

DEFICIENCIES IN HYDROLOGIC RESEARCH

UNITED STATES .

NATIONAL RESOURCES PLANNING BOARD

1940.

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RESEARCH**

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# DEFICIENCIES IN HYDROLOGIC RESEARCH

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Report of the  
Special Advisory Committee on Hydrologic Data



*A National Resources Committee Publication*

*Issued by the*

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EXECUTIVE OFFICE OF THE PRESIDENT  
NATIONAL RESOURCES PLANNING BOARD  
WASHINGTON, D. C.

March 2, 1940.

THE PRESIDENT,  
*The White House.*

MY DEAR MR. PRESIDENT:

A report on Deficiencies in Hydrologic Research, prepared under the direction of our Water Resources Committee, is submitted herewith for your consideration.

Although construction of works for water use and control is progressing on a wide front, understanding of the basic processes by which water circulates on the earth and in the atmosphere is far from complete. There are many very serious gaps in knowledge of that hydrologic cycle. The experience of the past ten years with unusually destructive droughts and floods has dramatized our lack of data; for example, on the frequency and intensity of low and excessive stream flow and on the effects of vegetal cover upon run-off. These gaps should be closed as speedily as practicable if adequate plans for drainage-basin development are to be prepared.

The attached document calls attention to the major deficiencies in current research work and suggests desirable lines of study by all interested groups—Federal and non-Federal. Prepared as a stimulus of improved research, it helps to lay a firm basis for practical and effective water planning in the future.

Respectfully submitted.

FREDERIC A. DELANO, *Chairman,*  
CHARLES E. MERRIAM,  
GEORGE F. YANTIS.

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<sup>1</sup> Mr. C. G. Paulsen succeeded Mr. N. C. Grover who retired from Government service on February 1, 1939.

<sup>2</sup> Maj. A. B. Jones succeeded Maj. W. D. Luplow, who participated in much of the preparation of this report.

NATIONAL RESOURCES COMMITTEE  
NORTH INTERIOR BUILDING  
WASHINGTON

*June 29, 1939.*

MR. FREDERIC A. DELANO,  
*Chairman, Advisory Committee,  
National Resources Committee,  
Washington, D. C.*

DEAR MR. DELANO: A report on Deficiencies in Hydrologic Research, prepared by the Special Advisory Committee on Hydrologic Data, is transmitted herewith.

The preparation of this report entailed a careful study of the research programs currently under way by various agencies. It involved also a study of the existing situation as to needs for information in considerable part growing out of the experience of the various committee members and others interested in water problems. It is intended that the report will serve as a guide for the use of research workers engaged in hydrologic or related investigations and in that way encourage further exploration in this field.

A previous report on Deficiencies in Basic Hydrologic Data presented a comprehensive outline, from a national viewpoint, for the adequate collection and publication of fundamental data relating to precipitation, stream flow, evaporation, ground water and other elements of the hydrologic cycle.

These basic data are the foundations upon which must be based the design and operation of all work for the conservation and utilization of water resources. But these data are valueless without adequate techniques with which to interpret and apply them to specific problems. Research alone provides the techniques which are essential to the solution of flood control, irrigation, drought, soil erosion, and other problems encountered in the development of a water policy which is both hydrologically and economically sound. Because the need for scientific approach to the interpretation of hydrologic phenomena and related factors is so important to the economic life of the country, the Water Resources Committee feels that the suggestions contained in this report are of paramount importance.

Present information on the significance and interrelation of different phases of the hydrologic cycle contains much that is in need of further verification and there is a serious lack of understanding of the significance of many phenomena. Improvement of this situation can best be effectuated by a competently organized and thoroughly coordinated long-range research program given continuity by adequate appropriations. Such an appropriation policy, with provisions for a reasonable and necessary expansion of the facilities, would very largely eliminate such duplication of effort as now occurs as a result of a fluctuating financial support and lack of continuity.

Such a program would involve expenditures insignificant in amount compared with the savings which would be effected in the cost of hydraulic structures which now have to be designed to provide for an adequate factor of safety based in part upon lack of knowledge of the effect of hydrologic and related phenomena.

Further advantages would accrue from the dissemination of information on current research activities, therefore the proposal for a central "clearing house" and coordinating agency should be immediately consummated.

The Water Resources Committee concurs in the recommendations of the Special Advisory Committee on Hydrologic Data.

Respectfully submitted,

The WATER RESOURCES COMMITTEE

ABEL WOLMAN, *Chairman*

*Chief Engineer, Maryland State Department of Health*

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*University of Chicago.*

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*Land Use Coordinator,  
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*Chief Engineer,  
Tennessee Valley Authority.*

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*Acting Chief Hydraulic Engineer,  
United States Geological Survey.*

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*Dean, College of Engineering,  
New York University.*

Maj. Gen. JULIAN L. SCHLEY,  
*Chief of Engineers,  
United States Corps of Engineers.*

(Represented by Col. W. A. SNOW.)

R. E. TARBETT,  
*Senior Sanitary Engineer,  
United States Public Health Service.*

JULIUS T. WENZEL

*In Charge Interdepartmental Coordination,  
Office of Land Use Coordination  
United States Department of Agriculture*

---

<sup>1</sup> Mr. C. G. Paulsen succeeded Mr. N. C. Grover, who retired from Government service on February 1, 1939.

NATIONAL RESOURCES COMMITTEE

NORTH INTERIOR BUILDING

WASHINGTON

*June 29, 1939.*

MR. ABEL WOLMAN,  
*Chairman, Water Resources Committee.*

DEAR MR. WOLMAN: The Special Advisory Committee on Hydrologic Data submits herewith a report on Deficiencies in Hydrologic Research.

The Committee, after a survey of the field of current hydrologic research, has prepared a brief description of investigations deemed essential to the clarification of existing information or in making available new information on many hydrologic phenomena. These proposals have been grouped by broad classification of phenomena and are designed to serve as guides in the attack on major problems in hydrology and hydrologic investigations.

Research in hydrology has advanced rapidly on a wide front during the past few years. On this account significant changes have occurred in certain lines of activity mentioned in this report during the time of its preparation and publication. No report of this character can be thoroughly up-to-date when it is issued, but the Committee feels that the items presented in Chapter III as individual research proposals are generally representative of the best contemporary thought on the several subjects. Intensive research on certain phenomena is responsible for a very rapid change of status of our knowledge of these phenomena and emphasizes the importance of a familiarity with current research on the part of anyone inaugurating hydrologic-research undertakings.

Chapter IV of the report is indicative of the manner in which the independent research items of the previous chapter may be integrated into a broad research program involving the many interrelated hydrologic phenomena. The areal unit upon which such a broad program is based is a small drainage basin.

The Committee realizes full well that research in this or any field of scientific investigation should not be hampered by numerous regulations and predetermined conclusions; rather the investigator should be encouraged to exercise initiative in his study. Certain advantages, however, are to be gained through the coordination of research activities, and the Committee has set forth recommendations to effectuate this as well as to encourage cooperative research by the many educational institutions throughout the Nation which have qualified personnel and adequate facilities. The research items of chapter III, however, constitute the essence of the Committee recommendations and are submitted without priorities as between items or sections.



In the work the Committee has had available as consultants the services of Robert E. Horton, consulting hydrologist, Voorheesville, N. Y., and Adolph F. Meyer, consulting engineer of St. Paul, Minn. The cooperation and assistance of W. D. Collins, Chief, Division of Quality of Water, Geological Survey; and A. G. Fiedler, Senior Engineer, Geological Survey, United States Department of the Interior; W. W. McLaughlin, Consulting Engineer, Soil Conservation Service; and D. B. Krimgold, Soil Conservationist, Soil Conservation Service, United States Department of Agriculture, were of great value in preparing many of the research items. The Committee is greatly indebted to the many persons who have reviewed the various research items and improved the report by their comments.

Respectfully submitted,

THORNDIKE SAVILLE, *Chairman, Special Advisory Committee on Hydrologic Data; Dean, College of Engineering, New York University*

DONALD M. BAKER,  
*Consulting Engineer,  
Los Angeles, Calif.*

H. K. BARROWS,  
*Consulting Engineer,  
Boston, Mass.*

MERRILL BERNARD,  
*Chief, River and Flood Division,  
United States Weather Bureau.*

N. C. GROVER,  
*Chief Hydraulic Engineer,  
Geological Survey.*

W. W. HORNER,  
*Consulting Engineer,  
Professor of Civil Engineering,  
Washington University.*

JOSEPH JACOBS,  
*Consulting Engineer,  
Seattle, Wash.*

A. B. JONES,  
*Corps of Engineers,  
United States Army.*

L. A. JONES,  
*Chief, Division of Drainage Investigations,  
Bureau of Agricultural Engineering.*

C. E. RAMSER,  
*Principal Soil Conservationist,  
Soil Conservation Service.*

ROYCE J. TIPTON,  
*Consulting Engineer,  
Denver, Colo.*

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# DEFICIENCIES IN HYDROLOGIC RESEARCH

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## INTRODUCTION

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During the course of preparation of the report *Deficiencies in Basic Hydrologic Data*<sup>1</sup> and following its publication, the existence of major deficiencies in hydrologic research became increasingly evident to the Special Advisory Committee on Hydrologic Data. The importance of an improved and coordinated program of research in hydrology as one of the basic needs in water planning was brought to the attention of the Water Resources Committee. The Special Advisory Committee on Hydrologic Data was subsequently authorized to prepare a report having as its objective the formulation of procedures for correcting some of the deficiencies in hydrologic research.

The Committee proceeded to canvass briefly hydrologic research activities throughout the Nation. From these data and from personal knowledge of the Committee and special consultants, specific research projects were drafted and submitted individually by members

of the Committee for consideration by the Committee as a whole.

The resulting revisions were sent to more than fifty selected reviewers in all parts of the Nation, for comments, suggestions, and criticisms of content, and to two outstanding hydrologists for critical analyses as to content and completeness of program.

The proposals presented in chapter III thus represent the coordinated thought of competent authorities located in all sections of the country with respect to deficiencies in present-day hydrologic research.

Mr. Robert E. Horton, of Voorheesville, N. Y., and Mr. Adolph F. Meyer, of Minneapolis, Minn., served as special advisors; Ivan Bloch served as secretary to the Committee during the preparation of much of the report; and O. J. Baldwin acted as secretary to the Committee in the completion of its work. The complete revision of the original research proposals in the interest of uniformity of style and smoothness of presentation has been a major contribution by Mr. Baldwin to the work of the Committee.

<sup>1</sup> National Resources Committee, September 1936, United States Government Printing Office, Washington, D. C., 30 cents.

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## APPENDIX E. BIBLIOGRAPHY

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Material published on hydrology and its many phases may be found in a wide variety of scientific literature. It would be a task well beyond the scope of this report to attempt to compile an exhaustive list of the articles, pamphlets, books, etc., which have been written on the subject. The compilation of bibliographies of the most important publications in each of the several fields of hydrologic research have been undertaken previously by different agencies, as, for example, those listed as references A-2-4-6-12-13. In addition, several scientific societies prepare annual bibliographies of current literature within the different fields.

To compile selective bibliographies on the research subjects covered in this report would, to a very considerable extent, duplicate bibliographical lists compiled within recent years and could scarcely be justified. For this reason, the Committee has limited the following bibliography to the listing of recently published works containing bibliographies; scientific societies whose publications contain articles on hydrology and hydrologic data; commercial technical periodicals; and general textbooks on hydrology and related subjects, all of which contain extensive bibliographic references. These references will provide the research worker with a point from which to initiate a review of the technical literature on hydrology but leave to the individual the evaluation of the material.

### A. Bibliographies on Hydrology and Some Related Subjects

1. *Bibliography of Hydrology*. Published annually for the United States, American Geophysical Union, Section of Hydrology.
2. Bibliography of Rainfall Intensities, Run-off and Flood Flows; *Water Supply Paper 771* and *772*, U. S. Geological Survey, 1936.
3. "Bibliography and Index of Publications of the Geological Survey, Relating to Ground Water," *Water Supply Paper 427*, U. S. Geological Survey, 1920.
4. *Bibliography on Soil Erosion, and Soil and Water Conservation* (compiled by S. H. Gaines), Miscellaneous Publication 312, U. S. Department of Agriculture, 1938.
5. *List of Publications and Abstracts*, R. E. Horton, Hydrologic Laboratory, Voorheesville, N. Y., Publication #112, September 1937.
6. *Bibliography on Soil and Water Conservation and Hydrology*, Sub-Committee on Bibliography and Reports, American Society of Agricultural Engineers, June 21-24, 1937.
7. Bibliography—*Public Health Engineering Abstracts* (include United States Sewage and Waste—current abstracts), Public Health Service, U. S. Treasury Department.
8. Bibliography—*Circular 24* (List of Publications), Current Hydraulic Laboratory Research, National Bureau of Standards, U. S. Department of Commerce.
9. Bibliographies of specific subjects are frequently published in Annual Reports of Committees, American Geophysical Union.
10. *Experiment Station Record* (Abstracts of Literature), published semiannually, U. S. Department of Agriculture, Washington, D. C.
11. *Selected Bibliography on Upstream Engineering*, Soil Conservation Service, September 22-24, 1936.
12. "Selected Bibliography on Erosion and Silt Movement," *Water Supply Paper 797*, U. S. Geological Survey, 1937.
13. *Bibliography on Land Drainage*, Bureau of Agricultural Engineering, 1936.
14. "Inventory of Unpublished Hydrologic Data," *Water Supply Paper 837*, U. S. Geological Survey, 1938.
15. Engineering Index Service, New York City.
16. *Annotated Bibliography of Economic Geology*, Economic Geology Co., Urbana, Illinois, Vol. I-X, 1928-1938 (published annually and contains section on ground water giving abstracts of current ground water literature).
17. *List of Publications of U. S. Geological Survey*, U. S. Geological Survey.

### B. Scientific Societies and Publications— With Reference to Hydrology

#### United States

1. American Academy of Arts and Sciences, *Proceedings*.
2. American Association of Petroleum Geologists, *Bulletin*.
3. American Association for the Advancement of Science, *Science*.
4. American Chemical Society, *Chemical Abstracts; Industrial and Engineering Chemistry*.

5. American Fisheries Society, *Transactions*.
  6. American Forestry Association, *American Forest and Forest Life*.
  7. American Geographical Society, *Proceedings; Geographical Review*.
  8. American Geophysical Union, *Transactions*, especially Sections on Hydrology, Meteorology, and Oceanography.
  9. American Institute of Electrical Engineers, *Transactions; Electrical Engineering*.
  10. American Institute of Mining and Metallurgical Engineers, *Mining and Metallurgy; Transactions*.
  11. American Mathematical Society, *Transactions*.
  12. American Meteorological Society, *Bulletin* (monthly).
  13. American Philosophical Society, *Proceedings*.
  14. American Physical Society, *Bulletin; Physical Review; Review of Modern Physics*.
  15. American Shore and Beach Preservation Association, *Shore and Beach* (quarterly).
  16. American Society of Agricultural Engineers, *Transactions; Agricultural Engineering*.
  17. American Society of Agronomy, *Journal; Proceedings*.
  18. American Society of Civil Engineers, *Civil Engineering; Proceedings; Transactions*.
  19. American Society of Mechanical Engineers, *Mechanical Engineering; Transactions*.
  20. American Society of Plant Physiologists, *Plant Physiology*.
  21. American Soil Survey Association, *Bulletin*.
  22. American Standards Association, *Bulletin*.
  23. American Statistical Association, *Journal*.
  24. American Waterworks Association, *Journal*.
  25. Association of American Geographers, *Annals*.
  26. Association of American State Geologists, *Journal*.
  27. Association of Scientific Apparatus Makers of the U. S. A. (also Optical Society of America), *Review of Scientific Instruments*.
  28. Boston Society of Civil Engineers, *Journal*.
  29. Carnegie Institution of Washington, *Bulletins, Reports, etc.*
  30. Connecticut Society of Civil Engineers, *Papers, Transactions and Proceedings*.
  31. Ecological Society of America, *Ecology; Bulletin*.
  32. Franklin Institute of Philadelphia, *Journal*.
  33. Geological Society of America, *Bulletin*.
  34. National Academy of Science, *Proceedings*.
  35. National Research Council, *Bulletins*.
  36. New England Waterworks Association, *Journal*.
  37. Smithsonian Institution, *Bulletins, Reports, etc.*
  38. Society of American Foresters, *Journal of Forestry*.
  39. Society of American Military Engineers, *Military Engineer*.
  40. Society of Economic Geologists, *Proceedings*.
  41. Washington Academy of Sciences, *Journal*.
  42. Western Society of Engineers, *Bulletin; Journal*.
- Canadian**
43. Canadian Society of Technical Agriculturists, *Scientific Agriculture*.
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48. *Annales des Ponts et Chaussées* (monthly), Paris.
  49. Association Internationale d'Hydrologie Scientifique, Paris, *Bulletins, etc.*
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  51. Institution of Water Engineers, *Transactions*.
- C. Publications—With Reference to Hydrology**
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  2. *Engineering News-Record*.
  3. *Scientific Monthly*.
  4. *Verein Deutscher Ingenieure*, Berlin.
  5. *Waterworks and Sewerage*.
  6. *Waterworks Engineering*.
  7. Canada Department of Interior, *Water Resources Papers*.
  8. Great Britain Department of Scientific and Industrial Research, *Water Pollution Research*.
  9. U. S. Weather Bureau, Circulars A, B, C, D, E, F, G, I, L, M, N, O, P, Q, and R; *Monthly Weather Review* (includes current bibliography); and *Bulletins*.
  10. U. S. Geological Survey, *Water Supply Papers; Professional Papers; Annual Reports; and Lists of Publications*.
  11. U. S. Bureau of Standards, *Bulletins; Current Hydraulic Laboratory Research* and *Research Bulletin* or reprints.
  12. U. S. Department of Agriculture, *Technical Bulletins; Miscellaneous Publications; Circulars; Lists of Publications* and other publications, including those from Bureau of Agricultural Engineering, Forest Service, Soil Conservation Service, Biological Survey, etc.
  13. U. S. War Department, Office of Chief of Engineers, "308" Reports, reports dealing with hydrology, navigation, flood control and hydro power of most of the important drainage basins of the United States (many unpublished hydrological

data are on file in the office of the District Engineers); Congressional documents, reports to Congress on navigation improvements; Stream Gaging Records on the Mississippi; Reports of the Mississippi River Commission; Reports of Chief of Engineers; and Reports of Beach Erosion Board.

14. U. S. Coast and Geodetic Survey, Bulletins; Manuals; *Hydrography*, including charts; Maps of Coastal Waters; and *Inland Coast Pilot*.

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#### E. General Textbooks on Statistical Analysis

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9. Mills, Cecil Frederick, *Statistical Methods*, New York, H. Holt and Company, 1924.
10. Rietz, Henry Lewis, *Handbook of Mathematical Statistics*, New York and Boston, Houghton Mifflin Company, 1924.
11. Running, Theodore Rudolph, *Empirical Formulas*, 1st Edition, New York, John Wiley & Sons, Inc.
12. Carnegie Institution of Washington—Reports of the Conference on Cycles.

The general references indicated below are to documents which contain data and which may be obtained from Federal agencies, or from the Superintendent of Documents, United States Government Printing Office, Washington, D. C. The number in parentheses at the head of each reference is the number of the price list, available for free distribution by the Superintendent of Documents, in which this publication would be listed if still in stock.

It must also be remembered that many items indicated in the Bibliography of this appendix include sources of data applicable not only to the specific subject treated by the item but to other phases of hydrology as well.

#### Climatology, Precipitation, Stream Flow, etc.

- (48) Climatological Data of the United States: *Weather Statistics* (monthly) and Special Bulletins, Weather Bureau.
- (48) *Climatic Charts for the United States*, Weather Bureau.
- (48) *Daily River Stages on Principal Rivers of the United States*.
- (15) *Floods: Miscellaneous Water Supply Papers on Various Important floods in various parts of the country*.
- (48) *Meteorological Yearbook*, Weather Bureau (annually).
- (48) *Miscellaneous Congressional Documents and Hearings on Flood Control for Various Sections and Rivers of the Country*.
- (48) *Monthly Weather Review* and supplements, Weather Bureau.

- (48) *Snow and Ice Bulletin*. Included in subscription to *Weekly Weather and Crop Bulletin*.
- (15) Stream Measurement: Miscellaneous Reports on Progress of Stream Measurement, etc.
- (48) Surface Water Supply of the United States. These are available for every major drainage basin of the United States and should be ordered accordingly.
- (48) Weather Maps—Daily Weather Maps.
- (48) *Weekly Weather and Crop Bulletin*.
- (15) Annual Reports of Geological Survey, including papers on Hydrography.

**Instrumentation, Hydraulics, etc.**

- (36) Bureau of Standards, *Journal of Research* (monthly).
- (36) Bureau of Standards, *Technical News Bulletin* (monthly).

**General**

- (15) Classified Lists of Projects of the Agricultural Experiment Station, 1930.

- (36) *Experiment Station Record* (monthly).
- (36) *Journal of Agricultural Research* (semi-monthly).
- (15) List of Bulletins of Agricultural Experiment Station for various calendar years.
- (36) *Soil Conservation* (monthly).
- (36) *Monthly Catalogue of United States Public Documents*.
- (36) *Monthly Check List of State Publications*.

**Maps**

- (53) *Forest Regions of the United States*.
- (53) Geological Survey: Geologic, topographic and other maps and folios.
- (53) *Land Use Areas*, published by Agriculture Department.
- (53) Maps issued by Coast and Geodetic Survey.
- (53) *Mississippi River Commission Map*.
- (53) Soil Conservation Survey Maps, Agriculture Department.
- (53) *Soils of the United States*, issued by the Bureau of Chemistry and Soils, Department of Agriculture.



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