PANEL ON ACCELERATED SURVEYING AND MAPPING PROGRAM*

18TH ANNUAL MEETING OF THE AMERICAN SOCIETY OF PHOTOGRAMMETRY

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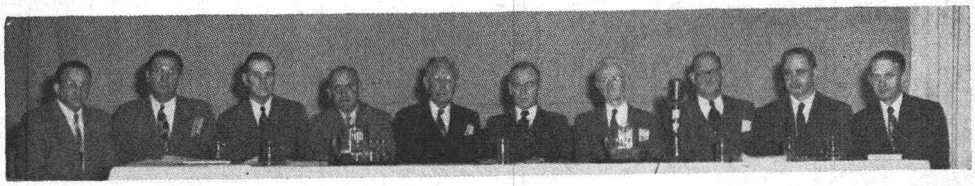

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Left to right: President Abrams, J. R. Mahoney, Robert Randall, Adm. R. F. A. Studds, W. E. Wrather, A. N. Sayre, W. H. Bradley, Gerald Fitzgerald, M. Clawson, and R. W. Simonson.

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INTRODUCTION

Dr. J. R. Maloney, Moderator

The first part of the Panel Discussion will consist of prepared papers by Dr. Wrather, Admiral Studds, Director Clawson, Dr. Simonson, Mr. Randall and by me. This will be followed by general statements and discussion by Gerald Fitzgerald, A. Nelson Sayre and others. The balance will consist of questions by panel members and the audience and answers by panel members.

Because the speakers and their interest in mapping and natural resources are well known, each speaker will not be separately introduced.

STATEMENT BY DR. J. R. MAHONEY

Senior Specialist in Natural Resources, Legislative Reference Service, Library of Congress

Before it was presented to Congress the program that we are to present required extensive consultation among various professional people interested in mapping and the scientific foundation in natural resources.

There was a widespread conviction of a need for reexamining the entire scientific foundation program in natural resources. This resulted in formulating two pieces of legislation which were introduced during the last part of the 81st Congress. These are entitled "An Accelerated Surveying and Mapping Program" and "A Comprehensive Basic Data Program in Water Resources."

These two measures have been under careful study by the committees of Congress, hearings have been held, and they have been reported favorably with the unanimous support of the committee.

As is generally known, Congress has the responsibility for formulating programs and determining policies. It has the additional responsibility for setting up administrative agencies to carry out these policies and to administer the programs.

The phenomenal rise of the United States to its present position of outstanding world leadership would not have been possible without a great wealth of natural resources that have supported and made fruitful the hard work and ingenuity of a rapidly growing population under free political and economic institutions.

America has always been characterized as a nation with boundless wealth in a great variety of natural resources. Unfortunately, however, the very richness and abundance of these great resources has often led to wasteful use of many resources.

In every direction our rapidly increasing population with its steadily advancing standard of living requires a corresponding progressive enlargement of the supply and variety of natural resources.

As these new problems are faced, it is evident that there is only a limited knowledge of our resources. Most conspicuous is our neglect of exploration and of basic scientific studies designed to discover the full extent and nature of our natural resources. In recent years it has seemed much easier to expand our appropriations for great construction programs than for the less spectacular scientific programs with the result that many Federal programs and those of the States and private enterprise as well must now proceed on the basis of inadequate knowledge of the national resources.

Suitable maps are the logical starting point for most Federal and non-Federal projects in a wide variety of natural resources. Often these are not available. Our mapping programs are generally proceeding so slowly that, at the current rate of progress, it will require from 40 to 100 years for their completion. It is universally recognized that nothing would contribute more to an effective and judicious development of our resources and to the economical operation of our many activities than a complete set of maps showing the necessary surface and subsurface features. Such maps are necessary for the effective development of our mineral and water resources, the effective use of our soils, the location of highways, railways, dam sites, industrial plants, telephone and electric lines, radio transmission stations, airports,

reclamation projects, drainage projects, and almost all activities dealing with the surface of the earth and the development of its resources. The effective use of the soil in the production of farm crops, timber production and other useful plant life can best be understood and carried out with suitable maps available.

Military needs are no less important than peacetime economic needs that actually are almost identical with the military needs. Military might depends upon strong economic and industrial institutions and activities, and these are everywhere dependent upon effective use of natural resources. The very existence of our country and its independent functioning may actually hinge on vital resources of which we may not now be aware but which may be brought to light by an accelerated mapping program.

We have developed resources that have been exposed by nature or are just beneath the soil surface. But we know far too little about our subsurface deposits and how the underground formations may be used in the conservation and more effective use of our water and mineral resources. Accordingly our potentials still are largely unknown and our development cannot be placed on a sound basis until more complete information is available. The completion of our mapping program in all of its important aspects at the earliest practical date consistent with the efficient scheduling of these accelerated programs seems to be the most fundamental and sound step for us to take.

Based on these interpretations, an accelerated surveying and mapping program has been prepared for consideration of the Congress. Extensive study and conferences have produced a complete and fully coordinated program of surveying and mapping in all of its essential forms that can provide an efficient, well-planned program of completing required surveys and maps of the entire country and give us the scientific foundation we now lack. The program also provides for an extension of the required surveys to the offshore areas as far as the edge of the Continental Shelf and beyond it where necessary. It includes the required surveys and maps in Alaska and other Territories and possessions in order that the same scientific foundation will be readily available for the development of the resources outside the continental United States.

Such a program will make it possible to plan carefully and thus replace our present slow, uncoordinated surveying and mapping program with an accelerated, carefully planned and coordinated undertaking.

On the public domain, where the Federal Government has special responsibility for the activity in mineral resources, forest and grazing management, and extensive reclamation and headwaters control projects, such programs must often proceed without the benefit of either topographic or geologic maps.

Much of the mapping program now under way is directed to project areas where major plans have already been formulated and, in many cases, actual construction is under way. This tardy development of adequate maps can only serve to alleviate in part the mistakes inherent in plans made without maps.

While the general and special uses of maps will be expanded and intensified in the future, the topography and geological character of the earth's surface will not change; where the mapping is well done it will serve a multitude of needs far into the future, many of which cannot now be visualized. Undoubtedly, new needs will require greater detail or the portrayal of additional features, but these can generally be sketched on the maps drawn by present standards and usually without the necessity of resurveys.

The stability and dependability of this projected program is of equal importance to its acceleration. The program will require a marked expansion of personnel and facilities. The recruitment and training of this larger staff will be feasible only under assurance of its maintenance at the higher level of functioning. A large portion of the personnel must necessarily be professional, requiring extensive training, and for which there is also a growing heavy demand by private industry. The accumulation of an adequate staff in the various mapping agencies will require assurance of unbroken employment.

The training program will require the full cooperation of American universities. The largest possible share of the total program should be carried on by State geological surveys and by the geologists and research staffs of the universities. Such cooperation, aside from being essential to the

success of the program, will be the most effective way of reducing the Federal expenditures and speeding the time for its completion.

Because it will form the scientific foundation for many vital and expensive development projects, it is essential that the planned work be done thoroughly and that the scientific integrity of all phases of the program be maintained at the highest possible level. These essential features of the program are within the power of Congress to establish and maintain.

The objective of the Bill now in the Congress as set forth in section 2 is—

"to establish accelerated programs of topographic, geologic, geodetic, soil and hydrographic surveying and mapping of the United States, its Territories and possessions and offshore areas, and the cadastral surveying of the public domain and other Federal public lands in order that suitable surveys and maps will be available . . . for the numerous uses for which these surveys and maps are needed . . . within the shortest period of time consistent with the orderly recruiting of personnel and the effective scheduling of such programs."

All of the various types of surveying and mapping programs provided for in the Bill are being carried on by various Federal agencies under programs long provided for by the Congress. The bill makes no fundamental change in the allocation of responsibility for these activities. Its chief purpose is to provide an accelerated program of surveying and mapping to meet the needs of the country without altering the distribution of activities among the agencies now responsible for these programs.

The surveying and mapping of the country will eventually be completed, even under present programs. From a long-run point of view, the accelerated programs do not call for an increase in total expenditures but instead for a concentration of effort and expenditures during the next 20 to 30 years and a reduction beyond that time. Experience, however, has demonstrated that the availability of the surveys and maps will reduce expenditures in so many other directions that the total cost to the Federal Government, even in the shorter period, probably will be offset many times over by savings in other directions.

Section 3 of the Bill defines the responsibility of the Geological Survey, acting under the Secretary of the Interior, for several subdivisions of the accelerated mapping program. Subsection (a) of section 3 provides for the completion of the topographic mapping of the United States within a period of 20 years.

Subsection (b) of section 3 makes similar provisions for the geologic mapping of the United States. A period of five years is specified for expansion to the maximum activity, instead of the four years provided for expansion in the topographic mapping program. A period of 25 years for operation at the maximum level is specified.

Section 4 of the Bill provides for an accelerated program of the Coast and Geodetic Survey, under authority granted to the Secretary of Commerce, especially in those parts of its activity as are related to the other surveying and mapping programs. Subsection (a) of section 4 provides for the establishment of adequate geodetic control points in advance of the needs of the surveying and mapping programs specified in the Bill.

Subsection (b) of section 4 authorizes the Coast and Geodetic Survey to provide surveys and charts, with adequate submarine contours, of offshore areas of the United States, its Territories and possessions, at scheduled rates which will make suitable data available in time to meet the requirements for effective and orderly development of mineral and of aquatic and other marine resources.

Section 5 authorizes a 30-year program to complete the soil mapping of the country and for similar maps as needed for the development of resources in Alaska and other Territories and possessions.

Section 6 of the Bill provides for a 10-year program for the completion of the cadastral surveying of the public domain and other Federal public lands within the United States. Approximately 116,000,000 acres of the public domain in the 11 Western States have not been surveyed and approximately 50,000,000 acres are in need of resurvey because of old markers and the incompleteness of earlier surveys for modern needs.

Section 7 of the Bill stipulates that the various agencies responsible for the surveying and mapping programs—

"shall develop and support effective procedures of collaboration and cooperation with each other and with other agencies concerned, both Federal and non-Federal, to the end that the accelerated program established by this Act shall be carried out as effectively and econom-

ically as possible and without duplication of activities."

The intent of provision is insurance that all features of the comprehensive program shall be planned and coordinated for greatest effectiveness and maximum economy. There is an orderly sequence in carrying out the various types of surveys and charts. The control survey by the Coast and Geodetic Survey which establishes elevations and horizontal locations provides the framework on which the topographic maps are based, and these in turn provide an effective foundation for geological and soil mapping. The cadastral surveys on the public domain are greatly aided by the control surveys of the Coast and Geodetic Survey and supply much useful data for topographic and geologic mapping programs.

COST OF THE ACCELERATED SURVEYING AND MAPPING PROGRAMS

The total cost should not exceed the eventual cost of completing the same programs over a longer period of years, provided the larger programs can be scheduled and carried out as efficiently as the programs of the present size.

The advantages of accelerating these programs are mainly in gains from having suitable surveys and maps for use on all projects involving the use of the surface of the earth or its resources. Some of the gains that may come through acceleration may be summarized as follows:

Through coordination all programs can be planned and carried out in logical sequence. In general, this means control surveying, followed by cadastral surveying where necessary, and then by topographic mapping, geologic mapping, soil mapping, and hydrologic mapping. Once the proper sequence of the various parts of the surveying and mapping program has been established, it will be possible to formulate a coordinated long-range program that may be more easily and economically administered.

By scheduling the various mapping activities in logical sequence, the required expenditure and the time and energy required to supply unavailable previous stages will be reduced or eliminated, for instance, geologic survey parties improvising bench marks and contours and, in the public land States, township and section corners.

The accelerated program with its assurance of more certain rates of mapping will permit better scheduling of work, provide better use of instruments and facilities, and make possible a more effective recruiting of specialized personnel.

A definite established program should attract the cooperation of State and local governmental agencies and educational institutions. Non-Federal agencies may then assume a larger percentage of the total surveying and mapping responsibility.

The greatest economy will come as an inevitable result of having at an earlier time a comprehensive scientific foundation for all projects for the development of natural resources. Mistakes will be avoided and resource potentials now unknown will be possible of development. Time and money will be saved by all Federal, State, and private agencies in planning, building, and operating projects making use of the surface or subsurface of the earth or any of its resources.

The proper sequence, coordination and timing of the different types of surveying and mapping are embodied in various sections of the Bill.

The fundamental factor, however, and the most important phase, is acceleration. Under present programs a period of from fifty to a hundred and fifty years will be needed to complete the various types of mapping programs.

The planned work will require a very great increase in present programs. This increase cannot be immediately made. The Bill now before Congress specifies periods for expansion of activity to the size required for completion of the programs, within the specified periods of time.

While these programs are scheduled for completion in various limited periods of time, it is realized that this will not end mapping. There will need to be more intensive surveys later. Also undoubtedly certain events may require modification in the program.

These measures when they become law will establish the program but will not appropriate the needed money. They will authorize appropriating the money for the purposes set up in the measures. The question of how these are to be financed and put on that reliable basis necessary to bring the

cooperation required and permit systematic expansion are problems we are trying to work out. We hope to be able to find effective ways of meeting and solving these problems. That however, will have to come later.

Statement By Dr. W. E. Wrather

Director, United States Geological Survey

The Geological Survey is deeply interested in the work of the American Society of Photogrammetry. This is not entirely due to participation, although many of its engineers have been closely connected with the Society's programs and activities. It stems more from the realization that aerial photogrammetry contributes so extensively to the present high quality of topographic maps. The photogrammetric techniques developed for the use of aerial photographs have been of prime importance in attaining the uniform quality necessary to insure compliance with the present National Standards of Map Accuracy.

Dr. Mahoney has described the two Bills now before Congress. He pointed out some of the surveying and mapping needs. Being photogrammetrists, you are probably as keenly aware of these needs as we are in the Geological Survey, but it is sometimes well to talk to ourselves about the things we think we know.

We pride ourselves on being one of the most modern and up-to-date nations of the world. We have attained a position of world leadership and are perhaps without peer in the fields of mass production and industrial capacity. We have achieved what is probably the highest general standard of living that the world has ever known, and we have extended general education to the point where no one need be without it. *But where do we stand in regard to concise knowledge of our country and its natural resources.*

Captain George M. Wheeler, in his "Report Upon the Geographical Surveys West of the 100th Meridian," published in 1889, says, "The topographic survey lies at the foundation of all that constitutes finally an exact knowledge of physical geography, and no such survey is complete until all the natural and artificial features are mathematically measured, recorded, and delineated." Therefore, as topographic maps are so useful and essential for recording findings related to our natural resources, their availability should provide a rough measure of the extent of a country's knowledge of its resources.

In the report of the United Nations entitled "Modern Cartography, Base Maps for World Needs," issued in 1949, there appears a map which shows the status of topographic mapping in the nations of the world. According to this map, the countries in Europe are the best mapped of all—most of them being completely covered with topographic maps at scales of 1:25,000 or larger. Complete coverage is also shown for India, Burma, Thailand, French Indo China, and the Malay States. Reconnaissance maps are available for the major portions of China and nearly all of Manchuria, and good-quality maps are indicated for all of Korea and the Islands of Japan. Even the British Colonies of Africa are well covered. What about the United States? About forty per cent is shown as unmapped area.

In the Mid-Century Convocation on the "Social Implications of Scientific Progress" held at the Massachusetts Institute of Technology in 1949, Lord Hailey, in his comments on underdeveloped areas, mentioned the undesirability of starting any major economic planning without having the scientific and technological knowledge essential for the purpose. He went on to say of the British Colonies that numerous gaps had been revealed in their topographic and geologic surveys and that one of their first efforts had been directed toward repairing these gaps in their knowledge. In view of the extensive map coverage of the British Colonies indicated on the status map, one wonders why greater efforts have not been made to repair the even wider gaps in our own knowledge of our native land.

There is very little doubt in the minds of most of us that accelerated programs of topographic and geologic mapping are fully justified and desirable if not absolutely essential. The resulting maps provide the data which facilitate finding and extracting new resources from the ground and for planning and building new engi-

neering structures upon the ground. The topographic maps naturally come first because they serve as the framework to which all other investigations are tied, and by which the recorded data can be quickly located and identified.

Many of the states have come to realize the value of adequate maps and are doing something about it. I have just learned of a case where this realization extends even beyond the realm of ordinary topographic mapping. Mr. Cass M. Rose, Senior State Highway Engineer, in the current issue of *California Highway and Public Works*, points out that District VII, comprising Ventura, Los Angeles, and Orange counties, has recently set up a substructure mapping section to map all underground facilities near every state highway in the district. Such mapping may not have a very close relationship to our national mapping program, but it illustrates the growing realization of the usefulness of maps in recording data pertinent to specific needs. We need a comprehensive inventory of our natural resources and a suitable and ready method of recording it. Geological and water investigations provide the inventory, and topographic maps provide the visual, push-button record and file.

There is no mystery about the value and importance of topographic maps. Practically everyone directly concerned admits that such maps are essentials of progress. Even Captain Wheeler, back in 1889, covered at least one page of his report with descriptions of the various activities in in which maps are of prime importance. Despite all this, about three fourths of the total area of the United States and Alaska is either unmapped or in need of remapping to meet modern requirements.

The two Bills covering the Accelerated Surveying and Mapping and the Basic-Data Programs are definitely in the public interest, and it is hoped that Congress will see fit to pass them. If they become law, the Geological Survey will certainly do its part to carry its share of the work. The large defense-mapping program that was started last year naturally takes precedence over normal schedules; but, rather than a handicap, this is more likely to prove to be a benefit because, with an initial momentum, acceleration thereafter will not need to be so rapid.

Having been in the business for nearly three quarters of a century, the Geological Survey knows how to make topographic maps. It early learned the truth of a statement ascribed to Josiah D. Whitney, a western State geologist: "At the foundation of our work lies the topographical survey, for without a map of the State we should be as much at a loss to describe its resources as a painter would be working without a canvas on which to embody his conceptions." Today, with four strategically located regional offices each of which is fully equipped with the latest surveying and photogrammetric instruments, the Geological Survey stands ready to accelerate its mapping program to the degree required to complete the topographic mapping of the United States in 20 years. I am sure the other Federal mapping agencies such as the Coast and Geodetic Survey, Forest Service, and the Tennessee Valley Authority would lend full cooperation to accomplish this objective.

It has already been mentioned that topographic maps provide the framework for other investigations. When geologic information has been added the map becomes a geologic map, and in that form, it reveals to geologists what lies hidden below the earth's surface. With a geologic map, geologists can predict whether or not the area is likely to be valuable for minerals or oil. They can also predict whether or not there are suitable aquifers for ground water and at what depth they will be found. Indeed, the principal value of a geologic map is that it provides the basis on which to predict what lies below the surface. Hence they are useful in any engineering operation that involves excavation. Geologic maps also provide basic data that are useful to the Department of Agriculture in mapping the soils.

The first geologic maps in the United States were prepared and published at private expense, but geologic mapping was early recognized as a public responsibility. Systematic mapping began with the preparation of geologic folios, the first of which was published in 1894. The folio series, which covers a little less than 200,000 square miles, has been discontinued, but similar information is now being furnished in a new geologic map series. These geologic maps are multicolor quadrangle maps designed for general-purpose use. Unlike the old folio series they are accompanied by only a very brief text.

The geologic picture would not be complete without mentioning two comparatively new fields of activity induced by our ever widening band of scientific and industrial progress. These are engineering geology and underwater studies of the continental shelf and the ocean floor. The former is well established as a separate branch of geology, and the Geological Survey has been carrying on investigations in this field for several years; the latter has practically never been touched, and for any extensive work in this field, involving, as it would, underwater investigations, the technical skills and equipment possessed by other Government agencies, or industrial organizations, would be sought to supplement various phases of the Geological Survey's work. The Navy, the Coast and Geodetic Survey, and the Hydrographic Office are already equipped to render whatever assistance is necessary to insure early action on submarine geologic mapping.

Considering the fact that after more than 70 years of geologic mapping only about 11 per cent of the United States is adequately covered and somewhat less than one per cent of Alaska, it is evident that any plan to complete this work during one generation must depend on extensive training and recruiting. Proficiency as a geologist is not acquired in a day, or even in five or six years of study. Experience is necessary, and there are now only about 10,000 experienced geologists in the United States most of whom are either connected with industrial organizations or engaged in full-time teaching. However, a 30-year program for completion of the geologic mapping is not out of reason. Here again the Geological Survey, with its background of experience and its staff of trained geologists, is prepared to undertake such a program which should provide for cooperation with state geological surveys, universities, and others who are qualified to contribute to the program.

A readily available inventory of our natural resources would be incomplete without some provision for their orderly development and use. The Geological Survey supervises the activities involved in the production of various minerals, solid fuels, and fertilizers, as well as oil and gas, from leases on Government land to insure compliance with existing laws. Also, in cooperation with the Bureau of Land Management, the Geological Survey classifies Government-owned land as to the mineral, oil, and gas potentialities and supplies the information necessary to administer withdrawals, restorations, and leases. The public lands are classified also with regard to potential sites for dams for the generation of electric power, irrigation and flood control.

Water is our most indispensable natural resource. Although replenishable, it is geographically unevenly available and varies within wide limits in its suitability for specific uses. Water investigations therefore are a matter of prime importance. The water problem is covered by the Basic-Data bill. This bill is so closely related to the one covering the Accelerated Surveying and Mapping Program that it can not be left out of this discussion.

The Federal Government is sponsoring and constructing huge projects to develop the full potential of our water and land resources and to curb the destructive power of floods. A program so far-reaching should rest on a basis of reliable data, but the development program is far outpacing the scope of Federal programs to acquire such data.

The fundamental reason for the present deficiency of adequate and dependable water data is that Federal agencies responsible for acquiring basic information on water resources, on a nationwide scale, have not been financed or staffed to keep abreast of the increasing needs. Their limited facilities have necessarily been devoted to measurements of precipitation, stream flow, water-table fluctuations and related variables at stations located in many instances for special-purpose objectives rather than at sites selected with a view toward establishing balanced nationwide networks. This effort has yielded a substantial reservoir of basic data related to water, but the total accomplishment has not kept pace with the expanding national economy.

It is important to keep in mind the vital role of topographic maps in providing information essential to the evaluation of stream flow and runoff observations. In ground water investigations, a good topographic map, supplemented by aerial photographs, provides the best medium for recording and correlating subsurface geology.

If we are to meet the challenge posed by

the public demands for development of our Nation's water resources to serve the ever-increasing requirements, (1) adequate networks of gaging stations should be developed and maintained; (2) intensive analysis of the resulting data should be undertaken on a continuing basis, and (3) investigations for ground water should be stepped up to more nearly keep pace with current demand.

In accord with long established practice, the Geological Survey has the primary responsibility with respect to determining the occurrence, location, quantity and quality of water on and beneath the land surface, and the Weather Bureau with respect to water in any form in the atmosphere. Other agencies are charged with specialized responsibilities for which water resource appraisals are a starting point rather than an end product.

In carrying on its present program of water resource investigations, the Geological Survey maintains about 100 field offices throughout the United States, its territories and possessions. These offices are staffed with competent engineers, geologists, and scientists, assisted by trained technicians who establish and maintain the observation stations and conduct the field investigations. Standard techniques and procedures for the work have been established through years of research and development to maintain the high quality and uniformity of the records and reports. Through this organization the Geological Survey can expand its activities to the extent required to meet the demands of an accelerated program for basic data.

These brief remarks were designed to point out and justify the importance of a special type of data, to illustrate our lagging steps in acquiring such basic data as compared with other nations, and to express the Geological Survey's earnest desire to remedy the situation by participation in the program described by Dr. Mahoney. The Geological Survey is prepared to carry out its proper phases of the program by expanding the regular duties of its four divisions, Topography, Geology, Conservation, and Water Resources.

Statement by Admiral Robert F. A. Studds

Director, U. S. Coast & Geodetic Survey

The responsibilities of the U. S. Coast and Geodetic Survey in connection with an accelerated mapping program are to provide the basic geodetic control surveys, to perform the hydrographic and topographic surveys of coastal water and land areas, and to analyze, process, publish, and distribute the resulting data in order that the public may obtain the full benefit of these operations.

The geodetic surveys determine the latitude and longitude by triangulation of a number of marked stations and prominent objects and the elevations above mean sea level of bench marks. The points for which horizontal positions and elevations are determined are distributed throughout the nation and are used to furnish the basic framework of latitudes, longitudes, and elevations for the maps. Maps in any section of the country controlled by this basic means will be shown in their correct relative position to each other both horizontally and vertically, no matter how widely separated they may be.

In the United States at the present time we have over 120,000 miles of first- and second-order triangulation and in excess of 385,000 miles of first- and second-order leveling. Our program with reference to mapping is to provide at least one accurately located triangulation station in each $7\frac{1}{2}$-minute mapping quadrangle sheet. For the leveling, our aim is to provide precise elevations of bench marks at one-mile intervals for lines of levels along highways and railroads at a spacing of about 6 miles. In the mountainous regions of the West the density of triangulation stations will be at least one station in each 15-minute quadrangle and the elevations will be determined by trigonometric leveling. Based on these criteria, we have adequate triangulation control for about 40 per cent and adequate vertical control for about 30 per cent of the United States.

At the present rate of progress of an expenditure of about $2,000,000 annually for geodetic control, it is estimated that it will take 50 years to complete this program. This, of course, is entirely inadequate for any accelerated mapping program. The geodetic control should be provided in any specific area before the detailed field sur-

veys are undertaken so that the resulting data will be available at the time of mapping. For a 20-year mapping program, the control surveys should be accomplished in 16 years.

The development of the natural resources of the coastal water areas requires that large scale hydrographic surveys be provided. At the present time detailed surveys have been provided by the Coast and Geodetic Survey for limited distances offshore, principally to assure safe navigation of shipping. The use of electronic methods, such as Shoran and the Electronic Position Indicator, in hydrographic surveying makes for accurate locations of soundings. It also speeds up the field work since the ship can operate day and night and in the fog as navigation is not dependent upon visual fixes. The use of the fathometer to obtain depths below the water surface provides accuracy for these determinations and enables a detailed delineation of depth curves.

In connection with the accelerated program, we plan detailed surveys out to the 1,000-fathom depth curve on the Atlantic Coast and to the 2,000-fathom depth curve on the Pacific Coast. We propose to expand our hydrographic survey program so that the detailed surveys may be completed in a 20-year period. This will require expenditures for new ships and equipment and the initial costs will be relatively high. We have a nucleus of commissioned and petty officers and we contemplate no difficulty in recruiting for the lower ratings on shipboard in any expanded program. Abour 300 special charts showing the detailed configuration of the ocean bottom will be required. The office processing of the hydrographic surveys and the printing of the resulting charts will require additional personnel and increased expenditures.

It is essential that the hydrographic surveys of the coastal water areas be correlated with the surveys of the adjacent land areas. The Coast and Geodetic Survey makes the topographic surveys of the coastal areas and is prepared to expedite this phase of our operations. These surveys are accomplished by photogrammetric means using the nine lens and single lens cameras, and the results are published in the nautical charts of the Bureau. Each compilation is also furnished to the U. S. Geological Survey in order that it may be incorporated in the quadrangle map of that agency. This close liaison avoids duplication of work in these areas.

The Coast and Geodetic Survey can, I am sure, contribute to a very great extent to the accelerated mapping program.

Statement by Marion Clawson

Director, Bureau of Land Management, United States Department of the Interior

Under basic law it is an exclusive function of the Bureau of Land Management to execute the official survey and resurvey of the public domain in continental United States and Alaska, regardless of administrative jurisdiction.

At present, the Bureau is gearing its cadastral survey program to meet the impact of national defense activities. The surveying program is being integrated with other functions of the Bureau and other Government agencies, and is designed to facilitate the production of timber, petroleum and other minerals; to identify lands for range improvements which result in increased livestock production; to provide control for mapping projects; and to make available suitable homesite units in critical areas.

The original public domain at its maximum extent consisted of approximately 2,825,000 square miles, or about 79 per cent of the total land area of continental United States and the entire Territory of Alaska. It included the Territory of Alaska, the States of Florida, Alabama, and Mississippi, and all States except Texas lying north and west of the Ohio and Mississippi Rivers. The rectangular system of surveys has now been extended over 2,077,000 square miles of this vast area. The unsurveyed area consists of 180,500 square miles in continental United States, and about 567,500 square miles in Alaska. Less than one per cent of the total area of Alaska has been surveyed.

Cadastral surveys are defined by the Pan American Institute of Geography and History—published by the United Nations in the document entitled "Modern Cartography, Base Maps for World Needs,

1949"—as follows:

"Cadastral surveys in general create, reestablish, mark and define boundaries of tracts of land. Such surveys, unlike scientific surveys of an informative character which may be amended with changing conditions or because they are not executed according to the standards now required for accuracy, can not be ignored, repudiated, altered, or corrected, and the boundaries created or reestablished can not be changed so long as they control rights vested in the lands affected.

"The official record of a cadastral survey ordinarily consists of a drawing or map and a written description of the field work. The drawing represents the lines surveyed showing the direction and length of each of such lines; the boundaries, description and area of the parcel of land; and, as far as practicable, a delineation of the topography of the region, including a representation of the culture and improvements within the limits of the survey."

Management of lands and their resources, transfer of property and title, appraisals, development of areas, defining the limits of jurisdiction between nations and States, all construction work on land, determining boundaries of areas for taxation purposes, and in fact every activity dealing with land, are to a large extent dependent upon cadastral surveys.

The cadastral survey is the first step in any form of land management. It is obvious that an administrator must know where the land is, if he is to administer it. The problem of the public land administrator is particularly complicated in areas where there are tracts of privately owned land within the boundaries of the Federal land holdings—a very common situation. It is also essential to know the character of the area; what portions are suitable for agriculture, grazing, forest, or other purposes. A good cadastral survey will locate and mark the boundaries of the land on the ground. The plat, or plan, if properly prepared from aerial photographs and the field notes of the survey, gives the designation and area of each individual unit and indicates by appropriate symbol a delineation of the topography of the area, including a representation of the culture and improvements within the limits of the survey. This gives the administrator a general idea of the type of land being administered.

The value and future need of timber and the potential mineral deposits in the unsurveyed public land areas located primarily in the eleven western States, constitute one of the primary needs for the completion of the original surveys (over 115 million acres). These unsurveyed lands also embrace school sections which will inure to the different States upon identification by survey. The responsibilities of the Federal Government can not be concluded until the original surveys are made and the States receive the lands to which they are entitled under the school grants.

Approximately 55 per cent of the area of the eleven western States is owned by the Federal Government. Many of the original surveys of these Government lands were made from 75 to 90 years ago, and the corners were marked with wooden stakes or other nonpermanent material. These corners are obliterated and there is now an urgent need for the resurvey of approximately 53 million acres of public domain within these eleven western States.

Resurveys are extremely urgent for the management of O. & C. lands in western Oregon and other public lands in forested areas; for the identification of oil and gas lands and other mineral areas for administration under the mineral leasing act; for improvements in connection with management of grazing areas, including reseeding, fencing, and soil conservation work; for administration of the Small Tract Act of 1938; for settlement of trespass cases; and for the survey of islands and other lands omitted from the original surveys, and areas formed by accretion, etc.

The lack of surveys is seriously retarding the settlement of Alaska and the development of the natural resources in that Territory. The identification of land areas by cadastral survey is a prerequisite to the acquisition or use of lands in the development of mineral resources, homesteading, the establishment of townsites, the adjudication of applications, and the general administration of the public land laws. Business and industry can not flourish and money can not be obtained by the settlers for the development of Alaska unless the lands are surveyed and patents are issued. The Bureau of Land Management is behind with its survey work. Applicants for lands are forced to wait two or three years or longer before the Bureau can make the surveys. This has resulted in criticism by the public concerning the administration of the public lands in Alaska.

The need for resurveys in continental United States can not be over-emphasized.

The situation existing in the O. & C. area in western Oregon clearly demonstrates that need. The United States owns over 2½ million acres of revested O. & C. lands. It owns the odd numbered sections and the even numbered sections have passed into private ownership. Resurveys are absolutely necessary to determine the boundaries between public lands and privately owned areas. Timber values in this area are extremely high, often running to $500,000 to $600,000 a section (640 acres). The location of the boundaries is essential in making timber sales, both for the protection of the Government and the owners of intermingled private lands. It has been necessary to postpone or decline O. & C. timber sales when the condition of the present survey makes impossible the fixing of sales boundaries with any assurance of correctness. Sales programs, although well planned from a forest management viewpoint, must continually be adjusted or curtailed because the parcels of land can not be appraised until the boundaries are fixed.

The loss to the Government by reason of lack of surveys in the O. & C. area is indicated by the Regional Administrator in submitting his justification for appropriation for 1951 fiscal year. He states in part as follows:

"A recent example is Tp. 20 S., Rg. 8 W., W.M., where a sale of fire-killed and green timber in three sections was under consideration for sale in May, 1949. Few if any authentic corners exist in this township. The proposed timber sale, which might have brought $250,000 or more, was necessarily dropped until the township can be resurveyed. In the meantime, fire-killed timber is deteriorating in value, is an increasing fire hazard, and the stumpage price is dropping. In this one case the loss to the Government, estimated at $50,000, could have been avoided had there been sufficient survey money to have made the resurvey at once."

(Note: The loss to the Government at the present value of timber is estimated at $100,000. The resurvey of the boundaries of the three sections would cost approximately $2,000.)

"This situation is repeated many times throughout the O. & C. area. . . . In fiscal 1949 alone, O. & C. timber valued at $500,000 had to be withheld from sale because of lack of resurveys in the Rock Creek and Smith River areas (Douglas County). No adequate measure can be had of the loss to private operators who were forced to look elsewhere for timber, but it probably is at least equal to the Government's loss."

(Note: The present value of this timber is approximately $1,000,000. The cost of the resurvey of the township involved would probably not exceed $20,000.)

The President's Water Resources Policy Commission in its report—Volume 1, Page 332—states, with respect to the need for cadastral surveys, that:

"Before development of the water resources can be undertaken in areas of intermingled public and private land, boundaries and limits of ownership must be established. The cadastral survey of the public domain constitutes a basic fact for any resource consideration of the public lands."

And, on Page 362 recommends:

"It is recommended that the cadastral survey of the public domain in continental United States, and necessary resurveys required in the administration of Government-owned lands, be completed in the next 10 years. This requires survey of 116,000,000 acres and resurvey of 50,000,000 acres. It is also recommended that an orderly program of cadastral surveys necessary for the settlement and development of Alaska be accomplished in the next 10 years. At present less than 1 per cent of the total area of Alaska has been surveyed."

The cadastral survey of the public land is an aid to mapping projects. All geodetically established control points are connected to the corners of the rectangular system of surveys at the time the field work is executed. Based upon these connections, the precise latitude and longitude of each monument in the township can be computed. The vast monumented net of cadastral surveys—8 monuments to a square mile—over the public domain, with the latitude and longitude known for the monumented corners, furnishes control for practically all types of mapping projects.

In the United Nations publication entitled "World Cartography," Volume 1, 1951, it is stated concerning the value and need for cadastral surveys, that:

Page 6: "In areas comprised of both public and private land, the boundaries and limits of ownership should be established during this phase, so that the studies and plans to follow will take into account the ownership of the areas involved. The cadastral survey of the public domain constitutes a basic fact of real significance for any resource development affecting both public and privately owned lands."

Page 41: "In order to reduce the cost of ground control, and to increase the density of available control, in topographic compilation,

the Geological Survey is making increasing use of survey stations established in cadastral and highway surveying. Where these are determined to be of sufficient accuracy, and where the survey stations can be identified on the aerial photography being used, they have been found very helpful. Work is underway to establish standard specifications of accuracy for such surveys, and consequently to increase their utility in this respect."

The Public Lands Committee, House of Representatives, in A Supplemental Report—House Document No. 706, 81st Congress, 2nd Session—to accompany hearings on H. R. 6257 and H. R. 6900, recommends on page 7 of that report that:

"The Federal mapping and resource management programs would be facilitated by the completion of cadastral surveys on the 116,000,000 acres of unsurveyed public domain in the United States, the resurveying of approximately 50,000,000 acres and an enlarged surveying program for the 365,481,600 acres in Alaska, less than 1 per cent of which has been surveyed."

And on Page 54, the costs of the recommended accelerated program are summarized as follows:

"Cost of completing the survey of the public domain (116,000,000 acres) in continental United States, including survey of mineral lands: $25,000,000, or $2,500,000 per year.

"Cost of resurveying 50,000,000 acres necessary to administer the Government-owned lands: $10,000,000, or $1,000,000 per year.

"Cost of carrying on an orderly program for the settlement and development of Alaska: $5,000,000, or $500,000 per year.

"The program involves a total cost of $40,000,000, or $4,000,000 per year, to complete."

(Note: The costs have increased at least 25% or 30% since submitted to the Committee.)

For fiscal year 1952, Congress provided $792,785 for surveying the public lands in continental United States and Alaska. Alaska received $160,000 of this appropriation for surveys in that Territory in 1952.

Region I, which includes the States of Oregon, Washington, and Idaho, received about $100,000 for surveys and resurveys in that Region, in fiscal 1952. Approximately $35,000 will probably be spent for resurveys in the O. & C. area. It has previously been shown that resurveys are vital for the management and sale of timber. In order to complete the resurvey of the entire O. & C. area—over 2½ million acres intermingled with private holdings—it will take at least $250,000 per year for a period of 10 years. At the present rate of progress, it probably will take at least 75 years to complete the job. In the meanwhile there will be a big loss to the Government in not being able to make timber sales; the value of the ripe timber will deteriorate; fire hazards will be created; and timber needed for defense purposes and domestic use will not be made available.

Since 1940, about 5,000,000 acres of public land in continental United States have been originally surveyed. At that rate of progress, it will take over 200 years to complete the survey of the remaining public lands (approximately 115,000,000 acres)

There is, as previously stated, an increasing demand for surveys and resurveys to facilitate the production of timber, petroleum and other minerals; the identification of lands for range improvements, which results in increased livestock production; to provide control for mapping projects; and to make available suitable homesite units in critical areas.

The cadastral surveying program contemplated under the provisions of H. R. 6900—81st Congress, and H. R. 1636—82nd Congress, is necessary to provide the administrators of the public land with the basic tool necessary for good land management.

Statement by Roy W. Simonson

Assistant Chief, Division of Soil Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture

GENERAL ORGANIZATION

The basic soil survey, in progress for a little more than 50 years, is a cooperative undertaking of the Department of Agriculture and State agencies, mainly the State agricultural experiment stations. Although the Soil Survey in the Department is the chief Federal agency concerned, others such as the Soil Conservation Service and the Tennessee Valley Authority have contributed in the past and are contributing now to the effort in soil classification and

mapping. The Soil Survey maintains a scientific staff for national coordination, for development of a nation-wide system of soil classification and nomenclature, and for cooperative field work. It also publishes a separate and distinct series of soil maps and reports (5).

The field work of identifying and mapping soils is the major and unspectacular part of a soil survey program. Most of the field work of identifying soils and plotting their boundaries on maps is accomplished by parties consisting of staff members from both National and State soil survey organizations. Cooperation ideally consists of assignment of state and federal men to each field party. This makes available the backgrounds of scientists from the Department who are familiar with regional soil classification problems and the backgrounds of scientists from the experiment stations who know State research programs and problems. Reports and interpretations of the data obtained in the field surveys and related research are also developed jointly. This kind of close cooperation brings to bear all available knowledge and experience for each area under survey.

Although the soil surveys are all cooperative, no definite formula for matching funds is required. At times federal contributions to the program have exceeded those made by states and vice-versa. During 1949 the number of soil scientists engaged in the National Cooperative Soil Survey was approximately 130. Roughly $\frac{1}{3}$ of this force consisted of staff members from state agricultural experiment stations. A few of the employees were graduate students in soil science working only during the summer season. Funds available in 1949 for soil survey field operations, laboratory studies, and publications from both state and federal sources were approximately $1,750,000 (5).

NATURE OF MODERN SOIL SURVEYS

The modern soil survey consists partly of field work, partly of laboratory investigations, and partly of cartographic operations (4). The surveys are designed to obtain information on the kinds, characteristics, distribution, extent, and behavior of soils and to make this information available in useful form to the public. Basic soil surveys include the research necessary (a) to determine the important characteristics of soils; (b) to classify soils into defined taxonomic units; (c) to establish and plot on maps the boundaries among soils; and (d) to predict the behavior of soils when used in various ways. A major purpose of soil surveys, from a practical point of view, is to provide a basis for predictions about soil behavior, using the term broadly to cover a wide range such as yields of crops under defined management, changes in soils under tillage, and usefulness of soil materials for subgrade construction. In order to have sound predictions, however, it is necessary to accumulate a large body of knowledge about soils. It should also be recognized in passing that far less attention has been given in past soil surveys to the need for engineering interpretations than to those for agriculture and forestry (1).

The principal mapping units in detailed soil surveys are soil types and phases. These units are geographic bodies. Each separate area of a soil type or phase is a small segment of the land surface that has width, breadth, and depth. Thus, each is a solid with an obvious and usually irregular surface, an indistinct lower boundary, and an evident but not sharply defined perimeter. Each soil type can be defined in terms of a modal profile (a vertical section to a depth of several feet), the deviations from that norm, and additional features such as slope and stoniness. Each soil type is also a product of a particular combination of climate, living organisms, topography, geological materials, and time. Wherever a given combination of factors of soil formation occurs, the same soil type will be found. This provides an opportunity for establishing a uniform system of classification and nomenclature which will permit the transfer of knowledge gained through research and experience in one place to similar soils in other places.

In definition of soil types, major emphasis is given to the soil profile, including its various horizons, because the profile is a reflection of the factors of soil formation, is important to the growth of plants, and has significance to engineering uses of soils. A large number of properties of individual horizons together with external characteristics of soils, such as slope, are considered together in the definition of individual soil types. All properties must be considered jointly and in their relations to one another in defining kinds of soil.

The determination of important characteristics of soils is accomplished in part

through field work and in part through laboratory investigations. For example, the study of soil morphology is largely carried on outdoors, whereas determinations of the kinds of clay minerals and of base exchange relations are essentially restricted to the laboratory. The classification of soils rests in part upon field observations and in part upon laboratory data. The identification of kinds of soils and the plotting of soil boundaries, usually on aerial photographs, is all field work. The distribution and extent of the various soils is shown by the maps prepared through field operations.

The field work and associated research answer the first three purposes of the modern soil survey. To meet the fourth purpose, however, it is necessary to draw on past experience and on experimental findings. Predictions of soil behavior under different uses cannot be inferred from soil characteristics alone, at least not under the present state of knowledge in soil science. To cite but one example, the predictions of crop yields from a given soil type under specified management are based partly on the observations made by field men during the course of a survey, partly upon farm records, and partly upon the results from experimental plots. Similar statements can be made about the behavior of soils in forestry or engineering. Observations on the behavior of a soil under defined conditions are therefore necessary for the making of reliable predictions. Predictions of soil behavior follow from interpretation of the data obtained in the soil surveys in combination with the findings of other research and the experience of program agencies and private organizations or individuals. Such interpretations are normally part of the joint effort necessary in preparing reports for publication.

Important parts of the soil survey, given slight mention so far, comprise cartographic operations in preparing and publishing the maps from the field sheets. Brief mention of this work seems appropriate, although the necessary operations should be well known to most. The field sheets used in soil surveys are now largely aerial photographs (2). In a few instances, other types of base maps, such as topographic quadrangles, are used for the field work. Rarely, the field men prepare their own base maps. For the publication of soil maps, topographic quadrangles are used as base materials wherever available. In some instances, it is necessary to construct base maps for the compilation of soil data and these are commonly prepared by photogrammetric methods. Soil maps now published are at scales ranging from 1:24,000 to 1:48,000, with a few at a scale of 1:63,360. Most of the soil maps are now being published at a scale of 1:31,680 (3).

PAST PROGRAM

Over the past 52 years, about one-half of the area of the continental United States, excluding Alaska, has been covered by soil surveys in a modest continuing program (5). Areas covered are shown in Figure 1 The survey coverage includes a number of reconnaissance surveys, many of them old, as well as older detailed surveys that are not adequate for modern needs. Approximately 700,000 square miles have adequate soil maps at present. Slightly less than half as large an area has been covered by soil surveys which provide less information than is now needed.

During the 52 years, the nature of surveys has gradually changed as the knowledge about soils has grown. The first soil surveys were made at the rate of 5 square miles per man-day of field work, whereas current rates of progress range from 100 to 640 acres per man-day, depending upon the nature and pattern of soils. The classification of soils was also far simpler in the early surveys. For example, five kinds of soils were recognized in Tama County, Iowa, in 1904, as compared to fifty kinds mapped in a resurvey 30 years later. Maps now being published carry about 16 times as many miles of soil boundaries as those printed 35 years ago (3). These changes have been gradual over the years and have followed the general growth of soil science, including field knowledge of soils. Moreover, increasingly detailed and specific information about soils and their behavior has been required over the same interval. As one illustration, the improvement in farm efficiency through greater use of technology increases the need and demand for accurate and detailed soil maps.

ACCELERATED PROGRAM

About 2,200,000 square miles in the United States, including Alaska, are without adequate soil maps now and ultimately need to be covered by surveys. Of this area, about 1,000,000 square miles need detailed soil maps and the remainder reconnais-

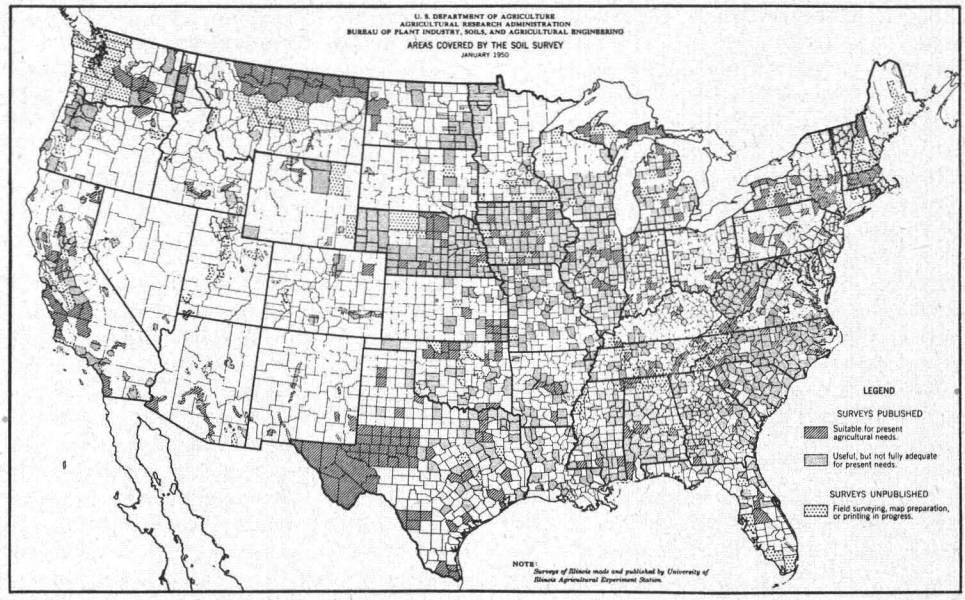

FIG. 1. Areas covered by soil surveys in the continental United States, excluding Alaska. Soil surveys have also been made of the Canal Zone, Hawaii, and Puerto Rico.

sance surveys. This total includes approximately 325,000 square miles covered by older detailed surveys which are no longer adequate although they are useful for some purposes.

The cost of completing soil surveys of 2,200,000 square miles was estimated to be $158,000,000 in 1949 (5). Spread over a period of 30 years, this amount would provide for employment at peak activity of approximately 430 soil scientists to investigate and map soils in various areas. It would also provide about 50 soil chemists, soil physicists, and technicians to make necessary laboratory analyses (5).

Expansion of soil surveys and essential related investigations should be orderly and gradual, if it is to be both effective and economical. In the first place, expanded training programs for soil scientists in universities and colleges would be necessary for an accelerated program. Men would have to be trained, both at the undergraduate and graduate levels, before the necessary expansion in staff could be accomplished economically. Efforts to recruit a large staff in a short time, such as a year or two, could only lead to the employment of many men with inadequate training. This would make the program very costly for the results that could be obtained.

Soil maps are used by large numbers of public agencies, private organizations, and individuals. The interests of these organizations and individuals range from judgments as to corn yield expectancy from a given soil type under certain management to the amounts of cement required to make effective soil-cement road surfacing. It will seldom be economical to provide for every conceivable need in each individual survey. Because of the many purposes served by soil surveys, however, it is important that the work be designed to meet as many important needs as possible for information about kinds, characteristics, distribution, extent, and behavior of soils. Moreover, provision should be made for continuing joint review of surveys by makers and users to insure their fullest possible utility. If adequate soil surveys were available now for the 2,200,000 square miles needing them, their contributions to more effective planning, both public and private, would far more than repay the original cost.

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Statement by Robert Randall

Chief Examiner, Surveying and Mapping Division, Bureau of the Budget

Surveying and mapping, or the field of cartography is rapidly arriving at a better status, with more recognition, and with more opportunity for service.

Several years ago I attended a union service in a church in Ohio. Various ministers took appropriate parts. The gentleman who had the real punch line, was the minister who included in his prayer this request: "Oh, Lord, bless all those that labor under extenuating circumstances." I feel that people in surveying and mapping are rather in that class. We always insist that information must be available before beginning to plan and design and especially before construction and operation. Too often this preliminary work is not done. We protest—possibly too much. However, I think that on the record, we are making progress.

Dr. Wrather mentioned a United Nations publication, "Modern Cartography, Base Maps for World Needs." I add a reference to a U. N. publication, a bulletin on cartography, which is a report directing attention to cartography, that is surveying, mapping and charting on a world basis.

In particular, I refer to the President's Policy Commission Report. This has been published and is available to citizens, Congress, and public officials. It is being reviewed by an interdepartmental committee. In that report will be found a rather extensive presentation of the different elements and steps in getting complete and systematic information upon which to plan improvements. It is good material for study.

We now have better comprehension of all of the different kinds of basic information that go into surveying and mapping and charting in the public interests. We are approaching the job which lies ahead with more confidence.

Most of the discussion this afternoon has been concerned with our domestic program, and quite properly so. That is the subject of this enabling legislation, H. R. 1636, and of its companionpiece, H. R. 1637. However, those of us in the mapping fraternity are active as well as interested in the same kind of thing, to different degrees, and with varying emphasis, in different parts of the earth. As our foreign aid program progresses and improves, we will be helping other parts of the world to get the same kind of information which we are striving to get here, in order that their development may proceed at a more logical and a faster rate. So I mention that we must not lose sight of our foreign interests.

Up to now, surveying has been quite largely a matter of exploration or discovery. This, of course, will be especially true in what we have come to call the more undeveloped parts of the world. Rapidly, in the United States, it is becoming more a matter of development. Having now passed from discovery through exploration to development, we are called upon to help out through such as the Technical Assistance Program, the so-called Point 4 program, to help people in other parts of the world speed up their own programs.

All of us should have in mind the list of the variety of surveys and mapping endeavors that comprise the National Surveying and Mapping Program. We should not confine our thoughts to photogrammetry, the part which we as individuals and as organization representatives personally and collectively play, but include topographic mapping, geology, soils, geodetic control and cadastral surveys, and still further hydrology, precipitation, surface water, underground water, vegetative cover, forests, and fish and wild life.

In closing I want you to understand that what the Bureau of the Budget does in this program is to insist that the agencies ask for more money year by year, and also to insist, in the interest of the taxpayers, that we get not only efficiency in the production of maps and charts of various kinds by the Federal Government, but that we take full advantage of the resources outside of Government.

General Statements and Discussion

MODERATOR MAHONEY

Several speakers have referred to the problem of increasing the personnel and of securing manpower and facilities to carry on this accelerated program.

One important feature has been mentioned—the need of securing the cooperation of universities, State and local agencies, and of private enterprise.

We cannot, of course, legislate for what private enterprise should do and what division of responsibility there should be, but we have specified in this legislation that there shall be complete and close cooperation between the Federal and the state and local agencies, and especially with the universities.

I ask Dr. Bradley, the Chief Geologist of the United States Geological Survey to discuss the real problems in building up an adequate staff. I understand that at the present rate it will require 150 years to complete the job of geologic mapping. What are the essential elements in a program to secure the necessary increase in personnel, and the cooperation of the states and the universities in carrying out this accelerated program? Also what emphasis must there be upon the reliability and continuity of the program, to accomplish the objectives of the program?

DR. BRADLEY—U. S. Geological Survey

It takes about as long to train a geologist to do the needed kind of geologic mapping and research as it does to train a physician. After that we must go through a training period in actual practice, just as doctors have to go through internship. To meet a thirty-year program, and to map the remaining 89 per cent of the United States on scales of one inch to the mile or larger will require many more geologists than the total profession can now round up. Obviously not all geologists will be available for a mapping program. Most are now employed by industry, and industry is eager for still more. It will be necessary, therefore, for the colleges and universities to interest a great many more freshmen in taking courses leading to geologic work.

We must make known the fact that there will be a continuing need for geologists and that the university will have to train them. They will not all come to the U. S. Geologic Survey by any means. There are many State Geological Surveys—not in every state, but in a good many. Those State surveys should be considerably increased, and the scope of their activities broadened.

We will also have to depend a great deal on summer field activities of the professors, and research associates of colleges and universities throughout the country.

Presumably, the map standards would be established, and adherence to them would be the responsibility of the U. S. Geological Survey.

The problem, as I see it from some thirty years of experience in the Geological Survey is little short of staggering, but I think the goal set can be met if we develop a dependable program and go into it gradually.

MODERATOR MAHONEY

One of the most important current features of our surveying and mapping program is the series of emergencies, or, shall we say, continuing emergency, in which we find ourselves. Any program designed for the general purpose of the domestic economy which of course is almost of equal fundamental importance for our security and military programs, is likely to be interrupted or modified.

I ask Gerald Fitzgerald, Chief of the Topographic Branch of the United States Geological Survey, to indicate the frequency with which scheduled programs are interrupted, or have to be altered to meet special circumstances. Also how he could maintain a continuing long-range scheduled program with each part carried out in its logical sequence?

COL. FITZGERALD: All mapping is important, but some mapping is more important than other mapping.

Six years ago we set up a very carefully planned twenty-year program to accomplish most of the immediate mapping requirements in as orderly a fashion as our facilities would permit. We worked this annual program in cooperation with the Bureau of the Budget. It sent us annual requests for mapping far exceeding our capacity. This shifting process of arriving at an annual program, of course is our biggest problem. With the national emergency, a new problem was introduced, throwing

out of gear our carefully planned twenty-year program, and putting much of the immediate emphasis on the mapping required for defense purposes.

We have attempted, in cooperation with the Department of Defense, to meet not only its requirements, but to continue as much of our normal program as possible. We have set up our so-called emergency period program to accomplish these three important objectives:

First, the strategic mapping for military defense purposes;

Second, the mapping needed to further investigations and developments in the field of natural and economic resources; and

Third, the mapping needed to support the long-range economy of the nation.

The fact that we have a greatly accelerated defense mapping program certainly will help in many ways. A great many areas that are in this first priority program are important, not only to the military, but to our civilian economy, our development programs. We are constantly adding and training new personnel, and procuring a limited amount of new equipment. So almost for the first time we are prepared to actually make a good try at a twenty-year national mapping program.

MODERATOR MAHONEY

Another member of the Panel, Dr. Nelson Sayre, has the responsibility in the Geological Survey for the important ground-water work.

Last summer I had the appreciated privilege of traveling extensively over the country with members of the Geological Survey, the Weather Bureau, and other scientists in an attempt to appraise the extent of our ground-water resources. We were attempting to bring into a little more complete focus what knowledge was already available, and what could be brought together by those who had been working most on the problems. We were trying to learn how extensive are our facilities for the management of water in subsurface channels and reservoirs.

I was much impressed with the complexity of the problem, and with the great number of difficulties brought about by proceeding without first having acquired information necessary for wise management of underground water resources. Most of all, I was impressed with the great undeveloped potentials that are only partly known and which will be known only when we have had an opportunity to put into effect the program we have outlined.

I hope that Dr. Sayre will tell us of the relation between his responsibility for mapping and ground-water studies and the accelerated surveying and mapping program.

DR. SAYRE

You have heard a lot in the last several years about water shortages. I should like to point out before we get very far that there is not any real evidence of a water shortage. Our precipitation is about the same as it was fifty or a hundred years ago. There have been local departures from the normal that have caused a good bit of trouble in places.

The real difficulty is that people want to use water where it isn't.

A large proportion of our water supply is actually in the East. The large development of consumptive use of water is in the West. Southern California gets something like ten per cent of the precipitation, and raises ninety per cent of the crops, whereas Northern California gets about ninety per cent of the precipitation and raises ten per cent of the crops.

So, one of our problems is providing water where people want it. There are a good many reasons why one area is more favorable for various activities, although it has little water, than another area which has a lot of water.

The precipitation, as you may know, goes back into the atmosphere. Of course, it falls on the ground and some sinks into the ground. If we have a heavy enough storm some runs off over the land surface, but of that part which goes into the ground a very large percentage is taken back into the atmosphere by plants. A little bit gets down into the ground-water. Where the geologic picture is favorable, we may have a ground-water reservoir from which water can be drawn to the surface for use through wells and pumps.

A fair example of some of the perplexities of our ground-water problems can be cited in the Southwest part of the United States—California, Arizona, New Mexico, and Texas, and part of adjoining states, which are now in the throes of one of the eight major droughts that have occurred

during the past six hundred years. Prior to the drought, certain reservoirs had been built, and largely on the basis of those surface reservoirs, a very thriving and rich agricultural industry had been developed. With the drought the farmers turned more and more to their very large bodies of underground water, some of which are enormous reservoirs. Since 1940, the number of wells in Arizona has increased to many more than 5,000.

The irrigated land in Arizona which was formerly irrigated 95 per cent from surface water sources is now being irrigated nearly 95 per cent by ground-water resources, and only 5 per cent by surface water. What has happened is that the surface streams most readily affected by drought have dried up. The enormous reservoir of underground water has been utilized more and more and has tided them over in a drought that otherwise would have ruined their economy.

One of the very unfortunate things about this situation is that in spite of ten years of investigation in Arizona, we are not yet able to say how much water is in the reservoir, how much the inflow is, or how much the outflow is. We have barely gotten around to describing the basic outlines of the reservoir itself.

We think that there are quite a number of ways in which we could increase the water supply that is available in Arizona and other places. Such studies depend very largely on topographic mapping and geologic mapping.

There are enormous problems to be solved but I sincerely hope that if and when these programs are in operation, the topographic mapping program will have preceded the geologic mapping and that the geologic mapping will be complete before the appraisal of water resources.

There will still be lots of geologic mapping for us to do, but having some of it already done for us will greatly simplify our problem.

Questions and Answers

MODERATOR MAHONEY

I have a whole list of questions I should like to ask but first the questions that have come in from the audience should be taken up.

The first two were directed at Admiral Studds.

ADMIRAL STUDDS

The first statement and question are:

"You state that the geodetic control surveys should be accomplished in advance of the mapping and for a 20-year program should be accomplished in 16 years. Do you anticipate any difficulty in accelerating your present rate of progress to attain this objective?"

There will be difficulties but they will not be insurmountable. Geodetic survey operations require the employment of professional engineers and highly skilled personnel. There will also be delays under present conditions in obtaining instruments, motor trucks, and portable steel towers. We now have a nucleus of experienced personnel and we propose to expand our program gradually so that recruiting and training of new employees and obtaining instruments and equipment may be provided and still have a productive program. After the third year we expect the program to operate at full capacity with maximum efficiency and economy.

The second statement and question are:

"I have heard mention of the state plane coordinate systems. Can you tell us something about these and how they may be used to advantage in an accelerated mapping program?"

In making use of geodetic data expressed in terms of latitude and longitude the mathematical formulae seem rather formidable to the practicing engineer and surveyor. A generation ago we found comparatively little use being made by the local engineer and surveyor of the control we were establishing. In 1932 a system of plane coordinates was devised for each state. In this system the geographic data for the triangulation stations are transformed from expression of latitude and longitude, which are spherical coordinates, to terms of x and y in plane coordinates. The practicing engineer can connect his local surveys to the triangulation stations and use the x and y terms to compute his own surveys by the ordinary means of computation with which he is familiar. He then connects his surveys to the Federal system of triangulation control and has the resulting advantages of coordination with ad-

jacent surveys and ease of recovery of corners and retracement of survey at any future time.

A number of state organizations such as the Department of Public Works, Commonwealth of Massachusetts; the Maryland Board of Surveys and Maps; California Highway Department; etc., are using the state plane coordinate systems for their surveys. Since these surveys are thus related to the Federal network, the survey points established thereon may be used as control in the mapping program. The state plane coordinate systems are a medium by which a tremendous amount of otherwise unrelated surveying data may be used in any mapping program.

MODERATOR MAHONEY

Other questions and answers will now be taken up.

Q.1. "What are the plans for making the products of the proposed accelerated and surveying mapping program readily available to the potential users throughout the United States?"—A.1. We do have a provision in the measure by which, if followed, reports will be made to Congress each year setting forth the progress made and the extent of the accomplishments of the purposes of this Act. The agencies are authorized to contract with private individuals or other public agencies for personnel and facilities to carry out the provisions of the Act. The agencies will print the maps and make them available much as they do now.

Q-2. "Has any provision been made, or is any contemplated for obtaining engineering graduates for the accelerated program, by special college training programs?"—A.2. In several places in the bills there is a definite delegation of responsibility for bringing the universities and colleges into cooperation. We have engaged in a series of preliminary conferences with some of the universities, to ascertain the problems involved in putting these programs into effect. I have no hesitancy in saying that that will be possible, provided it is approved and there is stability and dependability in the flow of funds necessary to carry it on. Most certainly, the existing agencies cannot do it without securing a lot more help, and if they do have the funds to carry it on they will have to transfer much of it to other agencies.

Q.3. "Is there any factual basis for assuming that the present Congress differs so greatly from former ones that it will provide funds for an accelerated mapping program"—A.3. I do not know of any statistics, and I would hesitate very much to use them if they were available. But we have found in various ways that we do change occasionally.

Q.4. "Must we not first obtain public acceptance of the program through publicity and education before we can obtain public support?"—A.4. I am sure that that is true and I think that is one of the fortunate features of having a chance of presenting this program to this audience, because you are the ones who must instruct and counsel with your Congressmen and others in bringing to them the advice that they very often seek in relation to these matters.

Q.5. "Without public support, will it not be necessary to use great political pressure in order to have portions of the program approved?"—A.5. The question gives me the opportunity of saying that unless we maintain these scientific agencies on a basis of absolute integrity, the foundation of our whole country and its program will have weakened. I am convinced that once we have secured all of the basic physical facts on which these resource developments must rest, a very large portion of the controversy will vanish. As an economist, I have become convinced that until we recognize and understand the physical foundation of an industry or economic activity based upon the use of the earth's resources, there is no possibility of our having a sound industry, either from the point of view of private operation or from that of public policy. Most certainly, it will not be possible for either of these programs to be approved or be supported and maintained without an informed public and public support.

MODERATOR MAHONEY

A few brief questions have been submitted from one of our representatives of a foreign government. They are now in the possession of Col. Fitzgerald.

COL. FITZGERALD

The first question is:—"Is all of the standard topographic mapping based on aerial photography, or are plane table surveys still carried on for preliminary contouring in areas in the United States?" The

answer is that all topographic maps are based on aerial photography. In flat terrain the photographs are used only for planimetry; the small-internal contours being surveyed by plane table.

The next question:—"What is the contact scale of photography and scale of enlargements for topographic mapping of a one-inch-to-the-mile scale?" The scale of photography used in Multiplex, which is the compilation or stereo method most used in the United States, depends again on the contour interval. For a 20-foot interval it is usually about 1:24,000 scale.

The third question:—"What Government agency in the United States carries on large-scale surveys in mapping for engineering, irrigation, hydroelectric projects, et cetera?" The answer is The Geological Survey. The largest scale normally accomplished by the survey in the National Mapping Program, is 1:24,000. If there are larger scales required—and of course there always are for detailed investigations or construction projects—that work is accomplished in some cases by the construction agency, or quite often by private contractors who are equipped to handle that type of work.

MODERATOR MAHONEY

We have another question: "What per cent of the over-all program will be turned over to private industry?"

I think it would be impossible to answer that in terms of percentage, but I am sure that if this program is carried out efficiently and effectively, as we are directed to do, some of the work will have to be done on a contract basis to private industry. We are all part of the same great America, and it is a question of trying to find the most effective way.

In closing, I should like to say that nothing in my entire experience has been more delightful than the time that I have been privileged to spend with this assigned responsibility from the committees of Congress. These two programs about which we have been talking have been explained and presented in a publication, House Document 706, entitled "A Program to Strengthen the Scientific Foundation in Natural Resources." It contains explanations of the programs by all the agencies participating. There is an introduction by the Chairmen of the Committees of Congress. These are available in our universities and some of our libraries. Unfortunately, our supply was exhausted rather quickly. I have acquired a very high admiration for the integrity of the agencies which will administer these programs, and certain other agencies that have not been mentioned.

I note that the allotted time has expired. Accordingly I declare this interesting panel at an end.