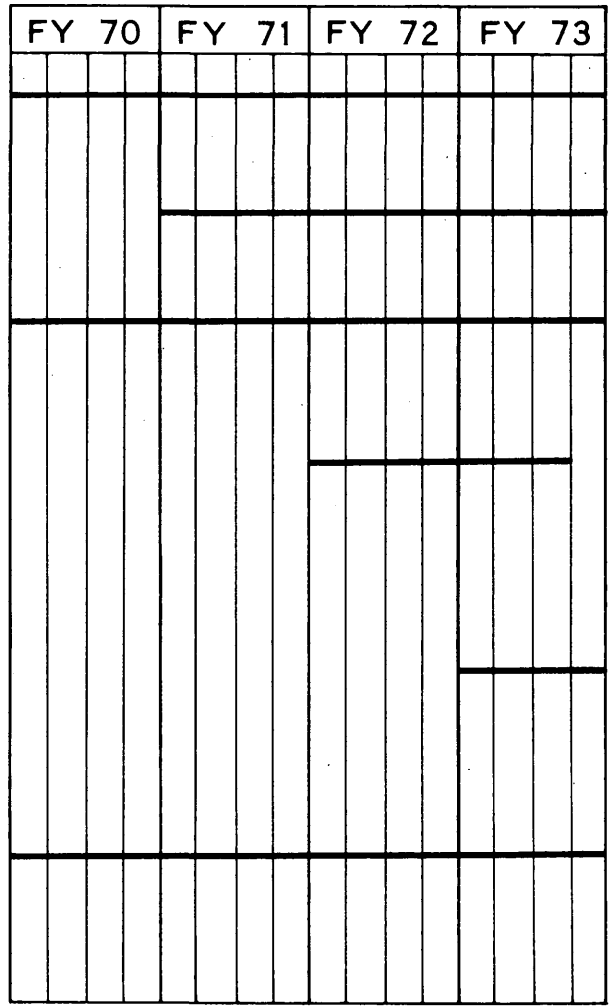
3. Epicenter map supported by lists of earthquakes, showing location, time, and magnitude

4. Maps and cross sections showing distribution and thickness of low-velocity sediments in basins based on seismic techniques (in conjunction with "Environmental geologic problems of unconsolidated deposits")

5. Summary maps of expected Mercalli intensities for Bay area earthquakes of various magnitudes originating on the major faults of the region. These computer-generated maps can be quickly updated as new information is accumulated

6. Technical journal articles reporting theoretical and experimental results of seismicity and ground-motion studies

*Schedule*



Mineral commodity utilization

1. Commodity maps

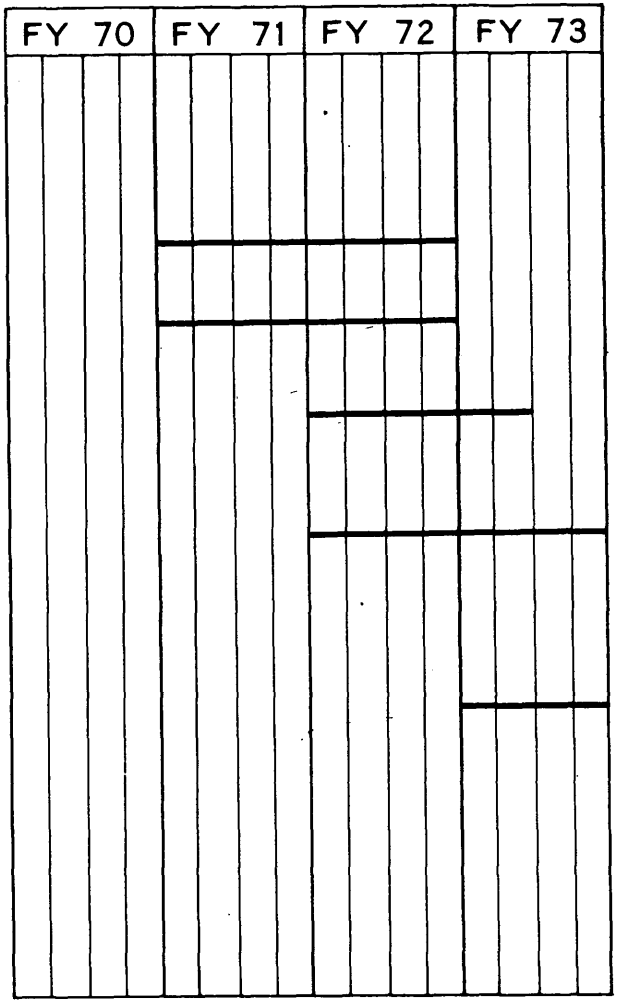
2. Catalog of data from the commodity inventory

3. Maps showing classification and ranking of various commodities

4. Interpretive report discussing impact of commodities on urban planning

5. Interpretive report discussing decision-making criteria with regard to utilization of local mineral commodities--based on geologic, economic, conservation, and urbanization considerations

*Schedule*



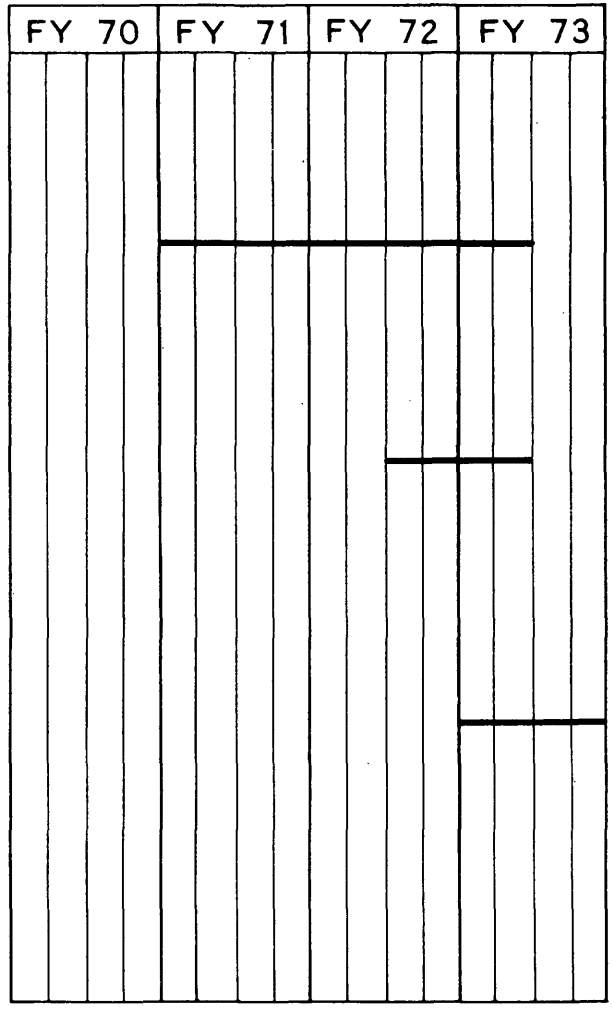
Open-space study

1. Catalog (with maps at 1:125,000) of undeveloped land and water resources, and of the current (and potential future) uses of these lands and waters

2. Interpretive report analyzing geologic, hydrologic, social, and economic factors that affect the total value of areas with potential for open-space use

3. Interpretive report aimed at developing a strategy for incorporating geologic, hydrologic, and topographic data and principles in making regional decisions on whether Bay region lands and waters should be developed or be preserved as open space

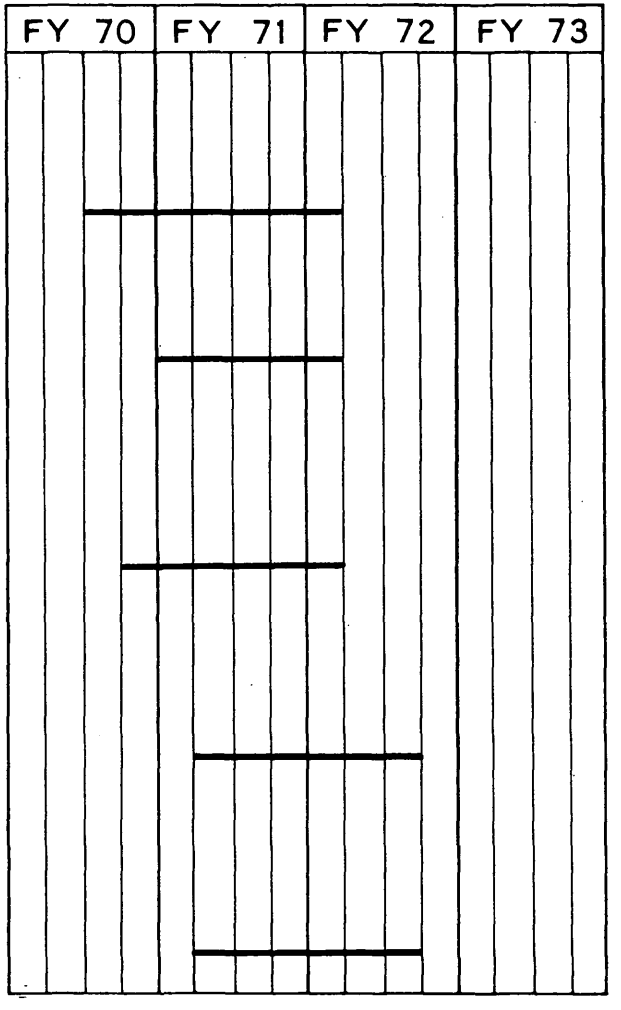
*Schedule*



## WORK SCHEDULE FOR HYDROLOGIC STUDIES

*Program Element and Subelement*

*Schedule*




Availability of water supplies

Public water-supply service areas

1. A revised map (1:250,000) showing service areas of municipal and private water-distribution agencies in the nine Bay area counties

2. Table or graphs showing source of water, population presently served, number of service connections, present water consumption, future population projection, and future water needs

The ground-water resource

1. Map showing potential yield of aquifers to wells in all land areas within the environmental study area. Yields shown will be of four magnitudes

2. Map (1:125,000) showing (a) areas where total dissolved-solids content of water from wells exceeds Public Health Service standards, (b) areas where saline water is found, (c) areas where the ground water has been degraded by the intrusion of saline water, and (d) areas where boron and nitrate in ground water constitute a hazard

3. Map (1:250,000) showing locations of water sources that could be used to provide emergency domestic supplies in the event of failure of existing supplies

Availability of water supplies--Continued

The ground-water resource--Continued

4. Map (1:250,000) showing the depth to water as of 1969 in each of the major ground-water basins

5. Map (1:250,000) showing areas where water levels of deep wells are or have been at or above the land surface

6. Table for each major ground-water basin giving the estimated ground water in storage to a depth of 200 feet below the water table, and the estimated usable storage capacity in unsaturated aquifers to a depth of 200 feet below the land surface, both as of 1970

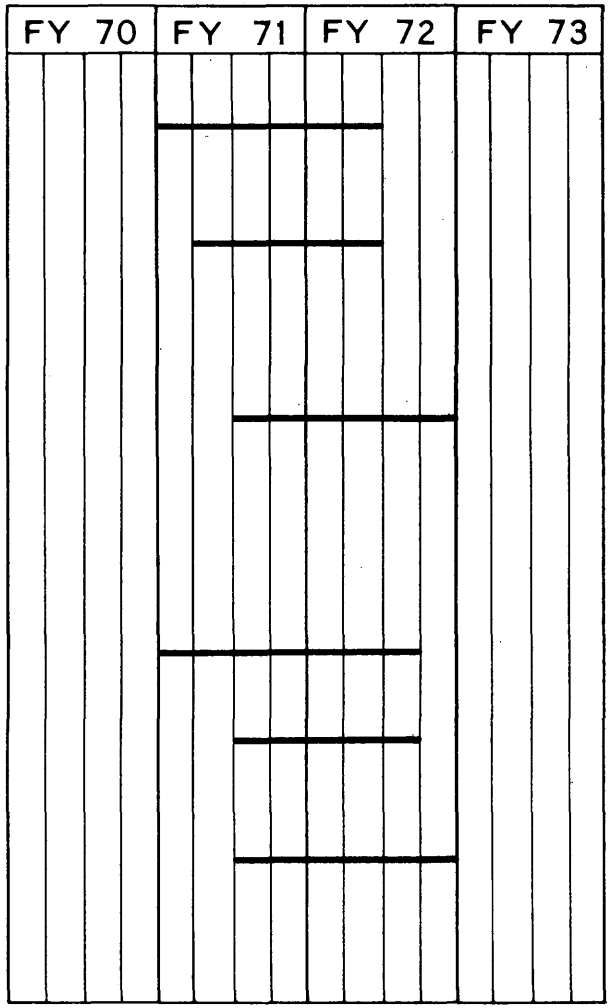
Aquifer-recharge areas

1. Map (1:250,000) showing areas of existing natural and artificial recharge

2. Map (1:250,000) showing areas having potential for artificial recharge

3. Report with tabular material on current status of artificial recharge with discussion on potential for additional artificial recharge

*Schedule*



Water quality and waste disposal

Wastewater sources and pollutional loadings

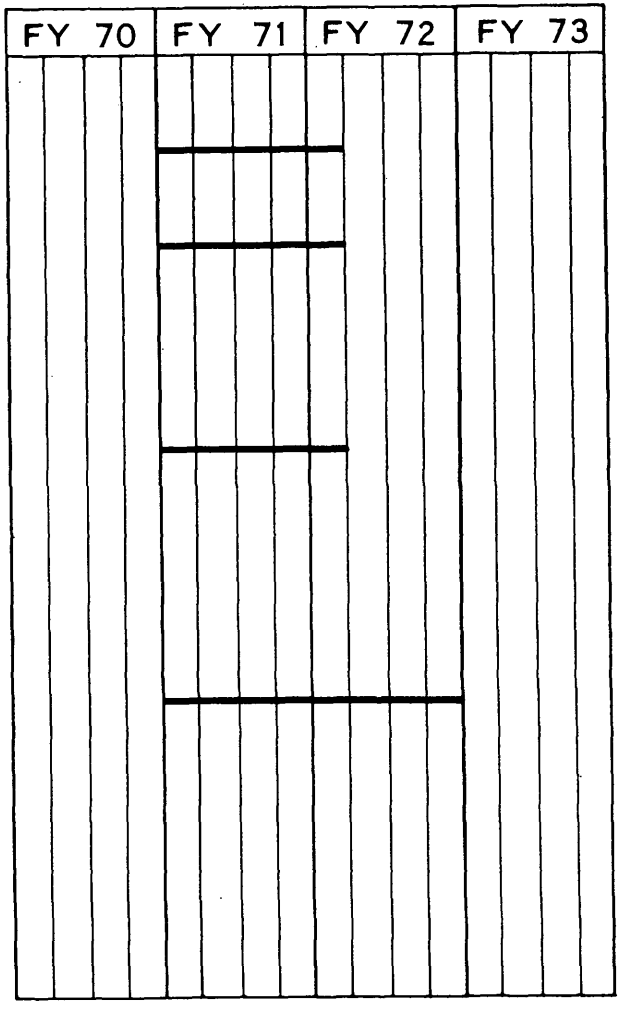
1. Revised map (1:250,000) of areas served by sewerage facilities

2. Map (1:250,000) showing municipal and industrial wastewater outfalls and accompanying descriptive data

3. Open-file report showing municipal and industrial wastewater loadings within six major regions of San Francisco Bay. The report includes a map of the Bay region, a compilation of wastewater volume, BOD, nitrogen, phosphate, and toxicant loadings, and a section describing the significance of each loading parameter

4. An interpretive report on the sources, geographical distribution, and pollutional loadings of wastewater in the Bay area. Concluding sections will include a discussion on the present effects of wastewater discharges on receiving water quality and wastewater management alternatives now available to the Bay area planning community

*Schedule*



Water quality and waste disposal--Continued

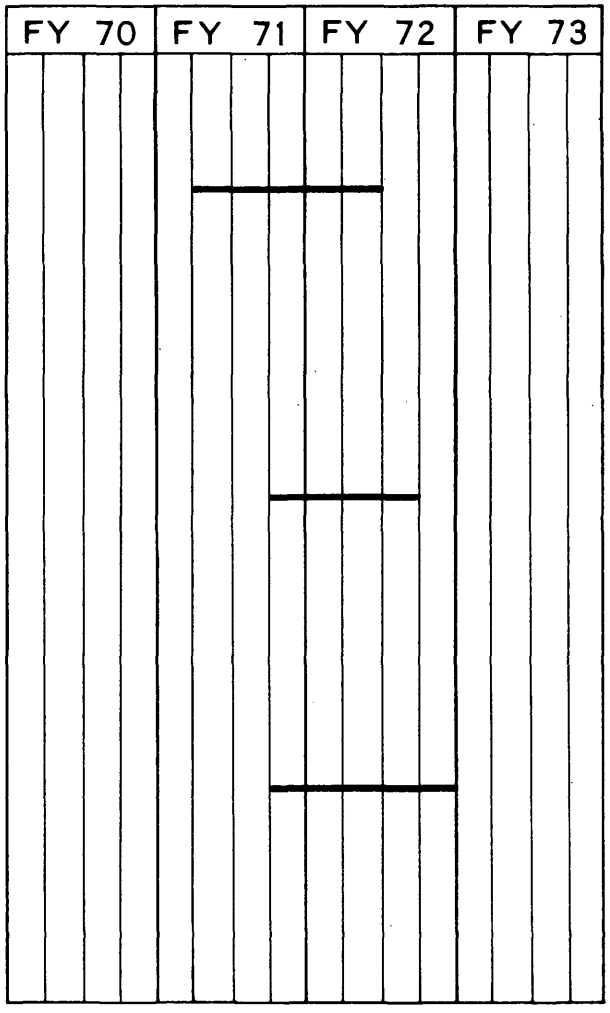
Quality of receiving waters

1. Map (1:250,000) identifying all major surface waters in the Bay area (streams, lakes, rivers, and estuaries). Accompanying text and tabular material will identify the beneficial uses and water-quality objectives which have been prescribed for each surface-water zone

2. Basic data report identifying the existing water-oriented beneficial use facilities and regions of the eight water-quality zones of the San Francisco Bay estuary (these include wildlife habitats, fish-spawning grounds, shellfishing beds, water-front parks and open space, boat harbors, industrial water-supply inlets, and navigation channels). Available water-quality data will be used to assess the compliance, within each of the eight water-quality zones, in meeting the prescribed water-quality objective.

3. Report discussing the chemical quality of Bay area waters. Present quality will be compared with historical data to assess changes due to urbanization

*Schedule*



Water quality and waste disposal--Continued

Land-pollution susceptibility

1. Map (1:250,000) of existing solid-waste disposal sites and pollution potential ratings as delineated by the State Department of Public Health

2. Map (1:250,000) identifying geographic areas in the nine Bay area counties most susceptible to water pollution

3. Interpretive report on land-pollution susceptibility, including guidelines for locating solid-waste disposal sites in the Bay area

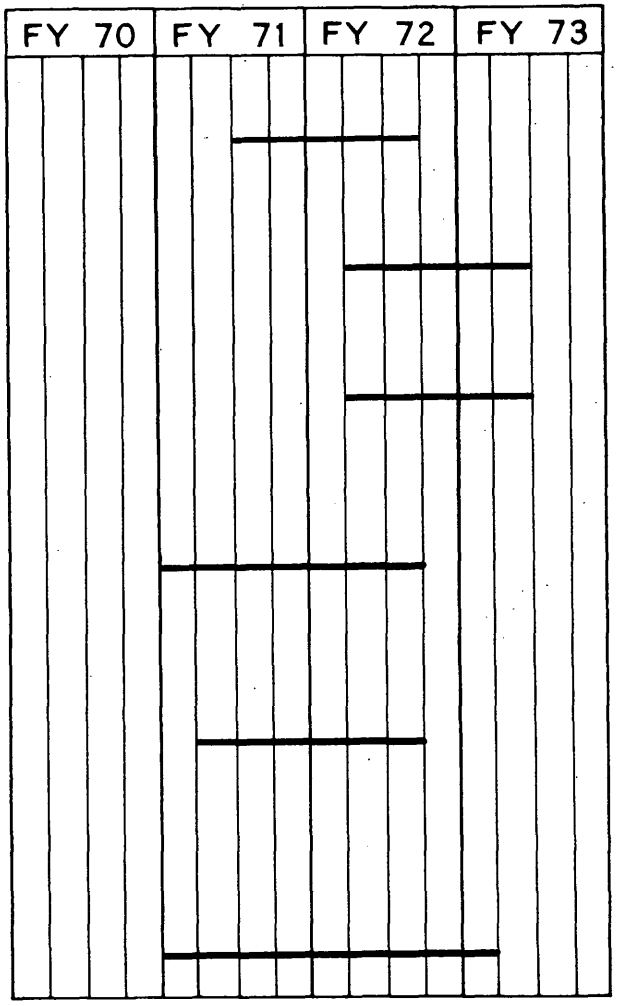
Eutrophication of fresh-water bodies

1. Map showing the location of lakes and their relative drainage areas

2. Depth profile for each lake at periods of maximum and minimum biological activity showing temperature, dissolved oxygen, specific conductance, alkalinity, and pH. These items as well as the drainage area, volume, inflow, outflow, nutrient data, and percentage of organic matter in the bottom sediments will be summarized in a table

3. An interpretive report summarizing the meaning of the collected data as it relates to lake enrichment. Methods that planners may apply to reduce enrichment will be discussed

*Schedule*



Hazards

Flood-plain inundation

1. Map (1:125,000) showing areas inundated by a flood having a recurrence interval of 100 years, with accompanying tabulations showing water stage, discharge, and stage-frequency curves at selected sites for notable floods. The "100-year flood" was selected to conform with the Federal Flood Insurance Act of 1968

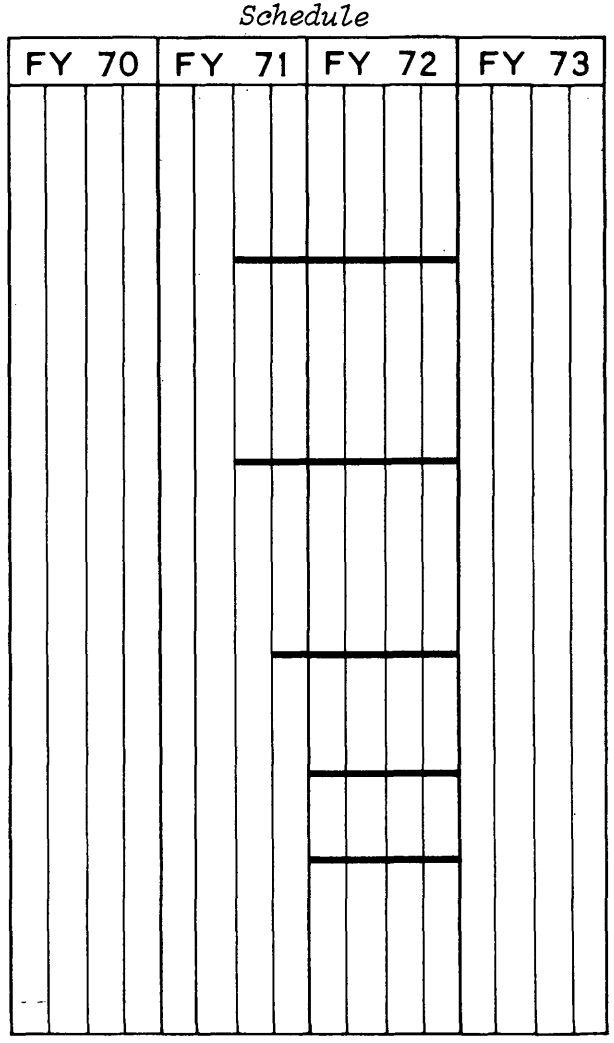
2. Interpretive report identifying specific flood-plain areas now undeveloped and uses to which those flood plains might safely be put

Coastal flooding

1. Map (1:62,500) showing areas that have been and that might be inundated as a result of high tides in combination with intense storms

2. Map (1:62,500) showing areas that might be flooded by tsunamis

3. Tables listing town, parks, and highways that might be damaged by coastal floods or tsunamis



Hazards--Continued

Storm-design criteria

1. A map (1:250,000) showing mean annual precipitation at contour intervals of 2 inches for mean annual precipitation values less than 40 inches, and 4 inches for mean annual precipitation values greater than 40 inches

2. Graphs, and their corresponding equations, relating precipitation for various durations to mean annual precipitation. A separate set of graphs will be presented for each duration; each set will include six graphs--one for each of the following recurrence intervals: 2, 5, 10, 25, 50, and 100 years

3. A report describing the deviation of graphs shown in (2), the procedure for obtaining depth-duration-frequency information for storm-drainage design

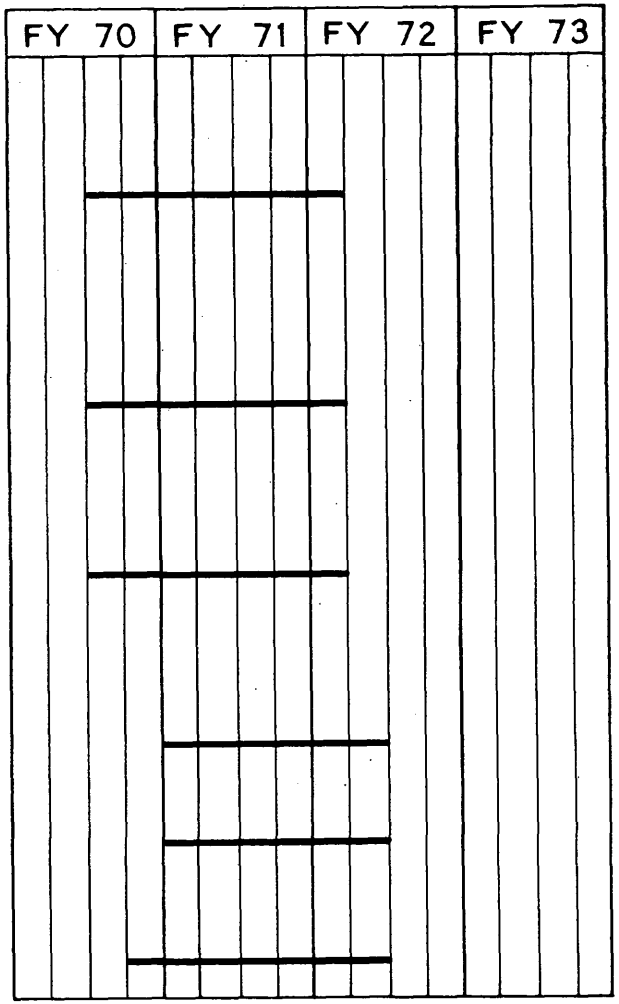
Design criteria for flood flows

1. A report describing and appraising current procedures for computation of design flood flows

2. A report evaluating the effects of urbanization on current procedures

3. A report containing developed technical relations for application of current procedures to computation of design flood flows in the San Francisco area

*Schedule*



Hazards--Continued

Stream-borne sediment

1. Map at a regional scale with explanatory text showing soil erodibility, values and areas of measured sediment yield, and special related parameters which are available for certain areas

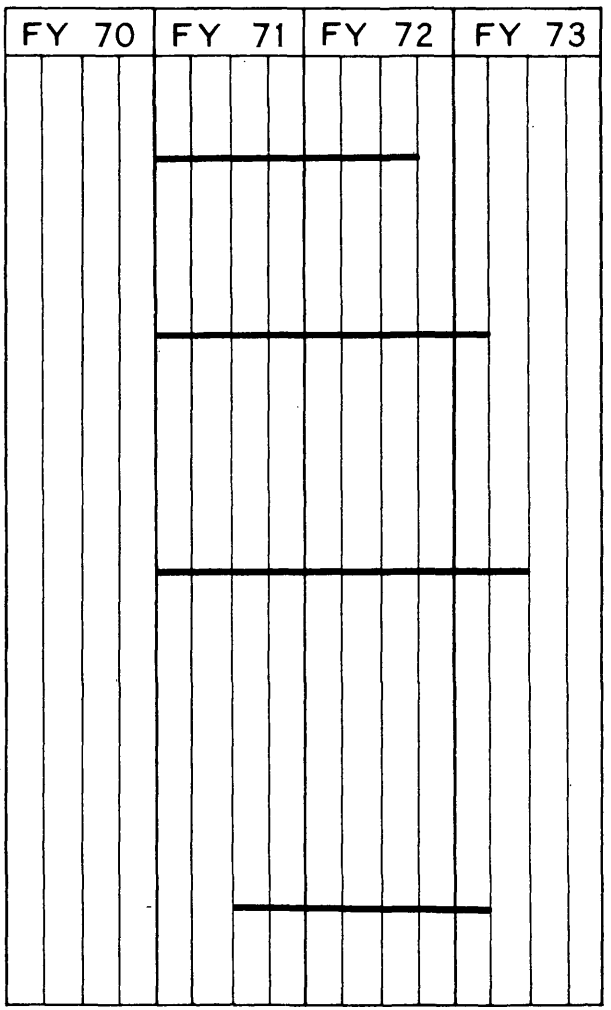
2. Selected maps with brief explanatory text showing (1) areas where erosion, transportation, and deposition of sediments constitute problems; (2) identification of the existing problems; and (3) areas where the potential for such problems is large

3. Interpretive report that includes a discussion of effect of urbanization on sediment yield, effect of floods on the movement of sediment, effect of sediment deposition on reservoirs, sources, of sediment, problems of sedimentation in urban and rural areas and ways of alleviating those problems, and filling rate of representative reservoirs with respect to the sediment yield of the area drained

Local drainage problems

1. Maps (1:24,000) of selected localities showing areas where natural runoff accumulates. Such areas of restricted drainage are clearly unsuited to some uses without expensive modification. Their recognition and delineation will allow planners to assign land-use patterns compatible with natural conditions

*Schedule*



Hazards--Continued

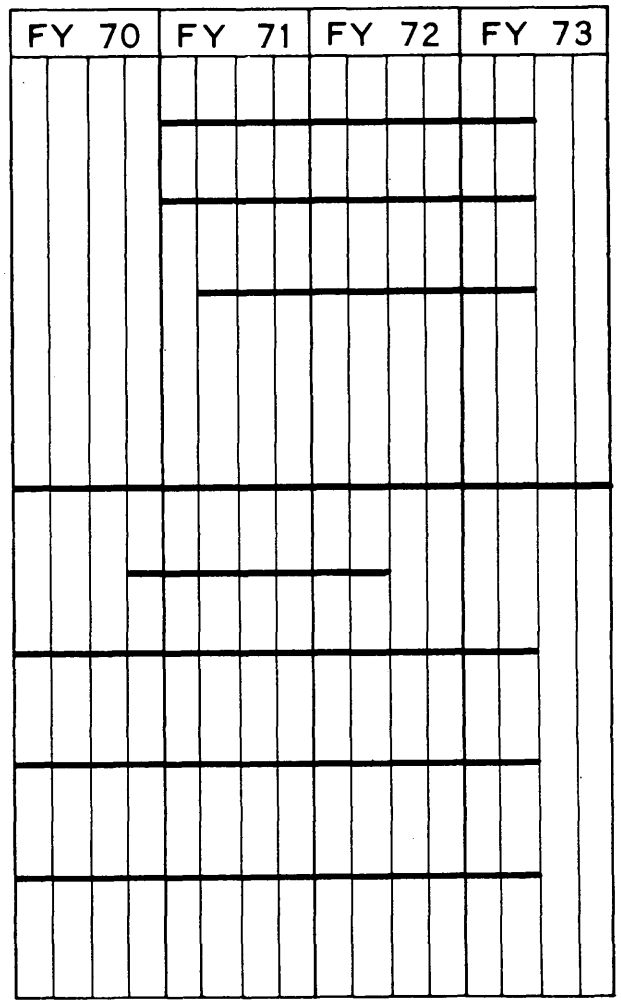
Land subsidence

1. Maps showing areas and amount of land subsidence
2. Map showing areas where subsidence could occur if artesian aquifers were heavily pumped
3. Report discussing relation of land subsidence to urban development

Physical and chemical hydrologic properties of San Francisco Bay

1. Summary of basic chemical and physical data of Bay waters
2. Summary report on movement of bottom currents
3. Technical analysis of source, movement, and final disposition of suspended sediment
4. Reports on seasonal changes in chemical properties as they relate to biochemical and organic processes and to water circulation
5. Report on seasonal changes in water circulation patterns in the Bay and adjacent Pacific Ocean

*Schedule*



Hazards--Continued

Physical and chemical hydrologic properties of San Francisco Bay--Continued

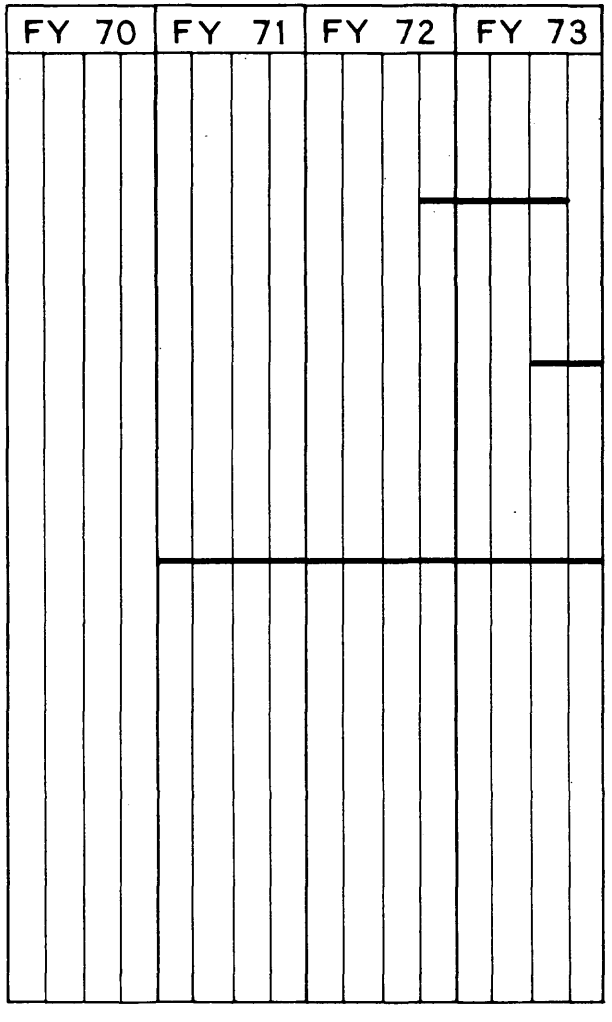
6. Technical report on the interrelation between physical and chemical processes in Bay waters to aid in evaluation of proposed modifications in the configuration or hydraulics of the Bay and adjacent Pacific Ocean

7. Interpretive report on the interaction of man's activities and the river-bay-ocean hydrologic system

Planning and management considerations

1. Reports discussing interrelation among the hydrologic program elements and interfaces with the urban decision-making process

*Schedule*



WORK SCHEDULE FOR PLANNING PROGRAM ELEMENTS

Program element and subelement

State-of-the-art Review and Analysis

1. Preparation of "Request for Proposal" and selection of a consultant or consultants

2. Preparation, presentation, and review of a detailed program and schedule of study

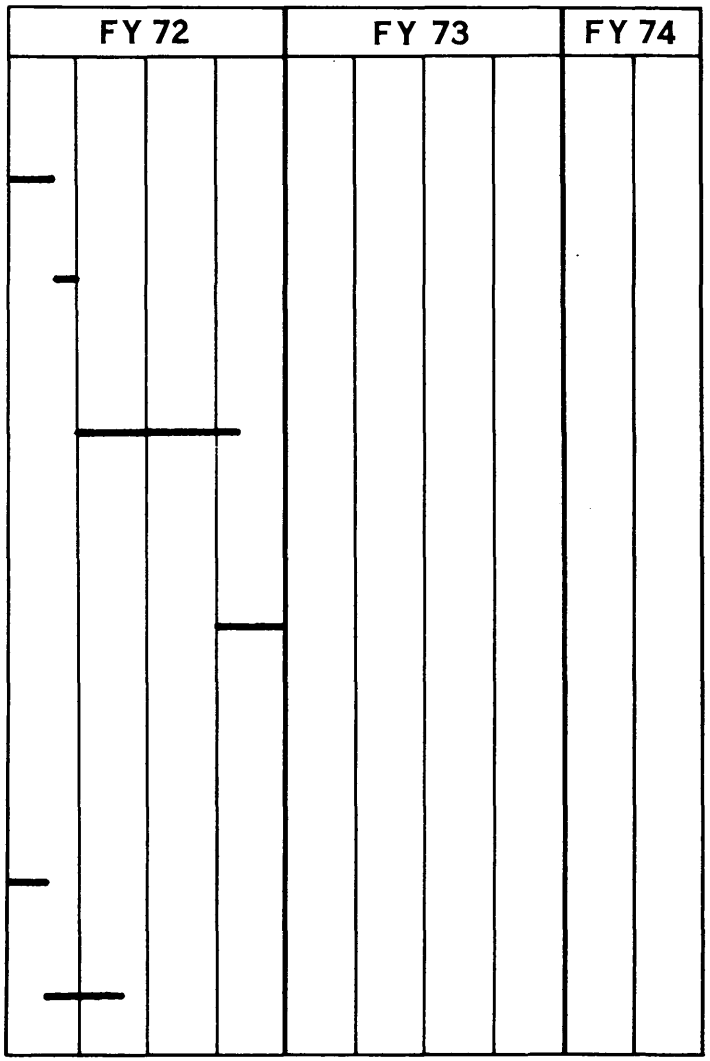
3. Data collection and analysis: review of relevant published documents, contact of selected agencies and individuals, analysis of findings, development of preliminary recommendations, regular reporting to Study staff and Consultative Panel

4. Preparation of written reports containing findings, analysis, and recommendations for urban planners, earth scientists, and selected public agency functions

Urban Information Systems -- Feasibility Study

1. Information Systems Committee review and detailing of Work Element

2. Selection of prototype earth-science data elements. Investigation of basic character of selected urban land-use information systems



Urban Information Systems--Continued

3. Earth-science data format modifications, problem identification, selected tests, analysis, regular reporting to study staff and Consultative Panel

4. Preparation of written reports containing findings, analyses, and recommendations for urban planners, earth scientists, and information system specialists

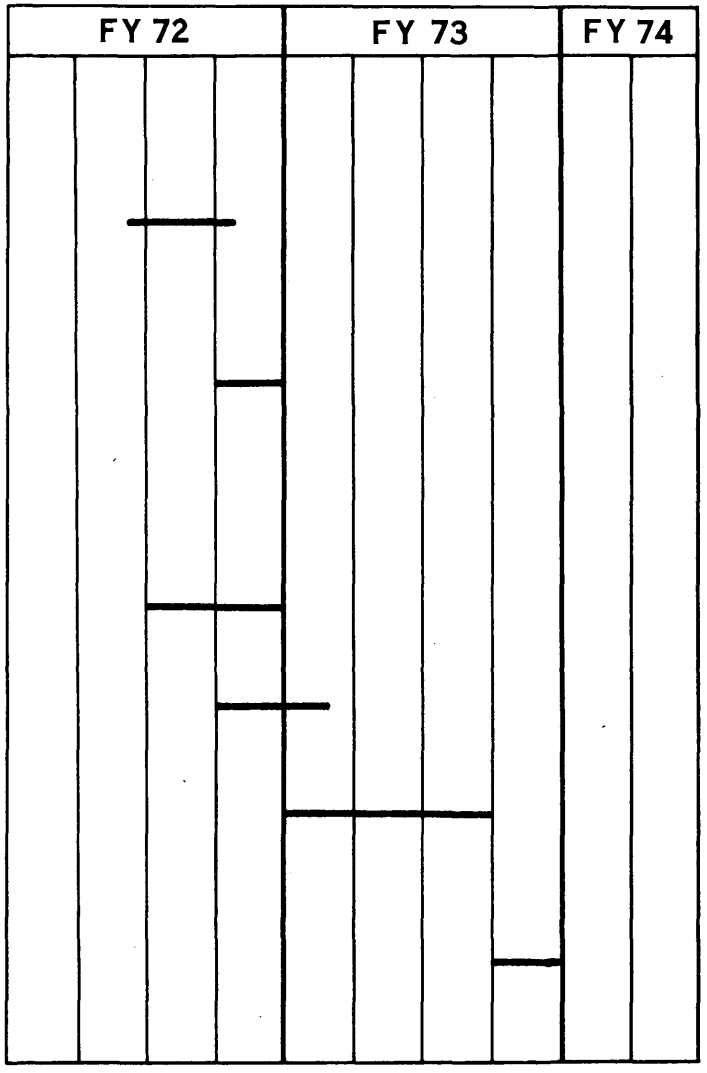
Application and Demonstration Studies

1. Identification, negotiation, and selection of Application and Demonstration Studies

2. Preparation, presentation, and review of detailed program of study

3. Earth-science data use, preliminary observations and analyses, regular reporting to Study Staff and Consultative Panel

4. Preparation of written reports containing findings, analyses, and recommendations for urban planners, earth scientists, and selected public agency functions



Planning Studies Synthesis

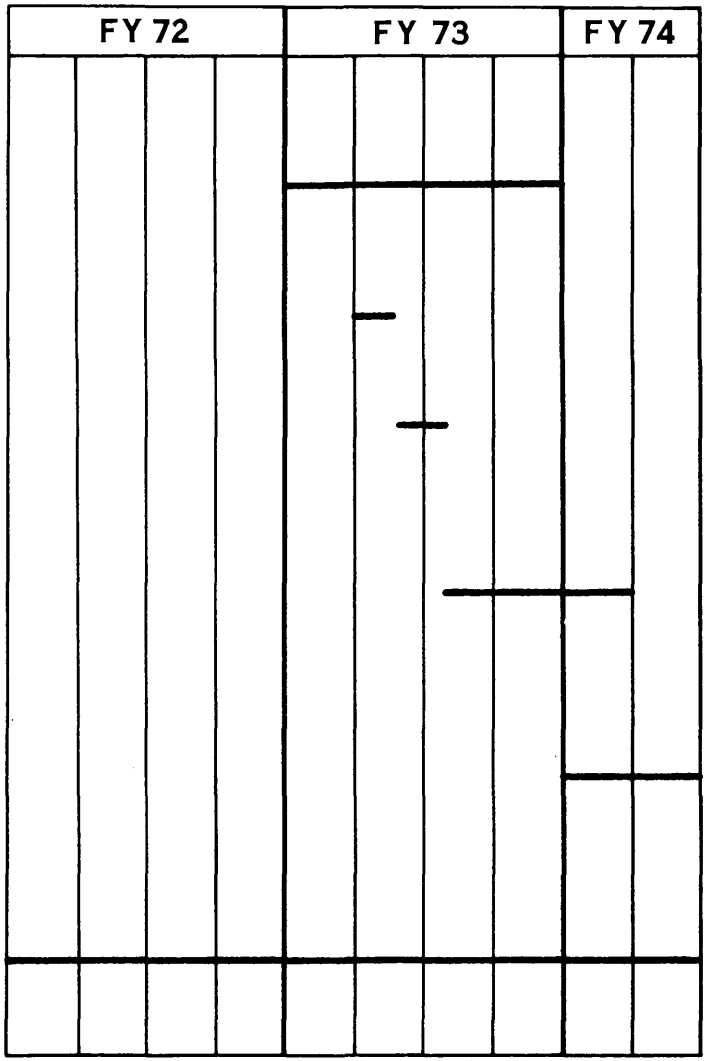
1. Planning Staff participation in preparation of earth-science Interpretive Reports

2. Selection of Consultant for participation in preparation of final Planning Studies report

3. Preparation of detailed outline for final report; preparation, presentation, and review of work schedule

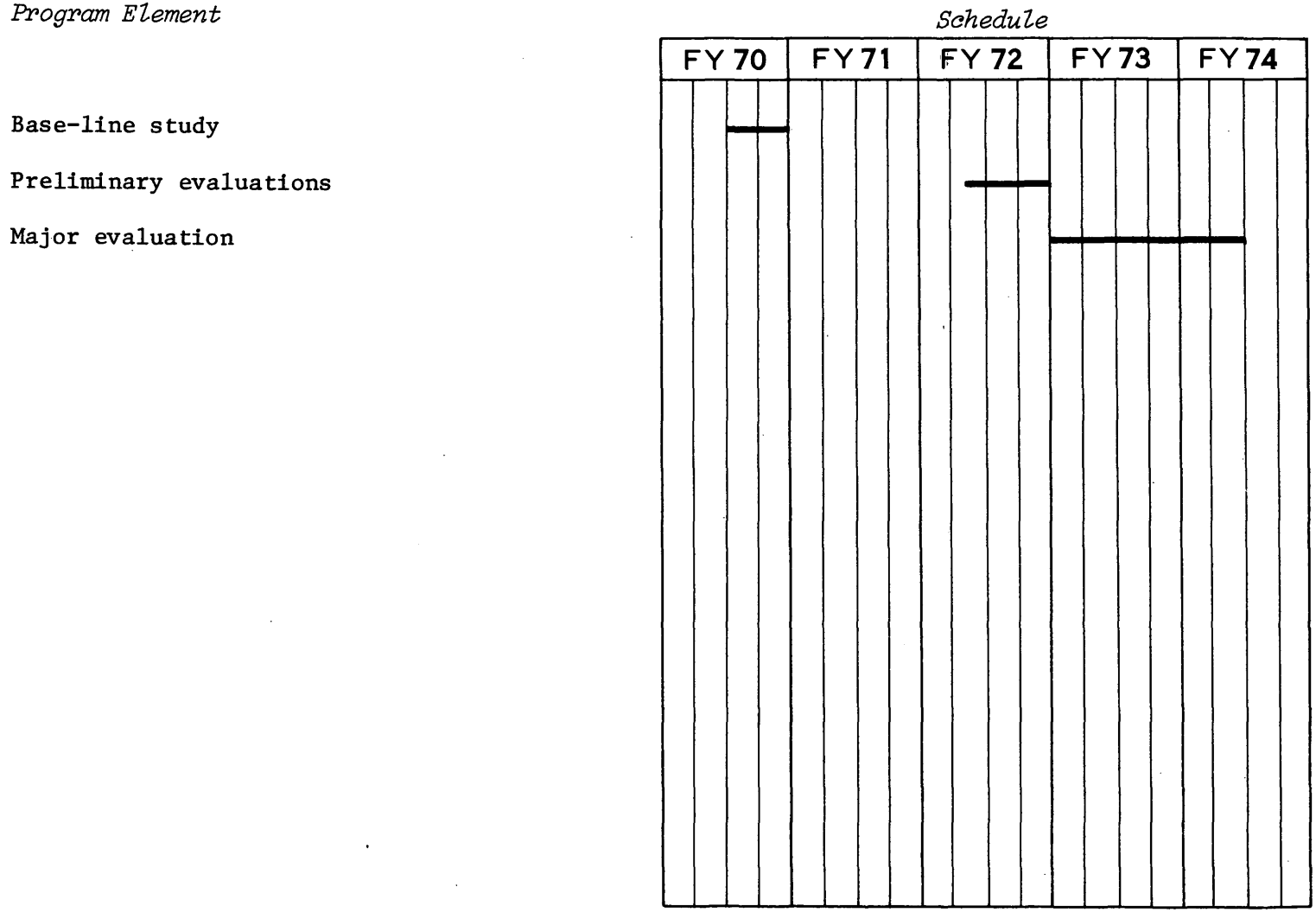
4. Analyses and synthesis of study findings to date, development of additional earth-science planning application concepts, procedures, and recommendations

5. Preparation of final written report focusing on the needs of the urban planning process and presenting a discussion of the "Nature of the Problem," outlining methods for "Developing the Plan," and suggesting means of "Implementing the Plan."




Continuing Activities of the Planning Staff

WORK SCHEDULE FOR EVALUATION STUDY



ONGOING PROGRAM

## ONGOING STUDIES RELATED TO SAN FRANCISCO BAY REGION STUDY

The following studies currently (1970) being carried out within the U.S. Geological Survey are pertinent to the goals of the San Francisco Bay Region Study. These studies were developed to serve a variety of goals other than the Bay Region Study; many are being carried out cooperatively with other Federal, State, and local agencies. In total the studies represent the base upon which the San Francisco Bay Region Study is built and without which the study would be impossible in its presently conceived diversity, depth, and rate of undertaking.

Most of these are long-term projects that are mainline research serving major responsibilities of the USGS. For a few, although funded independently of the Bay Region Study, the emphasis is being shifted to better accommodate the study's objectives.

Although no topographic or base-map preparation is being carried out within the Bay region other than that supported by augmentation funds, the San Francisco Bay region is the only urban area of comparable size in which all of the standard 1:24,000-scale topographic base maps have very recently been revised and updated. Without that recent effort, a regional map at 1:125,000 scale of the quality now possible would not have been practical within the present funding limitations of the San Francisco Bay Region Study.

The estimated level of funding for the ongoing program for FY 1971 is $1.27 million, and, if the same level is maintained over the 3-year life of the study, the support is expected to approximate $3.8 million.

### Geologic and Geophysical Studies

Ongoing programs in the geologic and geophysical fields related to the San Francisco Bay Region Study are listed below.

1. San Andreas tectonic
2. Multiple fault strands
3. Geology of San Francisco Bay region
4. Point Bonita quadrangle
5. Northwest Sacramento Valley
6. San Andreas geologic framework
7. San Mateo quadrangle
8. San Andreas geophysics
9. San Francisco Bay sediments
10. Soils Engineering Research
11. Geochemistry of San Francisco Bay
12. Remote sensing of San Francisco Bay
13. California strain net

14. San Andreas telemeter seismic net
15. Ground-motion studies
16. Microearthquake studies
17. California portable seismic net
18. Automatic processing of microearthquake data
19. Special Projects Office study*

| | |
|---|---|
| Estimated funds for FY 1971 | $ 817,000 |

*Funds to be expended in this classified study are not available.

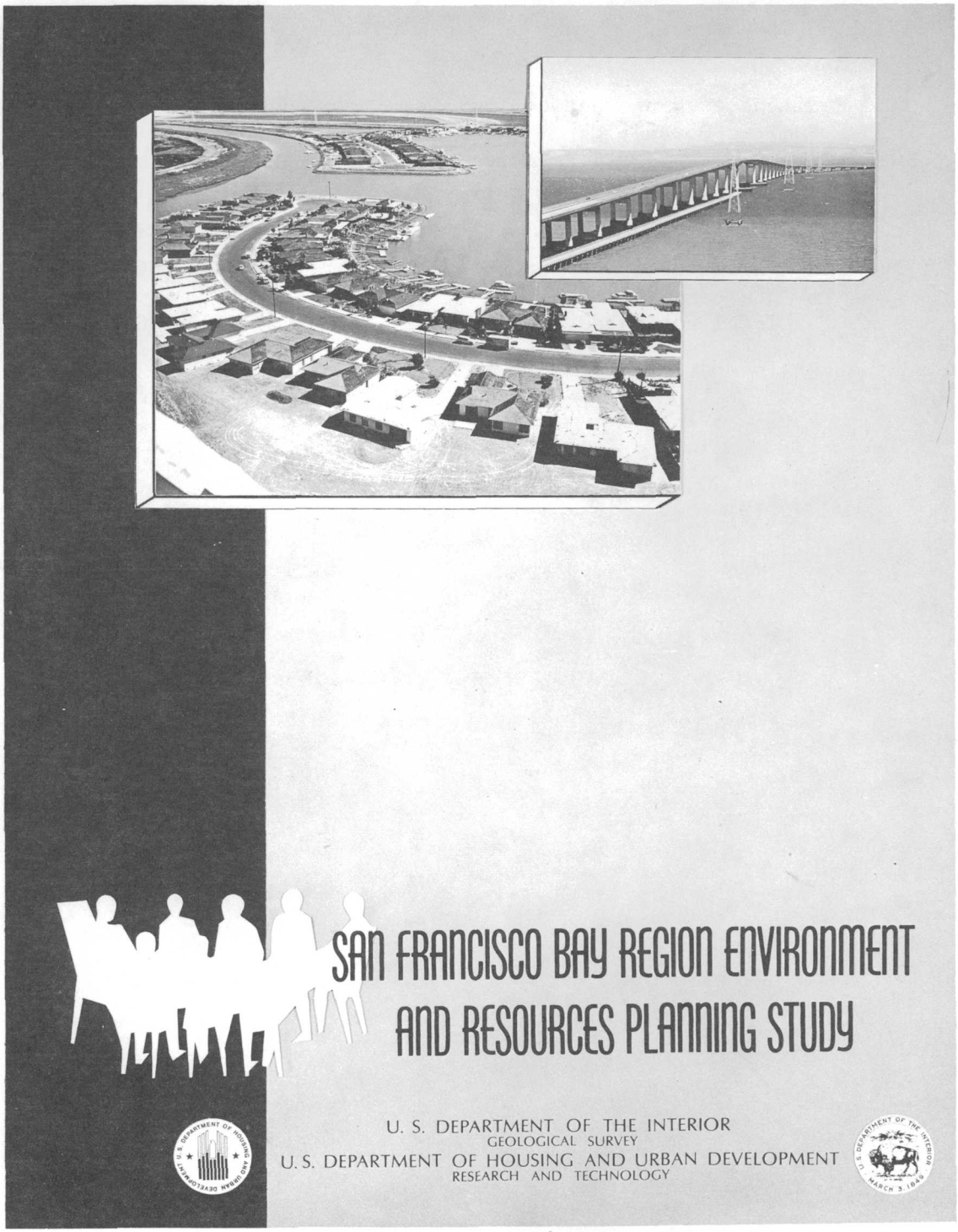
## Hydrologic Studies

Ongoing programs in the hydrologic field related to the San Francisco Bay Region Study are listed below.

1. Collection of base data in urban areas
   (Applied to nine Bay area counties)
   - Surface-water data
   - Ground-water data
   - Sediment data
   - Chemical-quality data
2. Fluvial-sediment transport to San Francisco Bay
3. Channel morphology of San Francisquito Creek tributary after a change in streamflow regimen
4. Santa Clara Valley analog model
5. Hydrology of Bolinas Lagoon
6. Trace elements and ground-water quality, Santa Clara County
7. Floodflows and sediment yield of Colma Creek basin
8. Mechanics of aquifer systems related to land subsidence
9. Aquifer-test compilation and re-evaluation
10. Graphical summary of sedimentation characteristics of California streams
11. Sediment transport in the Russian River basin
12. Development of time-lapse photography equipment for hydrologic studies
13. Estimating direct runoff from storm rainfall by use of the infiltrometer
14. Characteristics of selected lakes and reservoirs in California
15. Floods from small drainage areas
16. Temperature of California streams
17. Ground-water data network for California
18. California Comprehensive Framework Study
19. Flood inundation map - Napa
20. Surface-water network evaluation

21. Sediment exchange between San Francisco Bay and Pacific Ocean
22. Water Quality - San Francisco Bay

| | |
|---|---|
| Estimated funds for FY 1971 | $ 459,000 |
| Total estimated funds FY 1971 | $ 1,276,000 |




Design used on jacket covers for all publications of the San Francisco Bay Region Environment and Resources Planning Study

# PUBLICATION AND DISSEMINATION OF INFORMATION

## TYPES OF PUBLICATIONS

Documents for the San Francisco Bay Region Environment and Resources Study will be of three types:

1. Basic Data Contributions will consist of maps, tables, maps plus pamphlets, or short scientific articles. These contributions will be highly scientific in nature and include little or no interpretation. Most of the products issued early in the program will be of this type.

2. The Technical Series will consist of interpretive topical reports. Some of these reports will be written primarily for engineers and urban land-use planners while others will be written for hydrologists, seismologists, or geologists. Although technical, these reports will represent generalizations of a regional or topical nature that will lend themselves to regional planning use.

3. The Interpretive Reports will apply the basic data and technical information to problems of urban development. They will be written primarily for the private citizen, developers, and for those who make decisions and carry them out. The concepts back of this series are discussed in more detail in the section on "Focus and Methods."

Each of these series will be numbered sequentially so that, depending upon his interests, a reader may order a complete set of all three series, or only one or another.

Most of the reports and maps described above will be released initially as so-called "open-file" reports. These will be duplicated locally and distributed promptly. They will have the approval of the USGS and HUD, but will be considered preliminary and will not have been edited for conformity with USGS standards and nomenclature. Most of these reports will be reprinted in final form at a later date after complete processing through the government's publication "mill." Many of the maps will be republished in full color instead of black and white.

A few reports of special importance may be published as Circulars. These will be printed in Washington and will be edited for conformity to all Geological Survey standards. Circulars are distributed free to all who request them.

Topographic maps made specifically for this project are expected to be available within the second year of the project, as will orthophotomosaics and other special cartographic products.

## REVIEW PROCEDURES

Review procedures are a necessary part of the documentation program, particularly so, since this is a joint project involving two government agencies. In practice, the amount of actual review of specific documents will vary considerably. For example, Basic Data Contributions by the USGS which are part of ongoing programs may require only policy review by HUD. On the other hand, reports in the Technical and Interpretive Series may require careful discussion and review from the planning stage through final writing. It is believed that review procedures will be most effective if the Project Director in the USGS and his counterpart in HUD keep each other informed of plans for, and progress of, all manuscripts which are to be part of the cooperative project. If this is done, there should be a continuing interchange of ideas, and decisions can be made as to the reviews required as each report is prepared.

Within the Geological Survey itself, more interdivisional reviews may be appropriate than has been customary in the past. There should be close cooperation between the Geologic, Water Resources, and Topographic Divisions, so that each will know what types of reports the other is preparing. Branch Chiefs and the Project Director will determine the review procedures that seem warranted for the individual reports.

Reports resulting from cooperative programs with agencies other than HUD will be circulated to those agencies following long-established USGS policies. In addition, copies of reports may be sent to other interested agencies for their information prior to formal release if such distribution is deemed to be in the public interest.

## DISTRIBUTION AND NOTIFICATION OF PUBLICATION

Distribution of reports will be made free to a limited number. The free distribution list will include certain offices in the U.S. Geological Survey, the Department of Housing and Urban Development, State agencies specifically involved, such organizations as the Association of Bay Area Governments, and Bay area agencies and county planning officials in the specific areas covered by a given report or map. In addition, all agencies and individuals known to be interested in the project will be notified of the release of the publication. Information will be supplied as to where the publication can be seen, how it can be obtained for retention, and what it costs. Anyone wishing to have his name placed on such a list should notify the Office of Project Director, U.S. Geological Survey, Menlo Park, California 94025.

If the publication is felt to be of general interest, a story will be given to the local newspapers describing its content and giving details as to where it may be obtained.

Lists of available publications will also be printed from time to time in newsletters of Association of Bay Area Governments, and other organizations such as Association of Planning Directors, the Sierra Club, and any others that seem appropriate and are agreeable to performing this service.

If the report is highly technical and believed to be of limited interest, it may be listed only in the regular press notices sent out by the Geological Survey that include the titles of reports being released to the open files on a given date, or in the Monthly List of Publications published by the U.S. Geological Survey.

BUDGET

## BUDGET SUMMARY

The following budget is presented here primarily to indicate to the general reader the order of magnitude of funding necessary to carry out a complex program such as outlined.

The budget assumes that the ongoing program ($1.27 million per year) of the USGS which relates to the Bay Area and which is financed by a variety of other agencies as well as from direct appropriations, will continue to provide background support at about the same level as in fiscal year 1971.

In addition to originally planned augmentation funds at $1.2 million to be provided by HUD, the USGS has reinforced its program by additional funding and reprogramming, and HUD has provided additional funds to support the Planning Elements.

ESTIMATED 3-YEAR BUDGET SUMMARY -- SAN FRANCISCO BAY REGION STUDY
FISCAL YEARS (in thousands of dollars)

| | 1970 | 1971 | 1972 | 1973 | 1974 | Total |
|---|---|---|---|---|---|---|
| Topographic Elements | | | | | | |
| Ongoing | 0 | 0 | 0 | 0 | 0 | 0 |
| Augmentation | 63.9 | 106.1 | 66.7 | 8.0 | 0 | 244.7 |
| Geological and Geophysical Elements | | | | | | |
| Ongoing[1] | 408.0 | 817.0 | 833.0 | 417.0 | 0 | 2,475.0 |
| Augmentation[2] | 60.0 | 418.3 | 585.9 | 477.0 | 0 | 1,541.2 |
| Hydrologic Elements | | | | | | |
| Ongoing | 220.0 | 459.0 | 500.0 | 250.0 | 0 | 1,429.0 |
| Augmentation | 50.3 | 263.6 | 150.9 | 52.1 | 0 | 516.9 |
| Planning Elements | | | | | | |
| Base[3] | 0 | 15.0 | 30.0 | 15.0 | 0 | 60.0 |
| Additional | 0 | 0 | 79.5 | 159.0 | 51.3 | 289.8 |
| Grand total | 802.2 | 2,079.0 | 2,248.0 | 1,378.1 | 51.3 | 6,556.6 |

[1]Represents estimate of cost of ongoing programs in USGS pertinent to San Francisco Bay region.
[2]Represents estimate of funds needed for adequate support of the 3-year program.
[3]Represents funds provided under interagency agreement.



☆ GPO 790-481