Urban Hydrology—

A Selected Bibliography with Abstracts

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This bibliography of 650 selected references on urban hydrology is intended as a source document for scientific and water-management needs. It was stimulated by increasing interest in the problems of runoff and water quality caused by increasing urbanization. The bibliography brings together abstracts with citations that pertain to the rainfall-runoff process, urban groundwater problems, urban water pollution sources, urban climatic changes, and urban runoff modeling. Emphasis is given to technical advances of the past ten years as well as to needs for new research. This bibliography is arranged alphabetically by author and has separate geographic and subject indexes. Each abstract is followed by several added key words to relate it to other similar references.

17. Key Words and Document Analysis. 17a. Descriptors

*Bibliographies, *Abstracts, *Urban hydrology, *Urban runoff, Rainfall-runoff relationships, Storm runoff, Water pollution sources, Groundwater, Climatology, Urbanization, Cities, Urban drainage, Land use, Storm drains, Mathematical models, Suburban areas

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URBAN HYDROLOGY—
A SELECTED BIBLIOGRAPHY WITH ABSTRACTS

By G. L. Knapp and J. P. Glasby

INTRODUCTION

This bibliography has been prepared to meet an urgent need for a selective listing and abstracts of published information on the subject of urban hydrology—an ever-broadening field of interaction between man and one of his most important natural resources.

Water is a vital resource for human activities. Its natural distribution is governed by climate and the physical character of the surface and subsurface of the land. Urbanization, however, has altered this natural distribution. The concentration of people in urban areas has modified the natural landscape, bringing about problems of water supply, flooding, and water quality that affect their daily lives. Sewage and industrial wastes are removed by discharge into streams and other water bodies.

The severity of urban pollution depends on the degree of waste treatment and on the amount of waste effluent in relation to the amount of water available for dilution. Storm runoff also contributes heavy pollution loads as rainfall flushes contaminants from urban streets. The disposal of solid wastes in dumps and sanitary landfills poses a pollution threat to ground-water resources as water, leaching through the wastes, carries with it both biological and chemical contamination. Construction of housing and highways exposes bare soil to accelerated erosion. In Fairfax County, Va., highway construction involving 197 acres contributed 37,000 tons of sediment over a 3-year period. This sediment chokes streams and fills reservoirs, severely limiting their uses for recreation and aesthetic enjoyment and their capacity to accommodate floods. Paving of land surfaces and installation of storm sewers concentrate storm runoff and increase the flooding hazard. For example, in a one-square-mile area, complete storm sewering and paving of 60 percent of the surface (comparable to dense residential housing) can increase the average annual flood by a factor of more than four.

Urban problems are bringing about an increased awareness of the significance of the natural resources of urban areas, especially water, as components of the total urban environment. The concern for water in urban areas has increased the complexity and scope of water data and the amount of information that must be obtained. Storm drainage today is still largely designed on the basis of the empirical rational formula using rainfall intensity modified by a coefficient of runoff. The inefficiency of this method is well recognized. Greater knowledge of the part of the hydrologic cycle involving rainfall-runoff relations in urban environments is needed. New instrumentation will need to be developed and sophisticated data-collection networks installed.

Since the late 1950's, a strong emphasis has been placed on methods of computing urban rainfall-runoff relationships. The techniques include unit hydrograph methods, depth-area-duration analyses, systems analysis, and mathematical modeling. Although many valuable papers on urban hydrology were published earlier, the year 1959 marks a change in approach and a point at which to start a bibliographic search.

The current strong interest in urban hydrology led to assembly of significant references from 1959 to the present into this bibliography. Some particularly important earlier references, such as Kuichling's 1889 paper establishing the rational method in the United States, are also included. The bibliography, which contains 650 abstracts, was compiled using as a primary source the computerized files of the Selected Water Resources Abstracts (SWRA) from 1968 through 1971, followed by a general search of the literature for older material as well as that not included in SWRA.

About half of the abstracts pertain to the rainfall-runoff process as it is affected by cities and urbanization. About one-third pertain to the effects of cities on water quality. Only a small sampling of papers on urban climatology, eutrophication, effects of combined sewers, and water pollution effects is included to introduce the user to these fields, any one of which has a larger literature than urban hydrology.

The criteria for selection of the entries are: (1) the subject should be physical hydrology (excluding management, water supply, or social effects); (2) the subject should be the effect of cities on water, not the effect of water on cities.

The abstracts are arranged alphabetically by the name of the author, or senior author if authorship is multiple. Where more than one entry appears under an author's name, the arrangement is by date of publication. Each paper has an accession number. Within each entry the accession number is given first followed by the name(s) of the author(s) in bold type. The next line begins with the year of publication followed by the title and the remainder of the citation and the abstract. Notes are given at the end of some of the abstracts to assist the reader in locating the publications. A number prefixed by AD or PB indicates availability from the National Technical Information Service, Springfield, Va. A number prefixed by W indicates that the abstract was originally published in Selected Water Resources Abstracts.

Each abstract is concluded by a set of descriptors selected from The *Water Resources Thesaurus,* which was published by the Office of Water Resources Research, U.S. Department of the Interior. The descriptors are designed for computer storage and retrieval purposes and are included here as an aid to the reader interested in computer retrieval of similar subjects. Accordingly, the system of compounding words rigorously adheres to that in the thesaurus. For example, the compound noun *ground water*—normally written as two words in reports of the Geological Survey—is shown as a single nonhyphenated word in the descriptors and index parts of this report in conformance with descriptor usage in the *Water Resources Thesaurus.*

The index to the bibliography consists of a Geographic Index and a Subject Index. The subject index is simplified; some of the headings could be subheadings of other major headings, but because of a small number of entries or because the topic is relatively uncomplicated, they are entered independently.

BIBLIOGRAPHY

001 Abdel-Razaq, A.Y.; Hernandez, J. W.
1966. A numerical solution of the equations of motion as applied to surface flow: New Mexico State Univ., Eng. Expt. Sta., Tech. Rept. 36, 90 p., 15 tables, 30 references, 2 app.

Unsteady flow equations may be solved for the ideal case of a constant-slope open channel with lateral inflow. Lateral inflow is assumed to be constant with distance but variable in time. This technique may be applied to the solution of problems of urban surface runoff. The one-dimensional, nonlinear, partial differential equations of motion and continuity may be transformed into a system of ordinary, nonlinear, differential equations. This set of equations may be solved numerically to give the velocity, depth of flow, or cross-sectional area of flow at any point along the channel. Starting with the known initial conditions and utilizing Taylor's series, the velocity and depth of flow can be predicted after an increment of time.—W69-00636.

Descriptors: Unsteady flow, storm runoff, numerical analysis, routing.

002 Ackerman, E. A.
1968. Conservation of water in agriculture, industry, and municipal use: Water Resources Bull., v. 4, no. 1, p. 3–20, 4 figs., 1 table.

Effective water conservation lies in recognizing that water problems are not divisible, effective water management means integrated management, and future conservation actions must be based on broad and effective public communication. A conservation system, including man and his environment, is described as a variant of the hydrologic cycle. Maintenance of water quality is as important as conserving quantity: the traditional approach stresses natural waste disposal functions of streams but does not consider aesthetic and other values, and a new approach proposes that water as a part of the human environment, like air, should be as clean as we can make it.

Descriptors: Aesthetics, water pollution control, water management (applied).

003 Ackerman, W. C.
1966. Major research problems in hydrology and engineering, *in* Water Research: Baltimore, Md., Johns Hopkins Univ. Press, p. 495–501, 11 references.

Hydrologic and engineering research problems that need special attention are river forecasting for water resource management, urban hydrology, the engineering and geology of dams, evaporation and transpiration, and prime water resources. Sources of information on water resources are listed.—W71-06760.

Descriptors: Planning, bibliographies, data collections, water resources research.

004 Ackerman, W. C.; Crawford, N. H.; Izzard, C. F.; and others.
1966. Recommendations for watershed research programs: U.S. Dept. Interior, Office of Water Resources Research, Watershed Research Panel Rept., 21 p., 21 references.

An advisory report on watershed research covers: the subject matter and geographic areas of watershed research for which previous work has already provided adequate knowledge; watershed research which past work indicates is not likely now to yield results sufficient to justify additional substantial research effort; watershed research that now appears promising for increased emphasis; and recommendations under the Water Resources Research Act that might aid in bringing about needed increases in research. Specific recommendations to OWRR in administering programs under Public Law 88-379 cover research on experimental watersheds, representative watersheds, physical models, mathematical models, and effects of urbanization—W70-04760.

Descriptors: Water Resources Research Act, demonstration watersheds, model studies, planning.

005 Aitken, A. P.
1968. The application of storage routing methods to urban hydrology: Jour. of the Institution of Engineers, Australia, v. 40, no. 1–2, p. 5–11, 7 figs., 3 tables, 7 references.

Runoff routing methods for flood estimation in rural catchments are established procedure; however, the use of these methods in urban hydrology has met with considerable resistance, some of which is justified, as the methods are long and tedious and cannot be practically applied without the aid of a computer. One method of runoff routing developed in Great Britain and another method proposed in the United States are reviewed and extended in application, so that the results may be applied simply as a correction to the rational method of design. The method is specifically derived for localities like Victoria, Australia, and Great Britain, where runoff from the pervious area is of no significance, but it could be applied in other areas with suitable modifications.—W69–01533.

Descriptors: Rainfall-runoff relationships, routing, hydrograph analysis, rational formula, Australia.

006 Aitken, A. P.
1969. Storm water retarding basins solve urban drainage problems: Australian Civil Eng. and Construction, v. 10, no. 2, p. 35–37, 4 figs., 3 photos.

The Board of Works of Melbourne, Australia, has designed and constructed 16 storm-water retarding basins varying in capacity from 13 acre-feet to 2,350 acre-feet. The aim of the storm-water retarding basin is to reduce the peak flow downstream of the basin by temporarily storing a portion of the inflow from the upstream catchment. The normal outlet is generally designed to pass all storms with recurrence interval less than 20 years. Greater storms cause the spillway to operate. The capacity depends on the catchment size and the rainfall intensity-frequency-duration relationships for the locality. For Melbourne, the most satisfactory basins have capacities about 1/10 acre-foot per acre of catchment. The duration of the critical design storm is many times that of the storm usually used to calculate time of concentration; thus the spillway-design flood may be evaluated by transposing the maximum recorded storms in the region to the catchment under study. Alternatively, the spillway flood may be estimated using probable maximum precipitation.

Descriptors: Storm runoff, flood control, reservoirs, Melbourne (Australia).

007 Albertson, M. L.; Tucker, L. S.; Taylor, D. C. (editors).
1971. Treatise on urban water systems: Fort Collins, Colorado State Univ., 836 p.

This assemblage of lectures, supplemented with case studies, discusses the concepts of systems analysis and optimization in the urban water cycle. Sections I and II are designed to develop an understanding of how the many parts of the urban water system interact and fit together. The systems approach and the role of models are discussed. Newly developed computer programs for forecasting urban water demands are presented. The needs for various types of urban water data are outlined, and suggestions are given as to how these needs can be met. Sensitivity analysis should be used to study the effects of changes in system parameters and inputs as measured by changes in results. Environmental and humanistic factors that affect the decision-making processes are considered.

Descriptors: Water management (applied), systems analysis, storm runoff, planning, mathematical models.

008 Alexander, R. H.; Bowden, L. W.; Marble, D. F.; Moore, E. G.
1968. Remote sensing of urban environments, *in* Fifth symposium on remote sensing of environment, Ann Arbor, Mich., Apr. 16–18, 1968, Proc.: Ann Arbor, Michigan Univ., p. 889–911, 4 figs., 6 aerial photos., 1 table, 19 references.

Remote sensing can play an important role in the study of cities and the search for solutions to urban problems. Major tasks for applications of urban remote sensing include the delimitation of urbanism and the monitoring of its growth and changes, the determination of urban land use, and the study of urban dynamics, including forces of the physical environment acting upon cities. Recent advances in the application of photographic, thermal, infrared, radar, and microwave sensors are reviewed. These techniques can collect valuable data about urban environments.

Descriptors: Remote sensing, land use, aerial photography, reviews.

009 Allanson, B. R.; Henzen, M. R.; Coetzee, O. J.

1964. Environmental factors in relation to water use and protection against pollution, *in* Conf. on the problems associated with the purification, discharge and re-use of municipal and industrial effluents, Proc.: Pretoria, South Africa, Natl. Inst. Water Research, p. 77–92.

Conditions on the drainage surface of a catchment area which cause changes in the chemical and bacteriological quality of river water, factors responsible for the self-purifying capacity of streams and rivers, and criteria upon which the efficient use of South African rivers should be based are reviewed. Data are included to show how the physical and chemical quality of surface waters is affected by natural factors, agricultural activities, and runoff from residential and industrial areas.—W69-01496.

Descriptors: Storm runoff, water quality, water pollution sources.

010 Althoff, W. F.

1970. Geology and ground-water resources of Granby, Massachusetts: Amherst, Massachusetts Univ., Water Resources Research Center Report, 170 p., 18 figs., 7 pls., 4 tables, 53 references, 7 app.

Basic hydrogeological information is compiled for the bedrock and surficial aquifers underlying the rapidly growing community of Granby, Mass. Hydrogeologic studies include bedrock topography, thickness of the overlying surficial blanket, surficial (glacial) deposits, and the general pattern of ground-water movement. A generalized soils map, showing the correlation with the underlying geology, identifies favorable areas for septic tank systems. Sanitary analyses of ground water for coliform bacteria, chlorides, and nitrogen demonstrate the effects of municipal growth. Waste waters discharged from domestic septic-tank sewage systems pollute waters in both bedrock and unconsolidated aquifers. Pumpage of ground water is wholly for domestic purposes and averaged about 0.25 mgd in 1969. The estimated average annual use of ground water in the area is only about 2 percent of the total recharge.

Descriptors: Hydrogeology, Massachusetts, water yield, water pollution sources, Granby (Mass.).

011 Amein, Michael; Chu, H. L.

1969. Study of erosion in roadside drainage channels in North Carolina: Raleigh, North Carolina State Univ., School of Eng., Final Rept. ERD-110-68-4, 63 p., app.

An extensive field study was made of the resistance of roadside drainage channels in North Carolina to erosion, and criteria were developed for the design of stable roadside channels. Methods of determining whether a triangular shaped roadside drainage channel will be stable are given for fully grassed, partly grassed or bare earth channels when the discharge, the slope of the channel bottom, the side slope of the channel, and the soil characteristics of the channel are known.—W71-02525.

Descriptors: Erosion control, highways, North Carolina

012 American Public Works Association.

1967. Report on problems of combined sewer facilities and overflows, 1967: Washington, D.C., Am. Public Works Assoc., Research Found., 189 p., 9 figs., 61 tables, 10 app.

The effects of means of correcting combined-sewer overflows and separate storm and sanitary sewer discharges were inventoried on a national basis in 1967. Personal interviews with the public officials of approximately 900 communities in the United States collected over 250,000 replies which were analyzed and grouped by State, river basin, and population group to define the problems of combined-sewer facilities and overflows. Nationwide projections were made for area and population served by combined sewers, overflow locations, type and number of regulators, associated land and water uses, estimates of costs for sewer separation, alternate control, and treatment methods.

Descriptors: Combined sewers, floods, storm runoff, water pollution sources.

013 American Public Works Association.

1969. Water pollution aspects of urban runoff: Federal Water Pollution Control Adm., Water Pollution Control Research Ser. WP-20-15, 272 p., 11 figs., 31 photos., 32 tables, 32 references.

The factors in the urban environment which contribute to the pollution of urban storm water runoff and methods to limit this source of water pollution were determined. Street refuse is a significant factor, its magnitude depending on the efficiency of street cleaning methods and limitations of commonly used equipment. Catch basins with street inlets to the storm water disposal system were also a potential major source of pollution, as large quantities of septic liquid are released during periods of storm water runoff. Other potential sources of water pollution include polluted air, roof discharges, and chemicals used in the urban environment.

Descriptors: Water pollution sources, storm runoff, combined sewers.

014 American Society of Civil Engineers.
1968. Urban water resources research, systematic study and development of long range programs of urban water resources research, first year report, Sept. 1968: New York, Am. Soc. Civil Engineers, 632 p., 70 figs., 20 tables, 896 references, 11 app.

Systematic study and development of long-range programs by the American Society of Civil Engineers, Urban Hydrology Research Council for the Office of Water Resources Research are described. The objective of the research is to provide guidelines for initiating and expanding long-range studies in urban water problems. The U.S. Geological Survey is studying data requirements. First-year emphasis was on subjects requiring earliest consideration, such as urban storm drainage. An assessment is given of the potentials, liabilities, and available knowledge of the rainfall-runoff-water-quality process. Model requirements for process simulation are detailed—W69-03506.

Descriptors: Rainfall-runoff relationships, drainage engineering, simulation analysis, data collections, model studies.

015 American Society of Civil Engineers.
1968. ASCE research program in urban water resources: Civil Eng., v. 38, no. 5, p. 70–71.

The American Society of Civil Engineers, Urban Hydrology Research Council, has initiated a program to study and report on research and data needs for urban water problems. The program currently consists of two major projects: research and analysis of national basic information needs in urban hydrology, and systematic study and development of long-range programs of urban water resources research. An intensive study is being made of the types of data needed for improved design of storm-drainage facilities and for approval of kinds of networks necessary to collect adequate data. The ultimate objective is to facilitate transfer of data findings between metropolitan regions. A program of long-range studies on urban water problems includes prefeasibility studies to determine the possible effectiveness; cost and time requirements for systems-engineering analysis of a study of mathematical models for analyzing urban rainfall-runoff-quality processes; a study of damage; and a study of political, economic, legal, and social problems related to urban water management—W69-01557.

Descriptors: Water resources research, rainfall-runoff relationships, water quality, data collections, model studies, drainage (urban).

016 American Society of Civil Engineers.
1969. Basic information needs in urban hydrology. An analysis of national basic information needs in urban hydrology, April 1969: New York, N.Y., Am. Soc. Civil Engineers, Urban Hydrology Research Council, 112 p., 13 figs., 2 maps, 3 tables, 78 references.

An analysis of national basic information needs in urban hydrology is focused on data needs, data devices, and data networks. Intensive study was made of the data requirements for analyzing rainfall-runoff-quality relationships and of suitable data collection instrumentation, with consideration of the types of networks required for the collection of adequate data. Suitable data collected with properly coordinated instrumentation in networks representing a variety of climatic, topographic, and land-use conditions are virtually non-existent. Performance data with which existing or proposed storm drainage facilities can be checked or designed are meager. Transfer of findings between metropolitan regions is a primary objective. The replacement value of existing storm sewerage systems in the United States is at least $22 billion, and it is estimated that an average of about $3.5 billion per year will be spent on construction of new storm sewerage systems over the next several years. The plan recommended for a minimum national program of urban storm drainage research would cost about 1/3 percent of this average annual construction cost—W69-06770.

Descriptors: Rainfall-runoff relationships, urbanization, drainage systems, hydrologic data, data collections.

017 American Society of Civil Engineers.
1969. Effect of urban development on flood discharges, current knowledge and future needs: Am. Soc. Civil Engineers Proc. Paper 6355, Jour. Hydraulics Div., v. 95, no. HY 1, p. 287–309, 71 references, 2 app.

This progress report by the Task Force on Effect of Urban Development on Flood Discharges, Committee on Flood Control, Hydraulics Division of the American Society of Civil Engineers, attempts to provide, as a guide for engineers, planners, governmental officials, and all others interested in the problems of urban runoff, an annotated up-to-date bibliography of reports, papers, and other material pertaining to the effect of urban development on flood discharges. The report includes a brief discussion of the impact on flood runoff which can be expected to result from urban developments as suburbs and cities replace the rural ladscape. Included is a listing of pertinent research projects which are underway with identification of areas where additional research is required.—W69-04560.

Descriptors: Bibliographies, water resources research, floods, rainfall-runoff relationships, storm runoff.

018 American Society of Civil Engineers.
1970. Sediment sources and sediment yields: Am. Soc. Civil Engineers Proc. Paper 7337, Jour. Hydraulics Div., v. 96, no. HY 6, p. 1283–1329, 26 figs., 10 tables, 93 references.

Methods and procedures are analyzed for determining erosion rates, sediment yield, or deposition rates at locations downstream from the erosion source. Emphasis is given to the erosion types and processes which cause the most engineering problems, either by the large sediment quantities invloved or by the locally severe damages. Accelerated erosion and deposition rates caused by man's activities are of special concern; these derive from sheet erosion processes on tilled lands and from such specialized activities as strip mining, urban development, construction of highways and utilities, and sheet erosion on any portion of the land surface that is denuded or inadequately protected. Present bases for estimating these rates on both a storm and an average annual basis are given.—W70-06979.

Descriptors: Sediment yield, erosion, soil erosion, sedimentation.

019 American Society of Civil Engineers.
1970. Sediment measurement techniques, C. Accelerated valley deposits: Am. Soc. Civil Engineers Proc., Paper 7269, Jour. Hydraulics Div., v. 96, no. HY 5, p. 1157–1166, 1 fig., 2 tables, 11 references.

Culturally accelerated deposition of sediment in alluvial valleys has been recognized in the United States since 1801 or earlier. Such deposition is most common in valleys with drainage areas smaller than a few hundred square miles, where there is upland gullying and where a substantial amount of sand is available. The modern sediment deposit may be recognized by texture, color, compaction, distinctive minerals, buried artifacts, or stratification. These deposits are measured using base maps and by surveying, boring, mapping, and sampling. Guidance is given in calculating volumes, tabulating, interpreting, and reporting the data obtained.—W70-06110.

Descriptors: Accelerated erosion, sedimentation, mapping.

020 American Water Resources Association.
1968. American Water Resources Conference, 4th, New York, N.Y., Nov. 18–22, 1968, Proc.: Am. Water Resources Assoc., Urbana, Ill., 793 p., 127 figs., 53 maps, 23 photos., 60 tables, 456 references.

At the Fourth American Water Resources Conference, 1968, papers were presented on interdisciplinary interests in the fields of water resources research, planning, development, management, and education. Particular emphasis was given to water problems in metropolitan areas. Water resource problems of the cities, storm runoff and waste water disposal, the economics of pollution and quality of the environment, regional water planning, areal projects, flood control and flood plain management, citizen action, pollution, pollution control, ground water, international water resource programs, general water resources research, droughts, meteorology, and water policy were discussed.—W71-03625.

Descriptors: Water resource development, storm runoff, water quality, water resources research.

021 American Water Works Association.

1960. Survey of ground water contamination and waste disposal practices: Am. Water Works Assoc. Jour., v. 52, no. 9, p. 1211–1219, 5 references.

Information was collected on ground-water pollution in the United States primarily from replies to a questionnaire of the state governments. Of the 48 States that returned the questionnaire, 9 indicated no reported or observed contamination problems; 26 States indicated contamination by sewage; 22 reported oil and gas production waste or petroleum products contamination; 15 indicated other industrial waste or chemical contaminants; and 13 reported problems which developed from contaminants of another nature. The actual sources of contamination are: disposal wells, impoundments and lagoons, surface water dumping, septic tanks or cesspools, ground surface dumping, leaking storage tanks or pipelines, accidental spills, and leaking of chlorides from stockpiles.

Descriptors: Water pollution sources, surveys, groundwater pollution, United States.

022 American Water Works Association.

1967. Sources of nitrogen and phosphorus in water supplies: Am. Water Works Assoc. Jour., v. 59, no. 3, p. 344–366, 1 figs., 8 tables, 64 references.

Nitrogen and phosphorus nutrients are contributed to water in significant quantities from many manmade and natural sources. Nutrient contributions from various sources are presented in tabular form. The complete elimination of nitrogen and phosphorus nutrients from surface water supplies does not appear economically feasible because the sources are so widespread. Therefore, appropriate efforts must be made to cope with many of the problems that have been created, and increased effort must be devoted to the development of better methods for prevention of algal growth in reservoirs. A more concentrated effort to reduce the detrimental effects caused by eutrophication of water supplies is recommended.—W71-03577.

Descriptors: Water pollution sources, nitrogen, phosphorus, eutrophication.

023 Anderson, D. G.

1970. Effects of urban development on floods in northern Virginia: U.S. Geol. Survey Water-Supply Paper 2001-C, 22 p., 5 figs., 5 tables, 10 references.

Changes of land use in urban and suburban areas affect floodflows significantly. Improvements of drainage systems may reduce their lag times to one-eighth those of natural channels. This lag-time reduction, combined with the increased storm runoff resulting from impervious surfaces, increases flood peaks by a factor that ranges from 2 to nearly 8. Flood-peak magnitudes having recurrence intervals as long as 100 years may be estimated for drainage basins having different degrees of urban or suburban development. Five independent variables required to estimate flood peaks are the size, length, and slope of the basin, the percentage of impervious surface, and type of drainage system. Based upon analysis of flood information for 81 sites, 59 of which are in the Washington, D.C., metropolitan area, the relations should be useful for design of drainage systems and for definition of flood limits.—W71-06690.

Descriptors: Rainfall-runoff relationships, Virginia, District of Columbia, flood forecasting, storm runoff.

024 Anderson, H. W.; Wallis, J. R.

1965. Some interpretations of sediment sources and causes, Pacific coast basins in Oregon and California: U.S. Dept. Agriculture Misc. Pub. 970, p. 22–30, 5 tables, 16 references.

Sediment yield (erosion) varies between watersheds by a factor of 36 with differences in runoff potential, by a factor of 2 with differences in topography, and by a factor of 5 with differences in land use. Rain and snowmelt frequencies (by elevation zones and latitude) are tabulated. Erodibility indices of soil developed on some 27 different rock types are given.—W69-08501.

Descriptors: Sediment yield, sediment load, land use, erosion.

025 **Anderson, J. J.**
1970. Real-time computer control of urban runoff: Am. Soc. Civil Engineers Proc. Paper 7028, Jour. Hydraulics Div., v. 96, no. HY1, p. 153–164, 19 figs., 10 references.

A system of computer control and modernization of combined sewer overflow regulators uses a mathematical model of the hydraulics of urban hydrology. The system was installed to control the sewers of Minneapolis-St. Paul during stormwater runoff to improve the utilization of the existing interceptor sewers. Key stormwater regulators were modified to provide remote control of hydraulically operated gates and inflatable dams. Trunk sewer and interceptor sewer level-monitoring stations and rain gages are used as input to a mathematical model consisting of a rainfall-runoff model, a stormwater diversion model, and flood routing in the interceptor sewer. A high density monitoring system for river quality was installed to determine the effects on quality of runoff events and to evaluate the effectiveness of the control system.—W70-05882.

Descriptors: Water pollution control, digital computers, runoff, mathematical models.

026 **Anderson, J. J.**
1971. Case study on design of urban water data acquisition system, *in* Treatise on urban water systems, Albertson, M. L., Tucker, L.S., and Taylor, D. C., eds.: Fort Collins, Colorado State Univ., p. 557–596, 7 figs., 7 maps, 3 tables, 65 references.

This case study provides an introduction to the design of urban water data acquisition systems. A great deal of judgment is required concerning all aspects of urban water resources management, and a certain amount of trial and error is necessary. Fortunately, a computer-based data acquisition system is extremely flexible and can be revised easily. A trial design is outlined for acquiring data for major revisions to the waste water and surface water collection systems. The revisions might include lumped or distributed storage, relief or express sewers, transfer of flow between basins, and multiple facilities. The kinds of data needed concern surface water, rainfall, runoff, and waste water. Surface water information should include flow as well as quality measurements. Measurements should show the conditions before and after the addition of pollutants. Runoff data include flow and quality in both combined and separate storm sewer systems. Measurements should be taken at key junctions, major outlets, and treatment facilities. An attempt should be made to provide correlations with parameters measured on-line.

Descriptors: Data collections, instrumentation, model studies, storm runoff.

027 **Anderson, J. R.; Dornbush, J. N.**
1967. Influence of sanitary landfill on ground water quality: Am. Water Works Assoc. Jour., v. 59, no. 4, p. 457–470, 1 fig., 3 maps, 4 photos., 4 tables, 8 references.

A gravel pit area was selected for dumping of refuse by the city of Brookings, S.D. In order to collect information concerning the general quality of the ground water, the level of the ground-water table, and the direction of underground water movement, the city installed 11 well points at 5 different locations on the perimeter of the gravel-pit area. Water samples were collected at 3-month intervals and analyzed. The ground water leaving the 160-acre disposal site was not seriously impaired. The algae-laden pond located immediately downstream and receiving ground waters from the fill area is an important factor in reducing the hardness and alkalinity of these waters during the summer. Ground water in the immediate vicinity of and in direct contact with a refuse landfill can exhibit a significant increase in the concentration of dissolved minerals. These increases may be as great as three times that of the ground water not exposed to the fill operation.

Descriptors: Landfills, groundwater pollution, Brookings (S.D.), waste disposal.

028 **Anderson, P. W.; Faust, S. D.**
1965 Changes in quality of water in the Passaic River at Little Falls, New Jersey, as shown by long-term data: U.S. Geol. Survey Prof. Paper 525-D, p. D214–D218, 6 figs., 3 references.

A general increase in content of dissolved solids per unit volume of water and a 20 percent decrease in dissolved oxygen content of the Passaic River, N. J., is shown by preliminary analysis of 17 years (1947–64) of chemical quality and streamflow data. These trends occur during all months of the year and not only during months

having low streamflow conditions. The deterioration of quality of this water supply is attributed to the disposal of increasing volumes of municipal and industrial waste waters in the river basin.

Descriptors: Water pollution sources, water pollution effects, Passaic River (N.J.).

029 Anderson, P. W.; McCall, J. E.
1968. Urbanization's effect on sediment yield in New Jersey: Jour. Soil and Water Conserv., v. 23, no. 4, p. 142–144, 5 figs., 6 references.

In New Jersey streams, sediment yields are proportional to the degree of urbanization. The sparsely populated Pine Barrens yield 10–40 tons per square mile per year. The moderately heavily urbanized Delaware River area yields 25–100 tons generally and up to 500 tons near Philadelphia. The northwestern area of New Jersey is hilly with steep slopes and rapid runoff, but little urbanization; its sediment yields are 25–100 tons per square miles per year; while in the Trenton-New York City area, which is very heavily urbanized and probably has about the same topography as the northwestern area, yields are several thousand tons. Bacteria and organic content of water are also much higher in urban streams. In the Delaware River near Trenton, 5–25 percent of the suspended load is oxidizable. In the Stony Brook basin, about 48 square miles in area, 10 miles north of Trenton, the amount of sediment for a given rate of runoff has increased significantly with urbanization of the area from 1956 to 1958.—W69-00118.

Descriptors: Sediment yield, storm runoff, New Jersey, Delaware River, New York (N.Y.).

030 Angino, E. E.; Magnuson, L. M.; Stewart, G. F.
1972. Effects of urbanization on storm water runoff quality; a limited experiment, Naismith Ditch, Lawrence, Kansas: Water Resources Research, v. 8, no. 1, p. 135–140, 4 figs., 1 table, 9 references.

Storm water runoff is feasible as an auxiliary source of water providing the water is of proper quality. Water samples were collected in Lawrence, Kans., in dry weather periods, rainstorms, and snowmelts and evaluated for pH, residue (total, volatile, filterable), COD (chemical oxygen demand), BOD (biochemical oxygen demand), NO_3, Cl, and total alkalinity. Suspended solids concentrations during snowmelt and rainstorms do not differ; NO_3 is relatively high; COD averages 34 ppm. Other pollutants include Cr, 27 ppm; Br, 5 ppm; and Cl, 2,150 ppm; Pb concentrations in suspended solids were as high as 0.55 percent.

Descriptors: Storm runoff, water quality, water pollution sources, Lawrence (Kans.).

031 Annen, Gunther
1969. Calculation of peak discharge using time coefficients: GWF das Gas-und Wasserfach, v. 110, no. 12, p. 317–320, 6 figs., 9 references. [In German.]

Time coefficients may be used to calculate runoff quantity and the frequency of exceedence of the capacity of sewage or pumping works. The bases of the procedure are analysis of rainfall duration and frequency, travel time, outflow coefficients, and areal relationships of heavy precipitation. A nomograph shows the flow-time relationships.

Descriptors: Rainfall-runoff relationships, storm runoff, storm drains.

032 Antoine, Louis H., Jr.
1964. Drainage and best use of urban land: Public Works, v. 95, no. 2, p. 88–90, 1 fig., 1 photo., 2 tables.

Drainage channels in St. Louis, Mo., were designed for runoff from tributary watersheds of 400 or more acres. Rights-of-way sufficient to contain the improvement were delineated, and rough cost estimates were prepared to provide a basis for long-range planning of channels which would reduce or alleviate entirely the flooding of valuable lands. Projected land use maps were analyzed, and the impervious percentages were applied to various categories of land usage to calculate runoff factors. In general, severe flooding and resulting property damage are caused by sumps and sinkholes which do not drain readily and rapid land development with subsequent increases in amounts of runoff. In the project area two possible solutions to the potential of impounding excess runoff are based on retention in deep reservoirs, specifically in a small unused quarry and an actively producing large quarry.—W69-01559.

Descriptors: Floods, flood control, storm runoff, storm drains, St. Louis (Mo.).

033 Appleby, F. V.

1954. Runoff dynamics, a heat conduction analogue of storage flow in channel networks: Internat. Assoc. Sci. Hydrology pub. 38, p. 338–348, 1 fig., 1 photo., 1 table, 1 graph, 13 references.

The normal differential equation of storage flow may be developed into a form analogous to that for linear heat flow, where storage corresponds with temperature. Inherent in the resulting equations are two parameters, the outflow velocity and the storage transit factor which are, respectively, the response time and the mean time of concentration of the network. The product of these two factors is a characteristic length; and the product of this length and the surface width of flow at a control section when combined with area of flow at the outfall is the volume of storage. Volume of storage is directly analogous to diffusivity in heat flow and is a measure of the power of the system to eliminate its accumulated flood waters. Formulas are given for the lag of peak flow and the regulation of the peak under unit runoff conditions. Examples are given using runoff data from large catchment areas and urban drainage networks. The development of a heat conduction analog model is described, and it is applied to studies of the hydrograph of flow and in particular the study of brief inter-periodic correlation between runoff and rainfall.

Descriptors: Rainfall-runoff relationships, analog models, model studies, storm runoff, water storage.

034 Ardis, C. V.; Dueker, K. J.; Lenz, A. T.

1969. Storm drainage practices of thirty-two cities: Am. Soc. Civil Engineers Proc. Paper 6365, Jour. Hydraulics Div., v. 95, no. HY 1, p. 383–408, 13 figs., 12 tables, 12 references, app.

Wisconsin cities with populations of 7,500 to over 60,000 are rapidly developing comprehensive plans with all storm sewer designs by registered professional engineers. Storms with 5 to 10-year frequency are used in design. Storm water pollution is recognized, but only one-third of the cities have ideas on its alleviation. Urban drainage designers asked about current practice, policy, procedure, and cost information for a typical 15-acre, 6-block area produced wide diversity in results when using the rational method to compute flows. Only 6 of 23 cities which contributed sample designs used variable intensities correctly in the rational method. Error in the use of the runoff coefficient was common. The resulting designs gave flows of 68 to 100 cfs at outlet; total project costs varied from $8,000 to $65,000 for a sample area. The need for narrower guidelines for design is suggested.—W69-04551.

Descriptors: Storm drains, storm runoff, drainage systems, Wisconsin.

035 Association of Engineering Geologists; American Institute of Professional Geologists.

1969. The Governor's conference on environmental geology: Colorado Geol. Survey Spec. Publ. 1, 78 p., 3 figs., 8 maps, 8 photos., 3 tables, 14 references.

The Colorado Governor's Conference on Environmental Geology pertains mainly to the State, but it was also intended as a contribution to a broader understanding of the importance of environmental geology throughout the Nation. The topics discussed include: definition of environmental geology; the role of engineering geology in urban planning; urban growth and environmental geology; the Colorado Geological Survey's role in environmental geology; city, county, and State planning policies; natural resources, their protection, utilization and conservation; planning for disposal of oil shale, chemical wastes and mine wastes; ground water; approaches to prevention of water pollution; environmental design of urban storm runoff works; problem soil in Colorado; environmental aspects of Colorado street and highway engineering; and an environmental geology field trip.

Descriptors: Colorado, environmental geology, water resources development, hydrogeology, groundwater, engineering geology.

036 Atkinson, B. W.

1968. A preliminary examination of the possible effect of London's urban area on the distribution of thunder rainfall 1951–60: Inst. of British Geographers, Trans., no. 44, p. 97–118, 11 figs., 32 references.

The built-up area of London increases the local amount of thunder rainfall. Urban areas are similar to upland areas in their role of mechanical obstacle and thermal source. Three factors could account for the increase in

thunder rain over the city. First, the higher temperatures over the conurbation may give rise to a greater frequency and intensity of thermal convection. Secondly, the higher pollution levels in the city provide a greater number of condensation nuclei. Thirdly, there is a greater degree and a deeper layer of turbulence in the city owing to the increased roughness provided by buildings. The temperature differences are large enough to act as a localized thermal source in southeast England. The superdiabatic layer may be deepened and free convection may operate from the surface, whereas outside London, another mechanism is required to raise air to the level of free convection. Vapor pressures in London are often higher, so that the thermals rising from the city have greater chance of reaching their lifted condensation level sooner and at a lower altitude than their counterparts in the surrounding countryside.

Descriptors: Rainfall patterns, meteorology, London (England).

037 Atkinson, B. W.

1970. The reality of the urban effect on precipitation, a case-study approach: Geneva, Switzerland, Secretariat of the World Meteorological Organization, Tech. Note 108, WMO-no.254.TP.141, Urban Climates, v. 1, p. 342–360, 10 figs., 1 table, 15 references.

Thunderstorms which occurred over London, England, on August 21, 1959, were analyzed for the urban effect. Data from 608 rain gages revealed a marked localization of precipitation over the city with maximum amounts of 68 mm, and radar records showed that clouds developed over the urban area by 1200 G.m.t. and again at 1300 G.m.t. A synoptic trough lay north-west/south-east over the area, and convergence was strong over the London area. Weak divergence prevented cloud growth over neighboring high ground. Both wet and dry bulb temperatures at the surface defined a strong urban heat island over London by 1200 G.m.t. The storms were triggered by the high urban temperatures. Turbulence, potential condensation, and ice nuclei in the urban area played a negligible role in the initiation of the storms.

Descriptors: Precipitation (atmospheric), heat islands, rainfall patterns, thunderstorms, air temperature, London (England).

038 Australian Water Resources Council.

1969. Water resources research inventory 1969: Canberra, Australian Water Resources Council, Water Research and Education Steering Comm. Rept., 212 p.

An inventory of research into water resources and directly related matters in Australia, with brief reference to earlier work, is compiled from questionnaires circulated in mid-1968 and includes projects undertaken since 1964 or planned to commence during 1968–69. Subject index terms are allotted to each project so that a user may review all project titles associated with any given index term. Addresses of research institutions are given.—W71-08093.

Descriptors: Australia, water resources research.

039 Avco Economic Systems Corp.

1970. Storm water pollution from urban land activity: Federal Water Quality Adm., Water Pollution Control Research Ser. 11034-FKL-07/70, 325 p., 13 figs., 21 maps, 32 photos., 29 references, 14 app.

The pollution concentrations and loads from storm water runoff in an urban area were studied in Tulsa, Okla. The scope of the project included: a field assessment of the storm water pollution by obtaining samples of precipitation and surface runoff from test areas within the metropolitan area; development of an analytical procedure for correlation of storm water pollution with variables of land uses, environmental conditions, drainage characteristics, and precipitation; and development of a plan for implementing remedial measures. Storm water runoff samples were collected from 15 test areas in the Tulsa metropolitan area for laboratory analysis in terms of quality standards for BOD (biochemical oxygen demand), COD (chemical oxygen demand), TOC (total organic carbon), organic Kjeldahl nitrogen, soluble orthophosphate, chloride, pH, solids, total coliform, fecal coliform, and fecal streptococcus. Selected land use parameters, environmental conditions, drainage and precipitation data, along with storm water pollution factors, provided input data to enable assessment of pollution from storm water runoff. Recommendations were made for a plan of action for preventing and controlling storm water pollution from urban areas.—W71-00619.

Descriptors: Water pollution sources, land use, storm runoff.

040 (AVCO) Economic Systems Corp.

1968. A prefeasibility study of a comprehensive systems engineering analysis of all aspects of urban water, *in* Urban water resources research, first year report, Sept. 1968: Am. Soc. Civil Engineers, app. G, p. G1-G95, 6 figs., 6 tables, 27 references.

This study is an initial phase of development of systems analysis techniques for urban water resources research. It includes an assessment of possible effectiveness and design requirements of systems techniques. The underlying logic of the systems engineering technique is the development of an analytical model of the system operation and the mathematical procedure for calculating the optimum configuration of values. The modeling technique makes it possible to explore a wide range of reasonable alternatives in the search for an optimal solution. Interrelated problems resulting from design and development changes to meet changes in an entire urban water resource system are within the range of planning and systems analysis to provide maximum benefit at the least cost to the user.

Descriptors: Systems analysis, water resources development, optimization, water resources research.

041 Ayer, G. R.,; Pauszek, F. H.

1963. Creeks, brooks, and rivers in Rockland County, New York, and their relation to planning for the future: New York State Dept. Commerce Bull. 6, 140 p., 36 figs., 2 maps, 4 photos., 50 tables, 11 references, 1 app.

Drainage basin characteristics and water quality are discussed for each creek, brook, and river in Rockland County, N.Y. In general, the chemical quality of the surface water is satisfactory for many uses, but for use as a public water supply the level of dissolved solids must be reduced. The sediment load is a moderate problem. Streamflow varies because of precipitation, geography, and man's regulation. Water quality and flooding problems are caused by highway construction, urbanization, pollution, and changes in streamflow regimen.—W69–04036.

Descriptors: Water quality, flood control, sediment load, Rockland County (N.Y.).

042 Ayers, H. D.

1962. A survey of watershed yield: Australia, New South Wales Univ., Water Research Lab., Rept. 63, 82 p., 152 references.

A review and bibliography of methods used to predict watershed yield are presented. Stress is given to the effects of water yield improvement programs and to the effects of unplanned watershed changes.

Descriptors: Water yield, small watersheds, rainfall-runoff relationships.

043 Baffa, J. J.; Bartilucci, N.J.

1967. Wastewater reclamation by groundwater recharge on Long Island: Water Pollution Control Federation Jour., v. 39, no. 3, p. 431–445, 16 figs., 2 tables, 22 references.

The ground-water table on Long Island, N.Y., has dropped seriously where areas have been sewered and where withdrawal of ground water for water supply has continued. This has created the need for artificial recharge of the ground water to prevent salt-water intrusion. Renovation of waste water for this purpose is being studied, with removal of solids the primary requirement for economical injection. Preliminary studies involved filtration of trickling filter effluent through beds of anthracite and sand. Longer filter runs and better suspended solids removals can be obtained with the anthracite medium.

Descriptors: Artificial recharge, water reuse, groundwater depletion, groundwater pollution, Long Island (N.Y.).

044 Bandyopadhyay, M.

1972. Synthetic storm pattern and run-off for Gauhati, India: Am. Soc. Civil Engineers Proc., Paper 8887, Jour. Hydraulics Div., v. 98, no. HY 5, p. 845–857, 6 figs., 5 tables, 4 references, 2 app.

Factors generally not considered in the rational method are the effect of antecedent rainfall, as well as the time of peak intensity during the time of concentration. The rainfall-intensity-duration curve for a particular frequency indicates only average intensity. To determine at what time within the duration of storm the average intensity is to be applied, knowledge of storm pattern is necessary. Without this, proper application of the rational method in evaluating the effect of antecedent precipitation is not possible. A synthetic storm pattern was calculated from the rate-duration curve in the city of Gauhati in Assam, India. This storm pattern was used for the determination of the runoff coefficient in the rational method. Despite its limitations, the rational method was improved by considering the synthetic storm pattern. Furthermore, synthetic storms may be used in cases where field data are not available.

Descriptors: Rational formula, peak discharge, rainfall-runoff relationships, depth-area-duration analysis.

045 Barnwell, W. W.; George, R. S.; Dearborn, L. L.; and others

1972. Effects of urban development, *in* Water for Anchorage—an atlas of the water resources of the Anchorage area, Alaska: Alaska, City of Anchorage and the greater Anchorage area borough, p. 56–67, 7 maps, 5 photos., 1 table, 3 graphs.

Urbanization is steadily altering the hydrologic regimen of the Anchorage, Alaska, lowlands and is causing many new problems. Pumping of aquifers is lowering ground-water levels. In addition to variations in rainfall and the effect of drainage ditches, the construction of sanitary sewers and storm drains has also contributed to water-level declines in some areas. During the past 10 years, low-lying, muskeg-covered land has been drained and developed for residential and commercial use. High fecal coliform counts have been recorded downstream from urbanized areas in the water from Chester and Campbell Creeks. The channel of Chester Creek has been straightened and lowered. Buildings and pavement cover many formerly permeable areas. The net effect of these changes has been reduction in ground-water levels, a decrease in average annual flow of the stream, and more rapid rises and declines in the flow of the creek. As a result of increasing use of septic tanks, shallow-well users in areas without sewer service can probably expect increased water pollution.

Descriptors: Water pollution effects, groundwater depletion, storm runoff, floods, Anchorage (Alaska).

046 Bauer, K. W.

1965. Determination of runoff for urban storm water drainage system design: Southeastern Wisconsin Regional Planning Comm., Tech. Rec., v. 2, no. 4, 19 p.

Storm water runoff determinations are used to determine design criteria for urban drainage systems. The storm water runoff determination is usually by the rational method, of which the variables are the coefficient of runoff, rainfall intensity for the area, time of concentration, and soil characteristics. The correct application of these criteria should promote common storm sewer design methods and the adoption of common design methods for storm water drainage systems.

Descriptors: Storm runoff, rainfall-runoff relationships, rational formula, drainage (urban).

047 Bauer, K. W.

1965. Determination of runoff for urban storm water drainage system design: Southeastern Wisconsin Regional Planning Comm., Tech. Rec. (SEWRPC), v. 2, no. 4, 19 p., 12 figs., 9 tables, 2 maps.

A study of design criteria for urban storm-water drainage systems was incorporated in the first comprehensive watershed planning program undertaken by the Southeastern Wisconsin Regional Planning Commission. It is recommended that the rational method be used for the determination of storm-water runoff for urban storm-water drainage design within the region. The rational method, properly understood and applied, can produce satisfactory results for urban storm-sewer design. Good design practice limits its application to small drainage areas not exceeding five square miles in area. Application of the rational method to a design problem requires determination of the following basic data: drainage area tributary to point under design, existing and probable future land use, soil and slope characteristics, rainfall intensity-duration-frequency data, time of concentration, and tentative arrangement of the proposed drainage system to permit division of the whole drainage area into the components parts tributary to each section of the system.—W69-01560.

Descriptors: Rational formula, Wisconsin, rainfall-runoff relationships, depth-area-duration analysis.

048 Bauer, W. J.

1962. Economics of urban drainage design: Am. Soc. Civil Engineers Proc. Paper 3321, Jour. Hydraulics Div., v. 88, no. HY 6, pt. 1, p. 93–114, 5 figs., 1 map, 8 references.

The problem of urban-drainage design is primarily one of space allocation. In spite of large investments in storm sewers in urban areas, the problems associated with severe rainstorms cannot be solved without a system of controlling the location of water in a watershed during and after periods of excessive rainfall. In planning either new systems or improvements to existing systems, four steps are recommended: (1) allocate sufficient space for the volume of water that will temporarily occupy space during severe storms, (2) consider the cost of downstream storage in evaluating the economic justification of transportation systems, (3) strive for multiple-purpose use of space for temporary storage of storm water, and (4) restrict the construction of damageable structures in flood plains and in other areas subject to flooding.

Descriptors: Storm runoff, storm drains, planning, Chicago (Ill.).

049 Bauer, W. J.

1969. Urban hydrology, *in* International seminar Hydrology Professors, 1st, Urbana, Ill., July 13–25, 1969, Proc.: Urbana, Illinois Univ., Dept. Civil Eng., v. 2, p. 605–637, 3 figs., 3 tables.

Practicing consulting engineers are concerned with the following aspects of urban hydrology: the controlling economic factors, the need for improved analytical and design techniques, and the use of simplified methods pending the gathering of data required for the use of improved techniques. Storm runoff takes up valuable space and is generally polluted. The volume of runoff is more important than the rate of runoff for design purposes. The planner should design facilities for large storage and small rates of outflow because of the high cost of treatment at high rates of flow for short periods of time. All methods of analysis of storm runoff and the associated flow in open channels involve the use of mathematical models. Every decision regarding storm drainage, even one to do nothing, involves an allocation of space for the temporary storage of storm water and therefore involves acceptance of the cost associated with that decision.—W71-01822.

Descriptors: Storm runoff, rainfall-runoff relationships, flood routing, model studies.

050 Baxter, S. S.

1968. Effects of urbanization: Water Resources Bull., v. 4, no. 1, p. 51–56.

Existing urban water problems and the types of remedial research needed are reviewed. Particular stress is placed on economic, social, and political factors involved. Shortages and failure in water supply, needed water pollution control, flooding caused by undersized storm sewers, and fire losses resulting from low water pressures are the major water problems complicated by growing urbanization. Increased federal funding, particularly under various water quality acts, has lessened local and State control problems. Although basic research may provide a breakthrough in water knowledge, there is need to apply more fully what is already known to meet the growing problems as they occur.—W68-00333.

Descriptors: Floods, water pollution sources, water management (applied).

051 Beard, L. R.

1967. Hydrologic simulation in water-yield analysis: Am. Soc. Civil Engineers Proc. Paper 5134, Jour. Irrig. Drainage Div., v. 93, no. IRl, p. 33–42, 1 fig., 2 tables, 5 references.

Storage capacities required to maintain specific yields were determined independently for each half of 12 long-term streamflow records on unregulated streams. In two-thirds of the cases, design varied by a factor of 2, indicating the inadequacy of design based upon the repetition of past streamflows. A method is described for generating monthly streamflows that have the basic frequency and persistence characteristics of the recorded data. The advantage of simulating streamflow is that any length of record can be generated and that the expected benefits and the statistical consequences of the amount of storage capacity can be determined.—W69-05849.

Descriptors: Simulation analysis, water yield.

052 Beard, L. R.

1968. Hypothetical flood computation for a stream system: Internat. Assoc. Sci. Hydrology Pub. 80, v. 1, p. 258–267, 4 figs., 1 table.

The flood hydrograph package of computer programs performs all common operations in deriving and using flood hydrographs. One of the problems soluble by this program is flood computation throughout an entire hydrologic system in one operation. Essential features of the computer package and the simplified stream system analysis are described.—W69-08239.

Descriptors: Routing, flood forecasting, rainfall-runoff relationships, computer programs, mathematical models.

053 Beeton, Alfred M.

1969. Changes in the environment and biota of the Great Lakes, *in* Eutrophication, causes, consequences, correctives, Symposium Proc.: Washington, D.C., Natl. Acad. Sci., Natl. Research Council, p. 150–187, 11 figs., 3 maps, 1 table, 76 references.

The idea that the Great Lakes are undergoing accelerated eutrophication is recent. Environmental changes can be considered in three categories: pollution of inshore areas, long-term changes in open waters, and changes in sediments. Lakes Superior, Michigan, and Huron are oligotrophic; Lake Erie is eutrophic; and Lake Ontario is in an intermediate condition. Lakes Michigan and Huron have undergone changes of dissolved oxygen, total dissolved solids, and biota which indicate increasing eutrophy, especially in Green and Saginaw Bays. Lake Erie has shown major changes in limnological factors and biota; effects of increased pollution and eutrophication of Lake Erie have spread to Lake Ontario. The most important sedimentary changes are caused by the contribution of large quantities of allochthonous materials resulting from urbanization and industrialization. Changes in sediments are important factors in the observed changes in limnological factors and fish populations. Abatement of present conditions in Lake Erie is theoretically possible.—W70-07269.

Descriptors: Eutrophication, Great Lakes, water pollution sources.

054 Behnke, J. J.; Haskell, E. E., Jr.

1968. Ground water nitrate distributions beneath Fresno, California: Am. Water Works Assoc. Jour., v. 60, no. 4, p. 477–480, 1 fig., 7 references.

Approximately 50 wells in a 12-square-mile area in the northeastern section of Fresno, Calif., were sampled and analyzed for nitrate. Areas of increased concentration are located directly beneath the Clovis sewage treatment plant and under a subdivision containing individual septic systems. Unlined irrigation ditches may also influence the nitrate distribution.

Descriptors: Nitrates, groundwater, water pollution sources, Fresno (Calif.).

055 Benson, M. A.

1963. Factors influencing the occurrence of floods in a humid region of diverse terrain: U.S. Geol. Survey Water-Supply Paper 1580-B, 64 p., 9 figs., 1 map, 4 tables, 29 references.

Relations between flood peaks and hydrologic factors are discussed for a humid region with limited climatic variation but a diversity of terrain. Statistical multiple-regression techniques were applied to hydrologic data on New England. Drainage area size was the most important factor, and main-channel slope was next in importance. A simple yet efficient index of main-channel slope was developed. Multiple-regression equations relate peak discharges of 1.2- to 300-year recurrence intervals to six hydrologic variables, three of the variables are topographic, two are climatic, and one is orographic. The effect of urbanization is to increase peak discharges, but it is difficult to evaluate numerically because too few gaged basins exist within wholly or partly urbanized areas, and during the periods of gaged discharges there has been continual variation in the degree of urbanization.

Descriptors: Rainfall-runoff relationships, floods, peak discharge.

056 Berghinz, Carlo

1971. Venice is sinking into the sea: Civil Eng., v. 41, no. 3, p. 67–71, 1 map, 3 photos., 2 tables.

Venice, Italy, was founded 1,400 years ago on lowland in the middle of a shallow lagoon 35 miles long and 6 miles wide. Today, storm surges of water frequently flood the low-lying city, damaging her historic buildings. What is worse, the city is subsiding, largely due to ground-water drawdown and nearby industrial construction. Sea barriers have been proposed; they would create a new problem because Venice has no sewerage system and needs the tidal flush. As interim steps, the city's artesian wells are being progressively closed, and no oil or gas drilling is permitted. Many more steps must be taken to save the city.—W71-06120.

Descriptors: Land subsidence, groundwater, drawdown, Veince (Italy).

057 Berk, R. G.
1966. A storm drainage and open space master plan for Hamilton County, Ohio: Cincinnati, Ohio, Hamilton County Regional Plan. Comm., 77 p., 13 figs., 2 pls.

A planning study of Hamilton County, Ohio, provides a complete inventory of all streams having drainage areas greater than 300 acres. Complete physical characteristics of the drainage structures and the intervening reaches of their streams are given. The data may be used for determining floodflows, present and future flood hazards, their location and extent, erosion and siltation problems, and open space needs.

Descriptors: Drainage systems, storm runoff, Cincinnati (Ohio).

058 Bhatnagar, A.
1969. Determination of storm runoff by the use of infiltration index: Internat. Assoc. Sci. Hydrology Pub. 85, p. 804–810, 2 figs., 1 table, 4 references.

Storm runoff can be estimated accurately by estimates of interception, retention, and an infiltration index which includes other minor losses such as evaporation and transpiration. Hydrological data of 17 representative catchments in central India were analyzed to estimate initial losses and infiltration indices during storms. A relation between infiltration index, the antecedent precipitation index, storm rainfall, and storm duration was also estimated for the region. If storm duration, storm rainfall, and antecedent precipitation conditions are known, the infiltration index during a storm can be determined. Storm runoff can then be estimated by subtracting initial loss and infiltration index from storm rainfall rates.—W71-04397.

Descriptors: Storm runoff, depth-area-duration analysis, India.

059 Bidwell, V. J.
1967. Time analysis of rainfall on an urban catchment: New Zealand Jour. of Hydrology, v. 6, no. 2, p. 74–79, 3 figs., 2 references.

Short-duration rainfall was analyzed at Auckland, New Zealand. For urban catchments, the time of concentration, runoff, and other time parameters involved are relatively short, and thus the urban rainfall increment used for runoff analysis is short. In this analysis it is 10 minutes. An arbitrary division of the rainfall time series into storms of varying periods uses a critical time lag. This lag is a measure of the rainfall persistance, and the probability of occurrence of any rainfall event is assumed to be independent of an event which occurred at a time longer than the value of the critical time lag beforehand. Storm duration and total rainfall depth were correlated from the historical record to give synthetic values. A complete year (1965) of 10-minute rainfall values was extracted from autographic records for Albert Park, Auckland, New Zealand, for analysis—W69-01561.

Descriptors: Rainfall-runoff relationships, model studies, time of concentration, storm runoff, simulation analysis, Auckland (New Zealand).

060 Biesecker, J. E.; Lescinsky, J. B.; Wood, C. R.
1968. Water resources of the Schuylkill River basin: Harrisburg, Pennsylvania Dept. of Forests and Waters, Water Resources Bull. B–3, 198 p., 74 figs., 68 tables, 95 references, 1 app.

The water resources of the Schuylkill River basin, Pa., are evaluated by comprehensive study of ground-water and surface-water quantity, quality, and use. Special attention is given to the effects of coal mining,

urbanization, and the effects of restoration and water pollution control of the Schuylkill River. In many parts of the basin, human activities are the most important hydrologic factors. Coal mining affects both ground-water and surface-water quality in the headwaters and affects the quality of the entire main stem of the river. Philadelphia diverts up to 91 percent of the streamflow of the streamflow of the Schuylkill for public supply. Pumping is lowering ground-water levels in many areas. Mean annual runoff is 21.5 inches, or 48 percent of the annual precipitation of 44.7 inches. The population of the basin is 1.47 million, 91 percent served by public supply. The water problems of the basin result mainly from inadequate municipal water systems and degradation of sources by pollution.—W69-08744.

Descriptors: Water resources development, water pollution sources, Philadelphia (Pa.), Schuylkill River (Pa.).

061 Bishop, W. D.; Carter, R. C.; Ludwig, H. F.
1967. Water pollution hazards from refuse-produced carbon dioxide, *in* Advances in water pollution research, Third Internat. Conf. on Water Pollution Research, Munich, Germany, Sept. 1966, v. I, Proc: Washington, D.C., Water Pollution Control Federation, p. 207–228, 2 figs., 1 map, 4 photos., 5 tables, 12 references.

The Los Angeles, Calif., metropolitan area has more than 6,000,000 inhabitants and produces over 12,000 tons of municipal refuse per day. Landfilling is the least expensive of the available disposal methods. With the increasing use of landfills for disposal, there is concern over possible ground-water degradation. Refuse-produced gases are potential ground-water pollutants. Carbon dioxide is especially important because of its relatively high solubility in water, and some carbon dioxide impairment was reported in the main San Gabriel basin. A pilot-scale refuse landfill was studied for estimating the rates of movement of refuse-produced gases into the surrounding soil. The quantities of carbon dioxide moving into the soil agreed very closely with theoretical values based on Fick's law of diffusion. From 15 to 20 times more carbon dioxide passed upward through the one-foot silt cover than passed into the soil. Much of the carbon dioxide (30 percent or more) can be expected to remain at the bottom of the landfill for many years, and some of it passes into the ground.

Descriptors: Water pollution sources, landfills, waste dumps.

062 Bock, Paul
1958. A study of urban rainfall-runoff relations: Baltimore, Md., Johns Hopkins Univ., PH.D. thesis, 230 p., 17 figs., 41 references.

Urban rainfall-runoff relations were studied using several years of measurement of flows into storm water inlets and of flows in storm drains in Baltimore City and Baltimore County. The rate of flow into storm water inlets is primarily a function of the degree of imperviousness of the watershed and the magnitude of rainfall during the most intense parts of storms. Estimated inlet flows are combined to calculate the discharge at any point in the storm drainage system. Estimates of runoff rates correspond with the measured storm runoff better than any previously used method for estimating flows in storm drains.

Descriptors: Rainfall-runoff relationships, runoff forecasting, storm runoff, Baltimore (Md.).

063 Boughton, W. C.
1970. Effects of land management on quantity and quality of available water: Australian Water Resources Council, Research Rept. 120, 330 p.

This review and bibliography of the hydrologic effects of land management by the Australian Water Resources Council compiles the important sources of information with emphasis on Australian work. Overseas literature was searched largely for principle and methodologies. A major change that has occurred since settlement of Australia by Europeans is that large areas of native bush have been cleared for pasture or crops with apparent effects on the hydrologic cycle. An increase has been noted in total runoff in some stream basins, and the change from trees to grasses and crops has resulted in higher saline ground-water levels at the foot of slopes and in valleys. Subsequent salting of large areas is evident as water evaporates from the shallow ground-water bodies. Increased erosion has occurred, and turbidity levels in streams have risen. The report also cites work in progress and needed investigations. The bibliography contains 1,092 references distributed under 11 subject chapters.—W71-02452.

Descriptors: Water pollution sources, water pollution effects, bibliographies, land use, Australia.

064 Bourodimos, E. L.; Oguntase, A.

1971. Hydrodynamics and discharge measurements of storm sewers: New Brunswick, N.J., Rutgers Univ., Water Resources Research Inst., 13 p., 4 figs.

Theoretical and experimental research papers on gradually varied unsteady flows in storm sewers were reviewed for practical applications for storm runoff in urban areas. Lateral inflow dynamics (spatially varied flow) is used with mathematical modeling of diffusional processes to calculate flows in storm sewers. Other phases of the program are fieldwork, experimental laboratory study on a simplified sewer model, and comparison of theoretical predictions with field and laboratory data.—W71-08496. PB-199-712.

Descriptors: Storm drains, storm runoff, reviews, mathematical models.

065 Bowie, A. J.

1971. Pigeon Roost Creek Watershed; Toby Tubby Creek Watershed, Oxford, Mississippi, *in* Agricultural Research Service precipitation facilities and related studies, Hershfield, D. M., ed.; U.S. Dept. of Agriculture, Agricultural Research Service, Rept. ARS41-176, p. 43–50, 3 figs., 5 tables.

A sedimentation research project in the Pigeon Roost Creek Watershed, Marshall County, Miss., was initiated by the U.S. Department of Agriculture in September 1956. Studies on Toby Tubby Creek watershed at Oxford, Miss., began during the latter part of 1959. The gaging site for this 1,000-acre urban watershed is located adjacent to the sedimentation laboratory. The objectives of this study are to furnish precipitation data useful in studies of runoff, sediment yields, ground-water recharge, and the potential of rainfall to cause erosion. Precipitation data have been collected for 13 years on the Pigeon Roost Creek watershed and 9 years on the Toby Tubby Creek watershed. A long-term (48 years) precipitation record is available for comparison with the Pigeon Roost Creek precipitation data.

Descriptors: Sediment yield, rainfall-runoff relationships, Oxford (Miss.).

066 Brannan, R. W.

1962. Drainage problems in an area changing from rural to urban: Public Works, v. 93, no. 10, p. 193–196.

In Lucas County, Ohio, as long as watercourses served only to drain agricultural and forested areas, no more than 5 percent of the rainfall found its way immediately to creeks. As urbanization took place, residential subdivisions, parking lots, commercial buildings, schools, churches, driveways, highways, sidewalks, and other impervious improvements were made. Runoff increased rapidly, and the capacity of the natural watercourse was soon exceeded. As the choicer lands at higher elevations were improved, the lower-lying lands became more desirable for improvements. They in turn were developed, and they added to the storm water. Peak discharges rose to new highs and inundated lands that had never before been subject to flooding. High-water damage occurred at more frequent intervals. Accompanying this was physical deterioration of the stream. This further reduced the ability of the stream to transport sediment, and as a result deposits formed. At an increasing rate, the shape and frictional characteristics of the stream changed so that it had less capacity for the simultaneously increased runoff demand.—W69-01523.

Descriptors: Storm runoff, floods, rainfall-runoff relationships, Lucas County (Ohio).

067 Brashears, M. L., Jr.

1941. Ground-water temperature on Long Island, New York, as affected by recharge of warm water: Econ. Geology, v. 36, no. 8, p. 811–828, 1 fig., 1 map, 4 tables.

Ground water is often more economical than surface water for cooling purposes because of its lower temperature. On Long Island, N.Y., many supply wells have been drilled for cooling purposes. Since 1933, cooling water has been returned to the ground. The amount of recharge during the cooling season increased from about ½ million gallons a day in 1933 to 30 million gallons a day in 1940. The temperature of the water returned to the ground ranges from 2 to 20 degrees higher than the temperature of the water pumped from the ground. The return of warm water causes a rise in ground-water temperature, and this decreases the advantage of using ground water for cooling purposes. Since 1936 the return of warm water has caused a rise of water temperature as much as 20 degrees at some of the pumping wells. Ground-water temperatures have increased in a considerable part of western Long Island.

Descriptors: Water temperature, recharge wells, thermal pollution, groundwater pollution, Long Island (N.Y.).

068 Brater, E. F.
1968. Steps toward a better understanding of urban runoff processes: Water Resources Research, v. 4, no. 2, p. 335–347, 9 figs., 20 references.

Rainfall and runoff from drainage basins in various stages of urbanization were analyzed to determine the initial retention, the hydrologically significant impermeable area, and the infiltration capacities of the permeable portions of the basins. The drainage basins, ranging in size from 9.5 to 185 square miles, are located in the Detroit metropolitan area. Infiltration capacities in this region are from 3 to 5 times higher in late summer than in early spring. The average initial retention for the basins studied is approximately 0.2 inches. The hydrologically significant impermeable area appears to be closely related to the population density.—W69-03097.

Descriptors: Rainfall-runoff relationships, surface runoff, storm runoff.

069 Brater, E. F.; Sangal, Suresh
1969. Effects of urbanization on peak flows, *in* Effects of watershed changes on streamflow, Moore, W. L. and Morgan, C. W., eds., Water Resources Symposium No. 2, Oct. 1968, Austin, Tex.: Austin, Texas Univ. Press, p. 201–214, 8 figs., 36 references.

Urbanization results in impermeable surfaces in parts of drainage basins. The magnitude of impermeable areas must be considered in computing infiltration capacity and peak runoffs. The hydrologically significant impermeable area is probably smaller than the actual impermeable area, and there is evidence that it is related to population density. For basins near Detroit the significant impermeable area varies from 1 percent to 10 percent of basins for population densities varying from about 500 to 7,000 per square mile. Many routing techniques may provide the basis for a methematical model of the hydraulics of storm runoff. One method of evaluating the influence of urbanization on the runoff hydrograph is to study relationships between unit hydrograph shape parameters and drainage basin characteristics.—W70-04576.

Descriptors: Rainfall-runoff relationships, storm runoff, routing, mathematical models.

070 Bravo, S.; Carlos, A.; Harley, B. M.; and others.
1970. A linear distributed model of catchment runoff: Massachusetts Inst. of Technology, Hydrodynamics Lab. Rept. 123, 147 p., 40 figs., 4 tables, 18 references, 5 app.

A distributed linear model of direct catchment runoff simulates complex drainage areas by a network of overland flow and streamflow elements in which the one-dimensional equations for unsteady flow in a channel are assumed to govern. Solutions of these equations for suitable boundary conditions are obtained in the form of unit impulse response functions. Based on linear systems theory, any output may be estimated by performing the convolution operation between these impulse response functions and given inflows. The linear model was introduced into the M.I.T. catchment model as an alternative to the existing kinematic model.—W70-09831. PB-194-289.

Descriptors: Mathematical models, rainfall-runoff relationships, unsteady flow, routing, computer programs.

071 Brickell, R. G.
1968. The Maungaraki development: New Zealand Eng., v. 23, no. 3, p. 95–100.

Hilly land was developed for housing in the Wellington area of New Zealand. Problems arising from the development include erosion control, compaction control, and removal of unsuitable materials. Disposal of storm-water runoff was complicated by restriction of disposal of peak flows reaching the main storm-water system to the capacity of the culvert. The problem was solved by the use of flood-control dams, which store the flood waters and let them discharge at a controlled rate.—W69-01775.

Descriptors: Storm runoff, water pollution control, drainage (urban), Wellington (New Zealand).

072 Briggs, W. M.
1969. Roadside erosion survey: Soil Conservation, v. 35, no. 2, p. 27–28, 1 fig., 2 photos., 1 table.

A survey was made of roadside soil erosion in Wisconsin. More than 21,000 sediment-producing sites on 87,000 miles of road total 3,711 miles of erodible roadside. Town and country roads account for 97 percent of the erosion. Erosion control recommendations include seeding, mulching, sediment-control structures, and property acquisition.—W70-02327.

Descriptors: Erosion, erosion control, highways, Wisconsin.

073 **Brockel, H. C.**
1968. The Milwaukee River: Milwaukee, Wis., Milwaukee River Tech. Study Committee, Report, 163 p., 5 figs., 5 maps, 43 photos., 11 tables, 62 references.

The problems of the Milwaukee River, Wis., were inventoried, and recommendations are listed for improvment of the river for aesthetic and recreational uses for the city of Milwaukee. The present quality of the river water and banks is surveyed and compared with past conditions, as well as present conditions of rivers in other cities. The Milwaukee River can be a great asset to Milwaukee with a reasonable expenditure of time, money, and effort. The present blighted condition of the river banks in the downtown area should actually help in land acquisition for restoration, because it has depressed land prices. San Antonio, Tex., is used as an example of what a city can do in restoring a river for public enjoyment.—W69-09703.

Descriptors: Rivers, aesthetics, recreation, Milwaukee River (Milwaukee, Wis.).

074 **Broecker, W. S.; Schwartz, B.; Sloan, N.; Ancona, P.**
1971. Road salt as an urban tracer, *in* Street salting, urban water quality workshop, Syracuse, N.Y., May 5–6, 1971, Symposium Proc.: Syracuse, N.Y., Syracuse Univ., College of Forestry, p. 24–38, 6 figs., 4 maps, 2 tables, 1 reference.

Road salting affects the quality of waters in the suburban area northwest of New York City. The area studied is the drainage basin of the Hackensack River. The total amount of salt added to the roads of Bergen County, N.J., in the winter of 1969–70 was 150,000 tons. If the road salt from the 1969–70 winter were uniformly dissolved in the runoff water for 1 year, the average chloride ion concentration would be 40 ppm. Adding the background level of about 10 ppm gives 50 ppm for the expected mean annual chloride concentration. The chloride ion content of Oradell Reservoir, through which much of the drainage from Rockland and northern Bergen County passes, was 40 ppm.

Descriptors: Water pollution sources, deicers, highway deicing, New Jersey.

075 **Brown, S. G.**
1963. Problems of utilizing ground water in the west-side business district of Portland, Oregon: U.S. Geol. Survey Water-Supply Paper 1619-0, p. 01–042, 4 figs., 1 map, 1 graph, 4 tables, 8 references.

Withdrawal of ground water for industrial uses and for the heating and cooling of buildings in the west-side business district of Portland, Oreg., has increased greatly since 1955. As a result, ground-water levels are declining, even though some of the water withdrawn is returned by means of artificial recharge. Temperature and chemical quality of the ground water also are changing due to the increased pumping and the practice of recharging with water of different temperature and chemical composition from the natural ground waters. Marine sedimentary rocks that underly the aquifers contain saline water, which is migrating upward. With continued uncoordinated increases in pumped withdrawal and artificial recharge the problems of declining levels and changes in the temperature and chemical quality of the ground water probably will increase.

Descriptors: Groundwater depletion, groundwater pollution, Portland (Oreg.), saline water intrusion, water pollution sources.

076 **Brownlee, R. C.; Austin, T. A.; Wells, D. M.**
1970. Variation of urban runoff with duration and intensity of storms: Lubbock, Texas Technological Univ., Water Resources Center, Interim Rept. WRC-70-3, 68 p., 12 figs., 30 tables, 10 references.

Concentrations of pollutants carried by the storm runoff from a small residential watershed and the variations of pollutant concentrations with the duration of runoff were determined. Average total dissolved solids,

nitrates, and the average pH value of storm runoff are within the USPHS standards for drinking water, but solids concentrations and total alkalinity concentrations are as bad as those found in raw sewage. Average BOD (biochemical oxygen demand) concentration is approximately the same as that of secondary sewage treatment effluent. Regression and correlation analyses indicate a definite reduction in all concentrations with duration of runoff. Rainfall intensities, antecedent moisture conditions, storm movements, and other parameters also influence this relationship.—W71-01546.

Descriptors: Storm runoff, water pollution sources, urban runoff, combined sewers.

007 Bryan, E. H.
1965. Water supply and pollution control aspects of urbanization: Law and Contemporary Problems, v. 30, no. 1, p. 176–192, 2 tables, 18 references.

The need to develop new technical approaches and suitable legal and political structures for the control of pollution on a regional basis is discussed from a civil engineering viewpoint. Water supply and pollution are properly approached as aspects of a single problem. Water resources are inexhaustible provided the quality of waste water is sufficiently improved prior to its return, thus keeping waterways in satisfactory condition and enabling downstream users to withdraw water of useable quality. Water is an important transport medium for wastes in community systems, and costs are the greatest obstacle to effective pollution control when this water is returned to waterways. Urbanized America must have technically sound water management. The extent of industrial water consumption and the shift of population in Florida from rural to urban areas are illustrated using tabulated data.—W69-00290.

Descriptors: Water pollution control, water supply, Florida.

078 Bryan, E. H.
1970. Quality of stormwater drainage from urban land areas in North Carolina: Chapel Hill, North Carolina Univ., Water Resources Research Inst., Rept. 37, 43 p., 2 figs., 13 tables, 15 references.

Urban storm water from a 1,067-acre drainage basin in Durham, N.C., with a population density of 9 persons per acre produces an annual BOD (biochemical oxygen demand) load approximately equal to the contribution of the area's secondary waste-water treatment plant. Total organic matter exceeds the amount in raw sanitary sewage from a residential area of the same size. Mean basin yields (pounds per acre per day) are: BOD 0.23, COD (chemical oxygen demand) 2.85, total solids 43.6, volatile total solids 4.8, total phosphate 0.01, and chloride 0.20 (as NaCl). The concentration of total pesticides (Dieldrin, DDE, DDT, and DDD) weighted for flow significance is estimated to be 1.2 parts per billion.—W71-01360. PB-195-781.

Descriptors: Water pollution sources, storm runoff, pollutant identification, North Carolina.

079 Bubeck, R. C.; Diment, W. H.; Deck, B. L.; and others.
1971. Runoff of deicing salt; effect on Irondequoit Bay, Rochester, New York, *in* Street salting, urban water quality workshop, Syracuse, N.Y., May 5–6, 1971, Symposium Proc.: Syracuse, N.Y., Syracuse Univ., College of Forestry, p. 39–47, 4 figs., 13 references.

Salt used for deicing streets near Rochester, N.Y., has increased the chloride concentration in Irondequoit Bay at least fivefold during the past two decades. During the winter of 1969–70, the density of the saline runoff that accumulated on the bottom of the bay was sufficient to prevent complete vertical mixing of the bay during the spring. Comparison with 1939 conditions indicates that the period of summer stratification has been prolonged a month by the density gradient imposed by the saline runoff.

Descriptors: Water pollution sources, deicers, highway deicing, Rochester (N.Y.).

080 Bullard, W. E.
1965. Effect of highway construction and maintenance on stream sediment loads: U.S. Dept. Agriculture Misc. Pub. 970, p. 52–56.

Thousands of miles of freeway, highway, country roads, and forest access roads are built in the United States every year. Nearly all this construction is in watersheds, and all involves soil disturbance. Whenever there is soil

disturbance, there is a potential sediment source; too often in highway construction this potential sedimentation actually occurs. Maintenance operations subsequent to construction often accelerate the process. The adverse effects of road construction and maintenance on stream sediment loads and methods to avoid or reduce these effects are described.

Descriptors: Sediment yield, highways, road construction.

081 Bullard, W. E.
1966. Effects of land use on water resources: Water Pollution Control Federation Jour., v. 38, no. 4, p. 645–659.

Land use, among other factors, determines the quality of water in runoff. Erosion causes turbidity and sedimentation, lowers water quality, and damages aquatic life habitats. Fertilizers, pesticides, and other toxins and nutrients contribute to pollution. Agriculture, timber, mining, urban runoff, and recreation also are pollution contributors.—W69-01564.

Descriptors: Land use, water pollution sources, drainage (urban).

082 Burby, R. J., III
1967. Lake-oriented subdivisions in North Carolina; decisions, factors, and policy implications for urban growth patterns: North Carolina Univ., Water Resources Research Inst., Rept. 9, 177 p., 6 figs., 18 tables, 53 references, 4 app.

Land developers are innovative when they must compensate for bad site characteristics, when the innovative practices make up for their loss of revenue due to poor sites, and when the developer can save on other costs. Lake-oriented subdivisions are a growing phenomenon in North Carolina, and some serious problems arise from this use of lakes. These developments can cause threats to public health and safety due to improper design of dams, the problem of water pollution as a result of the use of septic tanks, and the question of ownership of the lake.—W68-00849.

Descriptors: Lakes, recreation, suburbs, North Carolina.

083 Burch, L. A.
1969. Solid waste disposal and its effect on water quality: California Vector Views, v. 16, no. 11, p. 99–113, 3 figs., 1 table, 32 references.

The disposal of solid wastes can cause impairment of ground- or surface-water quality. The complex relationships between solid waste disposal and water quality are summarized in this general discussion. Many types of municipal, industrial, and agricultural solid wastes may be sources of water pollutants. Some of the more significant studies have been conducted in California. Solid wastes can be sources of water pollutants by physical removal, leaching, and gas production. The resulting water quality impairment is in the form of floating debris, increased mineral content, discharge of micro-organisms, and potential release of toxic substances. Soluble materials may be leached out of a landfill resulting in pollution of ground water. Carbon dioxide may also cause increased hardness and corrosiveness of the ground water. Surface water can be impaired by dumping solid wastes directly into the water or by erosion of portions of landfills located in flood plains during floods. Measures available for control and prevention of water quality problems from solid waste disposal are also briefly discussed. Appended to the paper is a comprehensive list of references.

Descriptors: Landfills, water pollution sources, California.

084 Burgess and Niple, Ltd.
1969. Stream pollution and abatement from combined sewer overflows, Bucyrus, Ohio: Federal Water Pollution Control Adm., Research Ser. 11024-FKN-11/69, 197 p., 67 figs., 30 tables, 59 references.

Pollutional effects of combined sewer overflows on the Sandusky River were studied at Bucyrus, Ohio, to evaluate the benefits, economics, and feasibility of alternate plans for pollution abatement. Bucyrus has an incorporated area of about 2,340 acres, a population of 13,000, and a combined sewer system with an average dry weather waste-water flow of 2.2 million gallons per day. The overflows were measured and sampled at three

locations representing 64 percent of the city's sewered area, and the river flow was measured and sampled above and below Bucyrus. Any 20-minute rainfall greater than 0.05 of an inch produces an overflow. The combined sewers overflow about 73 times each year and discharge an estimated annual volume of 350 million gallons containing 350,000 pounds of BOD (biochemical oxygen demand) and 1,400,000 pounds of suspended solids. The overflows had an average BOD of 120 mg per liter, suspended solids of 470 mg per liter, total coliforms of 11,000,000 per 100 ml, and fecal coliforms of 1,600,000 per 100 ml. The total coliforms in the river varied from an average of 400,000 per 100 ml during dry weather to a high of 8,800,000 per 100 ml during overflow discharges.—W71-00412.

Descriptors: Storm runoff, combined sewers, water pollution sources, Bucyrus (Ohio).

085 Burgess and Niple, Ltd.
1970. Stream pollution and abatement from combined sewers, Bucyrus, Ohio: Federal Water Quality Adm., Research Ser. 11024—06/70, p. 291–320, 16 figs., 3 tables.

Pollutional effects from combined sewer overflows on the Sandusky River were studied at Bucyrus, Ohio by a year-long detailed sampling and laboratory analysis program. Any 20-minute rainfall greater than 0.05 inches produces an overflow. The combined sewers overflow about 73 times each year, discharging an estimated annual volume of 350 million gallons containing 350,000 pounds of biochemical oxygen demand and 400,000 pounds of suspended solids. Interceptor sewer and lagoon systems are proposed as the most economical method of providing a high degree of protection to the Sandusky River.—W70-09621.

Descriptors: Water pollution sources, storm runoff, water pollution control, Bucyrus (Ohio).

086 Burm, R. J.
1967. The bacteriological effect of combined sewer overflows on the Detroit River: Water Pollution Control Federation Jour., v. 39, no. 3, p. 410–424, 12 figs., 8 references.

A study was made of water quality at various points in the Detroit River before and after rainfalls causing overflows of combined sewers. Effects of these overflows on water quality persist for several days after discharge has ceased. The duration of effects increases with increase in the intensity of the storm. Bacterial densities increased as much as a thousandfold after moderate rains, at sampling points miles downstream from combined-sewer outfalls. Further downstream, increases in bacterial densities were less but affect more of the stream width. Fecal coliforms and fecal streptococci follow patterns similar to those of total coliforms.

Descriptors: Combined sewers, storm drains, storm runoff, water pollution sources, water pollution effects, Detroit (Mich.).

087 Burton, Ian; Kates, Robert; Snead, Rodman.
1969. The human ecology of coastal flood hazard in magalopolis: Chicago Univ., Dept. of Geography, Research Paper 115, 196 p., 51 figs., 41 tables, 89 references.

The effects of storm flooding on human use of the Atlantic Coast of the United States from Maine to South Carolina were studied using aerial photographs, surveys, case histories, and economic surveys. The extent of development, patterns of use, human adjustment to flooding, methods of adjustment to hazard, and shore-use policy and regulation are discussed.—W69-07942.

Descriptors: Flood damage, storms, coastal flooding.

088 Calkins, M. D.
1970. Planning standards for storm drainage: Am. Soc. Civil Engineers Proc., Paper 7133, Jour. of Urban Planning and Development Div., v. 96, no. UP1, p. 53–58.

Designers of comprehensive storm drainage networks must consider all storm water flow from watershed areas. The presence of governmental boundary lines which do not coincide with these watersheds introduces complicating factors to such designs. Cooperation between engineers responsible for planning in these jurisdictions can produce unified design results for entire drainage networks. The Kansas City, Mo., metropolitan area achieves such cooperation by adopting unified design standards produced by local engineers. Results of the use of

these criteria by agencies throughout the metropolitan area include uniform designs, stage construction of drainage networks, and a more comprehensive understanding by local officials of mutual problem solutions.—W71-02146.

Descriptors: Storm runoff, drainage (urban), planning, regional planning, Kansas City (Mo.).

089 Campbell, T. H.; Sylvester, R. O. (editors)
1968. Water resources management and public policy: Seattle and London, Univ. of Washington Press, 253 p.

This symposium represents an attempt to outline many of the technical, scientific, and policy issues that should be considered in the management of water resources. In the western United States, the desire for more water comes largely from pressures of government agencies and agricultural interests concerned with agricultural production on water-short land. One result of the present increasing desire for more water is the appearance of large-scale water transfers as typified by the California water project. In a case study of the Pullman-Moscow aquifer on the eastern boundary of Washington, the ages of the waters were determined as an aid in determining their movements. Standards for the State of Washington are based on an objective for clean water. As a result of a comprehensive research project on Lake Washington, now surrounded by metropolitan Seattle, a detailed history is given of the area's water-quality problems. The program of water-quality monitoring of receiving waters is a key element in Seattle's pollution-abatement program. The body of water law in the State of Washington is reviewed as interpreted by the courts.

Descriptors: Water resources development, planning, water law, water management (applied), water quality control, Washington (State).

090 Carter, L. J.
1970. Galveston Bay, test case of an estuary in crisis: Science, v. 167, no. 3921, p. 1102–1108, 1 fig.

Galveston Bay's water quality has been severely degraded by rapid industrial and population growth. A 1914 decision to build the Houston ship channel has had far-reaching environmental effects. The industries and residential subdivisions which have grown up along the channel dump raw sewage into it. This highly polluted water flows untreated into the bay. Shelldredging, water diversions, and landfill encroachments have severely reduced the nursery marshlands and increased salinity. The proposed Wallisville Dam will further aggravate these situations. The new facility of the Houston Lighting and Power Co. will add thermal pollution to the bay's problems.—W70-04432.

Descriptors: Estuaries, Galveston Bay (Tex.), water pollution sources.

091 Carter, R. W.
1961. Magnitude and frequency of floods in suburban areas: U.S. Geol. Survey Prof. Paper 424-B, p. B9–B11, 1 fig., 1 reference.

Suburban development changes two of the basic elements that determine the magnitude and timing of the volume and peak of the flood hydrograph, namely: the average infiltration rate (which is decreased because roofs and streets are impervious) and the lag time between rainfall excess and the flood hydrograph (which is decreased because of storm sewers and improvements to the principal stream channels). The net effect of these changes was evaluated in the vicinity of Washington, D.C. For drainage basins larger than four square miles in the Washington area, complete surburban development on flood peaks of any recurrence interval results in a maximum value of 1.8 for the ratio flood discharge (suburban): flood discharge (undeveloped).—W69-01663.

Descriptors: Drainage systems, hydrograph analysis, land use, infiltration, peak discharge, floods, suburban drainage, surface permeability, Washington (D.C.).

092 Carter, R. W.
1971. Urban water data needs, *in* Treatise on urban water systems, Albertson, M. L., Tucker, L. S., and Taylor, D. C., eds.: Fort Collins, Colorado State Univ., p. 480–498, 4 figs., 11 references.

Urbanization causes hydrological problems, namely: an increased demand for water for municipal, industrial, and recreational purposes; changes in the physical environment, including changes in the natural water regime;

and disposal of wastes that may contaminate streams or aquifers. The hydrologic impact of an urban area may extend far beyond its own border. Urbanization creates a special demand for hydrologic data, but there is no need to redefine the water regime in quality or quantity in the urban environment. Data are needed for the design of water supply facilities and the protection of raw water supplies, for planning the disposal of waste, for determining the optimum pattern of land use, and for the design of storm drainage facilities. Data may also be needed for the real-time management of water use to reduce floodflows and to insure optimum dilution of waste. Hydrologic problems of urban areas are reviewed, and deficiencies in present data programs are defined.

Descriptors: Data collections, planning, model studies, storm runoff.

093 Cartmill, R. H.

1970. Forecasting the volume of storm runoff using meteorological parameters: Norman, Oklahoma Univ., Ph.D. thesis, 117 p., 8 figs., 7 tables, 113 references.

An accurate forecast of runoff volume requires an accurate measurement of rainfall, good estimates of the infiltrated volume, and the amount of depression storage. A method is given for forecasting runoff volume without reliance on any empirical relationships between meteorological parameters and recorded runoff measurements. The method is, therefore, applicable to areas where there are no existing meteorological or hydrological records. After the parameters required to determine the infiltration rate are obtained, the infiltration rate is compared with the rainfall rate every minute. The excess of rainfall over infiltration is then consigned first to depression storage and then to runoff. This method was applied to two major and 13 smaller storms over a 208-square-mile watershed in south-central Oklahoma.

Descriptors: Rainfall-runoff relationships, storm runoff, meteorology, infiltration, soil moisture.

094 Caspers, Hubert

1964. Characteristics of hypertrophic lakes and canals in cities, *in* Internat. Assoc. of Theoretical and Applied Limnology, Proc.: v. 15, p. 631–638, 2 figs., 2 tables, 13 references.

Alster Lake in Hamburg, Germany, is an example of a typical urban lake and demonstrates the special conditions in city waters. Urban waters may constitute a restricted facies of eutrophic water in which destruction of original communities is common and in which no new equilibrium develops. The relationship between buildup and breakdown of nutritive material, between producers and consumers, is always in a state of temporary equilibrium and is constantly in danger of becoming unbalanced. The original community loses its most important zone of regeneration—the submerged plants along banks. The bottom fauna are inhibited by anaerobic conditions resulting from inflow of detritus, leaving only a few species. The surviving plankton tend to instability and extreme variations from year to year. Conditions in urban waters often improve when plants recolonize the banks.—W70-00268.

Descriptors: Lakes, eutrophication, water pollution effects, ecology.

095 Chandler, T. J.

1965. The climate of London: London, England, Hutchinson and Co., 292 p., 86 figs., 98 tables, 222 references, 5 app.

Three main factors may be the cause of urban-induced changes in precipitation. These are additional condensation nuclei, turbulence resulting from increased surface roughness, and thermal convection resulting from higher temperatures. As the result of these influences, a number of cities have been noted to have more rain days, more thunderstorms, and more total precipitation than the country around them. Significant differences in total precipitation that might reasonably be caused by large English conurbations have not been found, however. Heavy thunderstorms, roughly coincident with the built-up area of London, have occurred on many occasions, and similar instances have been commented upon in other cities, but it is impossible to be sure about their relationships with the towns, particularly in the absence of detailed surface and upper-air observations. There is a tendency for thunderstorms to develop or intensify in inner north London, and this might be related to the characteristic asymmetry of the heat island with the highest temperatures in the northeast.

Descriptors: Climatology, precipitation (atmospheric), London (England), weather patterns.

096 Changnon, S. A., Jr.

1963. A climatological evaluation of precipitation patterns over an urban area: Robert A. Taft Sanitary Eng. Center, Tech. Rept. A62-5, p. 37–67, 6 figs., 11 tables, 17 references. [Also published in Illinois State Water Survey, Reprint Series 1963-A, 80 p.]

Urban rainfall distribution was studied in Champaign-Urbana, Ill., for a period of 13 years. The annual precipitation pattern was compared with that of a nearby rural network to help evaluate the apparent urban-affected precipitation pattern obtained over the urban area. The precipitation increase in Urbana could result either from urban effects or from natural variations of precipitation. Rain-gage exposures were a problem in the evaluation of effects. To instrument an urban area for this purpose is difficult and expensive.—W70-00740.

Descriptors: Climatology, rainfall patterns, Champaign-Urbana (Ill.).

097 Changnon, S. A., Jr.

1968. The La Porte weather anomaly—fact or fiction?: Am. Meteorol. Soc. Bull., v. 49, no. 1, p. 4–11, 4 figs., 4 maps, 5 tables, 13 references.

A notable increase in precipitation, moderate rain days, thunderstorm days, and hail days has been occurring since 1925 at La Porte, Ind. Because La Porte is 30 miles east of the large complex of heavy industries at Chicago, there is a strong suggestion that the increases in precipitation are manmade. The increase at La Porte is sizeable: during the 1951–65 period, La Porte had 31 percent more precipitation, 38 percent more thunderstorms, and 246 percent more hail days than did surrounding stations. Since 1925 the year-to-year fluctuations in the annual and warm-season precipitation at La Porte agree with fluctuations in steel production in the Chicago area.

Descriptors: Climatology, climatic change, La Porte (Ind.), Chicago (Ill.).

098 Changnon, S. A., Jr.

1969. Increased precipitation from urban-industrial effects: Am. Soc. Civil Engineers Preprint 1015, 14 p., 1 fig., 1 table.

Urban-produced precipitation increases of four midwest cities and two large eastern cities range from 5 to 16 percent in annual precipitation and rain days, with 7 to 22 percent increases in summer thunderstorm days. Within the past 25 years, in an area downwind from Chicago, increases in precipitation were 31 to 246 percent. In Chicago, St. Louis, and Champaign-Urbana, district maxima were centered in or to the east of the cities. This supports the theory of urban-produced increases in the prevailing eastward-moving precipitation systems. Similar increases in precipitation were noted in Tulsa, Washington, D.C., New York City, and much greater increases in La Porte, Ind.—W70-06918.

Descriptors: Climatology, precipitation (atmospheric), weather patterns, weather modification.

099 Changnon, S. A., Jr.

1969. Recent studies of urban effects on precipitation in the United States: Am. Meteorol. Soc. Bull., v. 50, no. 6, p. 411–421, 2 figs., 4 tables, 39 references.

Urban-produced increases in precipitation range from 5 to 16 percent, and increases in number of thunderstorm days range from 7 to 20 percent. Even greater increases in precipitation have been observed downwind from major steel mill complexes. These changes have been credited to urban-induced nuclei concentrations and urban thermal effects. The results of these studies may indicate the effectiveness of ground-based seeding, the possibility of successful increases in all seasons, the likelihood of thunderstorm and hailstorm increases with rainfall increases, and the need for dense rain-gage networks to adequately determine the area and amount of increase.—W70-08126.

Descriptors: Precipitation (atmospheric), rainfall patterns, climatology.

100 Changnon, S. A., Jr.

1970. Recent studies of urban effects on precipitation in the United States: Geneva, Switzerland, Secretariat of the World Meteorological Organization, Tech. Note 108, WMO-no.254.TP.141, Urban Climates, v. 1, p. 325–341, 2 figs., 3 tables, 34 references.

Four cities in the midwestern United States have apparent increases of precipitation produced by urban effects. The increases range from 5 to 10 percent in annual precipitation and rain days, and 13 to 21 percent in summer thunderstorm days. Substantially greater increases in precipitation, thunderstorms, and hailfalls (31 to 246 percent) were found in a recent study of an area downwind from a major steel mill complex. There is little evidence of urban effects on the occurrence of extreme rainfall rates or on the amount of snowfall. Urban-induced nuclei concentrations are high and probably sufficient to produce the observed changes in precipitation. Other American studies show the importance of the urban thermal effects. The study of inadvertent precipitation increases from urban areas has particular significance for planned weather modification since the amounts of the inadvertent increases match those confirmed for planned experiments.

Descriptors: Rainfall patterns, precipitation (atmospheric), air pollution effects, climatology.

101 Chemerys, J. C.
1967. Effect of urban development on quality of ground water, Raleigh, North Carolina: U.S. Geol. Survey Prof. Paper 575-B, p. B212–B216, 1 map, 1 table, 7 references.

In the Raleigh, N.C., area, samples taken from wells 25 to 200 feet deep do not yield appreciable amounts of ABS detergent. The potential movement of ABS detergents in water was checked by analyses of water from selected wells in 1962 and again in 1965. Determinations were also made on related constituents that might be useful precursors of pollution. The area is underlain chiefly by granites, schists, and gneiss, which are blanketed in most places by residual soils and a cover of vegetation. Soil into which septic tanks drain is effective in removing or retarding the movement of most contaminants in the ground.

Descriptors: Water pollution sources, detergents, groundwater pollution, Raleigh (N.C.).

102 Chen, C. W.; Shubinski, R. P.
1971. Computer simulation of urban storm water runoff: Am. Soc. Civil Engineers Proc. Paper 7924, Jour. Hydraulics Div., v. 97, no. HY 2, p. 289–301, 9 figs., 1 table, 12 references.

As part of an overall storm-water management program, a model was developed to simulate the runoff phenomena of a drainage basin for any given rainfall pattern. The model represents the basin by an aggregate of idealized subcatchments and gutters. The computer is instructed to make a step-by-step accounting of rainfall, infiltration, detention, overland flow, and gutter flow in the calculation of a hydrograph. Three preliminary simulations demonstrate the validity of the method.—W71-04574.

Descriptors: Storm runoff, routing, simulation analysis.

103 Chiang, S. L.
1971. A crazy idea on urban water management: Water Resources Bull., v. 7, no. 1, p. 171–174, 2 figs.

The impervious catchment of cities increases storm runoff. Roof area contributes significantly to the imperviousness. Use of roofs as an urban flood control device and water-conservation measure is advocated. Two different schemes, one for built-up industrial-commercial areas, the other for residential areas, are suggested. The former utilizes the roof as a detention reservoir for flood control; the latter employs recharge pits to convert runoff into ground water. The proposed schemes are not only hydrologically, hydraulically, and structurally sound but also economically feasible. It is worth considering in the future planning of urban renewal and urban development.—W71-06309.

Descriptors: Water management (applied), storm runoff, flood control, groundwater recharge.

104 Childs, E. F.
1970. Effect of urban expansion on hydrologic investigations, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 1, 22 p., 6 plates, 6 tables.

A simple, straightforward procedure was used recently for studying the hydrology of a brook undergoing rapid changes in urban expansion. The method is acceptable for reconnaissance reports. In an example for Town Brook, Quincy, Mass., the hydrologic relationships are empirical, as there are no stream-gaging stations in the

watershed. The rational formula was used to compute discharges for different dates of analysis. Urban conditions are projected to the year 2000.

Descriptors: Floods, storm runoff, rainfall-runoff relationships, Quincy (Mass.).

105 **Chorley, R. J.**
1969. Water, earth and man, a synthesis of hydrology, geomorphology, and socio-economic geography: London, Methuen and Co., 588 p., 162 figs., 48 maps, 50 tables, 573 references.

The theme of this book is that the study of water provides a logical link between an understanding of physical and social environments. Each chapter develops this theme by proceeding from the many aspects of water occurrence to a deeper understanding of natural environments and their fusion with the activities on man in society. In this way, water is viewed as a highly variable and mobile resource in the widest sense. Not only is water a commodity which is directly used by everyone, but it is also needed for economic development, it is an element of aesthetic experience, and it is always a factor of the earth's physical and biological environment.—W70-05173.

Descriptors: Hydrogeology, water resources development.

106 **Chow, V. T.**
1952. Hydrologic studies of urban watersheds; rainfall and runoff of Boneyard Creek, Champaign-Urbana, Illinois: Illinois Univ., Dept. Civil Eng. Studies, Hydraulic Eng. Ser. 2, 66 p., 15 figs., 13 tables, 2 graphs.

A study of the hydrology of Boneyard Creek, Champaign-Urbana, Ill., includes duration analysis, calculation of rainfall intensity frequency and distribution, unit hydrographs, synthetic hydrographs, and consumptive use. The Boneyard, which floods often because of insufficient gradient and capacity, originates in and flows through an entirely urban area having 37 percent impervious surface and serves as the major storm drain.

Descriptors: Rainfall-runoff relationships, storm runoff, Champaign-Urbana (Ill.), depth-area-duration analysis.

107 **Chow, V. T.**
1962. Hydrologic determination of waterway areas for the design of drainage structures in small drainage basins: Illinois Univ. Eng. Expt. Sta. Bull. 462, 104 p., 23 figs., 7 maps, 19 tables, 194 references, 1 app.

A simple and practical method is given to determine the peak discharge of flow from small drainage basins for the design of waterway openings of culverts and small bridges. For practical applications of the method, a design chart for climatic and physiographic conditions in Illinois is presented. Major phases of the study include an historical review of engineering studies and methods of waterway area determination, a survey of design practice in different State highway agencies in the United States, a collection and analysis of available hydrologic data for the State of Illinois, the development of a method for waterway area determination, a simplification of the developed method, a compilation of formulas for waterway area determination, and an annotated supplementary bibliography.

Descriptors: Rainfall-runoff relationships, culverts, small watersheds, Illinois, peak discharge.

108 **Clark, J. B.**
1970. Urban hydrology considerations, State of Hawaii, *in* Seminar on Urbana Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 11, 9 p., 1 fig., 3 plates.

Kuliouou Valley is on the southeastern corner of the island of Oahu, about 10 miles southeast of Honolulu, on the leeward side of the Koolau Mountains. The population of Kuliouou Valley has increased from 800 in 1950 to 1,700 in 1963. The flood plain is presently fully developed. On islands such as Oahu, where mountain peaks do not exceed 5,000 feet, maximum annual rainfall accumulations and intensities occur along the ridge lines and decrease with elevation on both the leeward and windward sides. The increased runoff and shorter concentration times caused by urbanization areas are offset by the lesser rainfall depth-duration relationship at the lower elevations where the cities are located. Unit hydrographs for the project area were developed synthetically, utilizing mountain-lag curves transferred to the Hawaiian Islands on the basis of rainfall and

runoff studies. Runoff volumes from the 50-year and 100-year floods are 1.8 and 2.5 inches, respectively.

Descriptors: Rainfall-runoff relationships, storm runoff, depth-area-duration analysis, water yield.

109 Clawson, Marion

1966. Economics and environmental impacts of increasing leisure activities, *in* Future environments of North America, Darling, F. F. and Milton, J. P., eds.: Garden City, N.Y., The Natural History Press, p. 246–260, 2 figs., 1 table, 3 references.

The real wealth of a nation is the time of its members. Leisure, defined as discretionary time above that needed for basic subsistance, is distinguished from mere idleness. Further distinction is seen between leisure and recreation; while leisure is basically a time-oriented concept, recreation is a personal-experience concept or activity. Similarities are observed between leisure and discretionary income. With increases in leisure time expected, it is important to consider how each kind will be allotted. Discussion of outdoor recreation as a use of leisure involves a threefold classification: user-oriented areas, close to where people live; intermediate-use areas, designed primarily for day-long recreation; and resource-based areas, more suited to vacation time. Possible consequences of more leisure include greater emphasis on consumption and availability of time and a greater urban-dominated society with more urban leisure.—W71-02670.

Descriptors: Recreation, planning.

110 Claycomb, E. L.

1970. Urban storm drainage criteria manual from Denver: Civil Eng., v. 40, no. 7, p. 39–41, 1 fig., 2 tables.

A storm drainage criteria manual was developed by the Denver Regional Council of Governments to provide uniform guidelines and technical design information for those involved with storm-water drainage. The overall approach is based on two separate drainage systems: the initial, or convenience, system for regularly occurring flows (return frequency of once in 2 to 10 years) and the major system for relatively infrequent flows. The design of streets receives extensive coverage, with allowable drainage capacity related to traffic volume. Storm-sewer design is based entirely on hydraulics, replacing rule-of-thumb procedures for head loss at manholes. Hydrological design is based on a modified rational method in which summation of flows is used for areas under 200 acres and hydrograph analysis for larger areas.—W70-09534.

Descriptors: Storm drains, planning, storm runoff, rational formula, rainfall-runoff relationships, Denver (Colo.).

111 Cleveland, J. G.; Ramsey, R. H.; Walters, P. R.

1970 Storm water pollution from urban land activity: Federal Water Quality Adm., Water Pollution Control Research Ser. 11024-06/70, sec. I, p. 1–56, 6 figs., 14 tables, 4 references.

Pollution of storm water is related to land activity. The city planner and engineer can assess the quality as well as quantity of storm water by studying land activity, environmental factors, and precipitation. A field assessment of storm-water pollution used samples of precipitation and surface runoff from areas in Tulsa, Okla. Storm-water runoff samples were collected from 15 discrete test areas. These samples were analyzed in terms of quality standards for BOD (biochemical oxygen demand), COD (chemical oxygen demand), TOC (total organic carbon), organic kjeldahl nitrogen, soluble orthophosphate, chloride, pH, solids, total coliform, fecal coliform, and fecal streptococcus pollutants. Three approaches recommended to abate and control the pollution load of storm runoff are reduction of total runoff, reduction of runoff rates, and environmental policy.—W70-09615.

Descriptors: Storm runoff, water quality, land use.

112 Cleveland, J. G.; Ramsey, R. H.; Walters, P. R.; Miessler, G. L.

1970. A multi-phasic component study to predict storm water pollution from urban areas: Washington, D.C., Avco Economic Systems Corp., Completion Rept., 248 p., 20 figs., 71 tables, 40 references, 4 app.

Storm water pollution in an urban area is a result of land activity, precipitation, and runoff. Models are given for predicting this pollution and are evaluated by application to several selected demonstration cites. Also presented are criteria for pollution control strategies and for assessment of various structural and nonstructural control

measures, their general effectiveness, and their costs. The storm-water pollution models are feasible but of limited application unless adequate data are available on characteristics of hydrology, precipitation, and runoff, as well as of detailed land activity. Storm-water pollution control should be designed for the specific characteristics of each urban area. Maximum economies will result from pollution abatement measures taken during the early stages of area development.—W71-03917. PB-199-169.

Descriptors: Storm runoff, water pollution control, mathematical models.

113 **Coates, D. R. (editor)**
1971. Environmental geomorphology, 1st Annual Geomorphology Symposia Series, Binghamton, N.Y., Oct. 16–17, 1970, Proc.: State Univ. of New York at Binghamton, Publications in Geomorphology, 262 p., 62 figs., 18 tables, 2 plates, 220 references.

This seminar is a sampling of the type of work now being done in environmental geomorphology. Environmental geomorphology is the practical use of geomorphology for the solution of problems involved in man's wishes to transform landforms or to use and change surficial processes. It studies, interprets, and plans landfill operations, ground-water mining and subsidence, streamflow regime upsets, and hillslope modifications. The goal for geomorphic environmental studies is to minimize topographic damage and to understand the interrelated processes necessary in restoration or maintenance of the natural balance. The objectives of this symposium are to demonstrate that geomorphology can play an important part in providing solutions for some environmental problems, to illustrate the current status of environmental geomorphology in some areas, and to provide some educational guidelines.

Descriptors: Geomorphology, water resources development, environmental geomorphology.

114 **Cohen, Philip; Francke, O. L.; Foxworthy, B. L.**
1968. An atlas of Long Island's water resources: New York Water Resources Comm., Bull. 62, 117 p., 50 pls., 129 references.

The ground-water reservoir of Long Island, N.Y., is a wedge-shaped mass of sedimentary deposits ranging from 0 to 2,000 feet thick. The saturated volume is estimated to be 180 cubic miles, and dewatering would yield 3–6 trillion gallons. The artesian-pressure surface is a few feet lower than the water table near the middle of the island and a few feet higher near the coasts. Estimated natural ground-water discharge is 280 mgd. Dissolved solids average less than 50 ppm. Fresh and salty water are hydraulically connected, and local overdevelopment has caused salt-water intrusion. Recharge of water warmed by use for air-conditioning has caused thermal pollution, and there is some pollution of ground water by sewage and industrial wastes. Proposals for control of sea-water encroachment include: continuing present regulations; using injection wells to form a barrier; pumping to form water-table troughs; recharge by means of basins; use of skimming-wells to reduce stream discharge; and controlling encroachment to establish a new equilibrium.

Descriptors: Saline water intrusion, groundwater depletion, water balance, Long Island (N.Y.).

115 **Cohen, Philip; Kimmel, G. E.**
1970. Status of salt-water encroachment in 1969 in southern Nassau and southeastern Queens Counties, Long Island, New York: U.S. Geol. Survey Prof. Paper 700-D, p. D281–D286, 2 maps, 4 tables, 13 references.

In southern Nassau and southeastern Queens Counties, Long Island, N.Y., landward movement of a deep wedge of salty ground water underlying the fresh-water aquifer has been minimal from 1960 to 1969. Significant changes in chloride content were noted in only 3 of 30 observation wells. Chloride content of water from a well in southeastern Queens County increased from 34 mg per liter in 1960 to 112 mg per liter in 1969 as a result of intensive ground-water withdrawals in that county; chloride content in two wells in Nassau County increased 8,520 to 11,000 mg per liter and from 2,000 to 8,110 mg per liter during the same period. These increases resulted from local heavy pumping near the zone of diffusion. No increase in chloride content was noted in water from the Lloyd aquifer, except where leaky casings permitted downward flow of salty water.—W71-04976.

Descriptors: Saline water intrusion, water balance, hydrogeology, groundwater depletion, Long Island (N.Y.).

116 Cohen, Philip; Vaupel, D. E.; McClymonds, N. E.
1971. Detergents in the streamflow of Suffolk County, Long Island, New York: U.S. Geol. Survey Prof. Paper 750-C, p. C210–C214, 4 figs., 1 table, 6 references.

In 1962–69 the average MBAS (methylene-blue active substance) content of 46 streams in Suffolk County, Long Island, N.Y., was, on a yearly basis, approximately inversely related to the amount of streamflow. This relation partly reflected (1) the close similarity between the quality of the shallow ground water and the quality of the streamflow, coupled with the dilution effect of recharge from precipitation on the quality of the shallow ground water, (2) areal differences in the MBAS content of the shallow ground water and the effects of these differences on the quality of the streamflow as the headwaters of the streams shifted in response to drought, and (3) the substitution of LAS (linear alkylsulfonate) for ABS (alkylbenzenesulfonate) in 1965. The average MBAS content and load of the streams in 1962 were approximately the same as in 1969. However, during the same period, the average chloride content and load of the streams increased.

Descriptors: Detergents, path of pollutants, groundwater movement, Long Island (N.Y.).

117 Constant, J. A.
1970. A mathematical determination of the ordinates of the unit hydrograph, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 9, 12 p., 5 figs., 1 table.

An equation is given for the unit hydrograph, and a means of evaluating the parameters in terms of the time and magnitude of the unit hydrograph peak and the contributing area is presented. The method is easily programmed for use in an electronic computer as a program in itself or as part of a larger program, such as one for determining basin runoff during flood periods.

Descriptors: Unit hydrographs, rainfall-runoff relationships, storm runoff.

118 Corey, R. B.; Hasler, A. D.; Lee, G. F.; and others.
1967. Excessive water fertilization: Wisconsin Dept. of Resource Devel., Water Resources Div., Madison, Report, 50 p., 7 tables, 131 references.

Domestic sewage constitutes a major source of nitrogen and phosphorus, apparently the major causative elements of eutrophication in Wisconsin. Accelerated use of synthetic detergents accentuates a problem to which many other factors contribute: runoff and underground percolation from rural lands; manure applied on frozen soil; runoff from roofs and roads; washing of the atmosphere by precipitation; and release of nitrogen and phosphorus resulting from development of wetlands for agricultural and urban use. Improved removal of nutrients from sewage appears possible. Entire drainage basins, shores, and frontages may require rezoning to control discharges of nutrients to lakes and streams.—W69-10178.

Descriptors: Eutrophication, lakes, water pollution effects, water pollution sources, Madison (Wis.).

119 Coulter, J. B.
1958. The septic tank system in suburbia: Public Health Reports, v. 73, no. 6, p. 488–492, 3 references.

Septic tank systems can seldom be satisfactory for disposal of sewage from houses in a developing suburban area. Their use must be subject to a number of stringent conditions if unsatisfactory results are to be avoided. Use of septic tanks is a poor temporary measure, and septic tanks should never be used when conditions prohibit their proper operation. In general, the usefulness of septic tank systems decreases as the size of the individual establishment they serve increases. The essential conditions for the satisfactory use of septic tank systems are effective regulation and control, suitable soil, and proper design, construction, and operation. Sufficient area should be provided on each lot for replacing the absorption system in case of failure.

Descriptors: Septic tanks, suburbs, water pollution sources, groundwater pollution.

120 Council on Environmental Quality.
1970. Environmental quality; the first annual report of the Council on environmental Quality, together with the President's message to the Congress: Washington, D.C., U.S. Govt. Printing Office, 326 p., 10 figs., 10 tables, 12 app.

The principal environmental issues that confront the nation are water pollution, air pollution, inadvertent modification of weather and climate, disposal of solid wastes, urbanization and land use, pesticides, and radiation. Pressures on the environment are discussed in a chapter on population, economic growth, and resource. A national land-use policy is proposed. In water pollution, the report urges an increase in funds for waste treatment; a program to demonstrate concepts of water quality management; effective enforcement of water quality standards; a strong Federal policy to control thermal pollution; development of a policy for ocean disposal of wastes; creation of new methods to prevent, control, and clean up oil spills; and intensified attacks on agricultural pollution. Costs to clean up the Nation's water over the next 10 years will total $10 billion.—W70-19347.

Descriptors: Water quality, political aspects, water resources development, water pollution control, environmental quality, land use, weather modification, planning.

121 **Cowgill, U. M.**
1968. A comparative study in eutrophication: Developments in Applied Spectroscopy, v. 6, p. 299–321, 18 figs., 11 references.

Linsley Pond, Conn., has been studied for 30 years, while becoming increasingly eutrophic. From August 1965 through August 1966, water was sampled weekly; oxygen and temperature were monitored, and a geochemical study was made of the elements detectable by X-ray emission spectroscopy and their movement during thermal stratification. The process of heating, first described during 1937–38, has apparently changed. Late in the 1966 heating period, a vertically undisturbed layer (5–7 meters) apparently transmitted heat downward solely by molecular conduction. Below this, heat was probably distributed by chemical density currents. Concentrations of calcium, magnesium, phosphorus, and sulfur, though seasonally variable, are generally 2–8 times greater than in 1937–38. Iron concentration in the deep hypolimnion is markedly lower than the 1938 value, while manganese concentration is strikingly higher. Phosphorus is now greatly enriched but is stoichiometrically less than Fe (II) in deep water, so that phosphorus precipitates as iron oxidizes during autumnal overturn. Large seasonal changes in phosphorus were noted.—W69-05869.

Descriptors: Eutrophication, water chemistry, water pollution effects, Linsley Pond (Conn.).

122 **Crawford, N. H.**
1968. Infiltration and losses in urban hydrology, *in* Urban water resources research, first year report, Sept. 1968: Am. Soc. Civil Engineers, app. A, chap. 3, p. A22–A31, 3 figs., 12 references.

Urban watersheds include all watersheds where the hydrologic regime is substantially changed by the introduction of impervious areas, storm drainage, and channel improvements. Development ranges from widely spaced suburban homes to highly developed commercial-industrial areas. For highly developed conditions, runoff is entirely dependent on the precipitation regime, interception, and depression storage. Analysis of runoff from a fully developed watershed is not as complex as analysis of a low density suburban area, but the suburban area is the more common design problem. Losses from precipitation determine runoff volumes. Algorithms used for losses and infiltration are reviewed. Simulation methods are being studied in many universities. Improvements in the general accuracy of peak flow frequency estimates for urban drainage are possible from applications of simulation techniques.

Descriptors: Infiltration, rainfall-runoff relationships, water yield, impervious area, simulation analysis, model studies.

123 **Crawford, N. H.**
1969. Analysis of watershed changes, in Effects of watershed changes on streamflow, Moore, W. L. and Morgan, C. W., eds., Water Resources Symposium No. 2, Austin, Tex., Oct. 1968: Austin, Texas Univ. Press, p. 27–34, 4 figs., 2 tables, 6 references.

Watershed changes can be classified as alterations of runoff volumes, flow duration characteristics, or floodflows. Land surface changes occur as results of agricultural activities, forest fires, and urbanization. Deliberate land surface changes are seldom carried out for hydrologic benefits only. Hydrologic damages are seldom sufficient to prevent planned land surface activities. Hydrologic simulation using digital computers is particularly helpful in interpreting land surface changes. Flows can be simulated before and after a change to find the effect of the change on infiltration rate and soil moisture storage. Channel system changes are well

suited to analysis. Interaction between land surface runoff sequences and channel network response can be easily studied for many combinations of physical works. This is most helpful in tracing physical interactions between several projects in a watershed.—W70-04728.

Descriptors: Model studies, simulation analysis, rainfall-runoff relationships, watershed changes.

124 Crawford, N. H.
1970. North Branch Chicago River runoff simulation, *in* 25th Annual Midwestern States Flood Control and Water Resources Conf., Chicago, Ill., Sept. 3–4, 1970, Proc.: 10 p., 5 figs., 6 references.

The Hydrocomp Simulation Program (HSP) is a deterministic mathematical model for use in urban watershed engineering. The input includes precipitation, potential evapotranspiration, temperature, radiation, and where available wind movement and dewpoint. The calculations are made for all meteorologic conditions because the loss of water through evapotranspiration in dry weather is as important in the overall water balance as overland flow during storm periods. Applications include flood forecasting, urban drainage design, studies of land use and land management, and simulation of records for ungaged streams. In the North Branch of the Chicago River, HSP programming was used to develop stage and discharge information to estimate flooded areas for storms of various frequency for future conditions of urbanization. These simulation runs provide data for compliance with the National Flood Insurance Act of 1968.

Descriptors: Simulation analysis, model studies, storm runoff, rainfall-runoff relationships, Chicago River (Ill.).

125 Crippen, J. R.
1965. Changes in character of unit hydrographs, Sharon Creek, California, after suburban development: U.S. Geol. Survey Prof. Paper 525-D, p. D196–D198, 1 fig., 1 map, 3 references.

Unit hydrographs were derived from precipitation and stream-flow records collected in a small basin in the coastal region of central California. Hydrographs representing conditions before and after suburban development showed changes similar to those observed elsewhere: runoff was accelerated and peak flow was increased. However, the magnitude of the hydrograph changes did not correspond closely to the magnitudes reported in some other studies. Much of the difference can be ascribed to the very small size of the Sharon Creek basin. Developments in the basin included typical streets and buildings; they also included and irrigated golf course and channel modifications, which are not always considered in studies of this nature but which occur frequently in the growth of urbanization.

Descriptors: Storm runoff, unit hydrographs, hydrograph analysis, watershed changes, suburbs, Sharon Creek (Calif.).

126 Crippen, J. R.
1966. Selected effects of suburban development on runoff in a small basin near Palo Alto, California: U.S. Geol. Survey open-file rept., 19 p., 4 figs., 2 maps.

A study of the hydrology of three small drainage basins near Palo Alto, Calif., was started in 1958. Its purpose is to document hydrologic parameters before, during, and after the introduction of suburban development; to define the changes caused by development; to relate the nature and degree of changes to their causes; and to describe the changes so that they can be extrapolated to other regions of development in a similar environment.

Descriptors: Rainfall-runoff relationships, land use, Palo Alto (Calif.), sedimentation.

127 Crippen, J. R.
1969. Hydrologic effects of suburban development near Palo Alto, California: U.S. Geol. Survey, open-file rept., 122 p., 28 figs., 13 tables, 40 references, 1 app.

Data were gathered for 7 years in three small basins in the foothills west of San Francisco near Palo Alto, Calif., to detect changes in the hydrologic regime caused by suburban development. One basin remained in a natural state while another remained natural for the first 3 years, then suburban homes, offices, and a golf course were established. The third basin was unchanged for the first 4 years. Streamflow in the developed basins changed from ephemeral to perennial because of the introduction of imported water and an associated rise in the ground-water table. Runoff increased from 5 to 10 percent of annual precipitation to more than 30 percent.

Flow peaks of magnitudes that occurred only once or twice a year under natural conditions occurred with much greater frequency after development. Sediment production was markedly increased during times of construction activity but decreased after the developed areas became stable.

Descriptors: Rainfall-runoff relationships, land use, Palo Alto (Calif.), sedimentation.

128 Crippen, J. R.
1967. Change in quantity of dissolved solids transported by Sharon Creek near Palo Alto, California, after suburban development: U.S. Geol. Survey Prof. Paper 575-D, p. D256–D258, 1 fig., 1 table, 2 references.

In a small basin in the coastal region of central California studied before and after suburban development, the total load of dissolved solids carried from the basin by streamflow increased tenfold. The increased runoff from paved channels, pavements, and roofs ordinarily accompanying urbanization is likely to have a lower concentration of dissolved solids than the natural runoff. A higher concentration was observed in Sharon Creek after 1962 under developed conditions. The natural soil distribution was altered extensively during development, especially where cuts and fills were necessary to establish the desired golf-course topography, and thus much material which had not been thoroughly leached in the past was exposed. Irrigation water is supplied to lawns and to the golf course at a rate as nearly as possible equal to the consumptive need. Dissolved solids may be retained in the irrigated area and later be leached away by any excess of water. It is also possible that the year-round active growth in the irrigated areas may produce carbon dioxide that would increase the solvent power of soil moisture.

Descriptors: Water pollution sources, storm runoff, sediment yield, Palo Alto (Calif.).

129 Crosby, J. W., III
1968. Ground-water hydrology of the Pullman-Moscow basin, Washington, *in* Water resources management and public policy, Campbell, T. H. and Sylvester, R. O., eds.: Seattle, Univ. of Washington Press, p. 93–109, 5 figs., 9 references.

In the Pullman-Moscow ground-water basin of eastern Washington, withdrawals for municipal supply cause declining ground-water levels. Carbon-14 studies indicate that the upper water-producing zones are being depleted at rates well in excess of recharge. Because recharge of the shallower aquifers is slight in the Pullman sub-basin, future municipal well drilling should be confined to the deep artesian zone. This is essentially a stored body of water, and pumping may not induce significant amounts of recharge. Because both Pullman and Moscow will probably be pumping from the same system, effects of withdrawals could be magnified.

Descriptors: Groundwater, water level decline, municipal water, Washington (State).

130 Culham, W. B.; McHuch, R. A.
1969. Leachate from landfills may be new pollutant: Jour. of Environmental Health, v. 31, no. 6, p. 551–556, 1 photo., 1 table.

Sanitary landfill is the most accepted method for correcting open burning dumps. This method, therefore, has been recommended by the Oregon State Board of Health to improve handling of solid waste. Some communities have converted from burning and now bury the waste on the old sites, and some have converted by obtaining new sites for burial of waste. In western Oregon, conversion to burial of compacted waste has caused some problems involving leachates. Leachate from landfills and sanitary landfills may be acid and has more solutes, including sugars, than leachate from open-burning dumps. Leachate from landfills can create a greater biological oxygen demand (BOD) than leachate from burned waste and can produce growths of organisms such as slime and fungus because of the sugars and phosphates in the waste.

Descriptors: Water pollution sources, groundwater pollution, landfills.

131 Cywin, Allen; Hendricks, E. L.
1970. An overview of the U.S. Department of Interior's role in sediment control, *in* Natl. Conf. on Sediment Control, Washington, D.C., Sept. 14–16, 1969, Proc.: Washington, D.C., U.S. Dept. of Housing and Urban Devel., p. 34–40.

Objectives of the following organizations within the U.S. Department of Interior having programs related to sediment pollution and its control are reviewed: Federal Water Pollution Control Administration, U.S. Geological Survey, Bureau of Reclamation, U.S. Bureau of Mines, Bureau of Sport Fisheries and Wildlife, Bureau of Outdoor Recreation, Bureau of Land Management, Office of Water Resources Research, and National Park Service. Sediment represents a costly loss of valuable topsoil, it makes water unfit for use unless the water is treated at great expense, and it interferes with navigation, destroys esthetic values, and injures aquatic life. As a nutrient carrier, sediment promotes algal growths which degrade water quality and accelerate the aging process of lakes and reservoirs. Utilization of existing techniques and development of new techniques for sediment control are necessary in urban or urbanizing areas if adequate control of sediment problems is to be achieved.—W71-04147.

Descriptors: Sedimentation, erosion control, sediment control.

132 Da Costa, P. C. C.

1970. Effect of urbanization on storm water peak flows: Am. Soc. Civil Engineers Proc., Paper 7198, Jour. Sanitary Eng. Div., v. 96, no. SA 2, p. 187–193, 1 fig., 3 references, 1 app.

Urbanization of a natural watershed modifies the original shape and proportions of the hydrograph representative of the natural watershed. The unique runoff coefficient of the rational formula is the product of factors related to the degree of urbanization. The influence of urbanization is mainly expressed by the degree of imperviousness and the degree of artificial canalization. The general rational formula is given. Results from the formula are compared with those obtainable by the Chicago method.—W70-07671.

Descriptors: Rainfall-runoff relationships, rational formula, impervious area.

133 Davies, A. G.

1963. Pollution of the River Mersey: Effluent and Water Treatment Jour., v. 3, no. 4, p. 217–222, 1 fig.

The chief source of pollution in the River Mersey (England) is from large discharges of trade effluents. The treatment of such wastes would improve the condition of the river substantially. Another major source of pollution in urban areas is storm sewage overflows, which frequently happen in dry weather when streams are at low flow. The Mersey River Board has recommended that, where practicable, the overflows should not operate until at least 8 times dry weather flow has been reached. Typhoid, paratyphoid, and *Salmonella* infections can be caused directly by polluted water or indirectly by food contaminated by it.—W69-01501.

Descriptors: Storm runoff, water pollution sources, River Mersey (England), combined sewers.

134 Davis, R. K.; Brooks, D. B.

1967. Some economic aspects of urban sedimentation: Land Economics, v. 43, no. 3, p. 312–319, 20 references.

Urban sedimentation is largely caused by accelerated erosion resulting from the exposure of raw soil at construction sites and from the high peak runoff rates caused by the large portion of roofed and paved land in urban watersheds. A large share of third party losses consists of damaged recreational and esthetic values. Private economic incentives will not alleviate the problem. There are major gaps in our knowledge of the technical and economic effects of public control measures, gaps that are critical not just for the design of efficient control systems but even for predicting whether sediment reduction will improve or impair water quality. Several alternative public actions are evaluated. The procedures and regulations that coal-strip miners must follow in several States suggest an approach for urban land management. Land development should be compatible with the topography and drainage system of a site.—W69-08110.

Descriptors: Sedimentation, land use, economics, accelerated erosion.

135 Dawdy, D. R.

1961. Considerations involved in evaluating mathematical modeling of urban hydrologic systems: U.S. Geol. Survey Water-Supply Paper 1591-D, p. D1–D18, 4 figs., 2 tables, 16 references.

Interest in the hydrology of the urban environment leads to interest in modeling as soon as quantitative answers are desired to hydrologic questions. A stochastic model relates input to output statistically. It can also be a

statistical simulation of a synthetic streamflow trace. A deterministic model relates input to output in such a manner that, once the input is known, the output is wholly predictable. The most often used deterministic models in hydrology are those based on the laws of hydraulics, which use equations of continuity and motion. An analytic model usually describes a restricted area of hydrology in which the laws governing the process are fairly well known and accepted. A synthetic model specifies a conceptual relating function, and system parameters are identified through the use of input and output data. Thus, an analytic model usually describes a narrow or restricted subsystem in hydrology so that the problem is made manageable, whereas a synthetic model can be made as complex and can cover as broad an area of hydrology as desired.

Descriptors: Simulation analysis, numerical analysis, systems analysis, mathematical models, model studies, statistical models.

136 **Dawdy, D. R.**
1967. Knowledge of sedimentation in urban environments: Am. Soc. Civil Engineers Proc., Paper 5595, Jour. Hydraulics Div., v. 93, no. HY6, p. 235–245, 3 figs., 2 tables, 26 references.

Urbanization has changed the hydrology of affected areas, but little more than the qualitative nature of the changes is known. Sediment data are widely collected in the United States, mostly in large streams to measure runoff from nonurban areas for studies of reservoir silting. Measurements of urban sedimentation are scarce, and analytical studies are almost nonexistent. Urbanization increases the proportion of impervious areas, which increases peak discharges appreciably without necessarily affecting total volumes of flood runoff. This change of regimen increases sediment yield and has a marked geomorphological effect if channels are not lined. Of more significance are drastic effects of construction on urban sediment yield. More intensive studies are needed for quantitative predictions of the effects of urbanization on sediment yield.

Descriptors: Sedimentation, sediment yield, erosion, construction, storm runoff.

137 **Dawdy, D. R.**
1968. Considerations involved in evaluating mathematical modeling of urban hydrologic systems, *in* Urban water resources research, first year report, Sept. 1968: Am. Soc. Civil Engineers, app. A, chap. 6, p. A104–A121, 4 figs., 2 tables, 16 references.

Interest in the hydrology of the urban environment leads to interest in modeling as soon as quantitative answers are desired to hydrologic questions. A stochastic model relates input to output statistically. It can also be a statistical simulation of a synthetic streamflow trace. A deterministic model relates input to output in such a manner that, once the input is known, the output is wholly predictable. The most often used deterministic models in hydrology are those based on the laws of hydraulics, which use equations of continuity and motion. An analytic model usually describes a restricted area of hydrology in which the laws governing the process are fairly well known and accepted. A synthetic model specifies a conceptual relating function, and system parameters are identified through the use of input and output data. Thus, an analytic model usually describes a narrow or restricted subsystem in hydrology so that the problem is made manageable, whereas a synthetic model can be made as complex and can cover as broad an area of hydrology as desired.

Descriptors: Simulation analysis, numerical analysis, systems analysis, mathematical models, model studies, statistical models.

138 **Dawdy, D. R.; Lichty, R. W.; Bergmann, J. M.**
1972. A rainfall-runoff simulation model for estimation of flood peaks for small drainage basins: U.S. Geol. Survey Prof. Paper 506-B, p. B1–B28, 15 figs., 12 tables, 23 references.

A parametric rainfall-runoff simulation model may be used with data from a point rainfall gage and with data on daily potential evapotranspiration to predict flood volume and peak rates of runoff for small drainage areas. The model is based on bulk-parameter approximations to the physical laws governing infiltration, soil-moisture accretion and depletion, and surface streamflow. Three case studies are presented in which an objective fitting method is used for determining optimal best-fit sets of parameter values for the data available for use in predicting flood peaks. Errors of prediction result both from errors in rainfall input and from lack of model equivalence to the physical prototype. These two sources of error seem to be of the same order of magnitude.

Major gains in accuracy of simulation will require improvements in both data and model. The limit of accuracy of prediction of flood peaks by simulation with a bulk-parameter model using data obtained from a single rain gage seems to be on the order of 25 percent. The effect of manmade changes on a basin can be related to changes in model parameters, so that measured "before" conditions can be compared with simulated "after" conditions of sufficient accuracy for planning purposes.

Descriptors: Simulation analysis, storm runoff, rainfall-runoff relationships.

139 **de Laguna, Wallace**

1964. Chemical quality of water, Brookhaven National Laboratory and vicinity, Suffolk County, New York: U.S. Geol. Survey Water-Supply Paper 1156-D, p. D1–D73, 19 figs., 1 map, 6 tables, 30 references.

Chemical and radiological analyses were made of about 300 water samples collected from wells, lakes, and rivers in the vicinity of Brookhaven National Laboratory, Long Island, N.Y., during the period 1948–53. The widespread ground-water contamination found in the area was marked by high nitrate content. It was caused by the leaching of fertilizer in the intensively farmed areas, and a similar local contamination of ground water was caused by cesspools in suburban areas.

Descriptors: Groundwater pollution, nitrates, septic tanks, water pollution sources, Long Island (N.Y.).

140 **DeLuca, F. A.; Hoffman, J. F.; Lubke, E. R.**

1965. Chloride concentration and temperature of the waters of Nassau County, Long Island, New York: New York, Conservation Dept., Water Resources Comm. Bull. 55, 35 p., 2 maps, 4 tables, 10 references.

Chloride and temperature determinations are important aspects of the hydrologic monitoring program in Nassau County, Long Island, N.Y. About 6,200 chloride determinations from 540 wells and about 3,150 temperature determinations from 380 wells are given. Concentrations in excess of 10 ppm generally are attributed to one or more of five principal sources of contamination: (1) sea water, (2) fertilizer, (3) domestic wastes, (4) industrial wastes, and (5) road salting. Sea-water contamination is restricted to the near-shore areas. Part of the salty water occurs naturally, part is due to pumping of ground water, which draws in tongues of wedges of salty ground water, and part is due to inundation of low-lying shoreline areas during extraordinary high tides. Some scattered high chloride concentrations (as high as 2,000 ppm) in the ground water of northwestern Nassau County are due to contamination resulting from the use of salty bay water in washing sand and gravel. Domestic wastes are discharged in many parts of Nassau County through cesspools, septic tanks, or leaching beds. Ground water in the immediate vicinity of such installations commonly contains above-normal concentrations of chloride derived from human wastes.

Descriptors: Saline water intrusion, groundwater pollution, water pollution sources, Long Island (N.Y.).

142 **Dempster, G. R., Jr.; Massey, B. C.**

1971. Annual compilation and analysis of hydrologic data for urban studies in the Dallas, Texas, metropolitan area, 1969: Austin, Tex., U.S. Geol. Survey basic-data rept., 136 p., 4 figs., 3 tables, 8 references.

This report represents compilation and analysis of hydrologic data collected in urban or partly urban drainage basins in the Dallas, Tex., metropolitan area during the 1969 water year. The Dallas urban studies involve the collection of precipitation, runoff, and flood-elevation data in seven drainage basins within the city of Dallas and in two drainage basins outside the city in Dallas County. Two of the seven study areas in Dallas have headwaters in rural areas outside the city limits, but the largest part of each drainage basin is within the city. Total precipitation and rainfall intensities were determined from measurements at 34 recording gages. Runoff data were based on discharge measurements and stage records at eight continuous-record stations and 13 crest-stage partial record stations. Water-surface elevations were obtained at 99 flood-profile locations. Annual records of daily discharges at continuous-record gaging stations, maximum discharge at crest-stage partial-record gaging stations, and documented peak elevations at flood-profile, partial-record stations are tabulated.

Descriptors: Storm runoff, rainfall-runoff relationships, hydrologic data, Dallas (Tex.), data collections.

143 **Department of the Environment.**

1963. A guide for engineers to the design of storm sewer systems: Great Britain, Dept. of Environment, Road Research Lab., Road Note 35, 20 p., 2 figs., 10 tables, 4 references, 3 app.

This guide for engineers in the design of storm sewer systems for urban areas is based on the results of investigations carried out by a Joint Committee on Rainfall and Runoff of the Road Research Laboratory, the Hydraulics Research Station, and the Meteorological Office in Great Britain. The investigations were concerned with the whole field of problems that arise in the design of storm sewer systems, including the characteristics of heavy rainfall, rainfall-runoff relationships, and the hydraulics of sewer systems. The rational (Lloyd-Davies) formula is a satisfactory basis for the design of sewer systems of small compact urban areas. For larger urban areas, an accurate estimate of sewer sizes can be obtained only by the application of hydrological principles. Such a method has been adapted for solution by a digital computer in view of the complexity of the calculations involved.

Descriptors: Rainfall-runoff relationships, rational formula, Road Research Laboratory method, hydrograph analysis.

144 **Dettwiller, J.**

1970. Incidence possible de l'activite industrielle, sur les precipitations a Paris: Geneva, Switzerland, Secretariat of the World Meteorol. Organization, Tech. Note 108, WMO-no.254.TP.141, Urban Climates, v. 1, p. 361–362, 1 graph.

In the Paris area of France, the intensity and frequency of rain are higher during the working days of a week than during weekends. The statistics confirming this are more significant for the period 1960–67 than for 1953–59. This fact might be explained by the steady increase of industrial activities and air pollution. The same investigation was carried out for four other cities in northern France. The difference between mean day precipitation amount of a working day and a weekend day ranges in those four places from 14 to 32 percent, while in Paris it is 45 percent during the same period.

Descriptors: Precipitation (atmospheric), rainfall patterns, air pollution effects, rainfall frequency, Paris (France).

145 **Deutsch, Morris**

1963. Ground-water contamination and legal controls in Michigan: U.S. Geol. Survey Water-Supply Paper 1691, 79 p., 23 figs., 68 references.

Manmade and natural contaminants have entered many of the aquifers of Michigan. Aquifers have been contaminated by waste-laden liquids percolating from the surface or from the zone of aeration and by direct injection to the aquifer. Industrial and domestic wastes, septic tanks, leaking sewers, flood waters or other poor-quality surface waters, solids stored or spread at the surface, and even airborne wastes all have been sources of ground-water contamination in Michigan. Legal authority to control most types of ground-water contamination has been assigned to the Water Resources Commission. The practice of spreading salt on roads to melt snow is widespread. The melted snow is nothing more than contaminated recharge water. Leaking or broken sewers and pipelines are common sources of ground-water contamination. One especially great hazard lies in the pattern of development of the rapidly growing suburban areas around most of the larger municipalities. In many suburban developments, septic tanks are used to dispose of sewage. Many shallow aquifers that are recharged by septic-tank effluent will ultimately be contaminated.

Descriptors: Water pollution sources, groundwater pollution, water law, Michigan.

146 **Dharmadhikari, V. V.**

1970. Quality of runoff from diversified urban watersheds: Tucson, Arizona Univ., M.S. thesis, 197 p., 4 figs., 33 tables, 21 references.

Quality-of-water data are presented from analysis of samples collected during the summer and winter rainy seasons of 1969 from three different types of watersheds in Tucson, Ariz. Continuing expansion and intensification of urban and metropolitan development in semiarid regions of the southwestern United States are adding to the problems associated with water supply and management. Urban runoff shows values of COD (chemical oxygen demand) even larger than that of secondary sewage treatment plant effluent. In residential and commercial watersheds, this pollution appears to be suspended organic matter, and its concentration ranges from 91 to 347 mg per liter. The range observed in runoff from an industrial watershed is from 141 to 1,693 mg per liter. Tests indicate that runoff from domestic or commercial areas can be used for recreational or domestic uses after treatment with alum and adequate chlorination.—W71-03929.

Descriptors: Water quality, storm runoff, water pollution sources, Tucson (Ariz.).

147 **Diseker, E. G.; Richardson, E. C.**
1962. Erosion rates and control methods on highway cuts: Am. Soc. Agr. Engineers, Trans., v. 5, no. 2, p. 153–155, 6 figs., 3 tables.

The rate of annual soil loss on bare road cuts and highway ditches, in addition to destroying the natural beauty and creating unsightly scenery, is a serious problem to agriculture, reservoirs, streams, and highway maintenance. Further, it often creates hazardous driving conditions. Adaptable plants on properly fertilized areas can develop an effective cover which will control erosion. Mulches are essential for cover development on the steeper cuts and for plants that are slow in developing a complete cover. These findings in north Georgia should be applicable and beneficial to other similar areas.

Descriptors: Erosion control, sediment yield, erosion, road construction, Georgia.

148 **Douglas, Ian**
1967. Man, vegetation and sediment yields of rivers: Nature, v. 215, no. 5104, p. 925–928, 4 figs., 26 references.

Reconnaissance studies in a wide range of climatic conditions in Australia suggest that sediment yields of many rivers draining areas of long human use are far in excess of yields of the geological past. Sediment yield is a combined effect of runoff and vegetation cover, both of which are affected by human use of land. Comparison of Australian rivers draining largely unsettled areas with rivers elsewhere with similar mean annual runoff but which drain settled areas shows that the settled areas contribute as much as 50 times as much sediment as the unsettled areas.—W69-04269.

Descriptors: Sediment yield, vegetation effects, land use, Australia.

149 **Dow Chemical Company**
1972. An economic analysis of erosion and sediment control methods for watersheds undergoing urbanization (C-1677): Final Rept. to OWRR, Midland, Mich., Dow Chemical Co., 181 p., 27 figs., 28 tables.

Economic benefits may be expected from controlling erosion and sediment during urban construction. This study relates cost to effectiveness for many erosion and sediment control systems. The Seneca Creek watershed, near Washington, D.C., was used as a model. Estimated maximum soil erosion rates approach 200 tons per acre per year, or 128,000 tons per square mile per year. Sediment damages from uncontrolled erosion on urban construction sites in the Seneca watershed could reach $1,500 per acre. Present control practice includes sediment basins, diversion berms, level spreaders, grade stabilization structures, sodded ditches, seeding, and straw mulch. The average conventional system costs $1,125 per acre and controls 91 percent of the potential erosion. Control systems incorporating large sediment basins can control 96 percent at less total cost. Multipurpose impoundments designed with sediment forebays for chemical flocculation can control 99 percent of urban sediment and, in addition, contribute to controlling sediment from other land.—W72-08246. PB-209-212.

Descriptors: Erosion control, sediment control, economics, systems analysis, Seneca Creek (Md.).

150 **Duckstein, Lucien; Fogel, M. M.; Kisiel, C. C.**
1972. A stochastic model of runoff-producing rainfall for summer type storms: Water Resources Research, v. 8, no. 2, p. 410–421, 5 figs., 1 table, 20 references.

In calculating runoff from modified watersheds, the rainfall input must be properly modeled before the runoff output can be predicted. Runoff-producing summer precipitations of short duration and high spatial variability are considered to be an intermittent stochastic phenomenon. The probability distribution of seasonal total point or areal rainfall is obtained by convoluting a Poisson number of events with a geometric or negative binomial probability of rainfall amount. The probability of various combinations of rainfall amounts, given the seasonal total and the number of events, is computed. With these results, the theoretical seasonal water-yield distribution can be obtained by using a simple rainfall-runoff relationship, such as the Soil Conservation Service formula. The possibility of using regional input parameters to study the distribution of the output of poorly gaged small watersheds is discussed. In particular, extreme total flows can be computed.

Descriptors: Rainfall-runoff relationships, water yield, land use, mathematical models.

151 Duckworth, F. S.; Sandberg, J. S.
1954. The effect of cities upon horizontal and vertical temperature gradients: Am. Meteorol. Soc. Bull., v. 35, no. 5, p. 198–207, 8 figs., 1 table, 9 references.

For three California cities of various sizes, two low-level temperature patterns were determined by intensive traverses with automobile-mounted thermistors, and vertical temperature gradients in the lowest 1,000 feet were measured by wiresonde simultaneously at urban centers and peripheral open areas. In 35 evening surveys under varying weather conditions, a characteristic horizontal temperature pattern existed for each city. Temperatures increased from peripheral open lands to built-up center in direct proportion to structure density. Characteristics of the urban gradients were analyzed in relation to city size and to meteorological parameters. Built-up areas frequently caused instability up to about 3 times roof height in otherwise stable air, and a "crossover" point sometimes existed above which the air over the urban center was cooler than that over surrounding country.

Descriptors: Climatology, weather patterns, meteorology, precipitation (atmospheric).

152 Dupont, Andre
1969. Hydrologie, captage et traitement des eaux: Hydraulique urbaine, Paris, France, Editions Eyrolles, v. 1, 246 p., 113 figs.

This is volume 1 of a three-volume set.

153 Durum, W. H.; Langbein, W. B.
1966. Water quality of the Potomac River estuary at Washington, D.C.: U.S. Geol. Survey Circ. 529-A, 9 p., 6 figs., 2 tables, 5 references.

About 11,000 cfs of water from the Potomac River enters the estuary at Chain Birdge. During low flow the mineral content of the water is less than 260 ppm. Nearly 3 million tons of sediment is discharged annually by the Potomac River. Areas in the Washington metropolitan area undergoing urbanization have rates of sediment yield that are 50 times greater than rates in rural areas. More than 200 million gallons of waste effluent enter the estuary daily. Daily wastes from metropolitan areas alone contain an estimated 22,000 pounds of phosphorus and 68,000 pounds of nitrogen.

Descriptors: Water pollution sources, estuaries, Potomac River.

154 Eagleson, P. S.
1962. Unit hydrograph characteristics for sewered areas: Am. Soc. Civil Engineers Proc., Paper 3069, Jour. Hydraulics Div., v. 88, no. HY 2, pt. 1, p. 1–25, 11 figs., 4 tables, 17 references.

Measured storm rainfalls and coincident sewer flows were analyzed for 27 storms in five urbanized areas in Louisville, Ky. Characteristics of the resulting unit hydrographs were correlated with significant drainage basin and sewer properties. Volumetric runoff coefficients measured from the beginning of rainfall excess are constant for an area of given imperviousness and slope for which evaporation and infiltration losses are negligible. The unit hydrograph technique is well adapted for the prediction of discharge hydrographs from sewered areas. The synthetic unit hydrograph characteristics presented are applicable to sewered areas larger than 100 acres in Louisville and probably can be used in other cities.

Descriptors: Rainfall-runoff relationships, rain gages, distribution patterns, unit hydrographs.

155 Eagleson, P. S.
1967. Optimum density of rainfall networks: Water Resources Research, v. 3, no. 4, p. 1021–1033, 10 figs., 12 references.

Techniques of harmonic analysis and the concepts of distributed linear systems are used to study the sensitivity of peak catchment discharge to the characteristic spatial variability of convective and cyclonic storm rainfall. Application of the sampling theorem leads to general relations for optimum rain-gage network density in the study of long-term rainfall for flood forecasting. Specification of network density is accomplished by considering the long-term point rainfall as a homogeneous random variable to be sampled spatially. Incorporation of

catchment dynamics into the design of flood forecasting networks reduces the number of gages needed when compared with the number obtained solely through consideration of precipitation variability. Often little advantage is gained by utilizing more than two properly located stations for the determination of long-term areal mean rainfall.—W69-01046.

Descriptors: Rainfall-runoff relationships, rain gages, distribution patterns.

156 **Eagleson, P. S.**
1968. Modeling surface runoff in urban hydrology, *in* Urban water resources research, first year report, Sept. 1968: Am. Soc. Civil Engineers, app. A, chap. 4, p. A32–A78, 18 figs., 3 tables, 59 references.

Computation of surface runoff by numerical solution of approximations to the momentum and continuity equations is both feasible and accurate, and the development of general computer programs for performing these computations is well advanced. Numerical analysis allows consideration of areal as well as temporal variation in both storm and catchment parameters. Analytical experiments with these equations demonstrate the quantitative effect of simplifications in either the equations themselves or in the boundary and initial conditions for which they are solved. The coefficients which appear in these equations have a well-recognized physical significance; their evaluation, through careful field observation, insures the establishment of a generally applicable technique.

Descriptors: Rainfall-runoff relationships, overland flow, model studies, mathematical models, routing.

157 **Eagleson, P. S.**
1969. Potential of physical models for achieving better understanding and evaluation of watershed changes, *in* Effects of watershed changes on streamflow, Moore, W. L. and Morgan, C. W., eds., Water Resources Symposium No. 2, Austin, Tex., Oct. 1968: Austin, Texas Univ. Press, p. 12–25, 5 figs., 22 references.

The construction, operation, and interpretation of hydraulic models and mathematical models of the rainfall-runoff relationships of watersheds are discussed. Emphasis is given to the effects of manmade changes in watershed properties on their hydrologic performance. While there appears to be a class of watershed problems for which scale modeling may be a legitimate method of study, the class is small and is included in that larger class for which digital computer solution of the equations of motion shows at least equal promise. The errors inherent in each approach have yet to be defined, but the digital computer should ultimately have a clear economic advantage.—W70-04729.

Descriptors: Rainfall-runoff relationships, mathematical models, simulation analysis, watershed models.

158 **Eagleson, P. S.; Shack, W. J.**
1966. Some criteria for measurement of rainfall and runoff: Water Resources Research, v. 2, no. 3, p. 427–436, 7 figs., 6 references.

When designing or selecting instruments for urban hydrologic data collection, consideration should be given to the frequency response. The need for frequency-response information is influenced both by the nature of the signal to be measured and by the use to which the data will be put. Some of the relationships necessary for making decisions on frequency response for designing instruments and networks to measure rainfall and runoff are developed. Drainage basins and measuring instruments are low-pass filters, the relative bandwidths of which are important considerations in hdyrologic measurements. The tipping bucket is adequate to define the input rainfall signal over its entire bandwidth only when the product of instantaneous rainfall intensity and total storm duration exceeds 0.78 inches. The conventional stage recorder will give a distortionless measurement of outflow from natural areas so long as its time constant is less than 0.0015 times the storm duration. The small urban drainage basin filters the input signal only slightly; hence rainfall instruments should have a flat response. The usual system, employing a weir box in a storm water inlet, satisfies urban frequency response requirements.

Descriptors: Rainfall-runoff relationships, frequency analysis, rain gages, stream gages.

159 **Eagleson, P. W.; Majia, Ricardo; March, Frederic.**
1966. Computation of optimum realizable unit hydrographs: Water Resources Research, v. 2, no. 4, p. 755–764, 6 figs., 22 references.

The Weiner-Hopf theory of optimum linear systems is applied to the determination of the stable pulse response of a monotone hydrologic system from coincident records of input and output in the form of discrete time series. In application to the rainfall-runoff system, linear programming methods are used in the solution of the Weiner-Hopf equations to obtain physically realizable hydrographs. An actual urban rainfall-runoff event is graphed and used for illustration in developing the equation.—W69-01567.

Descriptors: Rainfall-runoff relationships, mathematical models, time series analysis, unit hydrographs.

160 Edmondson, W. T.

1965. The future of the lake: Metro Quarterly [Municipality of Metropolitan Seattle, Fall 1965], 4 p., 1 fig.

Originally, Seattle, Wash., released nontreated sewage into Puget Sound and treated sewage into Lake Washington. As a result, swimming in the Sound was prohibited, and Lake Washington became eutrophic. The Metro Act enacted in 1957 provided for the establishment of a metropolitan municipal corporation with the power to deal with matters of sewage disposal, garbage disposal, water, parks, transportation, and comprehensive planning. The prognosis is good for the recovery of Lake Washington.—W70-04455.

Descriptors: Lakes, eutrophication, water pollution control, water pollution sources, Lake Washington (Wash.).

161 Edmondson, W. T.

1968. Water-quality management and lake eutrophication—the Lake Washington case, *in* Water resources management and public policy, Campbell, T. H. and Sylvester, R. O., eds.: Seattle, Univ. of Washington Press, p. 139–178, 2 figs., 1 table, 104 references.

The first definite indication of enrichment of Lake Washington appeared in 1955 with abundance of *Oscillatoria rubescens,* followed by reductions in transparency and dissolved oxygen levels in water. The present solution to the problem is almost total diversion of effluents from the lake. The diversion was completed in 1967 at a cost of $85 million (including new treatment facilities). Evidence of the role of sewage in fertilization and lake deterioration comes from many sources: direct observation; urbanization followed by symptoms of increased lake productivity; nutrient budget studies, indicating relative nutrient percentages from different sources; comparison of similar lakes in different environments; changes resulting from sewage effluent diversions around lakes; bioassay techniques of lake water samples; and physiological studies of algae grown in nutrient solutions.—W69-09349.

Descriptors: Lakes, eutrophication, water pollution sources, Lake Washington (Wash.).

162 Edmondson, W. T.

1969. Cultural eutrophication with special reference to Lake Washington: Internat. Assoc. Theoretical and Applied Limnology (Internationale Vereinigung fur Theoretische und Angewandte Limnologie), v. 17, p. 19–32, 5 figs., 37 references.

Eutrophication of Lake Washington by urban sewage and its subsequent recovery after installation of treatment facilities and effluent diversion are well documented. Of many diatoms occurring in cores, *Fragilaria crotonensis* dominates; *Melosira italica* is in the deeper (older) sediments; and *Asterionella formosa* occurs at all depths. No species, abundant at any depth, is missing from significant core sections. Relative composition of centric versus araphidinate groups of diatoms correlates with the lake's eutrophication history; large decreases in araphidineae coincide with removal of raw sewage. Based upon a reasonably reliable marker layer, sedimentation has proceeded at a rate between 2.3 and 3.1 mm per year since 1916. Surficial sediments tend to be distinctly enriched in phosphorus.—W70-05663.

Descriptors: Lakes, eutrophication, water pollution control, Lake Washington (Wash.).

163 Emde, Wilhelm; Hoffmann, Seigfried

1969. Investigation of storm overflows in the sewer system of a large city: GWF das Gas-und Wasserfach, v. 110, no. 12, p. 321–325, 7 figs., 1 graph, 4 references. [In German.]

The Hamburg (Germany) sewer network contains sludge deposits, and the early flush caused by rainfall runoff causes pollution. Measurements and evaluations can yield insight into canal system efficiency. These measurements are made both in dry and wet periods. Recording gages show frequency of overflow, overflow duration,

and the flow of mixed storm water and sewage. Hydrographs yield important characteristics of overflows greater than storage and outflow capacity and show the ciritcal distribution of rain in an overflow-producing storm.

Descriptors: Water pollution sources, combined sewers, storm runoff, Hamburg (Germany).

164 Engberg, R. A.

1971. Nitrate and orthophosphate in several Nebraska streams: U.S. Geol. Survey Prof. Paper 750-C, p. C215–C222, 4 figs., 4 tables, 4 references.

At sampling sites on 11 streams in Nebraska, mean concentrations of nitrate ranged from 0.6 to 6.1 mg per liter, and mean concentrations of orthophosphate ranged from 0.35 to 2.0 mg per liter. Weighted by water discharge, average concentrations of nitrate and orthophosphate in all 11 streams were 2.1 mg per liter and 0.81 mg per liter, respectively. Concentrations of nitrate and orthophosphate do not correlate with total dissolved-solids content of the water nor with water discharge. However, nitrate concentrations show some correlation with population density, cattle density, and percentage of drainage area planted in corn.

Descriptors: Nebraska, water pollution sources, land use.

165 Engberg, R. A.; Renschler, T. O.

1971. Occurrence of phosphorus and nitrogen in Salt Creek at Lincoln, Nebraska: U.S. Geol. Survey Prof. Paper 750-C, p. C223–C227, 1 fig., 2 tables, 11 references.

Concentrations of phosphorus and nitrogen in Salt Creek is increasing markedly in the 6-mile reach of the creek within the city of Lincoln, Nebr. Most of the increase is due to inflow from the Lincoln sewage-treatment plant and from storm sewers and other urban runoff entering the reach. The city contributes 0.94 ton phosphorus and 1.8 tons nitrogen per day to the stream, indicating annual per capita contributions of phosphorus and nitrogen of 4.5 and 8.7 pounds per year, respectively.

Descriptors: Water pollution sources, Nebraska, storm runoff, Lincoln (Nebr.).

166 Engineering-Science, Inc.

1961. Effects of refuse dumps on ground-water quality: California, State Water Pollution Control Board, Pub. 24, 108 p., 7 figs., 17 tables, 82 references, 1 app.

The principal processes involved in the introduction of undesirable substances to the ground water from refuse dumps are infiltration and percolation, refuse decomposition, gas production and movement, and leaching. In southern California, refuse dumps with unirrigated soil covers do not seem to transmit surface-applied moisture in quantities large enough to cause noticeable pollution. In areas of higher precipitation, rainwater percolates through refuse, and heavy irrigation or occasional high precipitation may produce substantial percolation. Refuse contains mineral and organic substances in quantities capable of seriously damaging underground water supplies. The organic matter of refuse undergoes aerobic and anaerobic biological decomposition and produces large volumes of carbon dioxide and methane. Carbon dioxide can seriously degrade ground water by dissolving calcium, magnesium, iron, and other substances. Percolate from household refuse can contain high concentrations of organic matter and mineral salts. The substances most likely to prove objectionable if percolate pollutes a ground-water supply are hardness, iron, nitrate, and total dissolved solids.

Descriptors: Water pollution sources, garbage dumps, landfills, path of pollutants, California.

167 Environmental Protection Agency.

1970. Urban runoff characteristics: Washington, D.C., U.S. Govt. Printing Office, 340 p., 161 figs., 67 tables, 37 references.

Detailed information on the watershed characteristics and data on runoff quantity and quality were compiled from a one-year study of a combined sewer watershed of approximat ly 2,380 acres in Cincinnati, Ohio. The

information collected will be used to test and refine the storm water management model, developed for the Environmental Protection Agency, Water Quality Office. In addition, work has been done on urban runoff mathematical models.

Descriptors: Storm runoff, rainfall-runoff relationships, mathematical models, Cincinnati (Ohio).

168 Environmental Protection Agency.
1971. Control of sediments resulting from highway construction and land development: Washington, D.C., Environmental Protection Agency, Office of Water Programs, Rural Water Sections, 50 p., 38 figs., 53 references.

Land development activities upset the natural geologic process of sedimentation by greatly accelerating erosion. Deposition of excess quantities of sediments pollutes downstream waters and damages land. The technical capability of controlling erosion and sediment deposition is available. Disturbed soil can be protected from the energy of falling rain and flowing runoff water by installing protective covers. Runoff can be controlled, and sediments in transport can be trapped. The cost of effective erosion and sediment control is small. The principal problem lies in achieving effective administrative control and enforcement of erosion and sediment-control programs.

Descriptors: Sedimentation, erosion control, storm runoff, soil erosion, land use.

169 Environmental Protection Agency.
1971. Environmental impact of highway deicing: Environmental Protection Agency, Water Pollution Control Research Series no. 11040-GKK-06/71, 120 p., 13 figs., 30 photos., 9 tables, 147 references.

Deicing agents are used for removal of ice and snow from highways and streets for wintertime road maintenance in most snowy areas of the United States. This state-of-the-art report critically reviews the available information on the following: methods, equipment, and materials used for snow and ice removal; chlorides found in rainfall and municipal sewage during the winter; salt runoff from streets and highways; deicing compounds found in surface streams, public water supplies, ground water, farm ponds, and lakes; special additives incorporated into deicing agents; vehicular corrosion and deterioration of highway structures and pavements; and effects on roadside soils, vegetation, and trees. Highway deicing can cause environmental injury and damage. Recommendations are given for research, development, and demonstration efforts necessary to assess and reduce the adverse impact of highway deicing.—W71-13898.

Descriptors: Highway deicing, water pollution sources, deicers, runoff.

170 Environmental Science and Technology.
1969. Urban runoff adds to water pollution: Environmental Sci. and Technology, v. 3, no. 6, p. 527.

Chicago's urban runoff constitutes approximately 1 percent of the raw sewage load and amounts to 5 percent of the BOD (biochemical oxygen demand) discharged from the secondary waste treatment facilities. Water pollution from this urban source creates a shock pollution load on receiving waters. The most useful measure of pollution potential of street litter is the BOD of the soluble dust and dirt fraction.—W71-06634.

Descriptors: Water pollution sources, water pollution effects, runoff, Chicago (Ill.).

171 Escritt, L. B.; Young, A. J. M.
1963. Economic surface-water sewerage, a suggested standard of practice: Inst. of Public Health Eng. Jour., v. 62, pt. 4, p. 333–350, 3 figs., 5 tables, 22 references.

The amount by which calculated rates of runoff during storms exceed recorded rates may not be due to storage but to a change in impermeability of the catchment. An experiment using a sheet of plate glass as a catchment supports that view. The Lloyd-Davies method of calculation should be used with the assumption that roofed and paved surfaces in developed areas have an impermeability of 80 percent and not 100 percent as the Road Research Laboratory suggests.—W69-01569.

Descriptors: Storm runoff, surface runoff, urbanization, surface permeability, impervious area, rational formula.

172 Espey, W. H., Jr.; Morgan, C. W.; Masch, F. D.

1965. A study of some effects of urbanization on storm runoff from a small watershed: Texas Univ., Center for Research in Water Resources, Hydraulic Eng. Lab., Tech. Rept. HYD-07-6501-CRWR-2, 107 p., 24 figs., 3 maps, 10 photos., 12 tables, 64 references.

The effects of urbanization on the hydrologic characteristics of a small urban watershed located within Austin, Tex., were studied, using linear regression analysis of data from 24 urban and 11 rural watersheds to derive equations to evaluate past rural conditions and predict future urban conditions. The Waller Creek watershed contains two streamflow stations which gage areas of 2.31 square miles and 4.13 square miles. Upper Waller Creek watershed is relatively undeveloped when compared to the lower portion, located between the two stations. The lower portion has extensive residential development and some channel improvement. Urban development in Waller Creek watershed causes changes in the discharge hydrograph and runoff yield. The time sequence of the discharge hydrograph is shortened, the peak discharge is increased, and the unit yield is increased.

Descriptors: Rainfall-runoff relationships, water yield, hydrograph analysis, peak discharge, Austin (Tex.), unit hydrograph.

173 Espey, W. H., Jr.; Winslow, D. E.

1968. The effects of urbanization on unit hydrographs for small watersheds, Houston, Texas, 1964–67, v. 1: Austin, Tex., Tracor Inc., Tracor Doc. 68-975-U, 70 p., 17 figs., 1 map, 7 tables, 7 photos., 8 references.

Rainfall-runoff relations were studied on several small watersheds in Houston, Tex., to learn the effects of urbanization and to develop equations to describe the effects of urbanization on unit hydrographs. Rainfall and runoff data from 11 urban and 6 rural watersheds were reduced and 30-minute unit hydrographs obtained. This was combined with previously reduced data for 22 urban and 11 rural watersheds. Multiple linear regression analysis was used to develop equations to describe the 30-minute unit hydrograph for urban and rural conditions. The equations are used to predict effects on the unit hydrograph of changes in impervious cover, channel conditions, and secondary drainage facilities due to urbanization. In changing from a rural to a highly urbanized condition, the 30-minute unit hydrograph may show an increase in peak discharge of as much as 500 percent and a decrease in time of rise of as much as 90 percent. —W69-02354.

Descriptors: Storm runoff, rainfall-runoff relationships, unit hydrographs, Houston (Tex.).

174 Espey, W. H., Jr.; Winslow, D. E.; Morgan, C. W.

1969. Urban effects on unit hydrographs, *in* Effects of watershed changes on streamflow, Moore, W. L. and Morgan, C. W., eds., Water Resources Symposium No. 2, Austin, Tex., Oct. 1968: Austin, Texas Univ. Press, p. 215–228, 10 figs., 4 tables, 15 references.

Summaries are presented of work concerning peak floods for urban areas and of a recent study concerning watersheds in Houston, Tex. Increased urbanization results in increased peak flows and accentuated high and low flows. Equations presented show that peak flows may be expected to increase from 2 to 4 times the flows from the underdeveloped watersheds, depending upon the type of channel improvement, amount of vegetation in the channel, and the type of secondary drainage system. The capacity of the secondary drainage facilities may have a limiting effect on the peak discharge. —W70-04577.

Descriptors: Storm runoff, hydrograph analysis, rainfall-runoff relationships, Houston (Tex.).

175 Essex County Planning Board.

1969. Surface storm water runoff and drainage study for Essex County, New Jersey: Belleville, N.J., Essex County Planning Board, 55 p.

Storm frequency information is analyzed for Essex County, N.J., and design prototypes are given countywide for small watershed developments. Physical characteristics and surface imperviousness studies relate criteria of physical properties of soils, geology, topography (slope) and future land use to storm runoff expectations. Recommendations are made for future programs and measures required to better plan for future storm drainage facilities in Essex County. —W71-00448. PB-192-358.

Descriptors: Rainfall-runoff relationships, impervious area, planning, land use, Essex County (N.J.).

176 **Evelyn, J. B.; Narayana, V. V. D.; Riley, J. P.; Israelsen, E. K.**
1970. Hydrograph synthesis for watershed subzones from measured urban parameters: Logan, Utah State Univ., Utah Water Research Lab., 51 p., 35 figs., 10 tables, 17 references, 3 app.

An analog computer program was developed to simulate the outflow hydrographs at four locations within the Waller Creek urban watershed at Austin, Tex. Actual outflow was gaged at the final outlet of the watershed. This provided a checkpoint for comparing the simulated and observed final outflow hydrographs. The outflow hydrographs for each subzone were obtained by chronologically abstracting interception, infiltration, and depression storage from their precipitation hydrographs. These outflow hydrographs were then routed through Waller Creek channel to obtain the hydrographs at the four desired locations. The advantages of this model are the flexibility in varying the precipitation inputs to each subzone and the ability to obtain the contribution to the final flood hydrograph of each subzone.—W71-04184.

Descriptors: Simulation analysis, storm runoff, hydrograph analysis, Austin (Tex.).

177 **Fair, G. M.; Geyer, J. C.; Okun, D. A.**
1966. Water and wastewater engineering, v. 1. Water supply and wastewater removal: New York, N.Y., John Wiley & Sons, Inc., 505 p., 155 figs., 50 tables, 113 references, 1 app.

This textbook, which covers water supply and wastewater removal, is intended to be used by both students and practicing sanitary and water-supply engineers and urban planner. Each chapter includes both the scientific and engineering aspects of water engineering and the cultural and historical perspective.

Descriptors: Waste disposal, water management (applied), municipal wastes.

178 **Feddes, R. G.; Clark, R. A.; Runnels, R. C.**
1970. A hydrometeorological study related to the distribution of precipitation and runoff over small drainage basins, urban versus rural areas: Texas A. & M. Univ., Water Resources Inst., Tech. Rept. 28, 64 p., 27 figs., 5 tables, 20 references.

The effects of urbanization on streamflow were investigated for two adjacent similar watersheds located in and near Bryan, Tex. The Burton Creek watershed is 84 percent urbanized, and the Hudson Creek watershed is completely rural. Storms observed within each basin are used for comparison of pertinent hydrograph parameters. Simultaneous events are compared between the watersheds, and the urbanization effect is noted. A synthetic procedure was developed for predicting hydrographs on both watersheds. Reproduction of actual events indicates that the model yields better results in the rural watershed. There is conclusive evidence that the urbanization of a watershed decreases time-to-peak and increases the peak discharge.—W70-07980.

Descriptors: Rainfall-runoff relationships, storm runoff, simulation analysis.

179 **Federal Water Quality Administration.**
1970. Storm water pollution from urban land activity: Federal Water Quality Adm. Rept., Water Pollution Control Research Ser. 11034-FKL-07/70, 325 p., 13 figs., 21 maps, 32 photos., 29 references, 14 app.

See Avco Economic Systems Corp., Washington, D. C.

180 **Federal Water Quality Administration.**
1970. Combined sewer overflow abatement technology, a compilation of papers presented at the Federal Water Quality Administration symposium on storm and combined sewer overflows, Chicago, Ill., June 22–23, 1970: Federal Water Quality Adm., Water Pollution Control Research Series, no. 11024—06/70, 65 figs., 19 maps, 36 photos., 40 tables, 14 references.

This compilation of papers contains results of demonstration grants and contracts supported by the Federal Water Quality Administration. The papers discuss alternatives to storm and combined sewer pollution in a small urban area; screening and air floatation for solids removal; underflow deep tunnel system concept; urban erosion and sediment control; sewer monitoring and remote control; combined sewer overflow regulators; use of fine mesh screens; and land use and urban runoff pollution.—W70-09558.

Descriptors: Water pollution sources, water pollution control, storm runoff, combined sewers.

181 Feick, G.; Horne, R. A.; Yeaple, D.

1972. Release of mercury from contaminated freshwater sediments by the runoff of road deicing salt: Science, v. 175, no. 4026, p. 1142–1143, 1 table, 4 references.

Addition of NaCl or $CaCl_2$ increases the relative amount of mercury in the water in equilibrium with sediments by two to five or more orders of magnitude. The effect tends to increase as the mercury burden of the sediments increases. In addition to being a serious contaminant itself, road salt in natural waters can acerbate contamination by mercury and undoubtedly by other toxic heavy metals.

Descriptors: Water pollution effects, deicers, highway deicing, mercury.

182 Feig, A. M.

1968. An evaluation of the precipitation patterns over the metropolitan St. Louis area, *in* First Natl. Conf. on Weather Modification, Albany, N. Y., Apr. 28 to May 1, 1968, Proc.: p. 210–219, 3 figs., 4 tables, 9 references.

In the metropolitan St. Louis area, the pattern of precipitation suggests the presence of urban influences. Statistical tests and practical considerations were applied in an effort to establish the validity of the pattern and its implications. The St. Louis area affords a good environment in which to evaluate urban influences on precipitation because the city lies in a generally flat, featureless plain with changes of elevation only 500 feet within 60 miles. Furthermore, St. Louis is not subject to any lake effect that could produce a localized precipitation anomaly. There are a number of industrial sites concentrated within a radius of 30 miles from the center of the metropolitan area. Outside of this region, however, there are no other industrial complexes for several hundred miles. The generalized isohyetal chart based on a 30-year period of record shows a pronounced trough in the isopleth over St. Louis. One possible explanation for the St. Louis anomaly which would account for the "dry" area and the surrounding "wet" areas is the formation of a microhigh caused by asymetrical heat island.

Descriptors: Rainfall, climatology, precipitation (atmospheric), rainfall patterns.

183 Felton, P. M.; Lull, H. W.

1963. Suburban hydrology can improve watershed conditions: Public Works, v. 94, no. 1, p. 93–94, 2 photos., 2 tables.

To determine how suburbanization affects the capacity of the soil to absorb water in the Wissahickon Valley, Pa., ring-infiltration tests were made in woods, fields, and lawns. In all, 108 tests were made in the summer of 1961, mostly in groups of three at each site. Average depths of water infiltrated per minute were, for woods, 0.58 inch; for fields, 0.28 inch; and for lawns, 0.10 inch. Infiltration into the lawns was slow. In 8 of the 34 runs only 0.1 inch or less infiltrated in a 5-minute period. Relatively low infiltration rates of the lawns are attributed to the high density of suburban soil, usually man-mixed and bulldozed into position and further compacted by frequent mowing and trampling. Surface runoff from these compacted lawns, when concentrated, can be responsible for much soil erosion.

Descriptors: Storm runoff, infiltration, suburbs, Philadelphia (Pa.), erosion.

184 Ferguson, D. E.

1972. Annual compilation and analysis of hydrologic data for urban studies in the Houston, Texas metropolitan area, 1970: U.S. Geol. Survey open-file rept., 275 p., 6 figs., 3 tables, 1 reference.

Basic data of the urban hydrology of Houston, Tex., are compiled. Surface-water records are from gaging stations, crest-stage partial-record stations, rain gages, and miscellaneous sites. Each gaging-station record includes location, drainage area, gage type and history, average discharge, extremes, remarks, daily discharge, total discharge, mean discharge, annual maximum and mean discharges, and peak discharges. Runoff and rainfall

are computed for each drainage basin, and hydrographs and mass curves are drawn. A map of each basin shows locations of all gages. The objectives are to provide basic runoff data for small urban drainage areas which differ in topography, soil, vegetation, tributaries, basin shape, and degree of urbanization; to provide related rainfall data with consideration of variation in intensity and location; and to provide data showing the effects of progressive urbanization on flood peaks and volume.

Descriptors: Rainfall-runoff relationships, Houston (Tex.), data-collections, hydrologic data, floods, peak discharge.

185 **Flynn, J. M.**

1961. Impact of suburban growth on ground water quality in Suffolk County, New York: Cincinnati, Ohio, Environmental Protection Agency, Robert A. Taft Sanitary Eng. Center, Ground Water Contamination, Tech. Rept. W61-5, p. 71–82, 6 tables, 5 references.

Suffolk County, on the east end of Long Island, N.Y., is bounded on the north by the Long Island Sound and on the south by bays. The county had a population in 1960 of 665,550 at an average density of 723 persons per square mile. From 1950 to 1960 the population increased approximately 390,000 persons or 60 percent. The four western townships (about one-third of the total area) contain approximately 71 percent of the population at a density of nearly 1,600 persons per square mile. Intrusion of salt water has occurred where withdrawals exceed the safe yield. Stormwater recharge basins number over 400. These basins receive a large portion of the rainfall that accumulates on impervious areas such as roads, sidewalks, and parking lots. The daily recharge from existing basins is estimated to be 10,000,000 gallons. Approximately 95 percent of the sewage in Suffolk County is discharge through subsurface leaching systems into the ground waters. An ionic surfactant is the contaminant that appears with greatest frequency in Suffolk County. This surfactant, usually alkyl benzene sulfonate (ABS), is one of the common products used for household laundry. The growth rates in the suburbs of Suffolk County have had a devastating effect on ground-water quality.

Descriptors: Water pollution sources, groundwater pollution, saline water intrusion, Long Island (N.Y.).

186 **Fogel, M. M.; Duckstein, L.; Kisiel, C. C.**

1971. Space-time validation of a thunderstorm rainfall model: Water Resources Bull., v. 7, no. 2, p. 309–316, 3 figs., 2 tables, 9 references.

A probability model for predicting the occurrence and magnitude of thunderstorm rainfall in the southwestern United States was tested in the metropolitan Chicago area with reasonable success, especially for moderate-to-extreme runoff-producing events. The model required the estimation of the mean number of events per year and the conditional probability of rain, given that an event has occurred. Both of the model parameters can be obtained from daily warm-season rainfall records. Regardless of the definition used, a Poisson distribution adequately described the number of events per season. A negative binomial distribution represents the frequency density function for rainfall where several gages are employed in defining a storm. Chicago data fit both distributions very well at events with relatively high return periods. On a regional basis, limited amount of data may be used to estimate parameters for extensive areas.—W71-08530.

Descriptors: Rainfall, thunderstorms, rainfall-runoff relationships, Chicago (Ill.).

187 **Forsgate, J. A.; Temiyabutra, S.**

1971. Rainfall and runoff from an industrial area in Nairobi, Kenya: Great Britain, Dept. of the Environment, Road Research Lab., Rept. LR 408, 11 p., 4 figs., 1 table, 5 references.

Data were collected and analyzed from one urban catchment in Nairobi. Modifications to the Road Research Laboratory hydrograph method of sewer design were introduced to allow its use under conditions of tropical rainfall. The percentage runoff from unpaved areas may be estimated using an antecedent precipitation index, and the resulting contribution to the storm hydrograph is attenuated by routing through a linear reservoir.

Descriptors: Rainfall-runoff relationships, storm runoff, hydrograph analysis, Road Research Laboratory method, Nairobi (Kenya).

188 **Fosberg, R. F.**

1966. Restoration of lost and degraded habitats, *in* Future environments of North America, Darling, F. F. and Milton, J. P., eds.: Garden City, N.Y., The Natural History Press, p. 503–515.

Means of restoring destroyed and degraded areas to something approaching natural conditions are examined. Six biological consequences of habitat degradation are listed ranging from changes in the composition and structure of vegetation and biotic communities to creation of biological vacua. Causes of degradation discussed include: logging, agriculture, urbanization and industrialization, flooding, dredging and filling in shallow water, exploitation of material of the substratum, and degradation of habitats by pollution.——W71-01367.

Descriptors: Environmental effects, ecology, conservation, National Park System, erosion.

189 **Foster, J. W.**

1971. Nature's tectonic wastebasket: Public Works, v. 102, no. 10, p. 65–67, 2 figs.

Deep injection wells offer promise for disposal of liquid wastes. The geologic suitability for such systems in major North American cities is estimated and tabulated.

Descriptors: Waste disposal wells, injection wells, North America, hydrogeology.

190 **Franke, O. L.**

1968. Double-mass-curve analysis of the effects of sewering on ground-water levels on Long Island, New York: U.S. Geol. Survey Prof. Paper 600-B, p. B205–B209, 2 figs., 2 tables, 2 references.

Ground-water levels in a 50-square-mile area in Nassau County, Long Island, N.Y., which was sewered in the early 1950's, have declined on an average of 10 feet relative to an unsewered area nearby. About 7 feet was caused by sewering and the remainder by ground-water withdrawal, urbanization, and the 1961–66 drought. Water-level decline from sewering ranged from 1 to 15 feet. Assuming a specific yield of 20 percent for the shallow aquifer, the estimated average loss of ground water from storage as a result of sewering is about 3 mgd since 1953. The decline in ground-water levels has been accompanied by pronounced reductions in streamflow, corresponding to an average of about 2 mgd since 1953.

Descriptors: Surface-groundwater relationships, runoff, groundwater depletion, Long Island (N.Y.).

191 **Franke, O. L.; McClymonds, N. E.**

1972. Summary of the hydrologic situation on Long Island, New York, as a guide to water-management alternatives: U.S. Geol. Prof. Paper 627-F, p. F1–F59, 39 figs., 19 tables, 79 references.

The ground-water reservoir of Long Island is a wedge-shaped mass of unconsolidated deposits that attain a thickness of about 2,000 feet. The estimated volume of water-saturated material is about 180 cubic miles. At present, more than 2,000 recharge basins are used to infiltrate about 80 mgd of urban runoff. An estimated additional 60 mgd of direct runoff discharges to streams or directly to salty water. Gross ground-water pumpage increased from about 100 mgd in 1940 to about 330 mgd in 1965. The total sewage effluent discharged increased from about 15 mgd in 1950 to about 75 mgd in 1965. Most of this increased effluent was derived from ground water, and its removal from the area has caused lowering of ground-water levels. Much of the shallow ground water is contaminated with domestic wastes from cesspools and septic tanks. Fresh ground water will ultimately be depleted if total outflow exceeds total inflow. Proposals to manage the water resources include barrier injection wells, shallow skimming wells, recharge of treated sewage effluent, and allowing encroachment of salty ground water.

Descriptors: Hydrogeology, saline water intrusion, groundwater pollution, groundwater depletion, Long Island (N.Y.).

192 **Franklin Institute Research Laboratories.**
1969. Selected urban storm water runoff abstracts: U.S. Federal Water Pollution Control Adm., Water Pollution Control Research Series WP-20-21, 109 p.

Selected Urban Storm Water Runoff Abstracts is a compilation of abstracts summarizing articles from a variety of technical publications, covering the subjects of urban runoff, storm-water discharge, storm sewers, and combined sewers, together constituting the problem of urban drainage. This compilation represents as complete a bibliographic record as possible of storm-water articles up to 1968. Each of the 573 items includes a bibliographic citation, an abstract, and a set of indexing descriptors.—W69-10085.

Descriptors: Abstracts, bibliographies, storm runoff, combined sewers.

193 **Franklin Institue Research Laboratories.**
1970. Selected urban storm water runoff abstracts, July 1968–June 1970: U.S. Environmental Protection Agency, Water Quality Office, Water Pollution Control Research Series 11024 EJC 07/70, 375 p.

A compilation of abstracts summarizing articles from a variety of technical publications constituting the problem of urban drainage was developed by the Franklin Institute Research Laboratories, Philadelphia, Pa. This work includes 599 abstracts of documents published for the most part from July 1968 through June 1970. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers. A cumulative subject index provides the necessary access to individual concepts. An author index and journal list are also included.—W71-06253. PB-198-228.

Descriptors: Abstracts, bibliographies, storm runoff, combined sewers.

194 **Franklin Institute Research Laboratories.**
1970. Selected urban storm water runoff abstracts, first quarterly issue: U.S. Environmental Protection Agency, Water Quality Office, Water Pollution Control Research Series 11024 EJC 10/70, 37 p.

The first quarterly supplement to Selected Urban Storm Water Runoff Abstracts is a compilation of abstracts summarizing articles from a variety of technical literature concerning the problem of urban drainage published from July 1970 through September 1970. The 36 abstracts covering a range of eight sections are arranged alphabetically by author and numerically by abstract number in each category. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers.—W71-06254. PB-198-229.

Descriptors: Storm runoff, abstracts, bibliographies, combined sewers.

195 **Franklin Institute Research Laboratories.**
1971. Selected urban storm water runoff abstracts, second quarterly issue: U.S. Environmental Protection Agency, Water Quality Office, Water Pollution Control Research Series 11024 EJC 01/71, 45 p.

The second quarterly supplement to Selected Urban Storm Water Runoff Abstracts is a compilation of abstracts summarizing articles from a variety of technical literature concerning the problem of urban drainage published from October 1970 through December 1970. The 50 abstracts covering a range of ten sections are arranged alphabetically by author and numerically by abstract number within each category. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers.—W71-06255. PB-198-312.

Descriptors: Abstracts, bibliographies, storm runoff, combined sewers.

196 **Franklin Institute Research Laboratories.**
1971. Selected urban storm water runoff abstracts, third quarterly issue: U.S. Environmental Protection Agency, Water Quality Office, Water Pollution Control Research Series 11024 FJE 04/71, 75 p.

The third quarterly supplement to Selected Urban Storm Water Runoff Abstracts is a compilation of Abstracts summarizing articles from a variety of technical literature concerning the problem of urban drainage published from January 1971 through March 1971. The 89 abstracts covering a range of ten sections are arranged alphabetically by author and numerically by abstract number within each category. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers. An author index and a journal list are also included.

Descriptors: Abstracts, bibliographies, storm runoff, combined sewers.

197 Franklin Institute Research Laboratories.
1971. Selected urban storm water runoff abstracts, July 1970–June 1971: U.S. Environmental Protection Agency, Water Quality Office, Water Pollution Control Research Series 11024 FJE 07/71, 173 p.

The July 1970–June 1971 supplement to Selected Urban Storm Water Runoff Abstracts is a compilation of abstracts summarizing articles from a variety of technical literature concerning the problem of urban drainage published during this period. The 234 abstracts covering a range of ten sections are arranged alphabetically by author and numerically by abstract number within each category. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers. A subject index at the end of the volume provide the necessary access to individual concepts. An author index and a journal list are also included.

Descriptors: Abstracts, bibliographies, storm runoff, combined sewers.

198 Frost, T. P.
1968. The galloping ghost of eutrophy: Appalachia, v. 37, no. 1, p. 25–36, 1 fig., 4 pls.

The increased influence of man on the environment has caused a change in the definition of eutrophication from a natural aging process of lakes due to topography, degree of fertility, sediment loads from mineral and organic solids, subsurface geology, and weathering to an accelerated aging due to man's influence. Increasing urbanization, along with our changing life style, is suggested as the cause for "galloping eutrophy". The effect is the proliferation of algae. The result is esthetic deterioration, fish kills, septic odors, discoloration of objects in water, and organic debris buildups on bottoms, scums, and mats. The real need is nutrient removal from sewage effluent.—W69-07818.

Descriptors: Eutrophication, lakes, water pollution effects.

199 Fruh, E. G.
1969. Urban effects on quality of streamflow, *in* Effects of watershed changes in streamflow, Moore, W. L. and Morgan, C. W., eds., Water Resources Symposium No. 2, Austin, Tex., Oct. 1968: Austin, Texas Univ. Press, p. 255–282, 23 figs., 5 tables, 15 references.

The effects of impoundments and urbanization on the water quality of the Colorado River of Texas were studied in the reservoirs near Austin, Tex. Lake Travis, upstream from Austin, is large and deep and has no significant input of pollution. Lake Austin, the next reservoir downstream, is much smaller and shallower and receives some recreational and urban runoff pollution. Town Lake in Austin is small and narrow with predominantly river characteristics and receives some urban runoff pollution. Oxygen concentration and water depth data for the three reservoirs are tabulated. High concentrations of total and coliform bacteria were found in Lake Austin following periods of intensive rainfall. The urban stream, Barton Creek, had significantly higher concentrations of solutes, nutrients, and bacteria than Town Lake above the stream's entrance. All of Austin's urban streams enter Town Lake and Lake Austin, with the streams from the more highly developed areas entering Town Lake.—W70-04727.

Descriptors: Reservoirs, water quality, water pollution sources, Austin (Tex.).

200 Fry, Keith

1966. Land run-off—a factor in Potomac basin pollution: Washington, D.C., Interstate Commission on the Potomac River Basin, 17 p., 1 map, 5 tables, 4 graphs, 5 hydrographs, 11 references, 1 app.

Pollution in the Potomac basin is the concern of the Interstate Commission on the Potomac River basin. Bacteriological pollution in the river limits or prevents the use of the water for water supply and recreational activities. Bacterial counts at all the points sampled regularly exceed all of the limiting values for recreation. The dominance of farm animal pollution at the specific points used is clearly shown by the sampling program. The farm animal population of the Potomac basin produces far more wastes than the human population. None of the animal waste is treated; in contrast, only about 2 percent of the human wastes of the basin enter the river entirely untreated.

Descriptors: Water pollution sources, farm wastes, Potomac River.

201 Gameson, A. L. H.; Davidson, R. N.

1963. Storm-water investigations at Northampton: Institute of Sewage Purification, Journal and Proceedings, pt. 2, p. 105–130, 18 figs., 12 tables, 3 references.

The St. Andrew's drainage area, which is mainly residential, lies within the county borough of Northampton, England. It covers a total of 229.3 acres and has a resident population of about 9,600. During periods of rainfall, the sewage flow in the combined system is derived from two sources, the normal sewage flow which would occur in dry weather and the additional flow caused by the rainfall. The biochemical oxygen demand of the storm sewage is least for storms occurring during the latter part of the night, is less at high flows, falls off with the time since the storm started, and increases with the time elapsed since the previous storm. The suspended-solids content is little affected by either of these two factors; usually the storm sewage contains a greater concentration of solids than does the crude sewage. The greatest concentration of solids is associated with the first flush of storm sewage, and this maximum value is substantially enhanced when a storm follows several days of dry weather.

Descriptors: Storm runoff, water pollution sources, combined sewers, Northampton (England).

202 Gameson, A. L. H.; Davidson, R. N.; Threlfall, J. M.

1965. Storm flows from combined sewerage systems in three areas: Inst. of Public Health Engineers Jour., v. 64, pt. 3, p. 182–208, 9 figs., 3 tables, 10 references.

The flows in three combined systems in England—those of the St. Andrew's drainage area of Northampton, the Rastrick area of Brighouse, and the Cooper Lane area of Bradford—were analyzed. The chief differences between the three drainage areas are in impermeable areas and the population densities. The most important differences between the sewerage systems are the slopes, which range from 1 in 78 to 1 in 23, the total falls (87 to 434 feet), the mean cross-sectional areas of the sewers (0.7 to 3.9 feet), and their total capacities (0.16 to 1.14 million gallons). The Northampton area is far more densely developed than the Brighouse area. The latter was under development during the investigation, during which time the impermeable area increased from 59 to 68 acres and the population increased from 5,200 to 6,300. The number of days when discharge occurs is probably of greater importance than the number of runoff periods. The parameters of greatest importance relating to the discharge from a storm overflow are the frequency and duration of operation and the volume discharged. The results for Northampton and Brighouse show a remarkable degree of concordance, and those for Bradford are in fair agreement.

Descriptors: Rainfall-runoff relationships, combined sewers, water pollution sources, storm runoff.

203 Gann, E. E.

1971. Generalized flood-frequency estimates for urban areas in Missouri: U.S. Geol. Survey open-file rept., 18 p., 3 figs., 1 table, 9 references.

A method is presented for estimating flood-frequency information for urban areas in Missouri. Flood-frequency relations are presented which provide an estimate of the flood-peak discharge for floods with recurrence intervals from 2.33 to 100 years for basins with various degrees of existing or projected urban development. Drainage area sizes for which the relations are applicable range from 0.1 to 50 square miles. These generalized relations will be useful to the urban planner and designer until more comprehensive studies are completed for the individual urban areas within the State. The relations will also be of use in the definition of flood-hazard areas in Missouri.—W71-10714.

Descriptors: Flood forecasting, storm runoff, rainfall-runoff relationships, peak discharge, Missouri.

204 Geiger, Rudolf

1965. The climate near the ground: Cambridge, Mass., Harvard Univ. Press, 611 p., 281 figs., 98 tables, 1,218 references.

The basic reason for the differences between city and rural climates is the alteration of natural heat and water budgets by making natural ground largely impermeable and by increasing roughness of the surface by covering the ground with buildings. In addition, heat is supplied by domestic and industrial fires. City air is rich in dust stirred up by traffic, in fumes from vehicles, from fires, and from industrial works. In Germany, on the average, the manmade supply of heat is about 40 calories per square centimeter per day. In Hamburg, incoming radiation averages 34 cal per sq cm on a December day and 50 cal per sq cm on a January day. In winter, therefore, the artificial supply of heat is about the same as that obtained from radiation, and it is not negligible in summer. In general, the city's topographic situation is the deciding factor in determining the extent to which these influences will be effective. A town in a sheltered situation in a valley where winds are light will show greater climate differences inside and outside than will another situated on a plateau exposed to the winds. Situations on mountain slopes or on coasts will favor certain aspects of city climate. In extending cities or founding new ones, the known laws of city climatology should be taken into account.

Descriptors: Climatology, air temperature, air pollution effects, precipitation (atmospheric), heat islands.

205 Geldreich, E. E.; Best, L. C.; Kenner, B. A.; Van Donsel, D. J.

1968. The bacteriological aspects of stormwater pollution: Water Pollution Control Federation Jour., v. 40, no. 11, pt. 1, p. 1861–1872, 2 figs., 6 tables, 21 references.

Storm water can be a major source of pollution to bathing beaches and to water-supply reservoirs. Fecal contamination in separate storm-water systems is derived from the fecal material of pets and rodents in the city. In Cincinnati, Ohio, seasonal differences occur in the bacterial densities of total coliforms, fecal coliform, and fecal streptococci. The fecal coliform part of the total coliform population for all storm-water samples averages 8.6 percent. The sanitary significance of fecal coliform bacteria in storm water is further confirmed by the quantitative isolation of 4,500 *Salmonella* per 100 ml in one storm-water sample that also contained 450,000 fecal coliforms per 100 ml.

Descriptors: Storm runoff, water pollution sources, water pollution effects.

206 George, J. R.

1963. Sedimentation in the Stony Brook basin, New Jersey, 1956–59: U.S. Geol. Survey open-file rept., 71 p., 21 figs.

Approximately 11,100 tons of sediment per year have been deposited in Carnegie Lake at Princeton, N. J. These sediments range in particle size from clay to sand and are similar in average particle size to sediments carried in suspension by Stony Brook. Sediment yield increased 23 percent during the last half of the period reported. Urban expansion is taking place in scattered parts of the basin. Other changes in land use include treatment of agricultural land and construction of several sediment detention structures. Urban expansion and reservoir construction are creating temporary sources of high sediment yield. The average annual suspended-sediment

discharge from these sub-basins varied from 30 to 430 tons per square mile during the period of study. The average annual precipitation in the basin is about 44.6 inches. The distribution of heavy rains is uniform with respect to both time and location for those runoff events producing relatively large yields of suspended sediment.

Descriptors: Sedimentation, sediment yield, Stony Brook (N.J.).

207 Geraghty, J. J.

1959. Ground-water problems in the New York City area: New York Acad. Sci. Annals, v. 80, art. 4, p. 1049–1059, 4 maps, 1 graph, 6 references.

Since the earliest colonial times, use of ground water for municipal and industrial supplies has grown steadily in the New York City area. At least 300 to 400 mgd is pumped within a radius of about 20 miles from Manhattan Island. In New York City alone, withdrawals are approximately 100 mgd. The most serious problems are decline of ground-water levels, encroachment of salty water, increasing ground-water temperatures, pollution by domestic and industrial wastes, and flooding of subsurface structures caused by recoveries of ground-water levels. After reduction of pumping in Brooklyn in 1947, the water table began to rise. The deepest subway cuts and basements have been reached by the rising water, and it has become necessary to pump to prevent flooding. Increasing ground-water temperatures are caused by artificial recharging through wells of large amounts of warm water from cooling and air-conditioning systems. The ground-water body in southern Manhattan has unusually high temperatures, largely a result of heat loss from basements, subways, and buried steampipes. Another ground-water problem in some suburban areas is the underground migration of synthetic detergents to wells used for water supply.

Descriptors: Groundwater, water temperature, groundwater depletion, groundwater pollution, New York (N. Y.).

208 Gifft, H. M.; Symons, G. E.

1968. How to estimate storm water quantities: Water and Wastes Eng., v. 5, no. 3, p. 46–50, 7 figs., 1 table, 2 references.

The rate of flow for storm-drain design is dependent on the runoff rate and frequency. Drained areas are usually small, so movements of storms or uneven rainfall rates have little influence on the resulting floodflows. It is for these reasons that estimation of storm sewer designs is based on rainfall data. Considering the relative importance of the various influences, the degree of accuracy required, the importance of the structures being designed, and the accuracy of the available data, the rational method for estimating extreme rates of surface runoff appears to be most logical for the design of storm drains. The greatest weakness of the rational method is the difficulty of estimating the duration of storms that will produce peak flow. Imperviousness is logically compensated for by assuming a coefficient representing the proportion of the rainfall that does not soak into the ground. The length of storm required to produce peak conditions also has an effect in that the percent of runoff may increase as the ground becomes soaked. Several methods have been proposed for accurate computation of these factors, but it is questionable if these refinements are justified in practice.

Descriptors: Rational formula, rainfall-runoff relationships, storm runoff, peak dishcarge, impervious area.

209 Glancy, P. A.

1969. A mudflow in the Second Creek drainage, Lake Tahoe basin, Nevada, and its relation to sedimentation and urbanization: U.S. Geol. Survey Prof. Paper 650-C, p. C195–C200, 7 figs., 1 table, 2 references.

A mudflow of more than 50,000 cubic yards occurred in the 1/5-square-mile Second Creek basin in Nevada on August 25, 1967, after an intense thundershower. Although the mudflow originated naturally, its path was affected by manmade features. It damaged real estate and roadways in the lower part of the drainage and also polluted Lake Tahoe. The mudflow is typical of an erosional process common in the area. The sequence includes sheet and rill erosion of nonforested uplands; severe downstream channel erosion that flushes out

alluvium previously accumulated; and extensive deposition along the flatter and lower part of the drainage. Sheet and rill erosion of the upper basin contributed 60 to 80 percent of the debris, with the rest derived from the main channel. The event caused landscape denudation that averaged about 0.02 foot over the entire basin.—W70-01899.

Descriptors: Mudflows, sedimentation, mass wasting, Lake Tahoe (Nev.).

210 Glancy, P. A.

1971. A reconnaissance of streamflow and fluvial sediment transport, Incline Village area, Lake Tahoe, Nevada, first progress report, 1970: Nevada, Div. of Water Resources, Water Resources Inf. Ser. Rept. 8, 28 p., 1 fig., 2 photos., 7 tables, 5 references, 1 app.

Runoff during the 1970 water year from the five major streams in the Incline Village area, Lake Tahoe, Nev., was about 17,600 acre-feet. Sediment transported to Lake Tahoe was estimated to be about 10,000 tons, of which about three-fourths was from Incline and Third Creeks. About 85 percent of the sediment was delivered to the lake during the snowmelt runoff period. The annual sediment load was estimated to be about 68 percent sand, 20 percent silt, and 12 percent clay. Estimated annual sediment yields ranged from 50 to 650 tons per square mile from undeveloped areas, and 1,600 to 3,000 tons per square mile from developed areas. The estimated annual yield from the developed area was about 12 times that from the undeveloped area. Nitrogen transported by streams to the lake during periods of heavy sediment transport was largely in organic form, and the phosphorous at those times was mostly attached to the sediment particles.

Descriptors: Sediment load, water yield, sediment yield, Lake Tahoe (Nev.).

211 Goldberg, M. C.

1971. Sources of nitrogen in water supplies, *in* Agricultural practices and water quality, Willrich, T. L. and Smith, G. E., eds.: Ames Iowa, Iowa State Univ. Press, p. 94–124, 4 figs., 8 tables, 72 references.

Sources of nitrogen in water supplies are atmospheric, geologic, and biogenic, resulting from rural runoff, urban runoff, sewage, irrigation, return flow, pollen, rural waste, industrial waste, pond waters, deforestation, and land stripping, among others. Generally, salts of nitrogen applied as fertilizer do not move. Nitrate in a nonsalt form seems to have higher soil infiltration capacity than salt nitrogen. This is dependent, however, upon the physical conditions of the soil and the hydrology of the region. In general, industrial waste, rural runoff, farm animal waste, and domestic waste are the dominant sources in surface waters. In ground-water supplies the usual sources of nitrogen are feedlots, privies, septic tanks, and farm wastes.—W71-07255.

Descriptors: Nitrogen, water pollution sources, path of pollutants, storm runoff.

212 Gonzalez, D. D.; Ducret, G. L., Jr.

1971. Rainfall-runoff investigations in the Denver metropolitan area, Colorado: U.S. Geol. Survey open-file rept. 71003, 27 p., 3 figs., 16 tables, 2 references.

Definition of the magnitude and frequency of floods on small urbanized watersheds in the Denver metropolitan area requires the collection and analysis of rainfall-runoff data needed to synthesize long-term runoff records from precipitation records. Hydrologic models and synthetic unit hydrographs are the primary analytical methods used. Analytical applications of the rational method are also useful. Dual digital recorders provide the detailed records of rainfall and runoff required in a form convenient for computer translation and tabulation.

Descriptors: Rainfall-runoff relationships, storm runoff, model studies, Denver (Colo.).

213 Gould, B. W.

1970. Wastewater reclamation using groundwater recharge, a review: Manly Vale, N.S.W., Australia, New South Wales Univ., Water Research Lab., Report 113, Paper 6, p. 76–104, 43 references.

The use of waste water to recharge aquifers is a reclamation method which has a number of technical and esthetic advantages and has been the subject of laboratory, field, and full-scale investigations in America, Israel, and Holland. When waste water percolates through soil, natural, physical, chemical, and microbiological processes not only can cause large reductions in the amount of putrescible organic material and in the number of bacteria but also can remove suspended material and reduce the amount of nutrients which could cause eutrophic conditions. For injection wells, water should be treated to a fairly high degree of organic purity; but seepage basins operated on a suitable intermittent schedule under good conditions can produce potable ground water even from sewage which has had only primary treatment.—W71-03136.

Descriptors: Water reuse, artificial recharge, reclaimed water.

214 Grace, R. A.; Eagleson, P. S.

1967. Scale model of urban runoff from storm rainfall: Am. Soc. Civil Engineers Proc., Paper 5249, Jour. Hydraulics Div., v. 93, no. HY 3, p. 161–176, 8 figs., 1 photo., 3 tables, 9 references, 1 app.

The response of a small urban watershed to four storms was simulated in the laboratory by a scale model consisting of a rainfall generator, vertically distorted scaled topography, and a weighting device for recording the cumulative runoff. Comparison of these results with prototype measurements through use of derived scaling laws shows reasonable agreement.—W69-01570.

Descriptors: Rainfall-runoff relationships, storm runoff, hydraulic models, model studies.

215 Grava, Sigurd

1969. Urban palnning aspects of water pollution control: New York and London, Columbia Univ. Press, 223 p., 11 figs., 161 references, 1 app.

This study, strictly limited to waterborne wastes and water quality control, represents a synthesis of experience and thought on water pollution as it applies to urban planning and is intended as a guide and source of information for urban planners and community decision makers. Although nontechnical in nature, the work includes data, financial and administrative considerations, and reference material.—W71-06567.

Descriptors: City planning, water quality control, water pollution control.

216 Greeley and Hansen, Engineers.

1968. Alexandria, Virginia, Fourmile Run flooding, April, 1968: Chicago, Ill., Greeley and Hansen, Engineers, 42 p., 7 figs., 7 maps, 5 tables.

General design criteria are developed along with a basis of design for the construction of engineering works to protect property from flooding along Fourmile Run between the stream's outlet to the Potomac River and the Shirley Highway. Fourmile Run carries stormwater runoff from a 18.5 square-mile, 90 percent urban drainage area in Arlington County. Extensive damage to commercial and residential properties results from flash floods, particularly at the north boundary of the city of Alexandria. Maximum flood of record, which occurred August 20, 1963, discharged 11,700 cfs. The recommended design provides for a discharge of at least 24,000 cfs. The construction costs are estimated at $9,437,000. The Fourmile Run flash-flooding problem is similar to situations in various parts of the country.—W71-02286.

Descriptors: Flood protection, storm runoff, flood forecasting.

217 Green, J. H.; Hutchinson, R. D.

1965. Ground-water pumpage and water-level changes in the Milwaukee-Waukesha area: U.S. Geol. Survey Water-Supply Paper 1809-I, p. I1–I19, 6 figs., 2 plates, 13 references.

Artesian water pressure in the deep sandstone aquifer continued to decline throughout most of the Milwaukee-Waukesha area, Wis., between 1950 and 1961. Areas of greatest water-level decline were in northeast Waukesha

County and in northwest Milwaukee County. The chief cause of the decline was continued heavy pumpage. Water-level changes were directly related to the pumpage pattern and pumpage changes. Increased pumpage at Waukesha and in northwest Milwaukee and continued heavy pumpage at Wauatosa caused widespread water-level declines. Locally, decreased pumpage at West Milwaukee has allowed some recovery of water levels since 1957. Pumpage should decrease through the year 1975. Additional conversion to surface-water supply in Milwaukee County will account for most pumpage decreases. Pumpage may increase in Waukesha County where the population is expanding rapidly and an adequate surface-water supply is not readily available.

Descriptors: Groundwater depletion, hydrogeology, water level decline, Milwaukee (Wis.).

218 Gross, M. G.

1970. New York State metropolitan region, a major sediment source: Water Resources Research, v. 6, no. 3, p. 927–931, 1 fig., 1 table, 20 references.

Approximately 9.6 million tons per year of waste solids, including dredged sediment and construction debris from the New York metropolitan region, were dumped in New York Bight in western Long Island Sound between 1964 and 1968. This was apparently the largest sediment source discharging directly into the North Atlantic Ocean from the North American Continent. Considering the core metropolitan region—population about 9 million—as the dominant source, the average annual discharge was about 1 ton per person. This is equivalent to about 6 pounds per person per day.—W70-09203.

Descriptors: Sediment yield, New York, New York metropolitan region, water pollution sources.

219 Guy, H. P.

1965. Residential construction and sedimentation at Kensington, Maryland, *in* Federal Inter-Agency Sedimentation Conf., Jackson, Miss., Jan. 28 to Feb. 1, 1963, Proc.: Agr. Research Service, U.S. Dept. Agriculture Misc. Pub. 970, p. 30–37, 3 figs., 2 aerial photos., 4 tables.

Sediment transported in storm runoff near Kensington, Md., during the transformation of part of a 58-acre area from rural to residential land use was measured for 25 storm events from July 1959 to January 1962. These data were used with the water discharge record of nearby Rock Creek in a multiple regression analysis to show the magnitude and trend of sediment movement with time. Total sediment discharge from the area was 189 tons per acre for the entire period of construction and the subsequent change to a reasonably stable residential area. The high yield of sediment is attributed to the rolling topography (3 to 25 percent slope); a very friable soil and subsoil; the construction of a street in the major drainage channel; a tendency for construction methods to expose extensive areas of the soil for a long period of time; and a substantial amount of the 42 inches of annual rainfall occurring at a rate in excess of the infiltration capacity of unprotected soil.

Descriptors: Sediment yield, sedimentation, construction, Kensington (Md.), water pollution sources.

220 Guy, H. P.

1967. Research needs regarding sediment and urbanization: Am. Soc. Civil Engineers Proc., Paper 5596, Jour. Hydraulics Div., v. 93, no. HY 6, p. 247–254, 15 references.

Sediment derived from construction in areas of urban growth has profound impact on downstream channels and water resources. Such sediment pollution is usually much more dynamic and intense than sediment derived from rural areas. Research needs concerning urban-derived sediment are similar to those already underway in rural areas; however, new emphasis must be given to exposed subsoils, to problems in existing stream channels, to pollution of existing and future water resources, and to more effective planning and phasing of construction. Better planning and legal backing will make research findings more useful.—W70-07093.

Descriptors: Sediment yield, erosion, erosion control, planning.

221 Guy, H. P.
1970. Sediment problems in urban areas: U.S. Geol. Survey Circ. 601-E, 8 p., 6 figs., 1 table, 22 references.

Soil erosion and sediment deposition in urban areas are an environmental blight. In addition, sediment has many direct and indirect effects on streams that may either be a part of or very remote from the urban environment. Sediment is widely recognized as a pollutant of streams and other water bodies. Much of the disturbed soil in urban construction areas erodes and becomes sediment in streams; the sediment damages water-control works and aquatic habitat, degrades water quality, increases flood damages, and lowers the environmental attractiveness. During the process of stabilization of an area after construction, streams tend to erode their beds and banks as a result of increased runoff. Documentation of erosion sources and amounts, of sediment concentration in runoff, of stream-channel changes, and of the location and amounts of deposition, together with an economic analysis of sediment damages and pertinent research, provides the knowledge needed to find the best solutions.—W71-00393.

Descriptors: Sedimentation, sediment yield, water pollution sources, erosion control.

222 Guy, H. P.
1971. Control of sediment in the urban environment, *in* Treatise on urban water systems, Albertson, M. L., Tucker, L. S., and Taylor, D. C., eds.: Fort Collins, Colorado State Univ., p. 509–517, 1 table, 15 references.

Many urban water handling systems fail to some degree because of sediment. Such failures or damages are not limited to filling of reservoirs by sediment. Damages also include plugged storm drains, erosion and deposition in natural or artificial channels, degrading or failure of recreation facilities, damage to streams by toxic chemicals and radioactive materials, sheet and gully erosion in construction areas, reduction of ground-water recharge, increase in dissolved solids in stream systems, and channel erosion downstream from new urban areas. The most serious urban sediment problem is general deterioration of the environment. Many sediment problems can be alleviated by careful planning. Urban development should be avoided on flood plains and the steepest slopes along streams. Size of construction areas should be small, thus reducing the chance of eroded sediment reaching the stream. Construction can be planned for the time of year having a minimum of erosive potential.

Descriptors: Sedimentation, sediment yield, erosion control, planning.

223 Guy, H. P.; Ferguson, G. E.
1962. Sediment in small reservoirs due to urbanization: Am. Soc. Civil Engineers Proc., Paper 3070, Jour. Hydraulics Div., v. 88, no. HY 2, pt. 1, p. 27–37, 5 photos., 7 references.

Increasing urban development may cause severe silting in small reservoirs downstream from such developments. A typical example is that of Lake Barcroft, near Washington, D.C., where 19 acre-feet or 25,000 tons of sediment have been deposited for each square mile of completed residential construction. Factors affecting sedimentation in urbanized areas are listed. These are similar to those occurring under rural conditions but are more difficult to evaluate. Material deposited in a reservoir after urban construction will probably be coarser than that associated with rural conditions.—W69-01820.

Descriptors: Land use, sedimentation, sediment yield, drainage (urban), Lake Barcroft (Va.).

224 Guy, H. P.; Ferguson, G. E.
1970. Stream sediment, an environmental problem: Jour. Soil and Water Conserv., v. 25, no. 6, p. 217–221, 2 figs., 3 tables, 19 references.

Urban erosion involves construction sites that tend to be widely dispersed. Unlike the continuing erosion on poorly managed agricultural lands, construction sites erode mainly during the brief periods between land clearing and stabilization of the new surface. In Scott Run, a 4.54-square-mile watershed near Washington, D.C.,

highway construction affected about 11 percent of the watershed from 1961 to 1964. Measurements of 88 storm events showed that 37 percent of the runoff and 99 percent of the sediment movement occurred in 3 percent of the time and that highway construction areas, 1 to 10 percent of the basin, contributed 85 percent of the sediment. Erosion was about 10 times that normally expected from cultivated land, 200 times that expected from grassland, and 2,000 times that expected from forest land. Sediment transport in storm runoff was measured for 25 storm events from a 58-acre watershed in Kensington, Md., between July 1959 and January 1962. During this period, 89 single-dwelling houses were constructed on 20½ acres in the upper part of the watershed. An average of 189 tons of sediment per acre was lost from the area.—W71-02443.

Descriptors: Sedimentation, erosion, storm runoff, water pollution sources, Kensington (Md.).

225 **Guy, H. P.; Jackson, N. E.; Jarvis, Kenneth; and others.**
1963. A program for sediment control in the Washington metropolitan region: Washington, D.C., Interstate Commission on the Potomac River Basin, Tech. Bull. 1963-1, 48 p., 2 figs., 6 photos., 2 tables, 74 references, 3 app.

In the Washington metropolitan area, one of the fastest growing areas in the nation, rates of erosion and sediment production far exceed those in rural areas. While the consequences are numerous in the Washington area, the great concern is the effect on the quality of the water in the Potomac River. Three principal sources of sediment exist in urban areas: (1) commercial and residential development construction; (2) highway and other public construction projects; and (3) public parks and recreation areas. In the first two instances, rapid erosion occurs during the construction period. One of the least costly and most effective means of reducing erosion is a shortening of the construction time period during which the raw soil is exposed.

Descriptors: Erosion, sedimentation, erosion control, District of Columbia, water pollution sources, planning.

227 **Hackett, J. E.**
1965. Ground-water contamination in an urban environment: Ground Water, v. 3, no. 3, p. 27–30, 2 figs., 11 references.

The most widespread potential sources of ground-water contamination in the highly urbanized metropolitan area of northeastern Illinois are individual septic tanks, dumps and landfills, sewage effluent, and industrial wastes. Hydrogeologic criteria must be developed to determine whether the natural environment can adequately safeguard ground-water reservoirs against contamination, and engineering specifications should be established to provide protection where natural safeguards are lacking.

Descriptors: Water pollution sources, groundwater pollution, planning, Chicago (Ill.).

228 **Hackett, J. E.**
1969. Water resources and urban environment: Ground Water, v. 7, no. 2, p. 11–14, 5 references.

In some areas of intense urban development the problems of water quality control, recreational use of water, and water for cooling and waste transport have become more significant than problems of adequate supplies for withdrawal. The use of surface-water sources distant from the urban center has contributed to the development of the commodity concept of water use. By this attitude the water resource is viewed only in terms of its adequacy as a water supply; waste discharge and recreation uses are ignored or considered a downstream problem. This concept is particularly inappropriate when applied in the multicommunity complexes of the metropolitan areas where there is little or no downstream area. Water problems must be solved at the metropolitan level rather than at the individual community level and not by the proliferation of smaller units of government. The nature of the metropolitan complex requires thinking in terms of closed systems involving reclamation and reuse rather than in terms of the open system of withdrawal, use, and discharge.—W69-06428.

Descriptors: Water management (applied), water resources development, water pollution control, planning.

229 Hammer, T. R.

1971. Procedures for estimating the hydrologic impact of urbanization: Philadelphia, Pa., Regional Sci. Research Inst., Contract Rept. to Office of Water Resources Research, 33 p., 3 figs., 29 references.

The results of a recent study of the hydrologic impact of urbanization are stated in a form that may be readily applied to planning or to the estimation of current effects of urbanization. Conversion of land to impervious surface increases storm runoff by preventing infiltration of rainwater into the soil and by eliminating surface depressions which would provide storage; consequently, the peak streamflow accompanying a storm of a given magnitude is increased. This process is assisted by drainage alterations which speed runoff to the stream. Stream channel cross-section area increases in response to urbanization in the same proportion as the increase in the average annual flood. An impervious area index is employed along with a basin slope factor to estimate channel enlargement and peak flow increase. The index may be estimated on the basis of the limited information which is likely to be available. The two types of information considered here are: (1) the information contained in U.S. Geological Survey 7½-inch quadrangle maps, and (2) the number of persons per square mile in the watershed in question.

Descriptors: Rainfall-runoff relationships, storm runoff, peak discharge, Philadelphia (Pa.), impervious area.

230 Hammer, T. R.

1971. The effect of urbanization on stream channel enlargement: Philadelphia, Pa., Univ. of Pennsylvania, Graduate School of Arts and Sci., Ph.D. thesis, 350 p., 15 references.

Increases in peak streamflow magnitudes and in stream channel cross-section area are caused by impervious development in stream watersheds. Channel area was correlated with land use and other data for 78 small watersheds in the Philadelphia metropolitan region. The data consisted of measurements of amounts of land in more than a dozen basic land uses, plus information regarding sewerage, topographic data, and a complete numerical description of the stream-channel system. Particular attention was given to the amounts of impervious area. The object of analysis was the channel "enlargement ratio," the ratio of observed channel cross-section area to "natural" channel area for the given watershed size. The final estimating equations for channel enlargement permit the estimation of the impact of any impervious development at any location in a watershed on the stream channel at all downstream points. The results are presented both in equation form and also in the form of curves and graphs. For purposes of illustration, the equations are applied to a sample watershed to show how the impacts of development might be predicted. A simple, "optimal" land-use plan, which would minimize the hydrologic impact of locating a given population in this watershed, is prepared and discussed.

Descriptors: Land use, erosion, sedimentation, rainfall-runoff relationships, storm runoff.

231 Hare, G. S.

1970. Effects of urban development on storm runoff rates, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 2, 34 p, 17 figs.

Some of the developments in urban hydrology over the past 70 years are reviewed briefly, and some recent developments in the study of urban hydrology are described in more detail as they are applied to the design of such facilities as hurricane protection projects, flood control channels, stream rectification works, and flood-plain management or control activities in urban areas. While it is not difficult to determine that urban development generally increases both the total runoff and the peak runoff rates, it has been extremely difficult to develop relationships which accurately define the extent of these changes. The Corps of Engineers has used the basic unit hydrograph method extensively in development of hydrology for its civil works projects. Results obtained by this method are reliable and acceptable when proper coefficients are used.

Descriptors: Storm runoff, unit hydrographs, rational formula, rainfall-runoff relationships.

232 Harris, E. E.; Rantz, S. E.

1964. Effect of urban growth on streamflow regimen of Permanente Creek, Santa Clara County, California: U.S. Geol. Survey Water-Supply Paper 1591-B, 18 p., 3 figs., 2 maps, 2 photos., 3 tables, 3 references.

An investigation was made of the effect of urban growth on the streamflow regimen of Permanente Creek in Mountain View, Santa Clara County, Calif. The volume of storm runoff produced by rainfall on the valley floor has increased substantially as a result of urbanization. In 1945, storm runoff from the 5.12-square-mile project area was insufficient to balance channel losses, and the streamflow entering the project area in the Permanente Creek channel was greater than that leaving the area. By 1958, storm runoff from the project area was far in excess of channel losses, and the ratio of total outflow to inflow was 1.70. This increase in outflow is attributed to urban development during the period 1945–58 with increase of impervious surface from about 4 percent to 19 percent.—W69-01571.

Descriptors: Rainfall-runoff relationships, storm runoff, peak discharge, Mountain View (Calif.).

233 Harris, G. S.

1970. Real time routing of flood hydrographs in storm sewers: Am. Soc. Civil Engineers Proc., Paper 7327, Jour. Hydraulics Div., no. HY 6, v. 96, p. 1247–1259, 12 figs., 6 references, 1 app.

A rapid computation of routed flood hydrographs in circular sewers was required for use in the evaluation of the effect of storm flooding in the interceptor sewers of Minneapolis-St. Paul, Minn. The method of characteristics may be used to assess the routed hydrograph, but this method requires a comparatively large amount of computer time. The progressive average-lag method is used to carry out the evaluation in real time. The routing constants in the lag method are determined by comparing the results from the method of characteristics with those of the lag method until good agreement is obtained. It has not been possible to determine the routing constants in the lag method analytically.—W70-06977.

Descriptors: Routing, storm runoff, hydrograph analysis, Minneapolis-St. Paul (Minn.).

234 Harza Engineering Company; Bauer Engineering, Inc.

1969. The impact of the deep tunnel plan on the water resources of northeast Illinois: Chicago, Ill., Harza Eng. Company and Bauer Eng., Inc., 20 p., 2 figs., 4 maps, 3 references, 1 app. [Prepared for Metropolitan Sanitary District of Greater Chicago]

The possible effects of the proposed Chicago deep tunnel urban runoff retention scheme on the water resources of northeastern Illinois were estimated by surveying the hydrogeology, surface-water hydrology, and ground-water development of the area. Chicago has a combined sewer system, and storm runoff overloads cause discharge of raw sewage to waterways including recreational areas of Lake Michigan. A system of deep tunnels and protective recharge wells is proposed for temporary storage of peak combined loads. The system is expected to release treated storm runoff at a steady rate, greatly regulating the streamflow of receiving streams. High ground-water heads must be maintained to prevent loss of contaminated water from the tunnels, requiring good ground-water management practices for the entire area.—W69-09261.

Descriptors: Water pollution control, storm runoff, water storage, Chicago (Ill.).

235 Hawkins, R. H. (editor)

1971. Street salting, urban water quality workshop, Syracuse, N.Y., May 5–6, 1971, Symposium Proc.: Syracuse, N.Y., Syracuse Univ., College of Forestry, 94 p., 22 figs., 6 maps, 13 tables, 39 references.

The 12 papers included in this volume concerning water pollution and related environmental effects from highway deicers were given at the Street Salting, Urban Water Quality Workshop, held at Syracuse University May 5–6, 1971. Annual use of highway deicers is around 9 million tons of sodium chloride and about one-third

million tons of calcium chloride. Leading States in deicer use are Pennsylvania, Ohio, New York, Michigan, and Minnesota. Specific data and information are presented regarding methods, equipment, and materials; chlorides found in rainfall and municipal sewage during the winter; salt runoff from streets and highways; deicing compounds found in surface streams, public water supplies, ground water, farm ponds, and lakes; vehicular corrosion and deterioration of highway structures and pavements; and effects on roadside soils, vegetation, and trees.

Descriptors: Water pollution sources, deicers, highway deicing.

236 Hawkins, R. H.

1971. Street salting and water quality in Meadowbrook, Syracuse, New York, *in* Street salting, urban water quality workshop, Syracuse, N.Y., May 5–6, 1971, Symposium Proc.: Syracuse, N.Y., Syracuse Univ., College of Forestry, p. 62–69, 5 figs., 2 tables.

In Meadowbrook, which drains approximately 3.8 square miles of southeastern Syracuse, N.Y., the application of salt to remove ice from streets has a profound effect on water quality. The chloride content of the water varies greatly with the seasons. In the late summer, chlorides average 60–80 ppm. Following the first snows and initial street salting, chlorides rise to about 200–300 ppm. Further salting runs concentrations even higher, and an extreme of 10,650 ppm was observed in December of 1969, although highs of 1,000–3,000 ppm are more representative. The chloride concentrations taper off with the onset of summer but still remain abnormally high, suggesting that some of the previous winter's salt is turning up in the streamflow. Not all the salt applied runs off with the water at the first opportunity. The salt finds its way into the soils, ground water, and street masonry.

Descriptors: Water pollution sources, deicers, highway deicing.

237 Heath, R. C; Foxworthy, B. L.; Cohen, Philip

1966. The changing pattern of ground-water development on Long Island, New York: U.S. Geol. Survey Circ. 524, 10 p., 8 figs., 6 references.

Ground-water development on Long Island has followed a pattern that has reflected changing population trends, attendant changes in the use and disposal of water, and the response of the hydrologic system to these changes. The historic pattern of development has changed from individually owned shallow wells tapping surficial glacial deposits to large-capacity public-supply wells tapping deep artesian aquifers. Sewage disposal has changed from privately owned cesspools to modern large-capacity sewage-treatment plants discharging more than 70 mgd of water into the sea. In parts of Suffolk County in eastern Long Island, development is similar to the earliest historical stages. Westward toward New York City, ground-water development is more intensive and complex, and the attendant problems are more acute. If present trends continue, the ground-water resources of the island will continue to be depleted at an accelerating rate. Such depletion will cause salt-water contamination of larger parts of the ground-water reservoir.

Descriptors: Groundwater depletion, saline water intrusion, Long Island (N.Y.).

238 Helley, E. J.; Averett, R. C.

1971. A pre-urbanization reconnaissance study of Lake Earl, Del Norte County, California: U.S. Geol. Survey open-file rept., 17 p., 1 fig., 4 tables, 8 references.

Lakes Earl and Talawa occupy shallow depressions on the Smith River plain, an emerged marine terrace just south of the mouth of the Smith River in north coastal California. Ground-water discharge sustains the lake level during periods of low surface water discharge. Land development is planned on the north shore. With increased urbanization, more use will be made of the lake. The possibility of urbanization of the north shore has increased concern about the stability of the dunes, as well as the future water quality. The naturally

enriched status of Lake Earl is attested by the profuse rooted plant beds on its bottom, the extensive rush beds along its shores, and the organic carbon content of its bottom sediments.

Descriptors: Eutrophication, California, lakes.

239 Hennigan, R. D.

1968. Urban (municipal) water management: Fourth American water resources conf., New York, Nov. 18–22, 1968, Proc., p. 716–723.

The major water resources problem in the United States today is poor urban water management. With increasing urbanization, local water regimen changes drastically, resulting in loss of base flow and in greatly increased storm flows. Rapid runoff also adds to the pollution load. Controversies related to urban water management are reviewed. Separation of water supply service from other services is not efficient. Following World War II, multiple governmental units became more evident in large urban communities, and consolidation efforts were rare. Both technically and organizationally, water management needs cannot be dealt with separately. All water services should be consolidated in all urban areas and given an independent revenue base and status. Financing should be based on user changes.—W71-00317.

Descriptors: Water supply, waste disposal, water management (applied).

240 Henson, W. R.

1970. A unified method for computing peak discharge from ungaged urban areas for Corps of Engineers studies, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 4, 15 p., 2 figs., 12 references.

In urban hydrology, development cost, ease of use, and general applicability are the three most important characteristics that should be considered in selecting one of the methods for use in computing peak discharges from ungaged areas. Comprehensive digital simulation models will probably be limited to the major universities because of the computer capability required, but they may prove economical where a long period of record is required for design of an urban flood control project in an area of extremely high damage potential. Synthetic unit hydrographs appear to be the method most adaptable for use in studies by the Corps of Engineers. If a sampling of basic data can be provided from urban centers over the country, the resulting method will probably have general applicability. In urban areas void of gaging stations, new stations would have to be set up. Although development of a method of this type would involve a large initial investment, this would be offset by the ease of use and small recurring cost.

Descriptors: Unit hydrographs, rainfall-runoff relationships, storm runoff, model studies, peak discharge.

241 Herr, L. A.

1970. The control of erosion and sediment in highway construction, *in* Natl. Conf. on Sediment Control, Washington, D.C., Sept. 14–16, 1969, Proc.: Dept. Housing and Urban Devel., Environmental Planning Paper, p. 41–47.

Planning is necessary in highway construction to control erosion and sediment problems that deteriorate our natural resources. Erosion and scour of the banks and beds of streams and rivers are problems both during design and construction of our highways and for years after they are built. Rivers change course, and meanders move downstream which make our bridge piers and abutments vulnerable to attack by the main current. In some cases, the initial main river bridge becomes ineffective. Channel changes made downstream from our highway structures cause degradation of streambeds which make foundations of existing bridges unsafe and have caused failures. Suggestions for approaching these and other related problems are presented.—W71-04149.

Descriptors: Erosion, erosion control, highways, planning.

242 Hewson, E. W.

1970. Moisture pollution of the atmosphere by cooling towers and cooling ponds: Am Meteorol. Soc. Bull., v. 51, no. 1, p. 21–22.

Possible meteorological influences of water vapor releases from cooling towers and cooling ponds are reviewed. Such meteorological aspects as visibility, precipitation, humidity, wetting, icing, sunshine, temperature, and wind are discussed. An additional problem is effluents that contain chemical pollutants. This evaluation was made for both flat terrains and valleys. The atmospheric moisture problem was also evaluated for the special cases of urban areas and areas along shorelines. In general, the influence of cooling water on weather is likely to be local or nonexistent. Natural fogs may be stabilized by artificial heat input.

Descriptors: Cooling towers, precipitation (atmospheric), humidity, water pollution effects.

243 Hicks, W. I.

1944. A method of computing urban runoff: Am. Soc. Civil Engineers, Trans., Paper 2230, v. 109, p. 1217–1268, 26 figs., 18 tables, 10 references.

Hydrographs of runoff were developed for urban areas of various sizes, development, and times of concentration. Methods are given for computing runoff, and actual values of runoff are compared with computed values. The peak runoff rate for a given storm pattern is proportional to the volume of runoff resulting from the intense portion of the storm. The runoff hydrograph that will occur under selected conditions of drainage area and rainfall may be predicted. Hydrographs from homogeneous areas have a characteristic pattern of smoothly varying rates; when hydrographs from dissimilar areas combine, the outflow hydrograph has an irregular shape and a peak intensity unpredictable by a simple computation. In such cases, the outflow hydrograph may be constructed by summing the hydrographs from each of the dissimilar areas. For urban areas in Los Angeles and St. Louis, actual runoff rates are within 20 percent of calculated rates.

Descriptors: Rainfall-runoff relationships, storm runoff, Los Angeles (Calif.), hydrograph analyses, St. Louis (Mo.).

244 Hitchcock, L. B. (editor)

1967. The fresh water of New York State; its conservation and use, symposium [held at] State Univ. of New York at Buffalo, June 13–17, 1966, Proc.: Dubuque, Iowa, William C. Brown Book Co., 255 p., 21 figs., 15 maps, 55 photos., 1 table.

A symposium directed primarily at the water-resource challenges confronting New York State is applicable in many cases to water problems existing nationally and abroad. The symposium brought together representatives of virtually all fields concerned with water resources. These fields included pollution causes and control, water resources management, limnology, hydrology, economics, urban planning, and government. Emerging from this symposium is the inference that not much will be accomplished until the Federal Government finances a much larger portion of water protection.

Descriptors: Conferences, water management (applied), water pollution control, planning, New York.

245 Hoffman, J. F.; Spiegel, S. J.

1958. Chloride concentration and temperature of water from wells in Suffolk County, Long Island, New York, 1928–1953: New York State Water Power and Control Comm. Bull. GW-38, 55 p., 3 maps, 35 tables, 8 references.

Sea water contamination of the ground-water reservoir of Suffolk County, Long Island, N.Y., is a possibility because of increasing ground-water withdrawals from an aquifer that is hydraulically connected to the sea. Besides sea water, fertilizer and sewage are sources of contamination that contribute sizable amounts of chloride

to the ground water. Other possible sources of chloride contamination are industrial wastes and salts used in highway maintenance.

Descriptors: Saline water intrusion, water pollution sources, groundwater, Long Island (N.Y.).

246 Holeman, J. N.; Geiger, A. F.
1959. Sedimentation of Lake Barcroft, Fairfax County, Virginia: U.S. Soil Conservation Service, Tech. Pub. 136, 12 p., 7 figs., 1 map, 1 table.

A sedimentation resurvey of Lake Barcroft, Fairfax County, Va., was made by the Soil Conservation Service, U.S. Department of Agriculture. The resurvey was made to compare the sediment yield in 1957, after two-thirds of the watershed had been urbanized, with that 20 years earlier when the watershed was predominantly in agricultural uses; to measure the loss of capacity of the lake due to this change in sediment yield; and to provide a basis for predicting the future life of the lake. Lake Barcroft was originally constructed in January 1915 as a reserve water supply for the city of Alexandria, Va. The lake was purchased in 1950 by the Lake Barcroft Corporation for real-estate development. The greatly increased rate of sedimentation in Lake Barcroft is due primarily to the construction associated with conversion of land from agricultural to urban uses. The increase of sediment production from an average of about one-fourth acre-foot per square mile of drainage area per year before 1938 to a rate of about three-fourths acre-foot per square mile annually from 1938 to 1957 is indicative of the influence of removal of vegetation and topsoil during construction.

Descriptors: Sediment yield, land use, sedimentation, reservoirs, Lake Barcroft (Va.).

247 Holeman, J. N.; Sauer, E. F.
1969. Conservation in a new town: Soil Conserv., v. 35, no. 2, p. 35–38, 10 photos.

The sediment control program used in construction of the new town of Columbia, Md., consists primarily of immediate stabilization of all cleared sites, followed by the earliest possible establishment of binding vegetation. Trees, natural topography, and ground cover are retained wherever feasible for the beauty and protection of each subdivision. Builders are urged to stabilize lots with at least partial seeding or sodding before turning them over to new owners. Check structures are used to control sediment transport in watercourses. Sediment traps and basins are installed downstream from all large cleared areas. Stream banks are protected by gabions and riprap. A sediment-control ordinance regulates all construction practices.—W70-02329.

Descriptors: Sediment control, erosion control, construction, Columbia (Md.).

248 Holler, A. G.
1970. Urban hydrology considerations in the design of interior drainage facilities for local flood protection projects, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 13, 23 p., 4 figs., 5 tables, 6 references.

Usually drainage facilities whose capacities have been determined by an application of the rational method will function over a period of time long enough to include some changes in runoff relations. The runoff coefficient selected must reflect in some way future conditions expected in the drainage area. The future expected peak runoff can then be compared to the design capacity of the drainage facilities to determine their adequacy. Hydrologically significant impermeable area is related to population density. Based on a brief study of two local flood-protection projects, the runoff coefficients that were selected are sufficiently conservative to allow for some degree of future urbanization without significantly altering the degree of protection provided by the projects.

Descriptors: Rational formula, rainfall-runoff relationships, storm runoff, impervious area.

249 Hopkins, B. T.

1968. Map requirements for flood-plain studies: Civil Eng., v. 38, no. 2, p. 66–67, 3 figs.

Fairfax County, Va., was the site of a pilot study to determine probable extent of flood hazards in an area of rapidly increasing urban development. A procedure was established by which the extent of flooding on a network of stream basins can be predicted for 25, 50, and 100-year flood recurrence intervals as the watershed areas are developed. Flood plains comprise 6 percent (200,000 square miles) of the area of the 48 conterminous United States. Maps are essential for flood-plain studies to assist in greatest utilization of land. To support these studies the U.S. Geological Survey is mapping pilot areas in cooperation with local agencies. The maps which have a scale of 1:1,200 and a 2-foot contour interval are compiled from aerial photography. Flood boundaries determined for various recurrence intervals are delineated on the maps. Orthophotomaps, which retain photoimagery details with super imposed reference grids and contours, offer additional benefits.—W68-00331.

Descriptors: Flood plains, photogrammetry, mapping, Fairfax County (Va.), planning.

250 Horner, W. W.; Flynt, F. L.

1936. Relation between rainfall and runoff from small urban areas: Am. Soc. Civil Engineers, Trans., Paper 1926, v. 101, p. 140–206, 39 figs., 17 tables, 9 references.

The relation between rainfall and runoff was studied in small urban areas in St. Louis, Mo. Measurements were made of rainfall and stormflow for pactically all heavy rains from 1914 to 1933. Rainfall rates at each of the locations studied are reduced and developed into frequency diagrams. These three rainfall studies are combined into a master frequency study for the region. Runoff is also studied as an independent phenomenon; the runoff frequency curves are developed in a form similar to the rainfall diagrams. Ratios are then developed between corresponding values of rainfall and runoff frequencies. These ratios, applied to rainfall frequency curves for other localities, will give approximate runoff values for similar conditions of surface.

Descriptors: Rainfall-runoff relationships, frequency analysis, storm runoff, peak discharge.

251 Horner, W. W.; Jens, S. W.

1942. Surface runoff determination from rainfall without using coefficients: Am. Soc. Civil Engineers, Trans., v. 107, Paper 2153, p. 1039–1117, 21 figs., 12 tables, 24 references.

In hydraulic engineering practice, the relation between rainfall and runoff has generally been represented as a ratio or coefficient. The form of this relationship should instead be "rainfall minus losses equals runoff". Inadequacy of hydrologic data has discouraged attempts to evaluate losses during a storm period. Improvement in hydrologic data allows a method of evaluation of surface runoff from precipitation data without the use of a coefficient. The method is generally applicable to all drainage basins and is described in detail for use in urban storm drainage. Its application requires detailed physical data as to stream channels and valley storage areas, and it involves a material increase in the cost of the design phase of the engineering of hydraulic structures. The procedure is restricted to the determination of floodflow from surface runoff. For many basins, ground water or base flow during the rise of the hydrograph will have a small value and may be neglected. For some conditions, it may be large and may add materially to floodflow.

Descriptors: Rainfall-runoff relationships, infiltration, storm runoff, hydrograph analysis.

252 Huff, F. A.

1970. Time distribution characteristics of rainfall rates: Water Resources Research, v. 6, no. 2, p. 447–454, 6 figs., 2 tables, 6 references.

Data from a 50-storm sample on two dense networks in Illinois were used to investigate the time distribution of 1-minute rainfall rates in warm-season storms. Absolute and relative variability were analyzed for point and

mean rates on areas from 25 to 100 square miles. The variability parameters were found to fit closely a log normal distribution. Both absolute and relative variability showed a wide range within and between storms and between areas of different size. Little difference in variability properties was noted between rain and synoptic weather types associated most frequently with warm-season storms. No evidence of regular oscillations in the time distribution of rainfall rates in convective storms was shown by lag correlation analyses—W70-06740.

Descriptors: Rainfall disposition, time series analysis, rainfall-runoff relationships.

253 Huff, F. A.; Changnon, S. A.

1960. Distribution of excessive rainfall amounts over an urban area: Jour. Geophys. Research, v. 65, no. 11, p. 3759–3765, 8 figs., 3 tables, 5 references.

Data recorded over a 10-year period from a network of 11 recording rain gages was used in a study of the distribution of excessive rainfall over the 10-square-mile urban area of Champaign-Urbana, Ill. All storms were used in which one or more rain gages recorded an amount equaling or exceeding the 2-year rainfall for durations of 30 minutes, 1 hour, 2 hours, 3 hours, 6 hours, 12 hours, and 24 hours. Based on the 10-year sampling period, twice as many excessive rainfall amounts actually occur within the 10-square-mile area compared with the number recorded at gages; on the average, the percentage of the 10-square-mile area experiencing excessive rainfall amounts increases with increasing storm duration; the majority of the excessive amounts for duration of 30 minutes to 24 hours occur in the same storms; a point rainfall record is a satisfactory index of the areal mean rainfall frequency distribution in a 10-square-mile area; and urban influences, if present, are small.

Descriptors: Meteorology, rainfall patterns, depth-area-duration analysis.

254 Hughes, G.; Tremblay, J. J.; Anger, H.; D'Cruz, J.

1971. Pollution of groundwater due to municipal dumps: Canada, Dept. of Energy, Mines, and Resources, Inland Waters Branch, Tech. Bull. no. 42, 98 p., 4 tables, 72 references, 2 app.

A review is presented of the current literature on ground-water pollution due to municipal dumps. The following topics are covered: ground-water pollution by solid wastes; significant research in this field; regulations; criteria for site selection; safeguards; and observation, detection, and identification of pollutants. Ground-water pollution from other sources and basic problems that commonly arise in the development of a rational approach to solid-waste disposal are also reviewed. Two bibliographies are included.

Descriptors: Water pollution sources, groundwater, pollution, garbage dumps, bibliographies.

255 Hughes, G. M.; Landon, R. A.; Farvolden, R. N.

1971. Hydrogeology of solid waste disposal sites in northeastern Illinois: U.S. Environmental Protection Agency, Rept. SW-12d, 154 p., 33 figs., 20 tables, 86 references, 8 app.

A final report is presented of the results of detailed hydrogeologic and water quality studies of five landfills carried out over a 4-year period. The purpose of the studies is to develop guidelines to evaluate the pollution potential of existing and proposed landfill sites in northeastern Illinois. The distribution and concentration of dissolved solids at four of the landfills is controlled by the configuration of the ground-water flow system. In most cases, about one-half the annual precipitation infiltrates the surface. Infiltration first occurs by channeling through the refuse before the moisture content of the waste has reached field capacity. In refuse more than 5 to 9 years old and as much as 21 years old, there is a yearly decrease in the amount of materials leached. Conclusions given apply specifically to the soil types tested, but the procedures and methods used are applicable for any hydrogeologic landfill research.

Descriptors: Landfills, hydrogeology, path of pollutants, Illinois, water pollution sources, groundwater pollution.

256 **Humlum, Johannes**

1969. Water development and water planning in the southwestern United States: Aarhus, Denmark, Kulturgeografisk Institut, Aarhus Universitet (Munksgaard), 240 p., 4 figs., 37 maps, 55 photos., 14 tables, 188 references.

Water planning in the southwestern United States in the last 50 years is surveyed, and future wide-scale plans for transferring water into irrigated areas are reviewed. Localization of population in southern California and central Arizona is closely related to distribution of water. The influence of water development on population congestion is self-reinforcing and results in growth which may not be socially or economically beneficial and causes pressure for recreational facilities in areas that often cannot support heavy use. In the southwestern United States, an originally fine climate attracted people until population growth took on a cancerous aspect. Urbanization and pollution have affected the climate and made the area less livable. The question of desirability of furthering this development by constantly extending cities, roads, urban areas, and importing water is considered in detail in the worldwide outlook. The history and physical facilities of the water-supply works and irrigation projects of the Southwest are described in detail. It is concluded that water demand can be satisfied only by increasingly long inter-basin transfers and desalination of sea water. The large-scale transfer projects must be studied carefully to avoid doing more harm to the total environment and to the national or international economy than good to some urban areas.—W69-03949.

Descriptors: Water resources development, Southwestern U.S., inter-basin transfers, urban growth-water import relationships.

257 **Hutchinson, F. E.**

1970. Environmental pollution from highway deicing compounds: Jour. Soil and Water Conserv., v. 25, no. 4, p. 144–146, 1 fig., 1 table, 7 references.

During the period 1965–69, a study was made to determine how much environmental pollution resulted from the average annual application of 25 tons of sodium chloride to each mile of paved highway in Maine. Analyses of water samples indicated that wells and farm ponds were seriously contaminated with chloride ions. Soil sample analyses revealed that soils contiguous to highways contained sodium levels that threaten vegetation and soil drainage. Concentrations of these ions in rivers apparently were not influenced by this practice.—W70-09844.

Descriptors: Water pollution sources, sodium chloride, highway deicing, snow removal, Maine, deicers.

258 **Hutchinson, F. E.**

1971. The effect of highway salt on water quality in selected Maine rivers, *in* Street salting, urban water quality workshop, Syracuse, N.Y., May 5–6, 1971, Symposium Proc.: Syracuse, N.Y., Syracuse Univ., College of Forestry, p. 20–23, 3 tables.

Seven rivers in Maine were sampled in April, July, and October for a 2-year period to determine the effect of highway salting on water quality. The water samples were analyzed for content of sodium and chloride ions. Four of the rivers selected were from the southwestern section of the State because of the relatively high road density and consequent high salt usage in that area. Three rivers were from the eastern section of the State where there are few roads. Sodium and chloride concentrations were highest in the rivers in the southwestern part of the State (Androscoggin, Kennebec, Penobscot, and Saco), but the concentration never exceeded 11 ppm of either ion. The levels in April at the time of snowmelt were lower (1–4 ppm) than in October. The determinations of sodium and chloride concentrations are tabulated.

Descriptors: Water pollution sources, deicers, highway deicing, Maine.

259 **Hutchinson, F. E.; Olson, B. E.**

1967. The relationship of road salting applications to sodium and chloride ion levels in the soil bordering major highways: Natl. Research Council, Highway Research Board, Highway Research Record 193, p. 1–7, 2 figs., 6 tables, 6 references.

Sodium and chloride concentrations in soils adjacent to salted highways in New England were measured during July and October 1965, and April 1966, at 27 sites to determine the effect of salting for periods ranging from zero to 18 years. Concentrations of both ions were increased as a result of this practice, with the effect greatest at the edge of the road embankment and where salting had been practiced for the longest period of time. Salting increased sodium and chloride levels more at the 6-inch than at the 18-inch depth, and sodium concentrations were higher than chloride. Although concentrations of these ions were highest at the edge of the highway, they were also high at a distance of 60 feet from the highway in some instances. Wells near some of the highways contained chloride in excess of the recommended maximum.

Descriptors: Deicers, highway deicing, water pollution sources, water pollution effects, snow removal.

260 **Hydrocomp International, Inc.**

1970. Simulation of continuous discharge and stage hydrographs in the north branch of the Chicago River; report to Northeastern Illinois Planning Commission, Chicago, 1970: Palo Alto, Calif., Hydrocomp Internat., Inc., 56 p., 14 figs., 13 tables.

Streamflow simulation studies of the North Branch of the Chicago River used mathematical modeling techniques to aid the development of regional maps delimiting flooded areas for 25, 50, and 100-year frequencies and evaluation of flood control works, channel constrictions, and changes in urban development patterns. The river flows through the Chicago metropolitan area and is typical of watersheds in northeastern Illinois. It has a small channel gradient and floods a broad area at high discharge. The simulation studies showed that steps must be taken either to preserve the river's ability to flow over its flood plain or to substantially alter the channel. If flood-plain storage is used for a subdivision at one point, it could be returned to the stream at another point by land purchase and excavations. Alternately, if channel storage is not preserved, large floodways, detention basins, or underground caverns will be needed. Results of simulation studies of flood discharge and stage are presented by tables and graphs.—W71-00483.

Descriptors: Simulation analysis, flood forecasting, Chicago River (Ill.).

650 **Hydrocomp International, Inc.**

1971. Studies in the application of digital simulation to urban hydrology: Palo Alto, Calif., Hydrocomp Internat., Inc., prepared for Office of Water Resources Research.

261 **Isbister, John**

1959. Ground-water levels and related hydrologic data from selected observation wells in Nassau County, Long Island, New York: New York State Water Power and Control Comm., Bull. GW-41, 42 p., 2 figs., 2 maps, 27 tables, 3 hydrographs, 1 graph, 24 references.

Nassau County has experienced a rapid growth in population and industry in the past 20 years that has resulted in increased development of its ground-water resources. The county is located in west-central Long Island, and its boundaries enclose a land area of 274 square miles. The principal manmade cause of water-level fluctuations is withdrawal of water from wells. This report presents almost 3,900 measurements of water levels and other related hydrologic data.

Descriptors: Groundwater, water levels, hydrologic data, data collections, Long Island (N.Y.).

262 **Isbister, John**

1966. Geology and hydrology of northeastern Nassau County, Long Island, New York: U.S. Geol. Survey Water-Supply Paper 1825, 89 p., 16 figs., 5 maps, 20 tables, 56 references.

The ground-water reservoir of Long Island consists of saturated unconsolidated coastal-plain deposits. Northeastern Nassau County includes a wedge-shaped part of the reservoir about 112 square miles in extent, ranging from about 400 to 1,300 feet in thickness. The gross withdrawal of about 43 million gallons per day in 1960 was chiefly from the principal aquifer. About two-thirds of the withdrawal was pumped for public supply, and most of the remainder was for industrial use. Agricultural withdrawal was negligible. Most of the pumped water was returned to the ground through recharge basins, diffusion wells, and cesspools, but about 4 million gpd was discharged to Long Island Sound as sewage effluent.

Descriptors: Groundwater, water levels, hydrogeology, Long Island (N.Y.).

263 Iwagaki, Yuichi

1951. Theory of flow on road surface: Kyoto, Japan, Kyoto Univ., Faculty of Eng., Memoirs, v. 13, no. 3, p. 139–147, 8 figs.

The momentum equation of a thin sheet flow on a road surface was solved numerically. The condition of continuity was that rain falls on roads uniformly. Water depth, mean velocity of thin sheet flow, and the frictional velocity related to soil erosion may be computed. The effects of camber shape and longitudinal slope of the road surface on drainage and stabilization are also discussed.

Descriptors: Rainfall-runoff relationships, street runoff, storm runoff.

264 Izzard, C. F.

1947. Hydraulics of runoff from developed surfaces, *in* Ann. Meeting, Natl. Research Council, Highway Research Board, 26th, Washington, D.C., Dec. 5–8, 1946, v. 26, Proc.: Natl. Research Council, Highway Research Board, p. 129–150, 16 figs., 6 references.

Runoff produced by rainfall on a developed surface, such as a highway pavement or airfield runway, takes place as overland flow in a thin sheet. Usually this overland flow is collected in a longitudinal gutter. The hydraulics of overland flow were studied in a cooperative experimental project. A method was developed for computing the hydrograph of runoff resulting from given rates of rainfall taking into consideration the roughness, slope, and length of the surface. An analytical study was made of the hydraulics of flow in a gutter collecting runoff along the edge of a pavement. Storage in the gutter causes the outflow hydrograph to lag behind the inflow hydrograph. An approximate method is given for computing the hydrograph of outflow, taking into consideration the roughness, grade, and length of the gutter as well as the characteristics of overland flow. Charts give the maximum rate of runoff on a given roadway cross section for various lengths of roadway as limited by the intensity-duration rainfall frequency curves for a given locality.

Descriptors: Rainfall-runoff relationships, storm runoff, street runoff, hydrograph analysis, overland flow, depth-area-duration analysis.

265 James, I. C.

1967. Flood runoff from partially urbanized areas, Wichita, Kansas: U.S. Geol. Survey open-file rept., 62 p., 21 figs., 10 tables, 13 references.

The effect of changes in urbanization on flood runoff near Wichita, Kans., was studied by analyzing rainfall, runoff, and urbanization records. Data for the first 3 years of operation of the project include the degree of urbanization as of September 1964, the maximum flood hydrographs and associated rainfall experienced during the 3 years, and the developed unit hydrographs of six study basins. Imperviousness varies from 0.86 percent to 30.48 percent in the six study basins. Variations between unit hydrographs from individual storms are probably caused by non-uniform rainfall excess. Urbanization significantly affects flood peaks. For instance, fully urbanized Dry Creek, with a drainage area of 2.94 square miles, of which 30.48 percent is impervious, exhibited a unit hydrograph peak nearly the same as that of the far larger west branch of Chisholm Creek, with a drainage

area of 16.10 square miles and an imperviousness of 1.85 percent, although the unit peak on the west branch of Chisholm Creek should be 2 to 2½ times that of Dry Creek.—W69-03118.

Descriptors: Storm runoff, Wichita (Kans.), peak discharge, unit hydrographs, impervious area.

266 James, L. D.
1965. Using a digital computer to estimate the effects of urban development on flood peaks: Water Resources Research, v. 1, no. 2, p. 223–234, 3 figs., 8 tables, 4 references.

The Stanford watershed model was used to develop a long-term continuous hydrograph (1905–63) for Morrison Creek, Sacramento County, Calif. By varying constants describing the physical conditions within the watershed according to the amount of urban development and channel improvement within the tributary area, a number of continuous hydrographs were developed. A set of curves was developed from these hydrographs to estimate flood-peak frequency for any combination of urbanized area, improved channels, and tributary area. An analysis was also made of the effects of urban development on runoff volumes, the distribution of runoff volumes, and the distribution of runoff during the year.

Descriptors: Mathematical models, peak discharge, rainfall-runoff relationships, hydrograph analysis, Stanford watershed model, Sacramento (Calif.).

267 James, L. D.
1968. Economic analysis of alternative flood control measures: Lexington, Kentucky Univ., Water Resources Inst., Research Rept. 16, 41 p., 20 references.

An effective flood-control program must include nonstructural measures. No methodology is available for systematic evaluation of combined measures, and many prospective methodologies appear too time-consuming under current financial and manpower limitations. A computer program was developed to select the optimum combination of channel improvement, flood proofing, and land use management by location and by time within the flood plain. A second program selects the optimum detention storage in conjunction with the other measures downstream. Both programs go from raw data to a selected optimum combination of measures in one run. However, they do not produce a finished design of the selected measures. The programs have been successfully applied to four flood plains.—W68-00890.

Descriptors: Flood control, land use, Stanford watershed model, computer programs.

268 James, L. D.; Kelnhofer, G. J.; Elmore, G. R.; Laurent, E. A.
1971. The Peachtree Creek watershed as a case history in urban flood plain development: Atlanta, Georgia Inst. of Technology, Environmental Resources Center, Rept. ERC-0971, 83 p., 3 figs., 1 table, 99 references.

Programs to alleviate the consequences of flooding by restricting urban development in flood plains require understanding of the pressures causing urban development in hazard areas. Some insight must come from analysis of the history of flood-plain settlement. The Peachtree Creek flood plain in metropolitan Atlanta, Ga., occupies a small portion of a large, expanding metropolitan area. The history and causes of flood-plain development and the role of government officials in influencing development in the watershed from the time of earliest settlement are reviewed. Relative values of undeveloped lots on and off the flood plain are analyzed. Changes in stream-water quality are associated with urbanization; problems are created by storm-water washing of urban areas even if no sanitary sewer effluent is discharged untreated.

Descriptors: Storm runoff, Atlanta (Ga.), water pollution sources, sedimentation, planning, floods.

269 Jameson, D. L.
1970. A model relating water quality, vegetational structure and urbanization in the San Jacinto River basin: Houston, Tex., Houston Univ., Dept. of Biology, 49 p., 2 figs., 11 tables, 8 references.

This study was initiated to test the hypothesis that available information was sufficient to predict the relation between amount of urbanization and the quality of the water in the watershed of the San Jacinto River basin, Tex. Chemical water quality data are available in the published and unpublished records of the U.S. Geological Survey. Predictor variables included soil, weather, population characteristics, and estimates (from aerial photographs) of vegetation type and urbanization. Factor analysis, discriminant analysis, and canonical correlation analysis were used for data reduction. Two models were attempted. The first used the data to construct a matrix model of the relation between predictors and water quality. The second model used a probability distribution of biomasses in the vegetational community to examine the amount of reduction of the community that would not also destroy the contribution of the community to water quality. The results from both models were rejected because of the general incompleteness of the predictor data and because the available predictor data were not directly related to water quality in the areas where data were available.—W71-02271. PB-196-094.

Descriptors: Water quality, model studies, vegetation effects, San Jacinto River basin (Tex.).

270 Jaworski, N. A.; Villa, Orterio, Jr.; Hetling, L. J.
1969. Nutrients in the Potomac River basin: Federal Water Pollution Control Adm., Chesapeake Tech. Support Lab., Tech. Rept. 9, 40 p., 15 figs., 5 tables, 8 references.

The Potomac River system drained about 14,670 square miles of forested, agricultural, industrialized, and urbanized areas in December 1968 receiving 382 known discharges. Basin-wide studies were undertaken of water quality management, emphasizing eutrophication. Phosphate load was 94,130 pounds per day; total nitrogen load was 122,190 pounds per day. Of these loadings, 87 percent of phosphate and 53 percent of nitrogen originates in waste-water discharges. Inorganic nitrogen increases and phosphate decreases with increased streamflow in nontidal waters. Algal blooms of greater than 50 micrograms per liter were observed over 50 miles of the upper Potomac estuary during June–October 1968. During months of decreased flow, high concentrations of total Kjeldahl nitrogen, nitrates, and phosphates in the upper estuary are principally attributable to waste-water discharge from the District of Columbia metropolitan area. At steady-state flows, 38 percent of phosphates entering surface waters of the upper basin are retained in the river channel, apparently in sediments and plants.—W70-4386.

Descriptors: Eutrophication, phosphates, nitrates, runoff, Potomac River, District of Columbia.

271 Jeff, D. N.; Viirland, Jaak
1970. Special cases of water supply interference caused by urban development near Toronto, Ontario, Canada: Water Resources Bull., v. 6, no. 5, p. 746–753, 4 figs., 4 references.

A section of the Ontario Water Resources Act requires persons taking more than 10,000 imperial gallons per day of water for purposes other than domestic, stock, or fire fighting to have a permit and to take the water in accordance with specific terms and conditions. In cases of serious interference, the commission has required that steps be taken to restore water supplies or prevent continued interference. Construction of some new wells, sewers, and roads to meet the needs of urban development has caused interference with both ground- and surface-water supplies. Two cases are described where municipalities in the Toronto area restored supplies to overcome serious interference with several private wells and streamflow. Testing and operation of a 500-imperial-gpm municipal well caused loss of water flowing to a normally effluent stream, and interference with private wells was caused by dewatering at rates up to 2,000 imperial gpm during the installation of a trunk sewer.—W71-01363.

Descriptors: Water supply, surface-groundwater relationships, groundwater depletion.

272 Jens, S. W.
1948. Drainage of airport surfaces—some basic design considerations: Am. Soc. Civil Engineers, Trans., v. 113, Paper 2348, p. 785–836, 20 figs., 11 tables, 23 references.

A method for determination of runoff from the flat turf surfaces encountered on the inter-runway areas of airports employs knowledge of retention, infiltration, and overland flow. The detailed procedure takes into account not only the fact that antecedent precipitation within the storm reduces infiltration capacity but also that in many storms rainfall rates are less at times than the related infiltration capacities. Within most turfed areas pondage is available to reduce peak discharge. Procedures are given for obtaining the outflow rates from ponded areas. The capacity of a drainage system using pond storage varies little with frequency or duration due to the availability of large changes in total pondage with very small changes in depth.

Descriptors: Rainfall-runoff relationships, airports, storm runoff, overland flow, infiltration, street runoff.

273 Jens, S. W.; McPherson, M. B.

1964. Hydrology of urban areas, *in* Handbook of applied hydrology, Chow, V. T., ed.: New York, McGraw-Hill Book Co., p. 20-1 to 20-45, 16 figs., 7 tables, 58 references.

Hydrological effects of urbanization include increased water use, increase in the amount of surface drainage, accelerated water resources development, increased water pollution, increased flood damage and frequency, accelerated ground-water depletion, and sediment problems. New water-supply sources may require transportation over great distances. Uses of hydrologic data and methods in the solution of urban water problems and needs are reviewed. Storm-water drainage is given major emphasis, not only because of its economic significance but also because of growing dissatisfaction with established methods of runoff determination and the consequent attempts to develop more realistic and accurate, yet practical, engineering designs. In addition, brief mention is made of the utilization of urban hydrology in connection with designs dealing with floods, water supply, pollution, airports, and expressways.

Descriptors: Rainfall-runoff relationships, storm runoff, reviews, water pollution, groundwater depletion, floods, sediments.

274 Jens, S. W.; Jones, D. E., Jr.

1969. Water and metropolitan man: New York, Am. Soc. Civil Engineers, Hydraulics Div., Rept., 90 p., 4 app.

The second conference of urban water resources research stressed the interdisciplinary and systems analysis approaches to solving urban water and pollution problems. Recommendations were made for action and for further research in communication, planning, social impacts, regulation, data collection, precipitation, storage, urban design, and systems analysis.—W69-07722.

Descriptors: Water resources development, planning, water management (applied).

275 Johnson, K. A.

1970. An analysis of the effects of urbanization on unit hydrolograph characteristics, Antelope Creek basin—Lincoln, Nebraska, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 10, 19 p., 8 plates, 4 tables.

Hydrologic design requirements and hydrologic effects of a small dam were calculated in the Antelope Creek basin, Lincoln, Nebr. The proposed dam was located in the upper portion of the basin to control runoff from a 5.4-square-mile rural area. City planners forecast that the area above the dam would become a fully developed urban area. The results of this study were used in evaluating future flood probability conditions in the basin under the anticipated urban development with and without the dam in place. Unit graph characteristics were determined for the urban and rural portions of the basin. For the Antelope Creek area, the use of the generalized equations resulted in an increase in unit hydrograph peak discharge of 80 percent with the change from a rural area to one that is 60 percent impervious and fully sewered. The most important factor in determining the effects of urbanization on peak discharges is an estimate of the storm sewer and channel improvement factor.

Descriptors: Unit hydrographs, rainfall-runoff relationships, storm runoff, Lincoln (Nebr.).

276 **Johnson, S. L.**

1971. Annual compilation and analysis of hydrologic data for urban studies in the Houston, Texas metropolitan area, 1969: Houston, Tex., U.S. Geol. Survey basic-data rept., 272 p., 19 figs., 15 tables, 7 references.

Basic data of the urban hydrology of Houston, Tex., during the 1969 water year are compiled. Surface-water records are from gaging stations, crest-stage partial-record stations, rain gages, and miscellaneous sites. Each gaging-station record includes location, drainage area, gage type and history, average discharge, extremes, remarks, daily discharge, total discharge, mean discharge, annual maximum and mean discharges, and peak discharges. Runoff and rainfall are computed for each drainage basin, and hydrographs and mass curves are drawn. A map of each basin shows locations of all gages. The objectives are to provide basic runoff data for small urban drainage areas which differ in topography, soil, vegetation, tributaries, basin shape, and degree of urbanization; to provide related rainfall data with consideration of variation in intensity and location; and to provide data showing the effects of progressive urbanization on flood peaks and volume.

Descriptors: Hydrologic data, Houston (Tex.), rainfall-runoff relationships, storm runoff.

277 **Johnson, S. L.**

1968. Urban hydrology, Houston metropolitan area, Texas, 1968: Austin, Tex., U.S. Geol. Survey basic-data rept., 302 p., 14 figs., 14 tables, 6 references.

Basic data of the urban hydrology of Houston, Tex., October 1967 to September 1968, are compiled. Surface-water records are from gaging stations, crest-stage partial-record stations, rain gages, and miscellaneous sites. Each gaging-station record includes location, drainage area, gage type and history, average discharge, extremes, remarks, daily discharge, total discharge, mean discharge, annual maximum and mean discharges, and peak discharges. Runoff and rainfall are computed for each drainage basin, and hydrographs and mass curves are drawn. A map of each basin shows locations of all gages. The objectives are to provide basic runoff data for small urban drainage areas which differ in topography, soil, vegetation, tributaries, basin shape, and degree of urbanization; to provide related rainfall data with consideration of variation in intensity and location; and to provide data showing the effects of progressive urbanization on flood peaks and volume. Average rainfall over the Houston metropolitan area during the 1968 water year was 51 inches, or 5 inches greater than the 30-year (1931–60) average. Two area-wide storms and one localized storm of unusual magnitude occurred during the year.—W71-07184.

Descriptors: Rainfall-runoff relationships, hydrologic data, storm runoff, Houston (Tex.).

278 **Johnson, S. L.**

1967. Urban hydrology of the Houston, Texas, metropolitan area, compilation of basic data, 1967: Austin, Tex., U.S. Geol. Survey basic-data rept., 251 p., 15 figs., 12 tables, 5 references.

Basic data of the urban hydrology of Houston, Tex., October 1966 to September 1967, are compiled. Surface-water records are from gaging stations, crest-stage partial-record stations, rain gages, and miscellaneous sites. Each gaging-station record includes location, drainage area, gage type and history, average discharge, extremes, remarks, daily discharge, total discharge, mean discharge, annual maximum and mean discharges, and peak discharges. Runoff and rainfall are computed for each drainage basin, and hydrographs and mass curves are drawn. A map of each basin shows locations of all gages. The objectives are to provide basic runoff data for small urban drainage areas which differ in topography, soil, vegetation, tributaries, basin shape, and degree of urbanization; to provide related rainfall data with consideration of variation in intensity and location; and to provide data showing the effects of progressive urbanization on flood peaks and volume. Average rainfall in the Houston metropolitan area during the 1967 water year was 30.8 inches, or 15.2 inches below the 30-year (1931–60) average for the Houston airport station.—W71-00046.

Descriptors: Storm runoff, peak discharge, Houston (Tex.), hydrologic data, rainfall-runoff relationships.

279 Johnson, S. L.

1968. Urban hydrology of the Houston, Texas, metropolitan area, compilation of basic data, 1966: Austin, Tex., U.S. Geol. Survey basic-data rept., 275 p., 13 figs., 12 tables.

Basic data of the urban hydrology of Houston, Tex., 1965–66, are compiled. Surface-water records are from gaging stations, crest-stage partial-record stations, rain gages, and miscellaneous sites. Each gaging-station record includes location, drainage area, gage type and history, average discharge, extremes, remarks, daily discharge, total discharge, mean discharge, annual maximum and mean discharges, and peak discharges. Runoff and rainfall are computed for each drainage basin, and hydrographs and mass curves are drawn. A map of each basin shows locations of all gages. The objectives are to provide basic runoff data for small urban drainage areas which differ in topography, soil, vegetation, tributaries, basin shape, and degree of urbanization; to provide related rainfall data with consideration of variation in intensity and location; and to provide data showing the effects of progressive urbanization on flood peaks and volume.—W69-03538.

Descriptors: Data collections, hydrologic data, peak discharge, Houston, (Tex.), rainfall-runoff relationships, storm runoff.

280 Jones, D. E. Jr.

1967. Urban hydrology, redirection: Civil Eng., v. 37, no. 8, p. 58–62, 3 photos.

An improvement in urban drainage is suggested wherein cities would have two separate and distinct storm-water drainage systems, a "minor" and a "major" system. The minor system consists of carefully designed closed and open conduits and their appurtenances. The major system is the route followed by flood or runoff waters when the minor system is inoperable or inadequate. Cities today are overdesigning the minor systems. A reasonable design would provide that ordinary vehicular access to properties be impaired no more often than once in 2–10 years. Wiser use of natural land conditions when developing the land can obviate extensive storm-sewer construction. Examples are given of some methods for this wiser use, including "blue-green" land development employing ponds with open space for stormflow detention.—W69-01885.

Descriptors: Drainage systems, storm runoff, land use, drainage (urban), planning.

281 Jones, D. E., Jr.

1971. Where is urban hydrology practice today?: Am. Soc. Civil Engineers Proc., Paper 7917, Jour. Hydraulics Div., v. 97, no. HY 2, p. 257–264, 15 references.

The evolution of urban street construction and its effects upon urban drainage are reviewed. Rational method development and inconsistencies in its application are summarized. Lack of accurate precipitation data inhibits development of improved runoff prediction methods. Urban drainage areas need dual drainage systems to reduce drainage costs, reduce flood losses, enhance property values, stabilize neighborhoods, and improve urban life quality. Some basic methods for managing urban runoff are needed to attenuate peak flows. A low maintenance channel is more useful than usual urban channel designs. Direct losses from and expenditures for urban drainage approximate four billion dollars per year. The Nation could realize disproportionately great returns from urban hydrology research.

Descriptors: Drainage systems, storm runoff, storm drains, planning, drainage (urban), rational formula, reviews.

282 Jones, G. L.; Nakahara, R. H.; Chinn, S. S. W.

1971. Reconnaissance study of sediment transported by streams, Island of Oahu: Hawaii, Div. Water and Land Devel., Dept. Land and Natural Resources, Circ. C33, 45 p., 14 figs., 6 tables, 22 references.

Data collected during the first 3 years of a sediment-measuring program were used to compute sediment yields for seven basins draining the Koolau Range and central part of the island of Oahu, Hawaii. Sediment yields

range from 785 to 2,200 tons per square mile per year, suspended-sediment yields range from 630 to 1,400 tons per square mile per year, and bedload yields range from 75 to 900 tons per square mile per year. Estimated mean annual discharge of sediment to Kaneohe Bay is about 37,000 tons, consisting of 19,000 tons of clay, 15,000 tons of silt, and 3,000 tons of sand. Most of the data collected were from streams draining the part of the island undergoing the most intensive urban development. During urbanization, erosion and sediment-transport rates are altered greatly. Construction exposes large areas of soil. Compaction of soil by heavy equipment reduces infiltration, increasing surface runoff and erosion. The landscaping process may change slope and stream-channel dimensions. Similar effects result from other urbanizing processes, such as road building, drainage alteration, and paving of parking areas.

Descriptors: Sediment yield, sedimentation, storm runoff, land use, Oahu (Hawaii).

283 Jones, S. E.

1970. Tulsa District method of urban hydrology, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 5, 13 p., 2 figs., 1 reference.

Urban growth replaces forests and fields with the paved areas and structures of residential, commercial, and industrial development. Under these circumstances the design of flood-control projects by the Corps of Engineers must take into account the effects of this urban development on storm runoff rates. This is particularly true when flood plain information and local protection studies are requested for small drainage areas which are or will be largely overbuilt by urban development. The method used by the Tulsa District Corps of Engineers to determine the effects urbanization has on the surface runoff from small areas is presented. Where recorded hydrographs are not available to permit derivation of unit hydrographs, the synthetic unit hydrograph is usually selected.

Descriptors: Unit hydrographs, rainfall-runoff relationships, storm runoff.

284 Judd, J. H.

1970. Lake stratification caused by runoff from street deicing: Water Research, v. 4, no. 8, p. 521–523, 3 figs., 6 tables, 16 references.

Salt is used for winter street deicing throughout most of the northern United States. Much of the salt is dissolved in the melt water and flows into surrounding surface water. Salt entering First Sister Lake, west of Ann Arbor, Mich., increased the density of the water in the lower lake strata. During 2 of the 3 years studied, the increased density prevented complete spring overturn. This can be considered a temporary monomixis. The stability of stratification of the lake was from 3.5 to 8.5 times greater than when no complete overturn occurred. The lake mixed completely each fall. Laboratory and field tests indicate that salt left the lake and apparently entered the ground water of the area.—W71-02441.

Descriptors: Lake stratification, lakes, water pollution effects, highway deicing, deicers, Ann Arbor (Mich.).

285 Judd, J. H.

1971. Effect of urban salt runoff on lake stritification, *in* Street salting, urban water quality workshop, Syracuse, N.Y., May 5–6, 1971, Symposium Proc.: Syracuse N.Y., Syracuse Univ., College of Forestry, p. 74–79, 1 fig., 1 table.

The effect of runoff water from street deicing on the stratification within a small lake is described. First Sister Lake lies within the western limits of Ann Arbor, Washtenaw County, Mich. An extensive subdivision has developed along the eastern and southeastern shore of the lake. A two-lane highway is located on the hill to the north with a four-lane highway, Interstate 94, adjacent to it. The storm sewers carry runoff water from 34.8 hectares of the subdivision directly into First Sister Lake. The major factor inhibiting the spring mixing of First Sister Lake appears to be the salt entering the lake during the previous winter. This in turn depends on the amount of salt which was used for deicing. High density water entering the lake tended to flow along the

bottom. This layer of water of greater density increased the stability sufficiently to prevent mixing of the lower 3 or 4 meters.

Descriptors: Water pollution effects, deicers, highway deicing, Ann Arbor (Mich.), lake stratification, lakes.

286 **Kadner, Wilhelm**
1968. Retardation of discharge in public waters within the area of a community: GWF/Fas-und Wasserfach, v. 109, no. 6, p. 158–159, 2 figs., 1 table, 1 reference. [In German]

Sources of public waters often receive the discharge of rainwater overflows of mixed or separate sewer systems. A method is given to determine runoff at any point in the storm drain and the respective design flow. The method allows the addition of new drainage areas, determination of the maximum permissible amount of flow, and corrections for added urbanization without too much effort.—W69-01920.

Descriptors: Storm runoff, rainfall-runoff relationships, combined sewers.

287 **Kalvinskas, J. J.; Ware, S. J.; Sakaida, R. R.; and others.**
1968. Water reservoir systems: Anaheim, Calif., North Am. Rockwell Corp., v. 1, 184 p., 53 figs., 35 tables, 26 references, 1 app.

Water reservoir systems may be used in urban areas as an alternative or complement to storm-water drainage systems for flood control. Reservoirs provide benefits in water conservation and reduced costs. Santa Maria, Calif., has characteristics of seasonal rainfall that cause urban flooding. High underground water percolation rates favor a reservoir system. The study area includes 8,000 acres of which 2,500 acres are highly urbanized, 3,800 acres which represent future urban development, and 1,700 acres which are projected as agricultural through the year 2000. The Stanford watershed model was used for a computer simulation of the Santa Maria watershed and for design of the reservoir system. The reservoir system cost for the total Santa Maria area of 8,000 acres is $7.0 million, a significant decrease in cost over the conventional system. Water conservation and multiple land use benefits provide distinct economic advantages in favor of the reservoir system.—W70-03435. PB-189-340.

Descriptors: Flood control, drainage systems, reservoirs.

288 **Kalvinskas, J. J.; Ware, S. J.; Sakaida, R. R.; and others.**
1969. Water reservoir systems for metropolitan drainage areas: Anaheim, Calif., North Am. Rockwell Corp., v. 2, 73 p., 17 figs., 13 tables, 24 references.

Water reservoir systems may be used in urban areas as an alternative or complement to storm water drainage systems for flood control. Reservoirs provide benefits in water conservation and reduced costs. Santa Maria, Calif., has characteristics of seasonal rainfall that cause urban flooding. High underground water percolation rates favor a reservoir system. The study area includes 8,000 acres of which 2,500 acres are highly urbanized, 3,800 acres which represent future urban development, and 1,700 acres which are projected as agricultural through the year 2000. The Stanford watershed model was used for a computer simulation of the Santa Maria watershed and for design of the reservoir system. The reservoir system cost for the total Santa Maria area of 8,000 acres is $7.0 million, a significant decrease in cost over the conventional system. Water conservation and multiple land use benefits provide distinct economic advantages in favor of the reservoir system.—W70-03435. PB-189-341.

Descriptors: Flood control, reservoirs, drainage systems.

289 **Kaufman, R. F.**
1970. Hydrogeology of solid waste disposal sites in Madison, Wisconsin: Madison, Wisconsin Univ., Wisconsin Water Resources Center, 361 p., 25 figs., 62 tables, 11 refenences.

Two existing and 24 prospective sanitary landfill sites in Madison, Wis., were examined. Former ground-water discharge characteristics of the existing sites have been altered as a result of the placement of fill and ground-water pumpage. Surface and ground-water resources adjacent to landfill areas were found to receive pollutants. Less than 5 percent of the total organic and inorganic nitrogen and total soluble phosphorus entering Lake Monona was attributable to the landfill operation. The increase in dissolved chemical species was high but restricted to local areas. Over the past 27 years, background quality in the two creeks receiving drainage changed. Phosphorus increased 2–6 fold. Decreased base flow and urbanization may have influenced these changes.—W71-02825.

Descriptors: Landfills, groundwater pollution, Madison (Wis.).

291 **Kawamura, Takeshi**

1964. Analysis of the temperature distribution in the Kumagaya City—a typical example of the urban climate of a small city: Geographical Review of Japan (Chirigaku-Hyoron), v. 37, no. 5, p. 243–254, 5 figs., 2 tables.

Urban temperature distribution is affected by many factors, including topographical situation, size and functional character of a city, and others. City climate was studied by the Research Group of city climate in Japan, and intensive observation was carried out in several cities. Kumagaya City is located near the center of the Kanto Plain and had a population of about 50,000 in 1956. No houses and buildings are constructed of concrete or stone, nor do factories generate a large amount of heat. Results of regression analysis are similar to those of foreign stations, such as Uppsala, Sweden, and Bonn, Germany, in spite of the difference in construction materials of the city areas. Temperature distribution with calm conditions is closely correlated with building coverage. The area of the highest temperature is at the busiest part of the city in calm weather. Primary dominant weather factors affecting city temperature are the wind velocity and cloud cover. This suggests that the cause of the city temperature difference is the different radiation balance between the urban area and its surroundings.

Descriptors: Climatology, weather patterns, air temperature, precipitation (atmospheric), Kumagaya (Japan).

292 **Kawashima, Tatsuhiko; Hammer, T. R.; Coughlin, R. E.**

1970. A preliminary analysis of the effects of urbanization on water quality: Pennsylvania Regional Sci. Research Inst., Working Paper, 44 p., 7 figs., 3 tables, 3 app.

The hydrologic effects of urbanization were studied in the Philadelphia metropolitan area. Land uses, in combination with topographic and other natural features, affect water quality characteristics, streamflow regimen, and channel morphology. Approximately 80 watersheds, 1 to 6 miles in area, were sampled. These watersheds vary in development from completely rural to completely urbanized. Samples were taken to represent water quality conditions at base flow. Variance in the categorization by industrial density is unlike the variance in categorization by residential density. For the industrial density, the null hypothesis of equality of mean concentrations for the high, medium, and low densities was rejected at the 1 percent level of significance for 10 of the 21 chemicals and at the 5 percent level of significance for four additional chemicals. On the other hand, for the categorization by residential density, the null hypothesis was rejected at the 5 percent level for only one chemical, silicon dioxide.—W71-05359.

Descriptors: Water quality, Philadelphia (Pa.), water pollution sources, land use, sedimentation.

293 **Keller, F. J.**

1962. Effect of urban growth on sediment discharge, northwest branch Anacostia River basin, Maryland: U.S. Geol. Survey Prof. Paper 450-C, p. C129–C131, 2 figs., 2 references.

During the transition period from rural to urban land, erosion of denuded areas increases the sediment discharged by the receiving streams. The drainage basin of the northwest branch of the Anacostia River is in Prince Georges and Montgomery Counties, Md. This basin is in the path of the rapidly expanding Washington

metropolitan area. The area undergoing urban growth contributed 479 tons per day (or 17 tons per day per square mile), nearly a sixfold increase in suspended sediment discharge from an urban growth area compared to that from a rural area. Intensity, pattern, and methods of construction of street layouts, as well as physiographic and meteorologic factors, affect the quantity of sediment eroded in urban development. Furthermore, discharge peaks are increased after rural land is changed to urban land. High sediment discharge can be expected until all major areas of construction are stabilized and stream channels have adjusted to more frequent high flows.

Descriptors: Sediment yield, sedimentation, sediment load, erosion, Anacostia River (Md.).

294 Kellogg, C. E.; Enderlin, H. C.

1969. What urban building does to soil and water: Soil Conservation, v. 35, no. 4, p. 83–86, 6 photos.

The process of reshaping land for urban uses alters soils in many ways, often with drastic effects on drainage, runoff, and streamflow. Soils that were well drained under crops or native plants may become poorly drained and even unstable when the surface is overlain with houses and pavements. The remaining uncovered portions cannot take in all the extra water, so they become seasonally wet. Because of the greatly increased runoff, streams flood when heavy rains come. Peak discharges more than double when 80 percent of the soil surface is made impervious and may increase 75 percent when half the area is affected. These peak discharges are increased further when paved storm drains are used for rapid disposal of runoff water. Urban watersheds with 80 percent of the area covered or graded and completely served by storm drains have peak discharges increased 6 times. Soil erosion and sedimentation increase at comparable rates with those of runoff. Damages are most acute during construction of buildings and roads. Intense rains on bare slopes and spoilbanks, with drains and waterways still unpaved, produce maximum sediment yield. Under such conditions, rates of sedimentation may increase 100 times.

Descriptors: Storm runoff, sedimentation, floods, land use.

295 Kimmel, G. E.

1971. Water level surfaces in the aquifers of western Long Island, New York, in 1959 and 1970: U.S. Geol. Survey Prof. Paper 750-B, p. B224–B228, 6 figs., 1 table, 5 references.

During the period 1959–70, ground-water levels in northwestern Nassau and east-central Queens Counties, N.Y., declined 20 to 25 feet. The magnitude and extent of the declines in the water table and in the potentiometric surface of the artesian aquifer (Magothy Formation) were roughly similar. The data suggest a high degree of hydraulic interconnection between the water table and the base of the Magothy aquifer, which includes from 200 to 1,000 feet of saturated unconsolidated deposits. The decline in water levels probably resulted from decreased recharge and increased pumping in an area of relatively low transmissivity. Ground-water levels also declined because of the construction of sanitary sewers and the concurrent decrease in recharge resulting from the discontinued use of many thousands of cesspools.

Descriptors: Hydrogeology, water balance, water levels, water resources development, Long Island (N.Y.), groundwater depletion.

296 Kimmel, G. E.

1971. The water table on Long Island, New York, in March 1970: U.S. Geol. Survey open-file rept., 15 p., 4 maps, 2 hydrographs.

A net-change map of Long Island, N.Y., comparing water-table altitudes in 1951 with those in 1970 shows a maximum rise of about 30 feet in Kings County and a maximum decline of about 30 feet in Queens County during this period. In northern Nassau County, net declines ranged from about 5 to 20 feet. The net change in the water table in Suffolk County from 1951 to 1970 was less than 5 feet. The greatest changes resulted from changes in rates of withdrawal. Some declines are results of reduced ground-water recharge.

Descriptors: Water levels, drawdown, Long Island (N.Y.), groundwater depletion.

297 **King, M. V.**
1967. Storm runoff from urban areas: Inst. of Civil Engineers Proc., Paper 6996, v. 37, pt. 2, p. 43–56, 10 figs., 1 table, 1 reference.

A mathematical relation between rainfall and runoff in urban areas takes into account various calculable characteristics of a drainage area and the retention action of a sewage system as used in the Road Research Laboratory hydrographic method. The peak flow for any frequency of storm depends on the time of concentration, the effective impervious area, and the total volume of water in the sewerage system at the time of peak runoff; only the last of these is difficult to determine, and for very large areas it is considered adequate to use an approximation. Having determined the retention constant for a drainage system, it is also possible to draw the complete runoff hydrograph. This method may be used in designing large sewers but is not suitable for small ones.—W69-01886.

Descriptors: Storm runoff, rainfall-runoff relationships, drainage (urban), peak discharge.

298 **Kinosita, T.; Sonda, T.**
1969. Change of runoff due to urbanization: Internat. Assoc. Sci. Hydrology Pub. 85, p. 787–796, 9 figs.

The Public Works Research Institute of Japan set up a hydrological network on the Syakuzii River basin in the suburbs of Tokyo to determine changes of runoff due to urbanization. This basin is composed of flood plain deposits, and its area is 48 square kilometers. Increase of total flood volume, increase of peak discharge, and decrease of travel time are caused by decrease of infiltration area, decrease of roughness of the ground surface, and decrease of inundation area due to urbanization. Floods in 1966 were computed using a storage-runoff relation which uses data on drainage channels and the rate of infiltration. As the computation agreed well with observation, floods were estimated for the case of complete urbanization.—W71-04399.

Descriptors: Rainfall-runoff relationships, mathematical models, routing, Toyko (Japan).

299 **Klein, H.; Schneider, W. J.; McPherson, B. F.; Buchanan, T. J.**
1970. Some hydrologic and biologic aspects of the Big Cypress drainage area: U.S. Geol. Survey open-file rept., 94 p., 19 figs., 4 tables, 20 references.

The Big Cypress Swamp is important in maintaining an adequate water supply for the Everglades National Park, the expanding population of southwestern Florida, and the adjacent estuaries which constitute nurseries for fish. Hydrological information defining the boundaries of Big Cypress Swamp, on which Everglades National Park depends for its water supply, will assist in predicting effects of alternative land uses within Big Cypress Swamp on the ecology of the Everglades National Park.—W70-09704.

Descriptors: Land use, swamps, Big Cypress Swamp (Fla.), Everglades National Park (Fla.).

300 **Knapp, J. W.; Rawls, W. J.**
1968. Prediction models for investment in urban drainage systems: Dept. of Interior, Office of Water Resources Research, Rept. A-011-VA, 7 p.

A study of data from over 100 small urban drainage systems led to formulation of prediction equations for the cost of conventional storm drainage facilities. Multiple regression techniques and principal components analysis were used in selecting and fitting the prediction models. Nonlinear models provided the best predictors. To estimate total cost one model uses independent variables to describe slope, runoff factor, smallest pipe diameter, outlet capacity, and developed area; it can be used for planning factors before preliminary layout of the system. Another model uses largest and smallest pipe diameters, developed area, total length of lines, and number of inlets and manholes; it can be used for estimating costs after preliminary design layout. Both gave correlation coefficients over 0.95 and efficiency ratios over 70 percent. The models can be manipulated for use in comparative benefit-cost analysis.—W69-00324.

Descriptors: Drainage systems, storm runoff, model studies, storm drains.

301 Knapp, J. W.; Rawls, W. J.

1969. Prediction models for investment in urban drainage systems: Blacksburg, Va., Virginia Polytechnic Institute, Water Resources Research Center Bull. 24, 55 p., 7 figs., 15 tables, 15 references, 3 app.

Linear models were developed and used to study the significant factors controlling costs of conventional urban drainage systems. The objective of the study was to find decision-making methods for estimating the cost of alternative sizes of drainage facilities and the degree of protection to be afforded and to judge the potential for development. Factor analysis, component analysis, and nonlinear analysis were performed with data collected from 100 municipal agencies around the country. Physical features, although most important, were usually the fixed, uncontrollable variables. Design factors, on the other hand, were important in both degree and kind. The analysis explained the differences in the design methods and led to the development of equations to predict the cost for various levels of design.

Descriptors: Rainfall-runoff relationships, mathematical models, planning, systems analysis, economics.

302 Knapp, J. W.; Schaake, J. C.; Viessman, Warren

1963. Measuring rainfall and run-off at storm-water inlets: Am. Soc. Civil Engineers Proc., Paper 3644, Jour. Hydraulics Div., v. 89, no. HY 5, pt. 1, p. 99–115, 9 figs., 2 photos., 4 references.

An instrument system was developed to measure rainfall and runoff in small urban drainage areas draining to storm-water inlets. The system includes a rain gage on each area, a measuring device inside the inlets, a recorder, and control providing automatic operation during storms. The installation can be completed with few alterations to existing drainage facilities.—W69-01923.

Descriptors: Instrumentation, storm runoff, drainage (urban).

303 Kneese, A. V.; Ayres, R. U.; D'Arge, R. C.

1970. Economics and environment, a materials balance approach: Baltimore, Md., Johns Hopkins Press, 119 p., 22 tables, 13 charts, 48 references.

The economics of urban and industrial wastes (residuals) in an industrial economy are discussed. Public Investment programs and planning, including transportation systems, sewage disposal, and river flow regulation, are intimately related to the amounts and effects of residuals. In view of this, it is important to develop not only improved measures of the external costs resulting from residuals but more systematic methods for projecting emissions, technical and economic trade offs among them, and the effects of recycling. A formal mathematical model uses materials balance concepts. This model is of theoretical interest and also suggests how the more simplified versions of economic general interdependency models might be used to provide more coherent and accurate projections of residuals discharges as a function of the final products of an economy.

Descriptors: Economics, mathematical models, water pollution control.

304 Knochenmus, Darwin

1969. A reconnaissance of the quality of water in Lake Dicie and West Crooked Lake near Eustis, Florida: U.S. Geol. Survey open-file rept., 10 p., 1 fig., 1 table.

A study was made of two lakes near Eustis, Fla., to determine the cause of algal blooms in one of them, while the other had no blooms. Lake Dicie is smaller, shallower and thus at times probably warmer than West Crooked Lake. Significant land use differences in their drainage basins exist; private dwellings serviced by septic tanks comprise 50 percent of the drainage area of Lake Dicie as compared to only 20 percent of the drainage area of West Crooked Lake. The ratio of drainage area to lake surface is approximately 24:1 for Lake Dicie (after installation of a storm drain), whereas the ratio is only 10:1 for West Crooked Lake. The higher concentration of nutrients in Lake Dicie seems to be related to the larger drainage-area ratio and to the increase in nutrient and

water inflow through the storm drain, as well as to the many septic tanks in the Lake Dicie drainage basin. Many other small lakes and ponds in Lake County which receive street drainage have algal blooms.—W70-03260.

Descriptors: Lakes, eutrophication, storm runoff, Eustis (Fla.).

305 Knoll, C. G.

1969. Preliminary determinations of sediment discharge in San Juan drainage basin, Orange and Riverside Counties, California: U.S. Geol. Survey open-file rept., 28 p., 10 figs., 14 tables, 4 references.

During the 1967 and 1968 water years, the mean daily suspended-sediment discharges at the gaging stations on San Juan Creek and its major tributary, Arroyo Trabuco, near San Juan Capistrano, Calif., were 266 tons and 124 tons, respectively. Extrapolated over the 38 years of water-discharge record 1931–68, the mean daily suspended-sediment discharge at the gaging stations was 124 tons at San Juan Creek and 44 tons at Arroyo Trabuco. The mean daily coarse-sediment discharge for the same period was about 180 tons at San Juan Creek and 6.1 tons at Arroyo Trabuco. The discharge of coarse sediment at the mouth had a mean daily value of 200 tons. Because of urbanization, the mean daily coarse-sediment discharge at the beach will be reduced by about 33 percent during the next 30 years; and, depending upon the water-management practices, the reduction may be even greater.—W70-06144.

Descriptors: Sediment load, sedimentation, Capistrano (Calif.).

306 Koch, Ellis

1970. Effects of urbanization on the quality of selected streams in southern Nassau County, Long Island, New York: U.S. Geol. Survey Prof. Paper 700-C, p. C189–C192, 2 figs., 2 tables, 7 references.

The water quality of the streams in Southern Nassau County, N.Y., has diverged noticeably from natural conditions because of extensive urbanization. The quality of two streams in sparsely populated areas in Suffolk County was compared with the quality of three streams in moderately-to-densely populated parts of Nassau County. The estimated load of dissolved solids of all the Southern Nassau County streams presently is about 10.5 tons per day greater than the estimated load under natural conditions. The detergent content of the three streams in Nassau County is greater than in Suffolk County streams; the nitrate content is 14 times that of the Suffolk County streams; and the dissolved-solids content is about 3 to 4 times that of the Suffolk County streams.—W71-00175.

Descriptors: Water pollution sources, surface runoff, Long Island (N.Y.), storm runoff.

307 Kohlhaas, C. A.

1970. The optimization of storm holding tanks, a problem of water pollution control: Stanford, Calif., Stanford Univ., Dept. of Civil Eng., Ph.D. thesis, 321 p., 54 figs., 10 tables, 161 references.

System design procedures for the problem of combined-sewer overflows are proposed to provide information to regulation authorities. This information will aid them in making decisions regarding water-quality goals for watercourses subject to storm-sewage overflows. The hydrology, quality, effect on the environment, and control technology of combined-sewer overflows and overflows from sewers subject to heavy infiltration are reviewed. From a pollution standpoint, there is no real distinction between combined sewers and separate sewers subject to heavy infiltration. The relationship between storm-sewage overflow and competing urban needs is investigated. Two mathematical programs are given for optimizing control facilities for storm-sewage overflows; one achieves economic efficiency by means of the effluent tax; the other incorporates water-quality goals by means of stream standards. The stream standards program was applied to a practical problem of storm-sewage overflow in East San Francisco Bay, Calif. Treatment processes are based on the use of holding tanks. The effects of a holding tank on input discharge, BOD (biochemical oxygen demand), and coliform concentrations

are described by means of equations. For most cities, the high cost of solutions to storm-sewage overflow problems will prevent the implementation of control measures in the near future.

Descriptors: Storm runoff, water pollution sources, water pollution control, combined sewers.

308 Kohout, F. A.

1960. Flow pattern of fresh and salt water in the Biscayne aquifer of the Miami area, Florida: Internat. Assoc. Sci. Hydrology Pub. 52, p. 440–448, 8 figs., 7 references.

The coastal part of the Biscayne aquifer—a highly productive aquifer of limestone and sand in the Miami, Fla., area—displays a dynamically stable salt-water front as much as 8 miles seaward of the position computed according to the Ghyben-Herzberg principle. This discrepancy results largely from the fact that the salt water in the Biscayne aquifer is not static. Equipotential lines in terms of equivalent fresh-water head in wells show that when the fresh-water head is high, water in all parts of the aquifer moves seaward; but when the head is low, salt water circulates from the floor of the sea through the lower part of the aquifer into the zone of diffusion and thence back to the sea. By use of horizontal gradients derived from a low-head equipotential diagram, a flow net was constructed to show the movements of fresh and salt water in the aquifer.

Descriptors: Saline water intrusion, coastal aquifers, Miami (Fla.), groundwater movement, saline water-fresh water interfaces.

309 Kohout, F. A.

1964. The flow of fresh water and salt water in the Biscayne aquifer of the Miami area, Florida: U.S. Geol. Survey Water-Supply Paper 1613-C, p. C12–C32, 12 figs., 1 map.

In the coastal part of the Biscayne aquifer in the Miami area, Fla., the salt-water front is dynamically stable as much as 8 miles seaward of the position computed according to the Ghyben-Herzberg principle. The discrepancy results, at least in part, from the fact that the salt water in the Biscayne aquifer is not static. During periods of heavy recharge, the fresh-water head is high enough to cause the fresh water, the salt water, and the zone of diffusion between them to move seaward. When the fresh-water head is low, salt water in the lower part of the aquifer intrudes inland, but some of the diluted sea water in the zone of diffusion continues to flow seaward. Thus salt water circulates inland from the floor of the sea through the lower part of the aquifer, becoming progressively diluted with fresh water, after which it moves upward and returns to the sea. About seven-eights of the total discharge at the shoreline originates as fresh water in inland parts of the aquifer. The remaining one-eighth represents a return of sea water entering the aquifer through the flood of the sea.

Descriptors: Saline water intrusion, groundwater depletion, groundwater movement, saline water-freshwater interfaces, Miami (Fla.), coastal aquifers.

310 Kovacs, Gy

1968. Hydrological aspects of water management, *in* Second internat. postgraduate course on hydrology methods for development of water resources management, Budapest, Hungary, Jan.–July 1968: Manual 2, 59 p., 22 figs., 5 tables.

Water management is defined, and the hydrological aspects of water management are discussed in the introductory section of a text written for an international postgraduate course in water resources management. The topics introduced are flood control, river training, water control on the catchment, irrigation, water supply and sewage problems, water power, and economics. The objectives of water management and the needs for data of the various branches of water management are outlined and summarized. Various national water management organizations and policies are briefly described.—W69-06221

Descriptors: Water management (applied), water resources development.

311 **Kuichling, Emil**

1889. The relation between the rainfall and the discharge of sewers in populous districts: Am. Soc. Civil Engineers Proc., v. 20, Paper 402, p. 1–60, 15 tables, 6 graphs.

To predict urban runoff, it is necessary to estimate the probable future amount of impervious surface and to assume that all of the water which falls upon such surfaces will run off without loss. Because topography is known, the grades and length of the longest tributaries to the outlet sewer can be determined, as well as their approximate diameters and the velocities of flow. From these elements, the time required for the floodwaters to reach the outlet sewer from the most distant points in the area can be found. When the relation between the probable maximum intensity of the rain and its corresponding duration are known, the maximum rate of rainfall can be related to the time of concentration. This rational method compels the exercise of an engineer's judgment and discretion with respect to the future of localities of a city or parts of a large drainage area, instead of dealing alike with all. To illustrate the method, the relation between maximum sewer discharge and the rainfall was approximately established for five different districts in Rochester, N.Y. The flood volume is in direct proportion to the magnitude of the impervious surface and to the intensity and duration of the rain. Flood volume reaches a maximum when the precipitation continues uniformly for a sufficient length of time for the concentration of the storm waters from all portions of the area.

Descriptors: Rainfall-runoff relationships, rational formula, depth-area-duration analysis, time of concentration, storm runoff.

312 **Kunkle, S. H.**

1971. Effects of road salt on a Vermont stream, *in* Street salting, urban water quality workshop, Syracuse, N.Y., May 5–6, 1971, Symposium Proc.: Syracuse Univ., College of Forestry, p. 48–61, 6 figs., 5 tables, 16 references.

Studies were made in the Sleepers River basin of Vermont during 1968 to 1970 to determine the effects of road deicers on water quality. Streams not influenced by the highway averaged 2 to 5 mg per liter chloride, while concentrations in the stream affected by the highway were about an order of magnitude higher. Salt concentrations in the highway-influenced stream peaked during summer baseflow. Some of the winter's salt apparently contaminated the soil, emerging later in ground-water inputs into the stream. Chloride concentrations in individual seeps sampled near the highway exceeded 200 mg per liter.

Descriptors: Water pollution sources, deicers, highway deicing, Vermont.

313 **Kurzweil, H. A.**

1964. The pollution of runoff from urban housing estates: Gesundheits-Ingenieur, v. 85, no. 6, p. 178–181. [In German]

Rainfall and runoff in urban areas were studied during storms of varying intensity. Data are given on the changes in the quality of water from roofs and paved areas, including data on 5-day BOD (biochemical oxygen demand), dissolved oxygen, and organic substances. The discharge of this polluted water to the storm-water sewer or sewerage system is discussed, and preliminary treatment of this runoff is recommended to reduce pollution.—W69-01831.

Descriptors: Rainfall-runoff relationships, storm runoff, water pollution sources, drainage (urban).

314 **Lager, J. A.; Shubinski, R. P.; Russell, L. W.**

1971. Development of a simulation model for storm-water management: Water Pollution Control Federation Jour., v. 43, no. 12, p. 2424–2435, 9 figs., 1 table, 4 references.

A comprehensive simulation model is capable of representing urban storm-water runoff phenomena in quality and quantity. Hydrographs and pollutographs (time varying quality concentration or mass values) were

generated from points of origin in real time sequence to points of disposal with user options for intermediate storage and treatment facilities. Incorporated dry-weather flow routines permit the evaluation of both combined and separate sewerage systems. Internal cost routines and receiving water quality assisted in the direct costs benefit analysis of alternate programs of water quality enhancement.

Descriptors: Simulation analysis, storm runoff, mathematical models, water quality, rainfall-runoff relationships, economics.

316 Lancashire River Authority.
1964. 12th and 13th Annual reports of the Lancashire River Authority, for the period ending March 31, 1963 and March 31, 1964: Preston, Lancashire, England, Lancashire River Authority, Annual Rept., 106 p.

One of the principal problems in the industrialized parts of Lancashire, England, is the pollution caused by storm-sewage overflow. To alleviate pollution caused by the first flush of storm-sewage overflows, the use of holding tanks is suggested. Other special investigations included studies on the estuary to determine the composition and rate of discharge of effluents which would be considered unlikely to harm migratory fish. The criteria used in assessing the degree of pollution of a river or stream are summarized—W69-01509.

Descriptors: Storm runoff, water pollution sources, combined sewers, Lancashire (England).

317 Land, L. F.
1971. Annual compilation and analysis of hydrologic data for urban studies in the San Antonio, Texas metropolitan area, 1969: San Antonio, Tex., U.S. Geol. Survey basic-data rept., 109 p., 1 fig., 2 tables, 3 references.

This report presents a compilation and analysis of hydrologic data collected in the San Antonio, Tex., urban area for the 1969 water year. Precipitation data are based on 21 recording rain gages. Runoff data are based on discharge measurements and stage records at seven stream-gaging stations, seven crest-stage partial-record stations, one reservoir station, and water-surface elevations at four flood profile partial-record stations. Water quality data were collected from watersheds in various stages of urban development. Data are also provided on the concentration of pollutants as a result of runoff. In addition, these data relate water-quality parameters to discharge and seasonal conditions. The importance of water quality in this area is unique because of the large amounts of surface-water runoff recharged to the Edwards limestone, the major aquifer supplying ground water in the San Antonio area.

Descriptors: Rainfall-runoff relationships, data collections, water quality, San Antonio (Tex.), storm runoff.

318 Landsberg, H. E.
1956. The climate of towns, *in* Man's role in changing the face of the earth, Thomas, W. L., ed.: Chicago, Ill., Chicago Univ. Press, p. 584–606, 5 figs., 16 tables, 53 references.

Cities at moderate high latitudes cause undesirable local deterioration of climate. A few changes, such as the higher winter nighttime minimum temperatures, may be considered favorable. These are far outweighed by increase in pollution, increase in cloudiness, and reduction in illumination and ultraviolet radiation. Construction practices have aggravated rather than alleviated the situation. The adverse effects can be minimized if the climate aspects are adequately considered in plans for new settlements or for the reconstruction of old ones.

Descriptors: Climatology, heat balance, reviews, weather modification.

319 Lau, L. S.; Mink, J. F.
1967. A step in optimizing the development of the basal water lens of southern Oahu, Hawaii: Internat. Assoc. Sci. Hydrology Pub. 72, p. 500–508, 2 figs.

Honolulu, Hawaii, obtains its fresh water supply almost entirely from a Ghyben-Herzberg lens that underlies the southern portion of the island of Oahu. Many small communities and military bases derive their water from the same source, so that an average of about 100 mgd of fresh water is pumped from the lens. The largest withdrawals, however, serve agriculture, which utilizes up to 150 mgd. Thus the lens, which underlies no more than 200 square miles, is subjected to intense development, the pace of which is quickening. Recently the city of Honolulu planned a new pumping station designed to withdraw 10 mgd from the lens to assure optimum development. Laboratory and field tests were conducted to determine the best location for the well field. Laboratory investigations consisted principally of modeling the field situation. On the basis of laboratory-field evaluations, the well field was located and is now successfully supplying Honolulu with additional water.

Descriptors: Groundwater, saline water-freshwater interfaces, Honolulu (Hawaii), water resources development.

320 Leach, S. D.

1963. Hydrologic studies in the Snake Creek Canal area, Dade County, Florida: Florida Geol. Survey, Rept. of Inv. 24, pt. 3, 33 p., 19 figs., 10 references.

Snake Creek Canal was constructed primarily to drain rapidly urbanizing parts of northern Dade County and southern Broward County, Fla. During dry periods it conveys water from the Everglades seaward to replenish coastal sections of the Biscayne aquifer. A salinity-control structure at the mouth of the canal prevents the upstream movement of salt water and helps to maintain upstream water levels high enough to prevent salt-water encroachment into the aquifer. An inflow of 36 cfs from Area B is required in the canal to maintain a water level of 2.7 feet above m.s.l. at the control structure. This water is used to recharge the aquifer in the coastal ridge.

Descriptors: Surface-groundwater relationships, saline water intrusion, recharge, drainage systems, Miami (Fla.).

321 Leach, S. D.; Klein, Howard; Hampton, E. R.

1971. Hydrologic effects of water control and management of southeastern Florida: U.S. Geol. Survey open-file rept., 193 p., 47 figs., 12 tables, 25 references.

The prime effect of the water control works in southern Florida has been to facilitate the flow of water out of the Everglades by means of the canal system, thereby changing the spatial and temporal distribution of runoff from the Everglades. Reduction in flow to the ocean began with completion of levee systems in 1953. Discharge to the ocean through Miami Canal was reduced an average of 185,000 acre-feet per runoff year for 1956–65, and combined discharge from North New River, Hillsboro, and West Palm Beach Canals was reduced about 294,600 acre-feet per runoff year for 1953–65, from the average discharge of 1940–52. Overall reduction of fresh-water flow to the ocean since 1953 as a result of flood and water-control measures is about 20 percent. One principal effect of earlier land-reclamation practices was the lowering of ground-water levels throughout the coastal ridge and interior areas. Overdrainage of many coastal areas allowed sea-water intrusion of canals and intrusion into the Biscayne aquifer, the source of nearly all potable water in the area. The overdrainage has been arrested and, since 1954, water levels have tended to stabilize in most of Dade County.

Descriptors: Water resources development, surface-groundwater relationships, saline water intrusion, Everglades (Fla.), drainage systems.

322 Leach, S. D.; Klein, Howard; Hampton, E. R.

1972. Hydrologic effects of water control and management in southeastern Florida: Florida Dept. of Natural Resources, Bureau of Geology, Rept. of investigations, no. 60, 115 p., 47 figs., 12 tables, 24 references.

Most of the land in southeastern Florida presently utilized for urban, suburban, and agricultural purposes was inundated all or much of the time under natural predevelopmental conditions. Early settlement was on a higher ground, where flooding during the rainy season was less probable. Major urban expansion in the 1900's occurred

in the vicinity of Miami, Fort Lauderdale, and West Palm Beach. Drainage canals were extended inland along natural drainageways and through transverse glades. Urban areas expanded westward on land formerly inundated or used for agriculture, displacing agricultural land farther inland to the east edge of the Everglades. Before drainage, water levels were near or at land surface along much of the coastal ridge area. Overdrainage of many coastal areas allowed sea-water intrusion of canals and the Biscayne aquifer, the source of nearly all potable water in the area. The overdrainage has been arrested and, since 1954, water levels have tended to stabilize in most of Dade County. Yearly peak water levels are considerably lower than in pre-flood-control times, and yearly low-water levels are higher than in premanagement times. The improved conditions of well-field production and salinity control are results of salinity barriers in canals and replenishment of water in well-field areas from canals.

Descriptors: Saline water intrusion, drainage systems, Everglades (Fla.), Lake Okeechobee (Fla.), surface-groundwater relationships.

323 LeGrand, H. E.

1964. System for evaluation of contamination potential of some waste disposal sites: Am. Water Works Assoc. Jour., v. 56, no. 8, p. 959–974, 6 figs., 1 table, 4 references.

A system was designed to give preliminary estimates of the likelihood of finding contaminated ground water at points of water use. The system predicts the paths of contaminants that normally occur in sewage or general refuse disposed of at or slightly below ground surface. The system is especially intended for sites where both the waste and the ground water are in loose, granular materials; a slightly modified system is designed for two-media sites in which the water supply is in rock with fractures or solution openings and in which the waste is in overlying granular material.

Descriptors: Groundwater pollution, water pollution control, water pollution sources.

324 LeGrand, H. E.

1965. Paterns of contaminated zones of water in the ground: Water Resources Research, v. 1, no. 1, p. 83–95, 5 figs., 1 table, 21 references.

Movements of contaminants from waste sites into the subsurface water circulation system results in contaminated zones below the water table. Difficulty in predicting the areal extent of a contaminated zone stems from a multiplicity of factors that need consideration, including the great variety of waste materials and their range in toxicity and adverse effects; man's variable pattern of waste disposal and of accidental release of contaminants in the ground; man's variable pattern of water development from wells; behavior of each contaminant in the soil, water, and rock environment; ranges in geologic and hydrologic conditions in space; and ranges in hydrologic conditions in time. Two opposing tendencies need to be considered before an evaluation of contaminated zones is undertaken: (1) the tendency for contaminants to be entrained in ground-water flow and (2) the tendency of contaminants to be attenuated to varying degrees by dilution, decay, other attenuation, and absorption on earth materials.

Descriptors: Groundwater pollution, path of pollutants.

325 LeGrand, H. E.

1965. Environmental framework of ground-water contamination: Ground Water, v. 3, no. 2, p. 11–15, 5 references.

Contamination is increasingly involved in ground-water problems. The volume of usable ground water is shrinking in many places because of dispersion of contaminated water. Ways of contamination of the physical environment include: waste-disposal practices (at or near land surface and in deep formations), artificial recharge (at land surface and in aquifers), accidents, and salt-water contamination of aquifers (shallow depth from salty surface water and at variable depths from subjacent salty aquifers). Evaluation of waste-disposal problems calls

for appreciation of two opposing tendencies: the tendency of wastes to move with ground water and the tendency to be attenuated near disposal sites by decay or decrease in potency, by chemical and physical sorption, and by dilution through dispersion of ground water. Mixed wastes of differing attenuation habits represent special complex problems.

Descriptors: Water pollution sources, groundwater pollution, path of pollutants.

326 **LeGrand, H. E.**
1967. Role of ground water contamination in water management: Am. Water Works Assoc. Jour., v. 59, no. 5, p. 557–565, 1 table, 6 references.

Ground-water contamination should not be excluded in long-range integrated community plans, especially in urban areas and suburbs. It includes any deterioration of quality caused by waste disposal practices, artificial recharge, accident, or salt water intrusion at shallow or greater depths. Technically trained personnel capable of determining best use of land for water supply and waste disposal are a necessary part of water-resources administration. Specific problems are more often dealt with than long-range planning. Complex hydrogeologic conditions must be evaluated before decisions are made and policies established.—W69-06762.

Descriptors: Water pollution sources, water management (applied), planning, groundwater pollution.

327 **Leopold, L. B.**
1968. Hydrology for urban land planning—a guidebook on the hydrologic effects of urban land use: U.S. Geol. Survey Circ. 554, 18 p., 8 figs., 1 table, 28 references.

The effects of urbanization on hydrologic factors are discussed, and rainfall-runoff relations of urbanized and unurbanized watersheds are compared. Urbanization increases the amount of impervious area in a watershed so that the intensity and amount of runoff increase and peak discharges occur sooner. Sediment yields are 10–100 times larger in urbanized watersheds, water quality decreases, water temperature generally increases, and esthetic values usually decrease. Hydrographs, frequency curves, and sediment yield-discharge curves are used to show typical effects of urbanization on streams.

Descriptors: Peak discharge, rainfall-runoff relationships, sediment yield, water pollution sources, planning.

328 **Lewis, J. E., Jr.; Nicholas, F. W.; Scales, S. M.; Woollum, C. A.**
1971. Some effects of urban morphology on street level temperatures at Washington, D.C.: Washington Acad. Sci. Jour., v. 61, no. 4, p. 258–265, 6 figs., 5 references.

A temperature traverse along a 7-mile route in Washington, D.C., shows some typical microscale temperature differences for an urban area. The route was selected to sample all the major types of urban fabric ranging from park land to commercial land. Eight days were sampled, 5 days in the early morning and 3 days late at night. The profiles illustrate that the often generalized urban heat island actually possesses a large amount of internal variation when analyzed at the microscale level. In addition, the profiles point out the strong influence that the surface materials (both natural and manmade) have on the air temperature.

Descriptors: Air temperature, heat islands, climatology, microclimate, Washington (D.C.).

226 **Linsley, R. K.**
1971. A critical review of currently available hydrologic models for analysis of urban stormwater runoff: Palo Alto, Calif., Hydrocomp Internat., Inc., 83 p., 11 figs., 3 tables, 96 references.

Urban storm runoff models should be capable of continuous simulation of flow, including runoff from snowmelt and the effects of retention basins. Such models should incorporate nonlinear routing procedures. The

ideal model would utilize no "judgment" parameters and would derive all required parameters from field data in the watershed. No such model currently exists, and research in this direction should be emphasized. Of existing models, the Stanford watershed model most nearly satisfies the need for urban storm runoff models. The currently extensive research into linear systems models does not appear productive except as an approach to finding nonlinear methods. In particular, linear systems models directed only to deriving unit hydrographs are unproductive. The present small amount of urban hydrologic data is a serious deterrent to development and testing of storm runoff models. A network of six to ten urban experimental watersheds should be established promptly. Data from the network should be tested by simulation as soon as possible to verify the adequacy of both data and simulation.—W72-01978.

Descriptors: Simulation analysis, reviews, rainfall-runoff ralationships, storm runoff.

329 Los Angeles Bureau of Engineering.
1966. 1939 runoff instructions for design of storm drains: Los Angeles, Calif., Bur. of Eng., Office Standard No. 71, 51 p., 23 figs., 8 tables.

Tables, curves, and instructions are given for computation of urban storm runoff and for designing urban storm-water drains under various conditions of topography, imperviousness, soil types, slopes, and precipitation intensities. Hydrology of steep hillside or mountainous areas in natural state, a formula for computing the adjusted time of concentration at junctions of a main-line storm drain with its laterals, and other charts and tables are given. Detailed instructions are given for applying the peak-rate method and the method of summing hydrographs for computing runoff. Reduction factors to account for conduit detention in computing peak-runoff flows are given.—W71-03906.

Descriptors: Storm runoff, rainfall-runoff relationships, drainage (urban), routing, hydrograph analysis, peak discharge, Los Angeles (Calif.).

330 Lowry, W. P.
1967. The climate of cities: Scientific Am., v. 217, no. 2, p. 15–23, 14 figs.

The city itself is the cause of differences in climate between urban and rural areas. Its compact mass of buildings and pavement alters the natural landscape, and its activities are a considerable source of heat. Together these factors account for five basic influences that set a city's climate apart from that of the surrounding area. The first influence is the difference between surface materials in the city and in the countryside. Second, the city's structures have a far greater variety of shapes and orientations than natural features. Almost the entire surface of a city is used for accepting and storing heat, whereas in a wooded or open area the heat tends to be stored in the upper parts of plants. Third, the city is a generator of heat, particularly in winter. Fourth, the city has distinctive ways of disposing of precipitation. Finally, the air in the city carries a heavy load of contaminants. Every major aspect of climate is changed by an urban complex. The difference in a small city may be only occasional; in a large city, every day is different climatically from what it would have been if the city were not there.

Descriptors: Climatology, meteorology, heat islands.

331 Lubke, E. R.
1963. Hydrogeology of the Huntington-Smithtown area, Suffolk County, New York: U.S. Geol. Survey Water-Supply Paper 1669-D, p. D1–D68, 12 figs., 6 plates, 7 tables, 26 references.

The ground-water resources and related geologic environment of the Huntington-Smithtown area, Long Island, N.Y., are described. Agriculture, formerly a major activity, is decreasing with increase of suburban development. In 1960, less than 1,800 acres was farmed. The Huntington-Smithtown area is underlain by 400 to 1,300 feet of unconsolidated deposits resting upon a southeast-sloping bedrock surface. These deposits constitute the

ground-water reservoir. The average natural recharge is 147 mgd. In general, ground water supplied in substantial quantity and of good quality can be obtained from wells almost everywhere in the area. Between 1932 and 1957, average withdrawals for public supply increased from 1.5 mgd in 1932 to 8.8 mgd in 1957. In addition, about 5.9 mgd was used in 1957 for industrial, institutional, domestic, and agricultural purposes.

Descriptors: Hydrogeology, Long Island (N.Y.), groundwater.

332 **Ludwig, F. L.**
1970. Urban temperature fields: Geneva, Switzerland, Secretariat of the World Meteorological Organization, Tech. Note 108, WMO-no. 254.TP.141, Urban Climates v. 1, p. 80–107, 13 figs., 3 photos., 1 table, 11 references.

The nighttime heat island is evident in Dallas and Fort Worth, Tex. For Dallas, Fort Worth, and 10 other cities, the magnitude of the heat island is highly correlated with the low-level rural lapse rate. In 78 cases, the correlation between lapse rate and heat island intensity ranged from -0.81 to -0.95. The daytime temperature fields in Dallas and Fort Worth were explained by the increased heat capacity and thermal conductivity of the downtown building complex. The usual temperature pattern showed the areas of densely packed two to four-story buildings or of parking lots to be the warmest parts of the city. The central core with its closely spaced, very tall buildings is cooler, and the residential areas and the open environs are cooler still. These temperature differences are usually small, amounting only to about 1 degree C. The explanation is based on multiple reflections and absorptions of insolation between buildings. If this mechanism is the principal one involved, then similar features should be observable in the daytime temperature fields of other cities.

Descriptors: Air temperature, heat islands, climatology, meteorology.

333 **Lukovic, S.**
1968. Hydrogeological and engineering geological factors in regional spatial planning: Bull. Eng. Geol. and Hydrogeology, ser. B, no. 8, p. 125–131, 6 references.

Hydrogeological and engineering geological factors in regional spatial planning are reviewed. These factors always must be taken into account in an analysis of conditions in regional development and urbanization.—W71-04613.

Descriptors: Hydrogeology, planning, river basin development, Yugoslavia.

334 **Lull, H. W.; Sopper, W. E.**
1969. Hydrologic effects from urbanization of forested watersheds in the northeast: Upper Darby, Pa., U.S. Forest Service, Northeastern Forest Experiment Sta., Research Paper NE-146, 31 p., 4 figs., 4 tables, 46 references.

Urbanization of forest areas tends to reduce interception, reduce infiltration and increase overland flow, reduce soil-moisture storage, reduce evapotranspiration, increase runoff, increase peak flows, and reduce water quality. Annual maximum peak flows, annual hydrologic responses, and annual runoff were found (from actual streamflow records) to increase with progressive urbanization. The percentage of summer rainfall that appeared as runoff and the hydrologic responses were greater for partially urbanized watersheds than for mostly forested ones.—W70-06157.

Descriptors: Rainfall-runoff relationships, peak discharge, water quality.

335 **Lusczynski, N. J.**
1952. The recovery of ground-water levels in Brooklyn, New York from 1947 to 1950: U.S. Geol. Survey Circ. 167, 5 figs., 6 maps, 6 tables, 2 plates, 12 references.

The New York Water Service Corp. on June 29–30, 1947, stopped operating its ground-water facilities in the Flatbush section of Kings County (Borough of Brooklyn) in western Long Island, N.Y. The corporation had been using as many as 35 wells, which were screened both in the shallow water-table formation and in the deeper artesian aquifers. Withdrawals had averaged more than 25 mgd. A reduction of more than 50 percent in

the net ground-water withdrawals in the County was realized by the shutdown of pumping of the Flatbush wells. As a result, the water table, which was far below sea level for many years, recovered as much as 19 feet at some places in central Brooklyn from June 1947 to December 1950. In the artesian aquifers, similar large recoveries in the piezometric levels were recorded.

Descriptors: Groundwater depletion, recharge, water levels, Brooklyn (N.Y.).

336 Lusczynski, N. J.; Swarzenski, W. V.

1960. Position of the salt-water body in the Magothy (?) formation in the Cedarhurst-Woodmere area of southwestern Nassau County, Long Island, N.Y.: Econ. Geology, v. 55, no. 8, p. 1739–1750, 2 figs., 2 maps, 1 table, 2 references.

A sizable body of salt water is moving slowly landward from the south-shore bays of Long Island and Atlantic Ocean under the influence of ground-water withdrawal inland. The upper limit of the salt-water body in this area was at depths increasing progressively in a landward direction from 318 feet below sea level at Cedarhurst to 541 feet below sea level at Woodmere. The salt-water body is more than 300 feet thick at Cedarhurst, and it thins out to zero in the vicinity of a pumping center about 1¾ miles northeast of the Cedarhurst well. Electrical-log data show that the upper boundary of the salt-water body moved upward 21 feet between 1952 and 1958 at a site in Woodmere about half a mile southwest of the pumping center. Between 1952 and 1958 the leading edge of the salt-water front moved landward about 2,000 feet toward the pumping center.

Descriptors: Saline water intrusion, groundwater depletion, Long Island (N.Y.).

337 Lusczynski, N. J.; Swarzenski, W. V.

1962. Fresh and salty ground water in Long Island, N.Y.: Am. Soc. Civil Engineers Proc., Paper 3207, Jour. Hydraulics Div., v. 88, no. HY 4, pt. 1, p. 173–194, 5 figs., 1 table, 10 references.

Test drilling in 1959 and 1960 at Atlantic Beach and Lido Beach, Long Island, N.Y., provided the principal basis for the definition of the distribution and movement of fresh and salty ground water in sand, silt, and clay deposits beneath the barrier beaches. Multiple-observation wells were constructed for monitoring the intrusion of salty water. The lower part of the deep salty water body has nearly penetrated the entire thickness of clay deposits between Rockaway Park and Lido Beach; it is moving, though very slowly, toward the underlying fresh-water aquifer tapped by public-supply wells.

Descriptors: Saline water intrusion, groundwater movement, groundwater depletion, Long Island (N.Y.).

338 Lusczynski, N. J.; Swarzenski, W. V.

1966. Salt-water encroachment in southern Nassau and southeastern Queens Counties, Long Island, New York: U.S. Geol. Survey Water-Supply Paper 1613-F, p. F1–F76, 12 figs., 5 plates, 2 tables, 36 references.

Salty ground water occurs in southern Nassau and southeastern Queens Counties, Long Island, N.Y., as three wedgelike extensions that project landward in unconsolidated deposits from a body of salty water located seaward of the barrier beaches and Jamaica Bay. Zones of diffusion as much as 6 miles wide and about 500 feet thick are developed in the frontal part of the salty-water wedges. These large zones of diffusion were probably formed by both long and short-term changes in sea level, by changes in fresh-water outflow to the sea, and by dispersion due to movements of the water. Encroachment is principally under the influence of local withdrawals near the toe of the wedge. It is estimated that by the year 2000 the leading edges of the deep wedge may reach areas about a mile inland of South Ozone Park and the vicinity of Sunrise Highway at Valley Stream and Lynbrook. Elsewhere the deep wedge and the intermediate wedge of salty water may not advance more than about a mile by the year 2000.

Descriptors: Saline water intrusion, groundwater depletion, groundwater movement, Long Island (N.Y.).

339 **MacDonald, F. W.; Mehn, Adam**
1963. Determination of run-off coefficients: Public Works, v. 94, no. 11, p. 74–76, 1 map, 3 tables.

Times of concentration and an accurate value for the coefficient of imperviousness were determined in one of the large drainage districts of the city of New Orleans, La. The coefficient for built-up areas, which comprise over 4,000 acres in the district, is 0.548, whereas the coefficient for a typical suburban area is 0.455; the coefficient for the entire drainage district is 0.599. The rational formula was employed to determine runoff coefficients using a 79-minute time of concentration, and the average value obtained was 0.653, this value being within the ranges recommended for combined residential and commercial areas.—W69-01889.

Descriptors: Rainfall-runoff relationships, rational formula, New Orleans (La.).

340 **Maddock, Thomas, Jr.**
1969. Sedimentation engineering, economic aspects of sedimentation: Am. Soc. Civil Engineers Proc., Paper 6334, Jour. Hydraulics Div., v. 95, no. HY 1, p. 191–207, 30 references.

Sedimentation problems arise as a natural result of the change of the water-sediment regime. Sometimes cause and effect relations are not understood by decision makers. A method of farming on flatland may be undesirable when applied to sloping ground. Diverting stormflow from city streets to natural watercourses may be harmful. Responsibilities of engineers studying the sedimentation problems involved in civil engineering works are threefold: (1) identifying the problem and forecasting the nonbeneficial effects of the solution; (2) designing projects with desirable purposes to mitigate the undesirable effects; and when this is not possible (3) providing measures for controlling the undesirable reaction to an action for a desired purpose.—W69-07794.

Descriptors: Sedimentation, erosion, erosion control.

341 **Mallory, C. W.; Boland, J. J.**
1970. A systems study of storm runoff problems in a new town: Water Resources Bull., v. 6, no. 6, p. 980–989, 4 tables, 7 references.

The use of a large number of small reservoirs dispersed throughout an urban community as a means of storm-water pollution control was studied using systems analysis methods. The study used data from an area within the new city of Columbia, Md. A simulation model and a computerized evaluation technique were used to select the optimal locations and system configurations. Such a system is less expensive than a conventional engineering approach to storm-water pollution control. Further, the benefits derived from use of the storm as a water supply can offset a portion of the cost of pollution control. Several secondary benefits also result, including control of erosion and sediment, moderation of storm flow, and recreational facilities. Water collected and stored in the reservoirs is treated for release or use.—W71-03125.

Descriptors: Storm runoff, systems analysis, sediment control, Columbia (Md.), erosion control, water pollution control.

342 **Manji, A. S.**
1968. Uses of conventional aerial photography in urban areas; review and bibliography: U.S. Geol. Survey open-file rept. 1207, 27 p., 132 references. [Also available as Natl. Aeronautics and Space Adm. Tech. Letter 131]

Aerial photography can be used for obtaining data on a wide range of urban problems. For large surveys, aerial photography provides data more quickly and economically than ground surveys. These data are generally as accurate and reliable as those derived from ground survey. Types of studies include identification of present land use, determination of rate of land-use change, identification of source of air and water pollution, determination of the extent of flood damage, estimation of public utilities and services needed in developing areas, determination of route locations for streets and highways, making traffic counts, and parking surveys.

Descriptors: Aerial photography, remote sensing, land use, reviews, bibliographies.

343 **Marble, D. F.; Thomas, E. N.**

1966. Some observations on the utility of miltispectral photography for urban research, *in* Fourth symposium on remote sensing of environment, Ann Arbor, Mich., Apr. 12–14, 1966, Proc.: Ann Arbor, Mich., Michigan Univ., p. 135–144, 8 figs., 1 table, 7 references.

Some preliminary research on the use of multispectral photography in urban research was undertaken as part of a broader program dealing with the use of a variety of remote sensors to collect urban data. Multispectral imagery can provide information about static physical and manmade elements of the urban environment. Problems of urban traffic safety, transportation, land use, air pollution, and water pollution may be studied.

Descriptors: Remote sensing, aerial photography, land use, reviews.

651 **March, F. and Eagleson, P. S.**

1965. Approaches to linear synthesis of urban runoff systems: Cambridge, Mass., Massachusetts Inst. of Technology, Hydrodynamics Lab., rept. 85.

344 **Marcus, A. L.**

1972. Urban runoff and water-quality problems of an urban hydrologic response: The Monadnock, v. 46, [Worcester, Mass., Clark Univ.], p. 39–46, 15 references.

Urban development produces a unique range of hydrologic reactions of which an increase in the magnitude, duration, and frequency of storm-runoff flow is a major element. This increase in volume of flow is associated with decrease in water-quality. Recent studies are reviewed that show that runoff from the urban environment often becomes degraded from pollutants at the surface and in the atmosphere. Increased volumes of storm runoff produce critical problems with storage and transportation capabilities of systems designed for less frequent flows. Only recently has the need for reevaluation and implementation of an urban hydrologic cycle been realized. Urban growth is associated with the development of storm drainage systems which can alter the surface drainage pattern and reduce the lag time, or time of concentration of flow. These processes are manifested in a concentration of storm-water flow with sharper, shorter, and higher peak flows than those equated with natural runoff.

Descriptors: Rainfall-runoff relationships, storm runoff, reviews, water pollution sources.

345 **Martens, L. A.**

1968. Flood inundation and effects of urbanization in metropolitan Charlotte, N.C.: U.S. Geol. Survey Water-Supply Paper 1591-C, p. C1–C60, 24 figs., 2 maps, 12 tables, 6 references.

Significant increases in flood potential accompany urban development of drainage basins in Charlotte, N.C. Rainfall excess increases with the development of urban areas, which are more impervious than rural areas. The magnitude of the mean annual flow increases with increase of imperviousness. The effect of impervious area diminishes with increased flood recurrence intervals, becoming negligible for floods exceeding 50 years. Lag time for fully developed basins is about one-fourth the lag time before development. The increase in impervious area and decrease in lag time associated with the urbanization of a basin will about double the discharge of a 20-year flood. Increases of flood elevation of as much as 6 feet for some areas are a direct result of extensive watershed development.—W69-06445.

Descriptors: Floods, time lag, storm runoff, Charlotte (N.C.), peak discharge, impervious area.

346 **Martens, L. A.; Neely, B. L., Jr.**

1970. Tributary to the intracoastal waterway at Interstate Highway 10 near Port Allen, Louisiana: U.S. Geol. Survey open-file rept., 4 p., 3 figs.

Information is presented concerning the elevation and discharge of the 50-year flood at Port Allen, La., and the effect that a culvert will have on the flood elevations upstream from the highway. The basin is sparsely

developed (about 10 percent) above Interstate Highway 10. The 50-year discharge is estimated to be 1,580 cfs. Because of its proximity to Baton Rouge, the basin will become urbanized to a greater extent in the future. The 50-year stage at the upstream side of the culvert under rural conditions would be 9.3 feet, which reflects about 0.2 feet of backwater caused by the culvert; the 50-year stage after full urbanization would be 12.7 feet, which would have about 1.3 feet of backwater at the culvert.

Descriptors: Floods, routing, rainfall-runoff relationships, Port Allen (La.).

347 **Matthias, C. D.**
1970. Urban hydrology in connection with channel improvement project at Newmarket Creek, Virginia, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 8, 17 p., 8 figs., 4 tables.

Flood frequencies were determined for a proposed channel improvement in Newmarket Creek, Va. The drainage area contributing to the channel ranged from 2.33 square miles to 8.54 square miles depending on the conditions of watershed development and the proportion of channel improved. A large shopping center was constructed directly on the flood plain. A channel, which proved to be inadequate, was provided around the end of the shopping center to carry the flow of the stream. Slopes in the main study area are relatively flat, about 0.5 feet per 1,000 feet. Also, the cross section of the flood plain on either side is flat so that, under natural conditions, considerable water is stored along the stream and runoff is slow. Unit hydrographs were derived for a drainage area of one square mile for a number of different times of concentration covering the required range expected in the study. The 2, 10, and 100-year peak flood discharges were obtained by application of appropriate storm rainfall to the unit hydrographs.

Descriptors: Unit hydrographs, rainfall-runoff relationships, storm runoff, Newmarket Creek (Va.).

348 **Mawson, K. J.**
1959. Variation of runoff coefficient: New Zealand Eng., v. 14, no. 11, p. 381–388, 19 figs., 1 table, 4 references.

At Wellington, New Zealand, for about 30 years storm-water drainage systems have been designed satisfactorily on the basis of the runoff estimated by the rational method, which assumes that the highest peak flows from small catchments are produced by storms of the short-duration, high-intensity type; generally no provision is made for prolonged falls of relatively low intensity. Data on the rainfall and floods in the residential suburb of Karori and in the Wainui water-supply catchment area are discussed with particular reference to the runoff coefficient. The short-period high-intensity type of storm does not produce peak floods as high as those attained in longer storms of more moderate intensity. The rational method is also valid for designing drainage systems for the prolonged type of storm. The runoff coefficient can be calculated with reasonable accuracy by the method in the "Provisional Standard" of the Soil Conservation and Rivers Control Council of New Zealand.—W69-02246.

Descriptors: Storm runoff, runoff forecasting, rational formula, drainage (urban), Wellington (New Zealand).

349 **McCloskey, C. C., III**
1972. The rational method: Military Engineer, v. 64, no. 417, p. 28–29, 3 figs., 2 tables.

The Rational Method for computation of runoff from small watersheds is reviewed. It was introduced in the United States by E. Kuichling in 1889. Conveniently simple, it is expressed as: Q is CIA where Q is maximum runoff from a given area in cubic feet per second, C is a coefficient representing the ratio of runoff to rainfall, I is intensity of rainfall in inches per hour for the estimated time of concentration, and A is drainage area in acres. The variable factors of rainfall intensity (I) and the runoff coefficient (C) are easily obtained, although subject to error. While the Rational Method is rather crude, it may be the only method possible in many situations. Therefore, the engineer should understand the technique and not hesitate to use it when necessary.

Descriptors: Rational formula, rainfall-runoff relationships, depth-area-duration analysis.

350 McGauhey, P. H.

1961. Quality, water's fourth dimension, *in* Water policy conf., California Univ. at Davis, Jan. 11–13, 1961: Rept. 3, p. 44–48, 3 charts.

As America has moved into an urban-industrial-agricultural economy, the quality of the water supply has changed. The urban population and its supporting industrial and commerical activities will be an increasingly serious contributor to a decline in water quality. More intensive use of water inevitably leads to a lowering of water quality. The maximum benefit to all users will require management of water quality coordinated with management of water quantity. Our relatively fixed water resources have some maximum capacity to accept impurities and yet continue to serve all beneficial uses.—W69-05524.

Descriptors: Water quality, water uitilization, water resources development.

351 McGriff, E. C., Jr.

1972. The effects of urbanization on water quality: Jour. of Environmental Quality, v. 1, no. 1, p. 86–89, 19 references.

Urbanization increases the sediment load carried by streams, decreases ground-water recharge, promotes eutrophication, and causes temperature variation in streams, all of which tend to alter water quality. Urbanization increases the volume of runoff and the size of the flood peak and decreases the lag time. Ground water recharge is minimized, which reduces low flow augmentation and its dilution potential. The quality of urban runoff is a major factor in promoting the copious growth of plankton and algae. Stream temperatures increase during the summer and decrease during the winter, with reference to streams flowing through natural settings. Dissolved oxygen content tends to be critical during the low flow conditions found in the summer and, since the solubility of oxygen decreases with an increase in the temperature, the effect of urban runoff on a stream is adverse. Urbanization can also have a pronounced effect on the quality of ground water.

Descriptors: Water pollution sources, water pollution effects, water yield, peak discharge, sediment yield.

352 McKee, P. W.

1964. Sediment, *in* Problems of the Potomac Estuary, winter meeting, Arlington, Va., Jan. 23–24, 1964, Proc.: Washington, D.C., Interstate Comm. on the Potomac River basin, p. 40–46, 1 fig., 3 tables.

The control of erosion resulting from urban development has been largely ignored. This report presents some data to show the sediment yields of various areas in Maryland. Sediment yields from construction sites are from 3 to 100 times the average yield from rural areas.—W69-05029.

Descriptors: Soil erosion, construction, Maryland, Potomac River.

353 McKendrick, J.; Williams, R. K.

1969. The effects of urban drainage on Lake McIlwaine, Rhodesia: Water Pollution Control [Inst. of Water Pollution Control, London] v. 68, no. 5, p. 523–528.

From 1953 to 1959 there was little change in the quality of the water in Lake McIlwaine, which is the main source of supply for Salisbury, Rhodesia; but from 1960, trouble began to be experienced with heavy algal growths. When the lake water intake was lowered to avoid the algae, problems were caused by manganese and iron in the lower waters of the lake. The algal growths were caused by high concentrations of phosphate and nitrogen brought into the lake by the rivers to which the effluents from the city's sewage works and oxidation lagoons were discharged. Algal growths were most severe during periods of low rainfall when less dilution was available.—W71-07524.

Descriptors: Water pollution sources, runoff, Rhodesia.

354 McPherson, B. F.

1970. Water quality at the Dade-Collier training and transition airport, Miami international airport, and Cottonmouth camp, Everglades national park, Florida, November 1969: U.S. Geol. Survey open-file rept., 29 p., 2 figs., 9 tables, 7 references.

Water quality was determined at three areas in south Florida in November 1969 to compare conditions at a commercial jetport (Miami International Airport), in a natural environment (Cottonmouth Camp in Everglades National Park), and in a transitional environment (Dade-Collier Training and Transition Airport). Water in canals near Miami International Airport generally contained more nitrogen, phosphorus, organic carbon, trace elements and heavy metals, and less dissolved oxygen than waters at the other areas. Concentrations of chromium, lead, and oil in surface water at Miami International Airport exceed the limits established by the Federal Water Quality Administration; concentrations were below these limits in the other areas. Sediment at Miami International Airport was heavily coated with oil and grease (23 percent at station 5) and contained 85.2 micrograms per kilogram of the DDT family at station 1. Sediment at other stations contained less than 3.0 percent oil and grease and less than 4.2 micrograms per kilogram of the DDT family.—W71-06158.

Descriptors: Water pollution sources, airports, Everglades National Park (Fla.).

355 McPherson, M. B.

1968. The nature of changes in urban watersheds and their importance in the decades ahead: Am. Soc. Civil Engineers, Urban Water Resources Research Program, Tech. Memo. 5, 18 p., 3 tables, 23 references.

Urban changes, largely social and economic, that affect urban hydrology are discussed in a survey and bibliography of urban sociology largely consisting of quotations and reviews of nonengineering and non-hydrological literature. Urban expansion is considered largely a function of development of new forms and trends of use of high-speed urban transport; one important period of growth was associated with development of streetcar systems and another with the personal automobile. The urban areas of the country are growing rapidly with trends of increasing urbanization added to increasing growth of suburbs. Problems of crowding, water supply, waste disposal, and general environmental quality are growing even faster than the cities themselves. The need for comprehensive planning rather than solving single problems such as waste disposal or water supply is stressed. The environment of cities is a function of all social and physical factors. Hydrological problems can be solved only as part of the total environmental problem.—W69-03511.

Descriptors: Water resources development, social aspects, land use.

356 McPherson, M. B.

1969. Some notes on the rational method of storm drain design: Am. Soc. Civil Engineers, Urban Water Resources Research Program, Tech. Memo. 6, 74 p., 9 figs., 3 tables, 33 references, 2 app.

Because the rational method of designing urban storm-drainage facilities has substantial deficiencies, new design procedures are discussed, and the urgent need for more field stream-gaging data is stressed. The limitations of the rational method consist mainly of the weaknesses of projecting standard values of the rainfall-runoff relationship over wide geographical areas, the use of too many standardized assumptions, and using the same runoff routing methods in too many dissimilar situations. Suggested improved design methods would use on-site gaged rainfall-runoff relations to determine flow probabilities in mathematical models so that the optimum drainage system for each particular case may be designed. Presently there are no gaging programs of sufficient scope in operation. Other suggestions include the use of surface detention to flatten runoff peaks, storage of urban runoff for water-supply use, or use of urban runoff as a source of recreational water.—W69-07482. PB-184-701.

Descriptors: Rainfall-runoff relationships, storm runoff, rational formula.

357 McPherson, M. B.

1970. A framework for urban water resources research, *in* Annual Water Resources Research Conf., 5th, Washington, D.C., Feb. 3–4, 1970, Rept.: Dept. of Interior, Office of Water Resources Research, p. 143–148, 1 fig., 8 references.

The evolution of the United States from an agrarian to an urban society has outpaced the capacity for adjustment of our prevailing institutions of government. To meet needs of water services in urban America, government and academic cooperation in research and centralized direction in operation are desirable. In the past, water resource development has been essentially land-orientated; future planning must be people-orientated.—W71-05784.

Descriptors: Water resources development, water policy, municipal water, planning.

358 McPherson, M. B.; Taylor, D. C.; Tucker, L. S.

1969. Basic information needs in urban hydrology, an analysis of national basic information needs in urban hydrology: New York, N.Y., Am. Soc. Civil Engineers, 112 p., 13 figs., 2 maps, 3 tables, 78 references.

An analysis of national basic information needs in urban hydrology is focused on data needs, data devices, and data networks. Primarily aimed at improvement in design of storm drainage, intensive study was made of the data requirements for analyzing rainfall-runoff-quality relationships and of suitable data collection instrumentation, with consideration of the types of networks required for the collection of adequate data. Suitable data collected with properly coordinated instrumentation in networks representing a variety of climatic, topographic, and land-use conditions are virtually nonexistent. Transfer of data findings between metropolitan regions is a central and primary objective. An average of about $3.5 billion per year will be spent on construction of new storm sewerage systems over the next several years. The plan recommended for a minimum national program of urban storm drainage research would cost on the order of 1/3 percent of this average annual construction cost.—W69-06770.

Descriptors: Rainfall-runoff relationships, data collections, hydrologic data.

359 Meade, P. J.

1967. Rainfall and evaporation—distribution in space and time: Inst. of Water Engineers Jour., v. 21, no. 3, p. 210–215.

The Meteorological Office of Great Britain is undertaking intensive research into the problems of measurement, collection, and analysis of data on rainfall and evaporation to use in planning of both water resources and water disposal. Water disposal problems requiring an accurate analysis of rainfall data include: urban drainage, roof drainage, protection of dams, embankments for railways and roads, forecasting rainfall, the time of onset of rain, rainfall duration, and the quantity of rain that will fall. Studies range over a wide area of meteorology from the physics of clouds to the large-scale movements of the general circulation of the atmosphere.—W69-02247.

Descriptors: Water resources research, storm runoff, data collections, drainage (urban).

360 Meade, R. H.

1969. Errors in using modern stream-load data to estimate natural rates of denudation: Geol. Soc. America Bull., v. 80, no. 7, p. 1265–1274, 9 figs., 56 references.

The practice of calculating natural rates of denudation from routinely collected data on the loads of suspended and dissolved matter in modern rivers is subject to several significant errors. The largest error is caused by assuming that modern sediment loads in populated areas represent natural erosion, whereas in fact they mainly reflect the influence of man. Conversion of forests to croplands in the Middle Atlantic States causes about a ten-fold increase in sediment yield. Coal mining, urbanization, and highway construction have added extra loads

of sediment to the streams. Modern sediment loads in rivers of the eastern United States are probably 4 to 5 times greater than they would be if the area had remained undisturbed by man. Perhaps one-tenth of the dissolved load consists of industrial and agricultural wastes or acid mine waters that have been added directly to the streams.—W69-08939.

Descriptors: Sediment load, erosion, sedimentation, sediment yield.

361 Meyer, F. W.

1971. Preliminary evaluation of the hydrologic effects of implementing water and sewerage plans, Dade County, Florida: U.S. Geol. Survey open-file rept., 110 p., 19 figs., 17 tables, 51 references.

As urbanization continues in Dade County, Fla., water requirements will increase. If present trends continue, by the year 2020 the total demand for water supplies in Dade County will average 760 mgd. By the year 2020, 540 mgd of waste water will be discharged from sewers to the ocean. With increasing runoff and sewage discharged to the ocean, the total consumptive use of water will ultimately exceed the region's developed water supply capability. By 1976, available fresh water may be insufficient to satisfy all competing demands. Plans include reduction in storm runoff by large-scale backpumping to Lake Okeechobee and the conservation areas. Other alternatives include separation of storm and sanitary drainage systems and the prevention of fresh water leakage into the sanitary sewer system.—W71-09334.

Descriptors: Water resources development, water demand, water pollution control, Dade County (Fla.).

362 Meyer, L. D.; Wischmeier, W. H.; Daniel, W. H.

1969. Erosion, runoff, and revegetation of denuded construction sites: Am. Soc. Agr. Engineers, Paper 69-704, 8 p., 4 figs., 2 tables, 24 references.

Erosion and runoff rates were measured for six types of land treatment representing typical construction-site conditions that result from major land reshaping. Re-establishment of vegetation on these test areas was studied in relation to various methods of reshaping, mulching, fertilizing, and seeding. A series of simulated rainstorms totaling 5 inches was applied at an intensity of 2.5 inches per hour on 35-foot subsoil plots with 12 percent slopes. The resulting erosion and runoff were very great. The only treatment that effectively controlled erosion was straw mulch, which reduced soil loss to less than 10 tons per acre. Applied topsoil was by far the most successful treatment. Mulched surfaces were greatly superior to unmulched soil. A layer of good soil over a denuded area plus surface mulch is the best combination of treatments. Additional benefits may be expected from minimizing soil compaction, use of shallow surface tillage before seeding, use of a seed mixture containing fast-growing grasses, and application of supplemental irrigation as needed.—W70-10280.

Descriptors: Erosion, sediment yield, sediment control, slope stability, construction.

363 Miller, C. F.

1968. Evaluation of runoff coefficients from small natural drainage areas: Lexington, Kentucky Univ., Water Resources Inst. Research Rept. 14, 112 p., 25 figs., 14 tables, 36 references.

The Stanford watershed model was used as a basis for developing a simplified empirical method for predicting flood peaks and frequencies. Overland flow runoff coefficients may be estimated from local watershed characteristics. The coefficients of overland flow depend on the nature of the watershed surface, the probable soil moisture content, and the rainfall intensity. To predict the resultant streamflow, each overland flow hydrograph is routed downstream to a common point. The coefficient of resultant flow depends on areal distribution of overland flow, basin shape, drainage pattern, stream velocity, stream cross section, and tributary area. Equations and graphs are given to relate exposed surface index, percent impervious area, permeability, soil depth, and slope to coefficient of overland flow.—W69-00139.

Descriptors: Rainfall-runoff relationships, overland flow, peak discharge, routing, Stanford watershed model.

364 Miller, C. R.; Viessman, W., Jr.

1972. Runoff volumes from small urban watersheds: Water Resources Research, v. 8, no. 2, p. 429–434, 5 figs., 4 tables, 6 references.

An empirical equation estimates the runoff volume from rainfall on small urban watersheds. If the rainfall is less than 1.5 inches, the runoff is predicted by the relationship between the impervious area in the watershed and the excess rainfall. An adjustment is made for the initial abstraction combined with the initial surface depression storage. For rainfall amounts greater than 1.5 inches, an additional increment of runoff is added for the pervious areas by using the hydrologic soil class, the vegetative cover, and the controlling parameters. Detailed 1 or 5-minute rainfall and runoff records from four small urban watersheds for 77 storms were used to develop the procedure. The method was tested on 17 additional storms on these watersheds. The maximum prediction error was 37 percent for over 80 percent of the test events. The median error was 17 percent of the actual runoff.

Descriptors: Rainfall-runoff relationships, depth-area-duration analysis, storm runoff, impervious area.

365 Miller, E. M.; Kapinos, F. P.

1970. Flood of July 22, 1969 in the northern Virginia area: U.S. Geol. Survey open-file rept., 35 p., 4 maps, 3 tables, 5 photos., 12 graphs, 2 references.

Heavy rainfall during a thunderstorm on the night of July 22, 1969, produced record flooding in parts of the Washington metropolitan area. Runoff was the highest for the period of record at gaging sites in the Virginia suburbs. There was no loss of life, but hundreds of stores, homes, and apartment buildings were flooded, principally by Fourmile Run. Peak stages and discharges are given for 15 gaging stations and 6 miscellaneous sites.—W70-09530.

Descriptors: Storm runoff, floods, rainfall-runoff relationships, Virginia.

366 Miller, J. F.; Frederick, R. H.

1969. The precipitation regime of Long Island, New York: U.S. Geol. Survey Prof. Paper 627-A, p. A1–A21, 23 figs., 1 map, 7 tables, 16 references.

Mean annual precipitation ranges from 40 to 50 inches over the area of Long Island, N.Y., and averaged about 43 inches in the period 1951–65. The precipitation is greatest over the central part of the island. This may be due to greater altitude or to the distance of this area from the stabilizing effects of the Atlantic Ocean and Long Island Sound. Average warm-season and cool-season precipitation are almost equal. The number of days with precipitation equal to or less than 1.00 inch is randomly distributed geographically but shows a definite seasonal variation, being greatest in the spring and least in the fall. The number of days with precipitation of more than 1.00 inch and the amount of rain that falls on such days are both highly correlated with average seasonal and monthly precipitation. About 5–10 percent of the water equivalent of cool-season precipitation is in the form of snow.

Descriptors: Precipitation (atmospheric), Long Island (N.Y.), rainfall.

367 Miller, R. A.; Troxell, J.; Leopold, L. B.

1971. Hydrology of two small river basins in Pennsylvania before urbanization: U.S. Geol. Survey Prof. Paper 701-A, p. A1–A57, 20 figs., 11 tables, 19 references.

Basic data on water quality, chemical quality, and suspended sediment are tabulated to record the conditions existing in two small drainage basins near Philadelphia. The basins in 1970 are agricultural land for the most part, but urban and industrial development is imminent as the Philadelphia metropolitan area expands. As changes caused by urbanization occur in future years, the data will be useful as a base for comparison. Pickering Creek basin has a higher population than the upper East Branch Brandywine Creek basin. The two are comparable in discharge characteristics and in shapes and sizes of channels, but the Pickering Creek basin is

producing a considerably larger suspended-sediment load. The effects of urbanization are discernible in some chemical parameters. During the study a small sub-basin, one-half square mile in area, was converted from agricultural use to an industrial park. This change resulted in a marked increase in sulfates, nitrates, chlorides, and dissolved solids in the streamflow.

Descriptors: Data collections, rainfall-runoff relationships, land use, water yield, sediment yield, water quality, Pennsylvania.

368 Mills, W. C.

1971. Little River experimental watershed, Tifton, Georgia, *in* Agricultural Research Service Precipitation Facilities and Related Studies, Hershfield, D. M., ed.: U.S. Dept. of Agriculture, Agr. Research Service, Rept. ARS 41-176, p. 21–24, 1 fig., 1 table.

Little River experimental watershed near Tifton, Ga., is located in the Southern Coastal Plain and is generally representative of upstream agricultural watersheds in this land resource area. Demands upon water resources of this region are becoming greater as both agricultural and industrial uses expand. Information to be gained from the Little River hydrologic studies is needed for planning, development, and efficient use of upstream water resources throughout the Coastal Plain. Hydrologic measurements are made on a small adjacent watershed, which is becoming urbanized, to provide for evaluation of urbanization effects on the quantity and quality of streamflow. Precipitation on the Tifton watersheds and surrounding area is monitored by a network of 55 digital-type rain gages covering a 250-square-mile area. Average annual rainfall for a 47-year record at the Coastal Plains Experiment Station at Tifton is 47.10 inches. There is a very pronounced maximum and minimum in the seasonal rainfall distribution. Maximum rain occurs in midsummer and minimum in autumn. Individual summer rains are usually associated with thunderstorm activity, and the areal distribution is highly variable.

Descriptors: Meteorological data, hydrologic data, rainfall-runoff relationships, precipitation (atmospheric), Little River experimental watershed (Ga.).

369 Mische, E. F.; Dharmadhikari, V. V.

1971. Runoff—a potential resource: Water and Wastes Eng., v. 8, no. 2, p. 28–32, 3 figs., 10 references.

Samples of runoff from three urban watersheds of different characteristics were analyzed in order to provide a basis for the evaluation of potential pollution effects and to initiate exploratory studies of treatment methods. In Chicago, much of the runoff pollution comes from street litter and dust. Some pollution is contributed by soil, but human pollution through refuse seems to be a more important factor. Most and perhaps all the fecal coliforms found in surface waters are derived from fecal material of warmblooded animals. Fecal pollution increases with residential development. The fecal streptococci bacteria parameter represents those organisms that usually predominate in both human feces and fecal material from dogs, cats, and rodents. Although concentrations of fecal organisms are usually greater in arid regions, in Tucson, Ariz., pollution of storm runoff is primarily from human sources, such as garbage and food refuse. Urban storm-water runoff may usually be treated efficiently to provide water for most urban uses.

Descriptors: Water pollution sources, storm runoff, water treatment, street runoff.

370 Mitchell, J. M., Jr.

1961. The temperature of cities: Weatherwise, v. 14, no. 6, p. 224–258, 4 figs., 2 tables, 10 references.

Urban-rural contrasts of weather and climate are due more or less directly to the fact that cities are warmer than their environs. The characteristic warmth of a city, the urban "heat island," is particularly noticeable at night when skies are clear and winds are light. It is frequently possible to show a gradual increase of the intensity of an urban heat island as the city grows in size and population. The rates at which ten cities in the eastern half of

the United States have warmed relative to their environs since the 19th century are discussed. Growth rate is most easily compared with change in the city's heat island when growth is measured by the change of the square root of the population. A nocturnal inversion is commonly encountered. This inversion inhibits the upward dispersion of smoke and other pollutants in the city. In fact, the inversion may become intensified when the pollution layer cools at its upper surface by radiation to the sky. This in turn promotes the further increase of pollution concentration in the city, until arrival of morning when the sun's heat may destroy the inversion. Since cloudiness and strong winds inhibit the formation of ground inversions, and since wind speed also affects the rate of "ventilation" of the city, the intensity of the urban heat island depends substantially on these weather variables.

Descriptors: Heat islands, air temperature, climatology, meteorology, air pollution effects.

371 **Moore, W. L.; Morgan, C. W. (editors)**
1969. Effects of watershed changes on streamflow—Water Resources Symposium No. 2, Austin, Tex., Oct. 1968: Austin, Texas Univ. Press, 289 p., 138 figs., 50 tables, 211 references.

This special lecture series was arranged to present the most advanced approaches to evaluating the effects of watershed changes on streamflow. It is urgent to know the character and extent of the changes and how they affect plans for development. Numerous field studies designed to evaluate the effect of specific watershed changes by comparisons between watersheds have been in operation for sufficient time to build up a significant length of record. Methods of computer simulation of watersheds have reached a stage of development to offer an attractive tool for attacking the problem in new ways. When the entire performance of the watershed is understood in detail, all the physical processes can be followed and the performance of the watershed can be simulated by numerical or analog techniques. The topics discussed include model studies, land treatment in rural watersheds, flood control structures, rural pollution, the effects of urbanization on peak flow, the effects of urbanization on water yield, and urban water quality changes.—W70-04723.

Descriptors: Rainfall-runoff relationships, water quality, water yield, model studies, land use.

372 **Morrissey, K. B.; Kim, J. B.; Ellerman, F. W.; and others.**
1971. Storm water runoff from an urban highway drainage system, final research report, August 25, 1971: Washington, D.C., District of Columbia Dept. of Highways and Traffic, Materials Devel. and Research Div., 123 p., 92 figs., 9 tables, 20 references.

A modified area-time method was developed for calculating the rates of runoff in urban highway drainage systems. A drainage area of approximately 10 acres in Washington, D.C., was used for comparing the area-time method, the unit hydrograph method, and the rational method. Although the peak runoff rates computed by the modified area-time method and the unit hydrograph method did not compare favorably with the peak runoff rates that were actually measured, the peak rates computed by an empirical version of the rational method did give a reasonable estimate of the actual runoff rate. The design values (the runoff coefficient and the time of concentration) that are used in the rational method were determined from recorded data. This version of the rational method produced good results. When an accurate method is found for determining the runoff coefficient and time of concentration, the rational method will provide a simple, economical, and reliable tool that can be used in designing urban highway drainage facilities.

Descriptors: Rational formula, rainfall-runoff relationships, storm runoff, Washington, D.C.

373 **Mueller, R. F.; Lahn, R. M.**
1970. The Anacostia River, ecological imbalance of an urban stream valley: U.S. Natl. Aeronautics and Space Adm., Tech. Memo. NASA-TM-X-65549, 28 p., 11 figs., 21 references.

The Anacostia River, a tributary of the Potomac, flows in the eastern part of the District of Columbia and in adjacent suburban Prince Georges and Montgomery Counties. It is in many ways a prototype of the urban stream showing severe ecological imbalances resulting from intensive and unplanned land use and the general impact of technology. The Anacostia River valley is out of balance with respect to stresses placed upon it by ungoverned urban expansion. Symptoms of this imbalance are widespread biological, chemical, and physical pollution, as well as destructive land use and hydrologic practices. As a result, the regimen of the river is in continuous transition, and its great potential as an environmental asset is being lost to the nearly one million inhabitants of the watershed. The environmental deterioration will lead to high tax burdens for years to come.—W71-27650.

Descriptors: Water pollution sources, water pollution effects, Anacostia River (D.C.), ecology.

374 **Muller, R. A.**
1967. Some effects of urbanization on runoff as evaluated by Thornthwaite water balance models, *in* Annual American water resources conf., 3rd., San Francisco, Calif., Nov. 8–10, 1967, Proc.: p. 127–136, 4 figs., 5 tables, 5 references.

Water balance methods, including the Thornthwaite potential evapotranspiration and water balance models, were applied to the Raritan River basin in New Jersey to compare and contrast Thornthwaite water balance components as calculated by several standard techniques, to demonstrate that potential evapotranspiration and water balance models can be utilized to obtain first approximations of the consequences of urbanization, and to explore water balance changes with transformation of a watershed from rural to urban. Calculated runoff takes into account the monthly and seasonal variation of precipitation and soil moisture storage, as well as energy availability for evapotranspiration loss. Measured runoff not only includes the climatic variation but in addition the effects of land use change. Hence, the differences between calculated and measured runoff over time should be a measure of the effects of land use change on runoff.—W70-00057.

Descriptors: Rainfall-runoff relationships, water balance, evapotranspiration, New Jersey.

375 **Muller, W. J.**
1971. The contribution of rainfall runoff to the impurity of waters: GWF das Gas-und Wasserfach, v. 112, no. 1, p. 15–17, 10 references. [In German]

Control of pollution caused by urban surface runoff, municipal waste water, and industrial water in Germany is briefly reviewed and compared with practices and plans in England and the United States.

Descriptors: Water pollution control, storm runoff.

376 **Nace, R. L.**
1969. Arrogance toward the landscape, a problem in water planning: Bull. of the Atomic Scientists, v. 25, no. 10, p. 11–14, 2 photos.

The effects of water-resources development on water supplies and the environment are surveyed. Water is much more than just a resource to be manipulated on the basis of water data and engineering works. Demands and values change, and planning must be a continuing process. Rational planning and decision require a base of pooled knowledge from geologists, hydrologists, ecologists, engineers, economists, sociologists, managers, lawyers, politicians, and others. Water and its movement through the hydrological cycle are essential means for maintaining the heat balance in the complex system of the earth and its inhabitants. Water is the prime agent that shapes or misshapes the landscape. Is it mere coincidence that Persia, Egypt, West Pakistan, India, and China—all"underdeveloped" areas today—were the seats of the oldest civilizations? Perhaps it is an inherent characteristic of civilization that it wears out its landscapes. Human occupation, at least during the past 2,000 years, has operated chiefly to harm the landscape, not to preserve it. Ability to plan and create monumental

projects carries with it the likelihood of making monumental mistakes. Planning must include careful analysis of the possible results of any water development schemes.—W70-03465.

Descriptors: Water resources development, planning, land management, land use.

377 **Narayana, V. V. D.; Sial, M. A.; Riley, J. P.; Israelsen, E. K.**
1970. Statistical relationships between storm and urban watershed characteristics: Logan, Utah State Univ., Utah Water Research Lab., Research Proj. Tech. Completion Rept. PRWG-74-2, 55 p., 11 figs., 15 tables, 47 references, 2 app.

Because of rapid urban development in recent years, hydrologic problems associated with urban watersheds have gained importance. Large sums of money are being spent for the design of urban drainage systems based upon inadequate procedures for predicting peak runoff rates. A procedure is proposed for predicting peak runoff rates from small urban and rural watersheds based upon measurable storm and watershed characteristics. The technique was tested for a number of runoff events on the Boneyard Creek watershed at Urbana, Ill. The procedure will be particularly useful for estimating runoff rates from small ungaged drainage areas and thus will be directly applicable to both design and water management problems.—W71-05144.

Descriptors: Rainfall-runoff relationships, statistical methods, drainage (urban), Champaign-Urbana (Ill.).

378 **Narayana, V. V. D.; Riley, J. P.**
1968. Application of an electronic analog computer to the evaluation on the effects of urbanization of the runoff characteristics of small watersheds: Internat. Assoc. Sci. Hydrology Pub. 80, v. 1, p. 38–48, 6 figs., 3 tables, 5 references.

In the synthesis of hydrograph characteristics of small urban watersheds, the distribution of the water among the various phases of the runoff process is attempted by the concept of "equivalent rural watershed." For a given input into the urban and equivalent rural models, the outputs are identical. The hydrograph of outflow from an urban watershed is obtained by chronologically deducting the losses due to interception, infiltration, and depression storage from precipitation and then routing it through the surface and channel storages. This is accomplished with an analog computer. Testing and verification is done with rainfall and runoff data from the Waller Creek watershed at Austin, Tex. Coefficients representing interception, depression storage, and infiltration are determined by trial and error so that the simulated hydrograph is nearly identical to the measured hydrograph of the prototype. The variation in the values of these coefficients from year to year is assumed to be due to the percentage impervious cover and the characteristic impervious length.—W69-07951.

Descriptors: Analog models, rainfall-runoff relationships, Austin (Tex.).

379 **Narayana, V. V. D.; Riley, J. P.; Israelsen, E. K.**
1971. Simulation of runoff from urban watersheds: Water Resources Bull., v. 7, no. 1, p. 54–68, 6 figs., 5 tables, 5 references.

A mathematical model is being developed in stages for urban watersheds. In verifying the watershed as a unit, watershed coefficients are determined on the computer and related to the urbanization characteristics. The second stage of verification consists of dividing the watershed into subzones and determining the urban parameters within each subzone. Each subzone is then individually modeled, and outflow hydrographs are routed through succeeding downstream subzones to the gaging point. The model thus makes it possible to develop runoff models for subzone hydrographs within the urban watershed and to account for spatial variations of storm and watershed characteristics.—W71-06306.

Descriptors: Mathematical models, storm runoff, rainfall-runoff relationships, simulation analysis, routing, hydrograph analysis.

381 Nash, J. E.

1968. Determining run-off from rainfall: Inst. of Civil Engineers Proc., Paper 6282, v. 10, p. 163–184, 7 figs., 31 references.

Various methods of determining the relation between effective rainfall and storm runoff are particular cases of the general unit-hydrograph theory. A systematic approach should be used in the investigation of the relation between the characteristics of a catchment and its response to rainfall. Investigation into the relation between effective rainfall and storm runoff on either natural or urban catchments should isolate one parameter of the index response of each of several catchments. A correlation should be established between the values of this parameter and the characteristics of the catchments. The response of each catchment should then be expressed in terms of the chosen parameter, and if significant differences between the responses so expressed are observed, these should be correlated with the values of the chosen parameter and, if necessary, with other catchment characteristics. The choice of index response and of the parameter to represent it is largely arbitrary, but the instantaneous unit hydrograph and the peak of the instantaneous unit hydrograph are suitable. Consideration might also be given to using the time from the instant of effective rainfall to the center of area of the instantaneous unit hydrograph as the parameter instead of the peak discharge.

Descriptors: Rainfall-runoff relationships, storm runoff, hydrograph analysis, unit hydrographs.

382 National Academy of Sciences-National Research Council.

1966. Culverts and storm drains, 4 reports: Washington, D.C., Natl. Acad. Sci.-Natl. Research Council, Highway Research Board, Highway Research Record no. 116, 86 p., 83 figs., 7 tables, 23 references.

The four papers in this collection cover subjects related to highway culverts. Engineers involved in drainage design and in the structural design, selection, and installation of culverts should find useful information in these papers. The paper by Leach and Kittle demonstrates the economies in the use of ponded storage in a storm drainage system. John L. Grace offers recommendations of friction factors for the commonly used corrugations of annular corrugated pipe, including the 2 X 6-inch corrugations of structural plate pipe and the 1 X 3-inch corrugations used in some larger riveted sizes. The recommendations are based on model-test results extended by analytical methods. In the third paper, Robert C. Deen describes a simplified method for predicting the required camber in highway culvert installations. Fairly close agreement between predicted and observed settlements is reported. Jurgen Demmin reports on a series of load tests on a large structural plate pipe arch. The author interprets the results as a substantial verification of the ring compression method of conduit design.

Descriptors: Storm runoff, culverts, storm drains, drainage engineering.

383 National Academy of Sciences-National Academy of Engineering.

1970. Environmental problems in south Florida, part II: Washington, D.C., Natl. Acad. Sci.-Natl. Acad. Eng., 76 p., 2 maps, 6 references, 1 app.

In the spring of 1969, the Environmental Study Group undertook a summer study on environmental problems in Florida. The overriding issue is how south Florida can develop and the Everglades National Park can be maintained or improved. Development and the preservation of the Everglades National Park both require an adequate water supply. Assurance of such a supply depends on the establishment of a water-conservation region. Three possible developments call for consideration of their likely effects: a training jetport north of the Everglades Park; a commercial jetport at this site, with associated highway and mass-transit facilities; and commercial and residential developments in inland Collier County. The first two appear controllable, with proper effort, but the third would appear most difficult to control sufficiently. The establishment of a large part of the Big Cypress Swamp as a natural conservation area appears necessary both to the preservation of the park and to orderly development along the coast of Collier County.—PB-199-159.

Descriptors: Wetlands, Florida, Everglades National Park, conservation.

384 National Academy of Sciences-National Research Council.

1969. Eutrophication—causes, consequences, correctives, Internat. symposium on eutrophication, Wisconsin Univ., Madison, June 11–15, 1967, Proc.: Washington, D.C., Natl. Acad. Sci.-Natl. Research Council, Standard Book 309-01700-9, 661 p., 123 figs., 11 maps, 9 photos., 77 tables, 1,352 references.

The International Symposium on Eutrophication met at the University of Wisconsin, Madison, on June 11, 1967. Approximately 600 persons from 12 countries attended. This report of its proceedings includes an introductory address, "Eutrophication, Past and Present," and technical presentations including detection and measurement, prevention and correction, and scientific contributions from eutrophication research. The report also includes an introduction, summary, and a series of specific recommendations formulated by the organizing committee; 12 relate to education and information and 8 to research.—W70-03975.

Descriptors: Eutrophication, water pollution sources, water pollution effects.

385 Negulescu, M. G.; Rabinovici, Iacov

1964. Discharge of rain water from urban sewers into streams: Hidrotehnica Gospodarirea Apelor Meteorologia, v. 9, no. 4, p. 205–209, 1 photo., 7 references [in Rumanian].

Rainwater discharged from combined or separate sewers in urban areas can have as great or even double the polluting effect of domestic sewage and can damage the receiving stream. Storage reservoirs along the sewerage system or as part of the treatment plant are suggested as a means of protecting streams.—W69-01841.

Descriptors: Storm runoff, water pollution control, drainage (urban).

386 Neil, J. H.; Johnson, M. G.; Owen, G. E.

1967. Yields and sources of nitrogen from several Lake Ontario watersheds, *in* Conference on Great Lakes Research, 10th, Toronto, Canada, Apr. 10–12, 1967, Proc.: Michigan Univ., Great Lakes Research Div. Pub. 15, p. 375–381, 3 figs., 2 tables, 5 references.

The nitrogen yield from six southern Ontario watersheds, representing rural and urban land uses, was estimated on the basis of curves for total nitrogen discharge applied to the hydrograph of each watershed. Mean annual yield of nitrogen was approximately 3,200 pounds per square mile for rural streams, and 34,000 for urban watersheds. Yields for February, March, and April constituted 58–69 percent of the annual contribution in rural watersheds, while yields from urban watersheds showed little variation and were greater than spring maxima of rural streams throughout the year. Nitrogen to phosphorus ratio was 1.5 in urban watersheds and 8.0 for rural watersheds. Under present conditions of sewage treatment in one urban watershed, 28 percent of P and 22 percent of N are removed. Complete removal of both nutrients from the sewage would result in 85 percent reduction of gross yield of phosphate (25 percent presently being achieved) and 87 percent reduction in gross yield of nitrogen (20 percent presently achieved).—W70-04979.

Descriptors: Nitrogen, phosphorus, water pollution sources, eutrophication.

387 Nelson, T. L.

1970. Synthetic unit hydrograph relationships, Trinity River tributaries, Fort Worth-Dallas urban area, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 6, 18 p., 5 figs., 3 tables, 5 references.

Fort Worth and Dallas, Texas are a rapidly expanding urban area. Although much of the growth has been orderly and well planned, development in many flood-prone areas has resulted in severe flood damages and in the necessity for the construction of flood control works. Relationships are presented to be used to develop synthetic unit hydrographs for ungaged areas in the Fort Worth-Dallas area. The method accounts for

differences in urban development on adjacent areas and may be used to predict the effect that urban development might have on a given area. Preliminary calculations indicate that the lag relationship may also be valid in other parts of north-central Texas. Unit hydrograph determinations were made for each of eight stream gages for each storm period which could be analyzed. In order to generalize the results of these studies for use in ungaged areas, the coefficients were correlated with measurable watershed characteristics. Since in the Fort Worth-Dallas area full urbanization of an entirely rural area reduces the lag time by about 50 percent, the peak discharge of the unit hydrograph will be approximately doubled.

Descriptors: Unit hydrographs, rainfall-runoff relationships, storm runoff, Dallas (Tex.), floods.

380 **Neuberger, J. W.**
1969. Conservation programs in the urban fringe; the story of a Nebraska soil conservation district's effort to solve conservation problems spawned by suburban sprawl: Jour. Soil and Water Conserv., v. 24, no. 6, p. 216–218, 6 references.

Solutions to land erosion and drainage problems caused by suburban sprawl in a Nebraska conservation district are outlined. Increased paving, roofing, and compacted soils result in erosion and flooding; therefore, the construction of major and minor storm drainage and water runoff systems is recommended. An Omaha program to reduce sedimentation from developing areas is detailed in addition to guidelines for good land resource conservation. Examples of developers' initiatives towards furthering the urban conservation program are cited.—W71-06751.

Descriptors: Erosion control, sediment control, Nebraska.

388 **Nicholas, F. W.**
1971. The changing form of the urban heat island of metropolitan Washington, *in* Am. Cong. on Surveying and Mapping, 31st, Washington, D.C., Mar. 7–12, 1971, Proc.: Tech. Paper 71-229, 15 figs., 15 references.

The urban heat island of metropolitan Washington, D.C., changes in its form and intensity as it responds to the influence of prominent weather conditions. Data from the local climatic network were analyzed according to the primary meteorological controls of wind speed and amount of cloud cover. More than 200 daily isothermal maps were constructed by use of a computer mapping system. The heat island has definite and characteristic forms associated with typical weather situations. Calm, clear nights are dominated by a high pressure system which sometimes results in an air pollution episode. Another urban heat island feature associated with air pollution is the "sea breeze" effect. A microscale wind flow toward the urban center is a general characteristic for conditions of calm or light regional winds. Seasonal distributions of dustfall over the Washington metropolitan area are correlated with the urban heat island during these conditions. The low ventilation and reduced turbulent mixing associated with the sharply defined urban heat island and the inflow of pollutants inferred by dustfall analyses are all factors intricately interrelated in the unique climate of the city.

Descriptors: Climatology, weather patterns, air temperature, air pollution effects, precipitation (atmospheric), Washington, (D.C.).

389 **Nightingale, H. I.**
1970. Statistical evaluation of salinity and nitrate content and trends beneath urban and agricultural areas, Fresno, California: Ground Water, v. 8, no. 1, p. 22–28, 7 figs., 5 tables, 7 references.

The salinity and nitrate content of well water under Fresno and Clovis, Calif., and the immediate surrounding irrigated agricultural zone were studied using data for 1950 through 1967. Salinity of the urban zone ground water has increased with time, while that of the agricultural zone has fluctuated considerably. In a 12-square-mile area northeast of Fresno and southwest of Clovis, ground-water nitrate content was around 25 to

35 mg per liter downgradient from the Clovis sewage plant and leaching ponds, about the same as the nitrate concentration in an area of septic tank use.—W70-03649.

Descriptors: Water pollution sources, groundwater pollution, nitrates, Fresno (Calif.).

390 George S. Nolte and Associates.

1970. Drainage and flood control background and policy study, summary report: San Diego, Calif., San Diego County Comprehensive Planning Organization, 20 p., 5 figs.

A flood potential exists in many areas of San Diego County, Calif., and additional flood hazards are anticipated because of continuing population increases. The drainage and flood control information prepared in this study will be used as a basis for developing a regionwide plan and program. Physical descriptions are given for eight major drainage basins, urban growth factors are analyzed, and organizational arrangements are suggested for carrying out flood control work for the region. A computerized method is described for the systematic evaluation of urbanization's effect on design and costs of flood control facilities. Instructions for use and documentation of the computer programs are provided.—W71-08125. PB-196-840.

Descriptors: Flood control, drainage practices, storm runoff, San Diego County (Calif.).

391 Northrop, W. L.

1970. Kansas City District experiences in urban hydrology, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 12, 25 p., 9 figs., 3 tables.

Detailed hydrologic criteria were developed for 10 small basins near Kansas City with very limited gaging records. These criteria have been used for flood-plain reports, technical service-type information to local agencies, and survey-type studies for flood-control measures. The effects of existing and projected urbanization are factors in a majority of these projects. Discharge-frequency curves and standard project flood peaks were calculated for natural conditions, for existing development, and for proposed improvements in the drainage system. Satisfactory 100-year hydrographs were developed for all inflow points and tributary contributions. Routing studies assume "road culvert" configuration at outlets and broadcrested overflow weirs control the 100-year pool elevation. A relatively small amount of storage has a large reducing effect on the peak discharges.

Descriptors: Unit hydrographs, rainfall-runoff relationships, storm runoff, Kansas City (Mo.).

392 Otton, E. G.

1972. Solid-waste disposal in the geohydraulic environment of Maryland: Maryland Geol. Survey Rept. of Inv. 18, 59 p., 15 figs., 18 tables, 52 references.

Because Maryland is in a humid region having about 43 inches of precipitation annually, sufficient moisture passes through sanitary landfills to carry along metals, chemicals, bacteria, and other undesirable materials, collectively called leachate. Rates of leachate infiltration range widely depending on the nature of the earth materials and the available water. Maryland was divided into five terrane types on the basis of the hydrologic characteristics of the land. Degradation of the underlying ground water by leachate is least likely in areas underlain by shale, but leachate generated at such sites may enter nearby streams unless adequate precautions are taken. Limestone or marble is a somewhat less useful base for solid-waste disposal because of solution channels and crevices. Crystalline silicate rocks of the Piedmont are suitable for sanitary landfills where a relatively thick zone of saprolite lies well above the water table. Upland coastal plain sites may be locally suitable where underlain by clayey strata well above the local water table. Low-lying coastal plain deposits offer protection from leachate pollution of deep-lying artesian aquifers because of thick and extensive impervious strata.

Descriptors: Leaching, path of pollutants, landfills, Maryland, groundwater pollution.

393 Packer, P. E.; Haup, H. F.

1966. The influence of roads on water quality characteristics, *in* Forest resource decisions in a changing power structure, Detroit, Mich., Oct. 24–28, 1965, Proc.: Soc. Am. Foresters, p. 112–115.

Road systems needed to serve interregional traffic as well as local uses increase the potential for damaging the quality of water. Poorly built roads produce large amounts of sediment. Well built forest roads contribute some sediment after construction, but because of good location and design characteristics with respect to drainage, erosion scars heal rapidly. The importance of keeping even small quantities of sediment out of stream channels has been stressed repeatedly by fishery biologists. When well constructed roads are located some distance from streams, muddy overland flow does not reach the stream, but infiltrates harmlessly into the undisturbed intervening protective strip. Road location, drainage design, and nature of the protective strip, therefore, are essential factors in water-quality control.—W69-05886.

Descriptors: Road design, sediment control, water pollution sources, erosion control.

394 Papadopulos, I. S.; Larsen, W. R.; Neil, F. C.

1969. Ground-water studies—Chicagoland deep tunnel system: Ground Water, v. 7, no. 5, p. 3–15, 14 figs., 2 photos., 4 tables, 10 references.

The deep tunnel system planned by the metropolitan district of Chicago will provide flood and pollution control for the areas of the Chicago region that use combined sewers. Elements of the deep tunnel system that are of concern to the ground-water resources are the tunnels and mined storage reservoir. Aquifers in which these elements will be located will be protected from any deleterious effects of the polluted storm waters by insuring that a positive hydraulic head, causing an inward flow, is continuously maintained around the tunnels and the mined reservoir. This necessitates that ground-water levels are maintained by artificial recharge. Studies included field investigations, analog computer analyses, and evaluation of the data and analog results. The proposed aquifer protection is feasible. The recharge requirements will vary from 1.4 mgd in 1976 to 6.0 mgd in the year 2010. Seepage into the tunnels will be small, in amounts that can be easily controlled.—W70-00205.

Descriptors: Water storage, storm runoff, water pollution control, Chicago (Ill.), flood control.

395 Parizek, R. R.

1971. Impact of highways on the hydrogeologic environment, *in* Environmental Geomorphology, Coates, D. R., ed., First Annual Geomorphology Symposia Series, Binghamton, N.Y., Oct. 16–17, 1970, Proc.: Binghamton, State Univ. of New York, Pub. in Geomorphology, chap. 9, p. 151–199, 9 figs., 7 tables, 61 references.

Highways may have favorable or unfavorable influences on our environment. The presence or absence of deep cuts and extensive fills can produce a large variety of transformations on the terrain and in the hydrogeologic environment. Such possible changes include beheading of aquifers, development of extensive ground-water drains, damage and pollution of water supplies, changes in ground-water and surface-water divides and basin areas, reduction of induced streambed infiltration rates, siltation of channels, obstruction of ground-water flow, and changes in runoff and recharge. Changes occur by economic activity stimulated by the highway. Sanitary, industrial, and solid wastes may be disposed of in an unsatisfactory manner. Pollution may result from maintenance procedures used to control weeds, insects, snow and ice, and from exposed stockpiles of chemicals used for these purposes.

Descriptors: Highways, sedimentation, water pollution sources, storm runoff, deicers, highway deicing.

396 Parizek, R. R.; Myers, E. A.

1968. Recharge of ground water from renovated sewage effluent by spray irrigation, *in* 4th American Water Resources Conf., New York, N.Y., Nov. 18–22, 1968, Proc.: Am. Water Resources Assoc., p. 426–443, 5 figs., 1 table, 11 references.

The Pennsylvania State University waste-water system returns approximately 500,000 gallons per day of effluent to nearly 60 acres of recharge area by spray irrigation. The effluent has received primary and secondary treatment and has been chlorinated. Uniform distribution of the returned effluent is a necessity throughout the entire year, although in winter there are periods of freezing temperatures. The rate of application must be slow enough and the amount small enough to insure infiltration and renovation. The application rate used was ¼ inch per hour, the most frequently used amount was 2 inches per week, and satisfactory distribution was achieved down to temperatures of -12 degrees F.

Descriptors: Water pollution sources, waste disposal, spray irrigation, artificial recharge.

397 **Parker, G. G.; Cohen, Philip; Foxworthy, B. L.**
1967. Artificial recharge and its role in scientific water management, with emphasis on Long Island, New York, *in* Natl. Symposium on Ground-Water Hydrology, San Francisco, Calif., Nov. 6–8, 1967, Proc.: Am. Water Resources Assoc., p. 193–213, 5 figs., 56 references.

Artificial ground-water recharge is a major feature of the hydrologic regimen of Long Island, N.Y. Disposal of waste water is one of the major modes of artificial recharge. In most of Nassau County and in nearly all of Suffolk County, there are no sewers; consequently, most of the domestic waste water is recharged through cesspools and septic tanks. By the early 1950's parts of the shallow aquifer in Nassau and Suffolk Counties had become polluted by cesspool and septic tank wastes. Largely because of the pollution, a large-scale sewering program was initiated. The draft on the ground-water system resulting from eliminating recharge of waste water is about 60 mgd. More than 2,000 recharge basins dispose of storm runoff, and about 200 basins dispose of industrial and commercial wastes on Long Island. In 1966, about 100 mgd recharged the aquifers through the storm-runoff detention basins and about 30 mgd through the industrial and commercial basins.

Descriptors: Artificial recharge, surface-groundwater relationships, storm runoff, Long Island (N.Y.).

649 **Patterson, J. W.; Minear, R. A.; Nedved, T. K.**
1971. Septic tanks and the environment: Chicago, Illinois Inst. Environmental Quality Doc. 71-2, 98 p., 4 figs., 7 tables, 127 references.

This report reviews and evaluates the available literature on septic tanks and the influence of septic tanks on public health and envirnomental quality. The consistently poor performance of septic tanks indicates that other waste disposal methods are necessary in densely populated areas and that more regulation of design criteria, installation, and operation are required in sparsely inhabited areas suitable for septic tank installations. This report is intended to form the basis for appropriate administrative or legislative action in Illinois.—PB-204-519.

Descriptors: Septic tanks, groundwater pollution, planning, Illinois.

398 **Perlmutter, N. M.; Lieber, Maxim; Frauenthal, H. L.**
1964. Contamination of ground water by detergents in a suburban environment—South Farmingdale area, Long Island, New York: U.S. Geol. Survey Prof. Paper 501-C, p. C170–C175, 4 figs., 1 photo., 4 references.

Large-scale suburban development of Long Island caused, in some areas with many septic tanks and cesspools, the problem of foaming and bad-tasting ground water. Foaming is caused by ABS, a surface-active organic compound which constitutes about 30 to 40 percent of the ingredients in common household detergents. The ABS, along with associated contaminants such as chloride, phosphate, nitrate, nitrite, bacteria, and possible viruses in domestic wastes, enters the shallow water-table aquifer by seepage of effluent from cesspools. Where detergent in water supplies results in deterioration of quality, users are acutely aware of the recirculation of wastes in ground water.

Descriptors: Water pollution sources, groundwater pollution, septic tanks, detergents, Long Island (N.Y.).

399 **Perlmutter, N. M.; Soren, Julian**

1963. Effects of major water-table changes in Kings and Queens Counties, New York City: U.S. Geol. Survey Prof. Paper 450-E, p. E136–E139, 1 fig., 1 table, 6 references.

At least 49 billion gallons of fresh water was removed from storage in the shallow aquifer in Kings County, Long Island, N.Y., between 1903 and 1936. Nearly all the fresh water removed from the shallow aquifer was replaced or contaminated by sea water. The decline of the water table was due to excessive pumping from aquifers, to wasting to sewers of used ground water, and to a substantial decrease in recharge caused by paving. The deepest decline was to about 35 feet below sea level in the Williamsburg section of northern Kings County. In June 1947 the wells of a private water company, which had withdrawn as much as 27 mgd, were shut down, and a sharp rise of the water table began. Between 1947 and 1950, the ground water in storage in the water-table aquifer increased by about 20 billion gallons. However, a significant part of this increment probably consisted of salt water that continued to move toward the center of the cone of depression after the cessation of pumping. The water table in most of Queens County continued to decline during the period 1950–61, and the cone of depression noted as early as 1933 was greatly enlarged. In 1961, the water level in the center of the cone in the Woodhaven-Jamaica area was about 15 feet below sea level.

Descriptors: Groundwater depletion, saline water intrusion, Kings County (N.Y.), Queens County (N.Y.), Long Island (N.Y.).

400 **Perlmutter, N. M.; Geraghty, J. J.**

1963. Geology and ground-water conditions in southern Nassau and southeastern Queens Counties, Long Island, New York: U.S. Geol. Survey Water-Supply Paper 1613-A, 205 p., 21 figs., 7 plates, 13 tables, 55 references.

A deep confined body of salt water lies beneath southwestern Nassau and southeastern Queens Counties, Long Island, N.Y. The overlying fresh ground water is contained in unconsolidated gravel, sand, and clay, with a maximum total thickness of about 1,700 feet. The water table declined as much as 20 feet, and piezometric surface of the principal aquifer declined as much as 7 feet from about 1895 to 1955. In 1954 about 163 mgd of fresh water was pumped, mainly for public supply. Most of this water was pumped from wells within the project area. Part of the water was returned to the ground through cesspools and septic tanks; part was lost to the sea through sewers; and part was exported from the area by New York City. Salty ground water in the principal aquifer is believed to be encroaching very slowly at rates of less than 100 feet per year at most places. Locally, near centers of pumping, the rate may be higher.

Descriptors: Saline water intrusion, groundwater depletion, water levels, Long Island (N.Y.).

401 **Perlmutter, N. M.; Crandell, H. C.**

1959. Geology and ground-water supplies of the southshore beaches of Long Island, N.Y.: New York Acad. Sci. Annals, v. 80, art. 4, p. 1060–1076, 5 figs., 1 map, 3 tables, 20 references.

In 1957 an average of 7 million gallons per day of water was pumped from wells screened in upper Cretaceous, Pleistocene, and Recent deposits beneath the south-shore beaches of Long Island, resulting in some salt-water encroachment. Cretaceous aquifers contain fresh water in much of the area but yield salty water in the extreme eastern and western parts. Two Pleistocene aquifers, separated by an interglacial clay, contain fresh water in some places and salty water in others. Recent deposits commonly contain salty water except for a thin lens of fresh water floating on salt water in the uppermost part. The Recent and upper Pleistocene deposits are recharged by local precipitation. The deeper artesian aquifers are recharged mainly by underflow from the middle of the island. The problem of sea-water encroachment should be considered in planning additional large developments.

Descriptors: Groundwater depletion, saline water intrusion, Long Island (N.Y.).

402 Perlmutter, N. M.; Lieber, Maxim; Frauenthal, H. L.

1963. Movement of waterborne cadmium and hexavalent chromium wastes in South Farmingdale, Nassau County, Long Island, New York: U.S. Geol. Survey Prof. Paper 475-C, p. C179–C184, 3 figs., 1 photo., 5 references.

Contaminated ground water containing high concentrations of cadmium and chromium from plating wastes has been discharged during the past 20 years by an industrial plant in South Farmingdale in east-central Nassau County, Long Island, N.Y. The contaminated area was located in detail by test drilling in 1962. The contaminated water extends about 4,200 feet from recharge basins at a plating plant to Massapequa Creek, where part of the waste discharges naturally. Some waste moves a short distance downgradient beneath the stream before discharging into the stream.

Descriptors: Path of pollutants, groundwater pollution, artificial recharge, Long Island (N.Y.).

403 Perlmutter, N. M.; Koch, E.

1971. Preliminary findings on the detergent and phosphate contents of water of southern Nassau County, New York: U.S. Geol. Survey Prof. Paper 750-D, p. D171–D177, 5 figs., 8 references.

In Nassau County, Long Island, N.Y., MBAS (methylene blue active substance, a component of detergents) and phosphate has entered the ground water with the sewage effluent from several hundred thousand cesspools and septic tanks. Although some shallow ground water has MBAS contents of as much as 2 milligrams per liter, this constituent is not a significant problem in the Magothy aquifer, the major source of public water supply. MBAS content of streams in some areas averaged as much as 0.48 mg per liter. A slight downward trend in MBAS content since 1966 may be due to natural dilution after a regional drought and introduction of a more biodegradable detergent in 1966. The phosphate content shallow ground water averaged 0.07 mg per liter. The low concentrations of MBAS and phosphate in most of the water are not known to be toxic.

Descriptors: Water pollution sources, groundwater pollution, septic tanks, detergents, Long Island (N.Y.).

404 Perlmutter, N. M.; Geraghty, J. J.; Upson, J. E.

1959. The relation between fresh and salty ground water in southern Nassau and southeastern Queens Counties, Long Island, New York: Econ. Geology, v. 54, no. 3, p. 416–435, 5 figs., 1 table, 5 references.

In Long Island, N.Y., the four main aquifers are of Late Cretaceous and Pleistocene age. Ground water having a high salt water content is encountered in some wells that penetrate the upper three units. The presence of this water constitutes a potential threat to water supplies. Salt water probably has been and is now encroaching, very slowly, because of heavy pumping from the fresh-water bodies and possibly as a result of a post-glacial rise of sea level. The rate of encroachmen under present conditions probably is less than 100 feet per year. Application of the Ghyben-Herzberg principle to compute depths to the contact between salty and fresh ground water was found to give erroneous results. More accurate depths and a clearer understanding of the relation between heads in adjoining bodies of fresh and salty ground water are obtained by use of a formula adapted from M. King Hubbert.

Descriptors: Saline water intrusion, groundwater pollution, Long Island (N.Y.).

405 Perlmutter, N. M.; Koch, Ellis

1972. Preliminary hydrogeologic appraisal of nitrate in ground water and streams, southern Nassau County, Long Island, New York: U.S. Geol. Survey Prof. Paper 800-B, p. B225–B235, 6 figs., 15 references.

Increase in nitrate content of ground water and streams, mainly due to infiltration of sewage, leachate from chemical fertilizers, and wastes from decayed crops, is a major water-quality problem in a 180-square-mile area of Nassau County, Long Island, N.Y. This area has hydrologically similar adjoining sewered and unsewered parts. Nitrate content of water in the upper glacial aquifer averaged 30 mg per liter and in seven places equaled

or exceeded 100 mg per liter. In comparison, the estimated average natural nitrate content is less than 1 mg per liter. Nitrate content of streams fed by ground water averaged 11 and 25 mg per liter in the sewered and unsewered areas, respectively. Nitrate-enriched water has also moved down into the underlying Magothy aquifer. For example, the nitrate content of water from 234 public-supply wells screened in the Magothy averaged 10 mg per liter, but in 16 wells the nitrate content ranged from 45 to 94 mg per liter. Reduction of nitrate to ammonium ion and subsequent ion exchange or sorption of the ammonium ion may retard movement of the nitrate front. Increased pumping, however, could accelerate movement.

Descriptors: Water pollution sources, nitrates, groundwater pollution, Long Island (N.Y.).

406 Perlogg, H. S.

1969. The quality of the urban environment: Baltimore, Md., Johns Hopkins Press, 332 p., 21 figs., 26 maps, 47 tables.

A conference was held on the urban environment in 1967. The objective of the conference was to evaluate the existing information sources and new information that would be needed for measurement of environmental change and to study public policy issues related to environmental improvements. The first paper attempts to set up a decision-making framework for policy making on the urban environment. The papers on pollution demonstrate the interrelation between waste products and the urban environment. Other papers deal with urban space on a two and three-dimensional basis. This book is relevant for water-resource planners concerned with the impact of government water-investment expenditures on the urban environment.—W71-05214.

Descriptors: Environmental quality, planning, water resources development.

407 Peterson, G. L.; Gemmell, R. S.; Worrall, R. D.; Berry, D. S.

1969. Civil engineering and urban systems: Am. Soc. Civil Engineers Proc., Paper 6501, Jour. Urban Planning Devel. Div., v. 95, no. UP 1, p. 1–14, 2 figs., 5 references, 1 app.

Urban systems engineering uses the tools of mathematics, economics, and the social, behavioral and institutional sciences, all founded on an engineering base. The analytic methodology, theories, and descriptions of the behavior of urban systems and institutions and the use of inductive and deductive quantitative methods are outlined. Included in urban services which should be engineered as systems are water supply, waste disposal, transportation, health services, power supply, education, recreation, communication, protection (fire, police), and others. The responsibility of the civil engineering profession in meeting the challenge and opportunity of urban systems engineering is stressed.—W69-06491.

Descriptors: Engineering geology, systems analysis, water resources development, planning.

408 Peterson, J. T.

1969. The climate of cities; a survey of recent literature: Natl. Air Pollution Control Adm. Pub. AP-59, 48 p., 7 figs., 6 tables, 127 references.

City climate differs from that of the surrounding rural areas. This report reviews the literature on city climatology, particularly that written since a series of papers published by Dr. H. Landsberg (1956–62). The Landsberg papers provide the basis for review of city-rural meteorological differences. Cities and even small building complexes create nocturnal heat islands, and urban-rural differences in temperature depend strongly on local microclimatic conditions. The size of urban-rural temperature differences is highly correlated with the suburban low-level temperature lapse rate. The relative humidity of towns is almost always lower than that of adjacent rural areas. When regional wind speeds are relatively low, speeds over cities are higher than those over the countryside, and fewer calms occur over the city than over the country. When conditions are conducive to heat island formation, the wind flow converges toward the city.—W70-00988.

Descriptors: Climatology, weather patterns, precipitation (atmospheric), heat islands, reviews.

410 Pinkayan, S.

1972. Routing storm water through a drainage system: Am. Soc. Civil Engineers Proc., Paper 8642, Jour. Hydraulic Div., v. 98, no. HY 1, p. 123–135, 7 figs., 6 references, 1 app.

Unsteady flow equations for routing storm water through storm drainage systems with lateral inflow can be solved by the method of characteristics on digital computers. The storm drain consists of a single continuous line of circular channel with constant slope. The main inflow to the drain is at the upstream end. The lateral inflow comes through a circular conduit at the junction box, normal to the direction of the main drain. The outflow is a free fall downstream. Good agreement is found in comparing computed hydrographs and observed hydrographs at various locations along the drain.

Descriptors: Routing, computer programs, hydrograph analysis, storm runoff.

411 Pluhowski, E. J.

1961. Variation in temperature of two streams on Long Island, New York: U.S. Geol. Survey Prof. Paper 424-D, p. D55–D58, 4 figs.

Temperatures of streams on Long Island occasionally vary widely on the same day, and significant temperature variations also occur between points along the same stream. Large ground-water inflow characterizes all streams on Long Island, and the stream temperatures are greatly influenced by ground-water temperatures. The highest and lowest stream temperatures occur in the same months as the highest and lowest air temperatures, whereas the insulating effect of soil cover causes extremes of ground-water temperature to lag about 2 months. Air temperatures also have an influence. Ground-water inflow is small at the heads of the streams but increases in the middle reaches. A greater total area of ponds results in a larger variation in monthly water temperatures. During the summer, ponds raise stream temperatures by absorbing solar radiation, but during the winter, ponds lower the stream temperatures by increasing the rate of heat loss. Ground-water inflow and pondage produce opposite effects.

Descriptors: Water temperature, surface-groundwater relationships, Long Island (N.Y.).

412 Pluhowski, E. J.; Kantrowitz, I. H.

1963. Influence of land-surface conditions on ground-water temperatures in southwestern Suffolk County, Long Island, New York: U.S. Geol. Survey Prof. Paper 475-B, p. B186–B188, 1 fig., 1 reference.

Variation in absorbed solar radiation among differing surface environments in a partly suburban area in southwestern Long Island, N.Y., results in lower ground-water temperatures under wooded areas than under cleared areas. Shade and layers of organic material on the ground account for the smaller amount of solar radiation absorbed in the wooded area. In the summer, ground-water temperatures at shallow depths under residential, deforested areas may be 3 degrees to 5 degrees F higher than those observed under wooded areas. Heat added to the ground water by cesspool effluent is usually dissipated before the effluent reaches observation wells. The annual range of ground-water temperatures is about 6 degrees F greater in the wooded area at shallow depths and about 1 degree F greater at a depth of 70 feet.

Descriptors: Water temperature, groundwater, heat balance, Long Island (N.Y.).

413 Pluhowski, E. J.

1968. Urbanization and its effect on the temperature of Long Island streams: U.S. Geol. Survey open-file rept., 277 p., 56 figs., 13 tables, 38 references, 3 app.

To isolate and evaluate the effect of manmade changes of stream temperature, the thermal patterns of five streams on Long Island, N.Y., were defined and analyzed. The Connetquot River is included as a control stream because its upper part is in essentially its natural state. Urban development on the other four basins ranges from

slight to nearly complete; otherwise the five streams are similar. Urban development has increased stream temperatures in summer by 10–15 degrees F by clear-cutting of vegetation, streambanks, increasing storm runoff, and reducing ground-water inflow. Winter stream temperature averages 3–5 degrees F lower than normal. Storm-water runoff can raise stream temperatures about 10 degrees F. Solar radiation and ground-water seepage are the most important controls on stream thermal patterns on Long Island and are the most easily influenced by human activity.—W69-02830.

Descriptors: Water temperature, storm runoff, vegetation effects, Long Island (N.Y.).

414 Pluhowski, E. J.

1969. Effects of urban development on the hydrology of Long Island, New York, *in* First Annual Earth Resources Aircraft Program Status Review: Houston, Tex., Natl. Aeronautics and Space Adm., v. 2, p. 21-1 to 21-9, 4 figs.

Urbanization on Long Island has progressed from the densely populated western part of the island to the rural central and eastern parts. The effect of man's activities on the hydrology of Long Island has been most evident in the flood hydrographs of streams. The volume of flood runoff has increased several fold in urbanized areas. Recharge to the ground-water reservoir has dwindled because of sewerage operations and the spread of paved areas. Accordingly, there has been a lowering of ground-water levels in some urban areas. Less obvious, but nevertheless real, are the effects of man's activities on stream-temperature patterns. Infrared imagery may be used to detect man-induced changes in the thermal patterns of water bodies and nearby land areas.

Descriptors: Remote sensing, hydrogeology, water temperature, runoff, peak discharge, Long Island (N.Y.).

415 Pluhowski, E. J.; Kantrowitz, I. H.

1964. Hydrology of the Babylon-Islip area, Suffolk County, Long Island, New York: U.S. Geol. Survey Water-Supply Paper 1768, 119 p., 28 figs., 8 maps, 9 tables, 38 references.

Almost all the water used in the towns of Babylon and Islip, and part of the towns of Huntington, Smithtown, and Brookhaven in southwestern Suffolk County, N.Y., is obtained from wells screened in permeable zones of unconsolidated deposits of gravel, sand, silt, and clay as much as 1,800 feet thick. Floods are rare in the area, although continued urbanization may result in minor flooding problems. Some streams and parts of the water-table aquifer contain synthetic detergents and other dissolved constituents from domestic and industrial wastes. Ground-water withdrawals in 1960 averaged 39 mgd, most of which was returned to the ground through cesspools, leaching beds, and recharge wells. Pumpage did not appreciably affect the natural water balance of the ground-water reservoir. If withdrawals continue to be artificially recharged, pumpage can be increased at least fivefold before consumptive losses materially reduce ground-water levels. However, if the area were completely sewered in the future, adequate yield of ground water could not be obtained without ground-water depletion or recharging treated-sewage effluent.

Descriptors: Groundwater, water balance, Long Island (N.Y.), artificial recharge.

416 Poertner, H. G.; Wolf, K. W.; Anderson, R. L.

1966. Urban drainage practices, procedures, and needs: Chicago, Ill., Am. Public Works Assoc., Special Rept. 31, Proj. 119, 54 p., 2 figs., 22 tables, 9 references.

This report, produced under the direction of the Urban Drainage Committee of the American Public Works Association, presents information on flood protection and drainage practices and policies of urban areas, with emphasis on the planning, regulatory, and financing aspects. A questionnaire was mailed in 1965 to all communities of the United States and Canada having populations in excess of 10,000 persons. Responses were received from 627 communities. The results are presented under five chapter headings: (1) general information,

(2) organizational patterns for urban drainage management, (3) financing of capital improvements, (4) planning and regulatory functions, and (5) design, construction, and maintenance. Nineteen research projects are suggested. An extensive annotated bibliography on urban drainage and flood control is included.—W70-06920.

Descriptors: Drainage systems, storm runoff, water management (applied), planning.

417 Popel, Franz

1957. Effect of storm water on the sewerage system and the receiving streams: Zeitschrift Kommunalwirtschaft, heft 9, p. 340–352, 10 figs., 8 tables, 30 references. [In German]

The effect on streams of storm-water overflows in combined sewerage systems is discussed with special reference to planning of new towns. The permissible amount must be based on the annual amount discharge of water and of polluting matter, the self-purifying capacity of the stream, and the use made of the stream water. Investigations are required concerning the condition of the storm water, and efforts should be made to develop a reliable method of assessing the self-purifying power of a stream that receives sudden discharges of polluting matter.—W69-02153.

Descriptors: Storm runoff, water pollution control, combined sewers.

418 Potter, J. G.

1961. Changes in seasonal snowfall in cities: Canadian Geographer, v. 5, no. 1, p. 36–42, 4 figs., 5 references.

Changes in snowfall can be caused by the growth of a city. Any increase in the precipitation resulting from the growth of the built-up area of a city will tend to increase the snowfall. But an increase in the temperature may also be brought about this way and will cause some of the precipitation to melt and reach the ground as rain. The range of fluctuations of the 10-year mean temperature in all of Canada has been about 2 to 3 degrees F compared to the increase of 1 degree F attributed to the city effect. At Edmonton and Winnepeg the seasonal snowfall trend is steady or increasing slightly. In the maritime climate of the West Coast, where the temperature is more critical in determining whether precipitation falls in the form of rain or snow, the snowfall has reflected temperature cycles. These temperature cycles are great enough to cancel out any influence the city had on snowfall. The only definite downward trend in the amount of snowfall has been in Toronto and Montreal. These two cities are particularly favorable sites for such a trend to develop. Both the general warming trend in temperature which has persisted fairly uniformly for almost 80 years throughout the region and the rapid growth of the metropolitan areas would facilitate a downward trend.

Descriptors: Snowfall, precipitation (atmospheric), climatology, Montreal (Canada).

419 Powell, M. D.

1970. Organizing for soil erosion and sediment control in our nation's urban areas, *in* Combined sewer overflow abatement technology: U.S. Federal Water Pollution Control Adm., Water Pollution Control Research Series 11024-DTL-06/70, p. 321–336.

Some considerations involved in organizing an erosion and sediment control program along with some specific organizational structures that may be suitable, with modifications, to a variety of local situations are discussed. "Action Guide for Erosion and Sediment Control" is included in this report. It is a snythesis of sedimentation control concepts, principles, and techniques, which can be converted to general action plans by local, State, and federal levels of government.

Descriptors: Sediment control, erosion control, planning.

420 Powell, M. D.; Winter, W. C.; Bodwitch, W. P.

1970. Community action guidebook for soil erosion and sediment control: Washington, D.C., Natl. Assoc. of Counties Research Foundation, 64 p.

Erosion and sediment, once thought to be rural problems, are causing extensive damage to the soil and water resources of developing communities. Sediment caused by careless development and construction has become one of the Nation's most serious sources of water pollution. This guidebook is intended to help local officials to organize, plan, finance, staff, and implement comprehensive sedimentation control programs. In addition, it should help local officials and administrators understand the problem; it will also help soil and water experts and technicians understand the administrative aspects of sedimentation control. This mutual understanding is necessary if effective control is to be achieved. A model approach, with appropriate modifications, may be used by many local governments to control their sedimentation problems.—W70-06574.

Descriptors: Sediment control, legislation, legal aspects, erosion control, planning.

421 Powell, M. D.; Winter, W. C.; Bodwitch, W. P.
1970. Urban soil erosion and sediment control: U.S. Federal Water Quality Adm., Water Pollution Control Research Series 15030-DTL-05/70, 97 p.

This study was conducted to determine the causes and the extent of urban and suburban soil erosion and sediment problems and to describe ways in which local communities can organize and implement effective sedimentation control programs. An evaluation is provided of the state of urban sedimentation control, and the "Community Action Guidebook for Soil Erosion and Sediment Control" describes methods by which local goverments can organize, plan, finance, staff, and implement urban sedimentation control programs. Aspects of areawide approaches are discussed, and an action plan is outlined. Soil erosion and sediment developing areas is extensive, and these problems pose threats to soil and water resources. While many of the required technical means for controlling sedimentation problems already exist, new administrative approaches are needed to accommodate the interests and pressures associated with urban and suburban development.—W71-02276. PB-196-111.

Descriptors: Sediment control, legal aspects, erosion control, planning.

422 Pravoshinskiy, N. A.
1968. Description of the drainage of street flushing waters: Soviet Hydrology, Selected Papers, no. 2, p. 168–170, 2 tables, 9 references.

The quality and quantity of runoff from street washing operations in Minsk were measured to study the contribution of street washing to water pollution. Data from earlier studies in Moscow and Leningrad are included for comparison. The BOD (biochemical oxygen demand) of street cleaning runoff ranges from 6 to 223 mg per liter. Petroleum products are up to 110 mg per liter, and coliforms are nearly as abundant as in waste water. These waters, unless they are treated, can be a major source of pollution.—W69-08732.

Descriptors: Water pollution sources, storm runoff, storm drains, Minsk (USSR).

423 Pravoshinski, N. A.; Gatillo, P. D.
1968. Calculation of water pollution by surface runoff: Water Research, v. 2, no. 1, p. 24–26.

Water pollution by surface runoff was studied in two districts in Minsk and in Soligorsk. Water from asphalt surfaces was more polluted than the water from unpaved areas. The amount of pollutants in runoff water was about 13 percent of the amount measured in raw domestic sewage. Statistically analyzed data show a relationship between water quality and streamflow.—W70-01026.

Descriptors: Water pollution sources, storm runoff, storm drains, Minsk (USSR).

424 Pravoshinskiy, N. A.; Gatillo, P. D.
1969. Determination of the pollutional effect of surface runoff, *in* Advances in Water Pollution Research, 4th Internat. Conf. on Water Pollution Research, Prague, Czechoslovakia, Apr. 21–25, 1969, Proc.: London, Pergamon Press, Ltd., p. 187–195, 3 figs., 1 table, 27 references.

Pollution by urban surface runoff depends on the intensity of movement of street traffic and use by pedestrians, type of cover of catchment, duration and intensity of rain, standards of water discharge of watering and washing, the amount of dust deposition, the elevation of the catchment water basin, duration of preceding dry-weather period, quality and technology of town cleaning, and the means of dust control. Data were compiled from samples collected in the well built-up districts of Minsk, USSR, remote from big industrial enterprises, and Soligorsk, a rapidly developing town.—W70-08639.

Descriptors: Water pollution sources, storm runoff, storm drains, Minsk (USSR).

425 **Prawdzik, T. B.**
1970. Environmental and technical factors for open drainage channels in Milwaukee: Am. Soc. Civil Engineers, Urban Water Resources Research Program, Tech. memo. 12, 10 figs.

Some of the environmental and technical factors which influenced the adoption of open channels for drainage in Milwaukee are outlined. Criteria are given for the selection of channel cross sections when the improvement of existing watercourses traversing the city was essential to ameliorate flooding. The principles discussed have been applied generally in Milwaukee. The experiences the city has had with originally natural watercourses which have been improved as open storm-drain channels are discussed.—W70-06318. PB-191-710.

Descriptors: Storm drains, flood control, Milwaukee (Wis.).

426 **Prior, G. A.; Berthouex, P. M.**
1967. A study of salt pollution of soil by highway salting: Natl. Research Council, Highway Research Board, Highway Research Record 193, p. 8–21, 8 figs., 2 tables, 18 references, 3 app.

Heavy applications of salt to highways for snow and ice removal are common in New England, where several tons of salt per mile may be applied during a winter. The maximum concentrations of salts are at the soil surface and nearest the highway. The soil salinity problem resulting from highway salting is minimal for well drained field conditions. Adverse drainage conditions, however, create more serious problems and should be avoided. There is some tendency for salts to travel laterally away from the highway, but the most prevalent movement is downward into the soil. Salts are readily leached from the top several feet of soil, and by April most of the salt has disappeared. The salt concentrations continue to decrease gradually through the summer and reach a low level before salt applications are resumed the following winter.

Descriptors: Deicers, highway deicing, water pollution sources, water pollution effects, snow removal.

427 **Quackenbush, T. H.; Phelan, J. T.**
1965. Irrigation water requirements of lawns: Am. Soc. Civil Engineers Proc., Paper 4350, Jour Irrig. Drainage Div., v. 91, no. IR2, pt. 1, p. 11–19, 3 figs., 4 tables, 7 references.

Water requirements for lawn grasses can be estimated by an empirical formula when adequate climatological data are available. The modified Blaney-Criddle formula can be used for this purpose. When the soil is near wilting point, frequent light irrigations at a rate of approximately one-half the normal consumptive use will maintain an appearance rated from fair to good. Under these conditions, common lawn grasses seldom require irrigation to maintain appearance when the monthly net irrigation requirement is less than one-half the consumptive use computed for maintaining a full supply of moisture.

Descriptors: Storm runoff, lawn irrigation, rainfall desposition, evapotranspiration.

428 **Rahn, P. H.**
1968. The hydrogeology of an induced streambed infiltration area: Ground Water, v. 6, no. 3, p. 21–32, 5 figs., 4 maps, 5 photos., 2 tables, 45 references.

The University of Connecticut well field is located in a sand and gravel ice-contact stratified drift aquifer which fills the Fenton River valley to a depth of about 60 feet. The water that supplies these wells consists of captured ground-water underflow, which would normally discharge into the Fenton River, and water induced directly into the aquifer from river flow by pumping. Approximately 34 percent of the water pumped from the well is stolen from the river via induced streambed infiltration. The water table is detached from the river and is below the streambed near the pumped wells, a result of low vertical permeability of the rest of the aquifer. The streambed is unable to recharge the aquifer with as much water as the aquifer can carry away.

Descriptors: Surface-groundwater relationships, withdrawal, water resources development.

429 Raman, V.; Bandyopadhyay, M.

1969. Frequency analysis of rainfall intensities for Calcutta: Am. Soc. Civil Engineers Proc., Paper 6950, Jour. Sanitary Eng. Div., v. 95, no. SA 6, p. 1013–1030, 10 figs., 9 tables, 7 references, 3 app.

Analysis of the point rainfall data in Calcutta, India, for 23 years yields a procedure for arriving at the relationship between the average intensity of excessive rainfall, the corresponding duration, and the frequency with which these combinations of intensity and duration occur. Intensity-duration-frequency relations are expressed in tabular and graphical forms and as mathematical equations. The various methods do not give exactly identical results, and discretion must be used to choose between them for application in the design of a storm sewer system. No particular method can be considered as the best for rainfall frequency determination.—W70-02634.

Descriptors: Rainfall disposition, depth-area-duration analysis, rainfall intensity, storm runoff, Calcutta (India).

430 Ramey, H. P.

1959. Storm water drainage in the Chicago area: Am. Soc. Civil Engineers Proc., Paper 1995, Jour. Hydraulics Div., v. 85, no. HY 4, pt. 1, p. 11–37, 3 maps, 11 tables.

From a review of past and recent conditions of flooding in the Chicago area, it is concluded that the present outlet channels are inadequate to handle the runoff during heavy storms. Possible methods of improving the situation are indicated and discussed.—W69-01892.

Descriptors: Storm runoff, storm drains, drainage (urban), Chicago (Ill.).

431 Rantz, S. E.

1970. Urban sprawl and flooding in southern California: U.S. Geol. Survey Circ. 601-B, p. B1–B11, 1 fig., 1 map, 5 photos., 3 tables.

The floods of January 1969 in south-coastal California provide an example of the effect of urban sprawl on flood damage. Despite record-breaking stream discharges, damage was minimal in the older developed areas that are protected against inundation and debris damage by carefully planned flood-control facilities, including debris basins and flood-conveyance channels. By contrast, heavy damage occurred in areas of more recent urban sprawl, where the hazards of inundation and debris or landslide damage have not been taken into consideration, and where the improvement and development of drainage or flood control facilities have not kept pace with expanding urbanization.—W70-04832.

Descriptors: Flood control, storm runoff, land use, California, floods, sediment control.

432 Rantz, S. E.

1971. Suggested criteria for hydrologic design of storm-drainage facilities in the San Francisco Bay region, California: U.S. Geol. Survey open-file rept., 132 p., 18 figs., 18 tables, 15 references.

Basic criteria are given in the form of tables and graphs for each of the four methods of hydrologic design most commonly used in the San Francisco Bay region—flood-frequency analysis, rational method, unit-hydrograph method, and runoff simulation by means of hydrologic basin modeling. The term "hydrologic design" refers to the computation of either design values of peak discharge or design hydrographs of storm runoff. Use of the suggested criteria results in fairly close agreement between peak discharges computed by the flood-frequency and unit-hydrograph methods. Those peak discharges are not directly comparable with discharges computed by the rational method, in part because the results obtained by the rational method are affected by the values assigned to parameters for overland and channel flow. An original technique is given for transposing storm rainfall in the region, storm transposition being commonly required to obtain the precipitation input used with hydrologic basin models.

Descriptors: Rainfall-runoff relationships, storm runoff, unit hydrographs, mathematical models, rational formula, San Francisco Bay area (Calif.).

433 Rantz, S. E.

1971. Mean annual precipitation and precipitation depth-duration-frequency data for the San Francisco Bay region, California: U.S. Geol. Survey open-file rept., 31 p., 6 figs., 4 tables, 3 references.

Precipitation depth-duration-frequency relations were derived for the San Francisco Bay urban region by correlating precipitation depths of given duration and frequency at climatological stations with the mean annual precipitation at those stations. Satisfactory correlation is obtained in this region because the bulk of the annual precipitation occurs in general storms during the wet winter season, and intense local convective storms are almost unknown. Because the total number of hours or days of precipitation does not vary greatly among sites in the region in any given year, general relations are expected between precipitation intensity and total depth of precipitation. An isohyetal map of mean annual precipitation is used with the derived relations to estimate the depth of storm precipitation corresponding to a given duration and frequency at any site in the region. The durations used range from 5 minutes to 60 consecutive days; the recurrence intervals range from 2 to 100 years.

Descriptors: Depth-area-duration analysis, rainfall frequency, precipitation (atmospheric), San Francisco Bay area (Calif.).

434 Rantz, S. E.

1971. Precipitation depth-duration-frequency relations for the San Francisco Bay region, California: U.S. Geol. Survey Prof. Paper 750-C, p. C237–C241, 3 figs., 2 tables, 1 reference.

Precipitation depth-duration-frequency relations were derived for the San Francisco Bay region, Calif. The regime of precipitation in the region is such that depth-duration-frequency characteristics for a site are closely related to the mean annual precipitation for that site. The derived relations are to be used as criteria for both local drainage design and the study of the stability of land slopes. The frequencies studies were those corresponding to recurrence intervals of 2, 5, 10, 25, 50, and 100 years; the durations studied ranged from 5 minutes to 60 consecutive days. Data for the shorter durations are required for local drainage design and also for the study of surface-erosion potential, with land slope and soil type as additional factors. Data for the longer durations, to be used in conjunction with land slope and soil and geological factors, are needed for the study of land slippage potential.

Descriptors: Depth-area-duration analysis, rainfall-runoff relationships, San Francisco Bay area (Calif.).

435 Rao, R. A.; Delleur, J. W.; Sarma, B. S. P.

1972. Conceptual hydrologic models for urbanizing basins: Am. Soc. Civil Engineers Proc., Paper 9024, Jour. Hydraulics Div., v. 98, no. HY 7, p. 1205–1220, 6 figs., 3 tables, 25 references, 1 app.

After a preliminary analysis of urban rainfall-runoff relationships, the single linear reservoir and the Nash model were selected for further study. Analysis of about 200 storms from watersheds with different degrees of

development indicated that the parameters of these models varied not only with the urbanization factor (related to the ratio of the built-up area in a watershed to the total watershed area) but also with other physiographic and meteorological factors. Regression analysis relates the parameters of the models to the significant meteorological, urban, and physiographic factors. These regression relationships were used to simulate the instantaneous unit hydrographs on a watershed for various urbanization factors. Changes in runoff from a watershed with increasing urbanization factors were then simulated for a variety of rainfall characteristics.

Descriptors: Storm runoff, rainfall-runoff relationships, unit hydrographs.

436 Raudkivi, A. J.; Lawgun, N.

1970. Synthesis of urban rainfall: Water Resources Research, v. 6, no. 2, p. 455–464, 4 figs., 7 tables, 3 references.

A statistical analysis of rainfall records is used to develop a computer model for generation of a sequence of short-period rainfalls. The time intervals between rainfalls are generated by sampling from a frequency distribution fitted to the historical data. The model also uses a first order Markov Process to obtain the rainfall durations. Rainfall depths are obtained by sampling from the joint distribution of rainfall depths and durations. Model parameters are based on the meteorologic conditions of the Auckland area, New Zealand. All statistical tests were performed at a 5 percent level of significance. The model produces comparable time intervals between storms and there is no linear correlation between rainfall depths and durations in the generated data.

Descriptors: Statistical models, depth-area-duration analysis, precipitation (atmospheric), model studies, simulation analysis.

437 Reich, B. M.

1968. Flood computations for suburbs, *in* American water resources conf., 4th, New York, N.Y., Nov. 18–22, 1968, Proc.: Am. Water Resources Assoc., p. 276–294, 11 figs., 7 tables, 18 references.

Although the notion of multiple use of land and water has reached the planners of suburban communities, the necessary flood hydrographs have been lacking. Techniques are available for rural watersheds and urban areas but not for suburbs. Therefore, three rural methods and one urban procedure were modified for use on three suburban watersheds in southeastern Pennsylvania. These methods were: McSparran's Pennsylvania synthetic hydrograph; Reich's small rural synthetic hydrograph; Soil Conservation Service's curvilinear hydrograph; and John Hopkins urban inflow hydrograph. The input to all four methods was rainfall with both reservoir and channel routing. Extrapolation of these four hydrograph methods to suburban design in terms of the "blue and green" requirements gives incompatible results. Radically different structural dimensions would result from each alternative hydrograph procedure. Economic analysis would be correspondingly variable.—W70-06948.

Descriptors: Storm runoff, hydrograph analysis, routing, suburbs, planning, rainfall-runoff relationships.

438 Reich, B. M.

1970. Routing modifications to suburban design hydrographs: Am. Soc. Civil Engineers, Preprint 1141, 27 p., 12 figs., 1 table, 22 references.

Storm water disposal in heterogeneous watersheds that typify modern suburbs involves routing of floodflows which arise on first and second-order tributaries. Streamflow measurements are usually absent, so the input to the routing must be synthetic hydrographs. Urban and rural hydrographs generated from drainage basin features and a hypothetical rain are combined and routed through streams and proposed reservoirs so that effective use may be planned for the valley bottoms downstream. Four watersheds in the fringe suburbs of Philadelphia, Pa., were studied as examples of the suburban setting common to the northeast. Neither channel routing nor reservoir routing obliterate hydrograph differences. A very small improvement in flood control is achieved by combining flat parabolic swales rather than deep rectangular channels with reservoirs.—W70-08540.

Descriptors: Routing, flood control, storm runoff, hydrograph analysis.

439 Reid, G. W.; Cleveland, J.

1967. Evaluation of dispersed pollutional loads: Am. Soc. Civil Engineers, Environmental Eng. Conf. Preprint 422, 10 p.

An experimental technique is proposed to determine quality of storm water from individual drainage basins that make up urban Tulsa, Okla. The component analysis technique evaluates effects of land-use practices on quality of runoff. The stream is sampled twice monthly during dry weather flow, and several times during storm runoff period. It is estimated that at least 1 or possibly 2 years of data will be needed to make representative estimation of true quality and quantity of runoff.—W69-01848.

Descriptors: Storm runoff, water quality, drainage (urban), Tulsa (Okla.), land use.

440 Remson, Irwin

1969. Hydrologic and disposal problems in urban areas, *in* Environmental Planning and Geology, Symposium on Eng. Geology and Urban Environment, San Francisco, Calif., Oct. 1969, Proc.: Washington, D.C., U.S. Geol. Survey and Office of Research and Technology, Dept. Housing and Urban Devel. Coop. Rept., p. 36–41, 3 figs., 3 photos., 1 table, 7 references.

An important objective of regional planning is to minimize damage caused by urbanization. Some of the hydrologic problems of urbanization are illustrated by preliminary hydrologic analysis and design for the watershed of the Upper East Branch of the Brandywine Creek in Chester County, Pa. A plan was prepared for the orderly development of this basin. The objective was to plan the urban development with the minimum of damage to the water, scenery, and other natural resources. The average annual surplus of precipitation in excess of evapotranspiration is 16.7 inches. Although large volumes of water would move through the local hydrologic system, the natural capacities to provide a source of potable water and to absorb wastes would be exceeded for the design population, despite the favorable hydrologic characteristics. Furthermore, a completely acceptable hydrologic environment could not be engineered for the design population, using currently available technology, at an acceptable cost. This led to the development of a philosophical approach to hydrologic design for urbanization. It might be possible to go beyond the confines of the developed watershed for water supply and waste disposal, to restrict the density of development, or to engineer the watershed more intensively. For example, the eutrophication problem could be solved by a chemical precipitation facility. However, every increase in technology involves costs that increase nonlinearly with population. It is the role of the hydrologist to provide the urban developer with basic data and hydrologic predictions upon which management decisions can be based. Hydrologists find hydrologic models useful for this prediction and extrapolation.

Descriptors: Water quality, land use, storm runoff, Brandywine Creek (Pa.), planning.

441 Remson, Irwin; Fungaroli, A. A.; Lawrence, A. W.

1968. Water movement in an unsaturated sanitary landfill: Am. Soc. Civil Engineers Proc., Paper 5904, Jour. Sanitary Eng. Div., v. 94, no. SA 2, p. 307–317, 1 fig., 4 tables, 14 references.

Contamination of ground water from leaching of sanitary landfills will become more common as use of this waste disposal method spreads. An understanding of the moisture regimen of the landfill is basic to a knowledge of the character and quantity of the waterborne contaminants it generates. Moisture-routing methods provide an approximate method for predicting vertical movement of moisture through landfills. The method is based on climatological techniques and incorporates the hydraulic characteristics of unsaturated permeable materials. The time that elapses before the first leachate appears depends on the season of emplacement and the initial moisture content. Various objectives in landfill management may be obtained by varying the time of emplacement, initial moisture content, soil cover, and other factors.

Descriptors: Groundwater pollution, landfills, garbage dumps, water pollution sources.

442 **Leonard Rice Consulting Waste Engineers.**
1971. Reduction of urban runoff peak flows by ponding: Am. Soc. Civil Engineers Proc., Paper 8351, Jour. Irrigation Drainage Div., v. 97, no. IR 3, p. 469–482, 5 figs., 7 tables, 3 references, 1 app.

Rooftop ponding and short-term onsite detention storage can be incorporated into the design of urban storm drainage facilities. By limiting the rate of runoff from flat roofs and other flat areas, the peak rate of runoff to the storm drainage system can be reduced. Ponding can also reduce peak runoff rates. These techniques are used in the Denver region to minimize the impact of new developments on the storm drainage system. Because storage volumes are relatively small and the runoff hydrographs have short-time bases with steep peaks, it is necessary to consider the magnitude-frequency relationship and intensity-duration characteristics of rainfall, as well as its geographic distribution.

Descriptors: Water storage, flood control, peak discharge, storm runoff, Denver (Colo.).

443 **Rickert, D. A.; Spieker, A. M.**
1971. Real-estate lakes: U.S. Geol. Survey Circ. 601-G, 19 p., 7 figs., 7 references.

A real-estate lake can be either an asset or a liability. With proper planning and management, it can enhance the esthetic quality of the landscape, provide water-oriented recreation, and increase the property value of the surrounding land. With poor planning and management, a lake can become a weed-choked, foul-smelling mud-hole. The basis for proper planning is thorough knowledge of the hydrology of lakes combined with an anticipation of the problems that may arise in their development and use. Assessment of problems permits a realistic estimate of the total cost of developing a real-estate lake rather than simply the cost of construction. In the long run, time and money can be saved by preventing or minimizing problems at the outset and by eliminating those areas where combined construction and maintenance costs would be economically prohibitive. Even well planned lakes require constant management to be maintained at a desirable level of physical, chemical, and esthetic quality.

Descriptors: Land use, eutrophication, planning, lakes.

444 **Riley, J. P.; Narayana, V. V. D.**
1969. Modeling the runoff characteristics of an urban watershed by means of an analog computer, *in* Effects of watershed changes on streamflow, Moore, W. L. and Morgan, C. W., eds.: Austin, Texas Univ. Press, p. 183–200, 14 figs., 3 tables, 7 references.

In the synthesis of hydrograph characteristics of small urban watersheds, the distribution of the water among the various phases of the runoff process is attempted by the concept of "equivalent rural watershed". For a given input into the equivalent watersheds, the outputs are identical. The hydrograph of outflow from an urban watershed is obtained by chronologically deducting the losses due to interception, infiltration, and depression storage from precipitation and then routing it through the surface and channel storages. Coefficients representing interception, depression storage, and infiltration are determined by the trial-and-error process on the analog computer in such a way that the outflow hydrograph predicted by the model is nearly identical to the measured prototype hydrograph.—W70-04575.

Descriptors: Rainfall-runoff relationships, analog models, Austin (Tex.).

445 **Robbins, W. D.**
1970. Annual compilation and analysis of hydrological data for urban studies in the Austin, Texas metropolitan area, 1969: Austin, Tex., U.S. Geol. Survey basic-data rept., 46 p., 3 figs., 1 table.

Rainfall and runoff data are presented to compare the urban Waller Creek and the rural Wilbarger Creek study areas for the 1969 water year. The Waller Creek drainage area lies entirely within the city of Austin, with the headwaters in the northern part of the city. Storm sewers and street gutters divert runoff both into and out of the natural drainage area. The weighted-mean rainfall upstream from 38th Street was 30.25 inches, 7 percent

below the mean annual rainfall for Austin of 32.58 inches. Mean daily discharge was 1.38 cfs; annual runoff was 8.08 inches, or 27 percent of rainfall. Wilbarger Creek is in a rural area about 15 miles north of the city of Austin. Weighted-mean rainfall in this study area was 27.92 inches, 14 percent below the mean annual rainfall for Austin. Mean daily discharge was 1.49 cfs; annual runoff was 4.40 inches, or 16 percent of the rainfall.—W71-09086.

Descriptors: Rainfall-runoff relationships, data collections, Austin (Tex.).

446 Robbins, W. D.

1971. Annual compilation and analysis of hydrologic data for urban studies in the Bryan, Texas, metropolitan area: U.S. Geol. Survey open-file rept., 49 p., 2 figs., 1 table.

This report contains the rainfall, runoff, and storage data collected during the 1969 water year for the Hudson Creek and Burton Creek watersheds in the vicinity of Bryan, Tex. Average rainfall over the Burton Creek study area during the water year was 49.67 inches, or 27 percent more than the 30-year (1931–60) average. Mean daily discharge was 3.25 cfs, and the total runoff was 2,360 acre-feet, or 33.24 inches (67 percent of rainfall). Average rainfall over the Hudson Creek study area during the water year was 49.36 inches, or 26 percent more than the 30-year (1931–60) average. Mean daily discharge was 2.42 cfs, and the total runoff was 1,750 acre-feet, or 16.94 (34 percent of rainfall). Computations, hydrographs, and mass curves for each storm are included.

Descriptors: Rainfall-runoff relationships, hydrologic data, data collections, hydrograph analysis, water yield, Bryan (Tex.).

447 Roberts, E. C.; Zybura, E. L.

1967. Effect of sodium chloride on grasses for roadside use: Natl. Research Council, Highway Research Board, Highway Research Record 193, p. 35–42, 5 figs., 4 tables, 14 references.

More than 24,000 pounds of sodium chloride per mile of four-lane highway have been used per year for ice removal on some sections of Interstate 80 in Iowa. Salt applied at this rate during the winters of 1963–64 and 1964–65 affected median and foreslope soil structure and prevented satisfactory establishment of grass cover. Injury to grass seedlings and established turf has been greatest on heavy soils with little organic matter. Soluble salt determinations made on soil samples taken along Interstate 80 indicate concentrations of sodium chloride sufficiently high to restrict grass growth up to 10 feet from the pavement. Kentucky 31 fescue and western wheatgrass are the most salt tolerant. Injury became evident and increasingly more pronounced as salt levels increased from 1,000 to 5,000 ppm.

Descriptors: Deicers, highway deicing, water pollution sources, water pollution effects, snow removal.

448 Robey, D. L.

1970. Effects of urbanization on annual peak flow frequency analysis, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 3, 14 p., 10 references.

Urban hydrology was originally concerned only with the downtown paved area; this is not sufficient today because of urban sprawl. The frequency of flooding is a necessary consideration in planning land use and development. Relationships for estimating the magnitude and frequency of occurrence of flood peaks on a drainage basin having a high degree of urban and suburban development are reviewed; their results vary greatly. The basin used in this study is Fourmile Run located in northern Virginia. The drainage area is 14.4 square miles, and the channel capacity is approximately 2,700 cfs. In recent years the area has undergone considerable development and redevelopment. Flood conditions are produced by intense rainfall of short duration. Lag time, the parameter most affected by urbanization, is for a completely storm-sewered system about one-eighth that of

a comparable natural system. On small, steep basins, drainage improvements alone may triple average flood discharges, and complete development of stream channels and the basin surface may increase average floods by a factor of 8. A complete impervious surface will increase the average size flood by a factor of 2½ but may decrease the discharge of a larger-than-average flood. For the 100-year flood the discharge estimates ranged from 12,740 to 29,600 cfs. The use of the log-Pearson Type III distribution, modified to include the recent U.S. Geological Survey study, is recommended to define the mean annual flood.

Descriptors: Storm runoff, rainfall-runoff relationships, floods, peak discharge, Fourmile Run (Va.).

449 Robinson, A. R.
1970. Technology for sediment control in urban areas; *in* Natl. Conf. on Sediment Control, Washington, D.C., Sept. 14–16, 1969, Proc.: Environmental planning paper, Dept. of Housing and Urban Devel., p. 48–54, 4 references.

Under urban construction activity, sediment loads of 25,000 to 140,000 tons per square mile have been measured. Specific efforts to reduce or manage the adverse effects are required for satisfactory development of water and land resources. There are needs for new knowledge and methods particularly adapted to the situation where large areas are suddenly changed to urban uses. Generally overlooked is the fact that a flowing stream is a dynamic body which has the energy to transport silt and sediment. Recommended control measures are presented under the following headings: permanent vegetation, diversions, outlet channels, bench terraces, waterway stabilization structures, bank erosion structures, stream channel construction, sediment basins, and timing of consturction.—W71-04148.

Descriptors: Sedimentation, erosion control, erosion, sediment load.

450 Rockwell, M. L.
1968. Water resources as an element of urban planning: Am. Soc. Civil Engineers Proc., Paper 6056, Jour. Urban Planning and Devel. Div., v. 94, no. UP 1, p. 1–9.

Complex technical, legal, and administrative problems are involved in the water situation of northeastern Illinois. Water is intensively used and reused in this area. Even storm-water runoff along with its pollutants is retained in reservoirs to be used later beneficially. Existing problems related to storm-water runoff in this area include the restriction of infiltration and, thus, the production of increased runoff caused by the construction of impermeable surfaces (rooftops, streets, and parking lots) and the maintenance of unsightly storm-water basins in areas where recreational facilities are needed.—W71-06753.

Descriptors: Storm runoff, water management (applied), Chicago (Ill.).

451 Rogers, R. A.
1968. Rational "rational" method of storm drainage design: Am. Soc. Civil Engineers Proc., Paper 6301, Jour. Irrig. Drainage Div., v. 94, no. IR 4, p. 465–480, 4 figs., 6 tables, 5 references, 2 app.

A method of storm drainage system design utilizes the rational formula with a modification to allow non-uniform runoff. The system is designed for those critical periods when flow in the system or parts of the system is a maximum as determined from a hydrograph of the runoff. The method is particularly suited to design of submerged systems and has been computerized for this type of problem. An example problem is presented, and the results show larger pipe sizes than would be found using the common method of adding times of flow in the lines to a concentration time at some arbitrary starting point.

Descriptors: Rational formula, storm runoff, rainfall-runoff relationships.

452 Romer, Harold; Klashman, Lester
1963. How combined sewers affect water pollution, part I: Public Works, v. 94, no. 3, p. 100–104, 170, 172.

This article on studies of pollution of combined sewers discusses results of a questionnaire survey of 148 cities (50,000 to 2,100,000 population), 80 of which replied. The 11 questions deal with characteristics of combined sewage, combined sewer treatment practices, and effects of combined sewage discharges on quality of receiving waters.—W69-01850.

Descriptors: Water pollution sources, storm runoff, combined sewers.

453 Root, R. R.; Miller, L. D.

1972. Identification of urban watershed units using remote multispectral sensing: Colorado State Univ., Environmental Resources Center, Completion Rept. Ser. no. 29, 51 p., 22 figs., 6 tables, 12 references, 6 app.

Changes due to urban development of natural watersheds are shown by an areal analysis of 13 small watersheds from 40 to 600 acres located in the Denver suburbs. Airphotos for each of the watersheds were obtained at 5 to 10-year intervals for as far back as 1935. The surface composition of each watershed was determined from the airphotos. Developmental trends result in changes in the impervious cover of each watershed and the effects on this imperviousness of different seasonal characterisitcs. Relating changing surface cover to urban hydrology requires refined and timely measurements. Remote multispectral imagery can provide detailed analysis of surface characteristics which can be related to hydrologic effects and can be used in watershed models. A method is proposed for determining the optimum wavelength bands to be used for differentiating 10 types of urban surface materials via automatic image processing based on measured spectral curves of the materials. The results can be used in the design or use of instruments to map urbanizing areas. Appendix A is a bibliography containing 153 entries.

Descriptors: Remote sensing, land use, Denver (Colo.).

454 Rorabaugh, M. I.

1960. Problems of waste disposal and ground water quality: Am. Water Works Assoc. Jour., v. 52, no. 8, p. 979–982, 4 references.

The problems associated with waste disposal and its effects on ground water are complex. Wastes enter underground reservoirs through septic tanks, injection wells, ponds, sinks, and spreading basins, and by accidental seepage through retention basins, by failure of structures, poor maintenance, accidents, seepage of irrigation water, recharge from rainfall contaminated by wastes, and infiltration of polluted surface waters. An example of complex conditions is found in the Miami, Fla. area. Permits (as of 1960) to recharge with swimming pool water, laundry water, and air-conditioning water are granted if the injection well is cased into salt water. The salt water is part of the sea-water wedge. If the recharge rate is low, the waste can probably not reach the zone of fresh water. If recharge rates are high, some waste water rises into the fresh-water zone. The most obvious method of protection is treatment of the waste at its source; however, complete treatment may be out of economic reach. Intentional recharge with some types of waste will almost certainly be continued.

Descriptors: Water pollution sources, waste disposal wells, groundwater pollution, Miami (Fla.).

455 Ross, G. A.

1970. The Stanford watershed model; the correlation of parameter values selected by a computerized procedure with measurable physical characterisitcs of the watershed: Lexington, Ky., Water Resources Inst., Research Rept. 35, 178 p., 22 figs., 28 tables, 67 references, 2 app.

Streamflow simulation provides a powerful tool for developing better information on flow magnitudes and time patterns for the design of water resources projects. A self-calibrating simulation model was applied to 20 Kentucky watersheds to estimate appropriate values for model parameters. The procedure required to develop the input data is explained in sufficient detail for a user's manual. Physical descriptions of the watersheds include soil depth, permeability, cover, and other measured quantities. Relationships between model parameters (based on the Stanford watershed model) and watershed characteristics were explored. Parameter values were also estimated for a series of years spanning a period of intensive urbanization. The results provide fremework for modeling changes in streamflow magnitudes and time patterns associated with urban development.—W71-07062.

Descriptors: Rainfall-runoff relationships, mathematical models, Stanford watershed model.

456 Rowe, E. S.; Storr, E. D.

1966. Flooding frequencies for urban drainage design: Australian Road Research, v. 2, no. 10, p. 24–30.

Effects on expected rainfall intensity, runoff, pipe sizes, and cost of using different flooding frequencies for road drainage design are illustrated for the situation in Sydney, Australia.—W69-01893.

Descriptors: Rainfall-runoff relationships, storm runoff, Sydney (Australia).

457 Ryling, R. W.

1966. Water quality and flow of streams in southeastern Wisconsin: Southeastern Wisconsin Regional Planning Comm., Tech. Rept. 4, 342 p., 66 figs., 17 maps, 299 tables, 36 references.

A study of stream-water quality in the southeastern Wisconsin region was made as part of an effort to adjust regional land use and transportation system development plans to the natural resource base. An attempt was made to relate stream-water quality to land-use development and to forecast such water quality under alternative land-use development patterns. Stream-water quality data are tabulated, present stream-water quality is related to existing major sources of pollution, the effect of stream-water quality on various water uses is assessed, and the interrelationships between stream-water quality and land-use patterns are studied.—W69-09947.

Descriptors: Water quality, water pollution sources, land use, Wisconsin.

458 Sarles, W. B.

1961. Specific problems in lakes, *in* Algae and metropolitan wastes: Cincinnati, Ohio, The Robert A. Taft Sanitary Eng. Center, SEC Tech. Rept. W61-3, p. 10–18.

The five lakes at Madison, Wis., have been subjected to eutrophication. The sources of nutrients include both urban wastes and agricultural drainage. The consequent obnoxious effects have prompted efforts for their control, including community action, legislation, executive study, scientific research, administrative fiat, and legal action. This is a short summary of the history of activities which finally led to understanding the difference between nuisance conditions caused by pollution with solid sewage wastes and those caused by pollution with plant nutrients. The ultimate solution was diversion of effluents from Madison's secondary treatment plant.—W70-06213.

Descriptors: Lakes, eutrophication, Madison (Wis.), water pollution control.

459 Sarma, P. B. S.

1970. Effects of urbanization on runoff from small watersheds: Lafayette, Ind., Purdue Univ., Ph.D. thesis, 231 p., 58 figs., 30 tables, 105 references.

Urban and suburban development changes the quantity and time distribution of runoff. Analysis of data from watersheds which are in the same region but in different stages of urbanization reveals the effects of urbanization on runoff characteristics. Data for the study were obtained principally from watersheds in West Lafayette, Ind. Hydrologic data from several other urbanized watersheds were also used to make the study more general.

Descriptors: Rainfall-runoff relationships, storm runoff, mathematical models, peak discharge, West Lafayette (Ind.).

460 Sarma, P. B. S.; Delleur, J. W.; Rao, A. R.

1969. A program in urban hydrology, part II, an evaluation of rainfall, runoff models for small urbanized watersheds and the effect of urbanization on runoff: Lafayette, Ind., Purdue Univ., Water Resources Research Center, Tech. Rept. 9, 241 p., 58 figs., 30 tables, 105 references, 3 app.

Four watersheds with varying degrees of urbanization in West Lafayette, Ind., were studied by linear system analysis. The conceptual systems considered were the single linear reservoir model, the double routing method, the Nash model, and the single linear-reservoir with linear-channel model. The single linear reservoir model was

selected to simulate the rainfall-runoff process on small urban watersheds (less than 5 square miles) because of its superior regeneration performance, while the Nash model was best on the larger watersheds.—W70-03035.

Descriptors: Storm runoff, water yield, rainfall-runoff relationships, model studies, systems analysis, mathematical models, West Lafayette (Ind.).

461 Sasman, R. T.; Baker, W. H., Jr.; Patzer, W. P.
1962. Water-level decline and pumpage during 1961 in deep wells in the Chicago region, Illinois: Illinois State Water Survey Circ. 85, 32 p., 8 figs., 5 tables, 3 references.

The water-level declined during 1961 in deep wells penetrating the Cambrian-Ordovician aquifer, the most highly developed aquifer for large ground-water supplies in the Chicago region. Pumpage from deep wells has increased from 200,000 gpd in 1864 to 91.7 mgd in 1960. As a result, artesian pressure in the Cambrian-Ordovician aquifer at Chicago has declined about 670 feet. Pumpage is concentrated in six centers: Chicago area, Joliet area, Elmhurst area, Des Plaines area, Aurora area, and Elgin area. In 1961, pumpage was 96.5 mgd, or 4.8 mgd more than in 1960. This annual increase in pumpage has resulted in excessive declines in water levels in some deep wells. Water-level declines during 1961 ranged from 8 feet in the Aurora area to 15 feet in the Des Plaines and Elmhurst areas and averaged about 11 feet. The 1961 average decline is greater than the average annual rate of decline (10 feet) for the period 1945–60. Withdrawals in 1961 exceed the practical sustained yield with the result that ground-water users in the Chicago region continue to mine water.

Descriptors: Chicago (Ill.), groundwater depletion.

462 Savini, John; Kammerer, J. C.
1961. Urban growth and water regimen: U.S. Geol. Survey Water-Supply Paper 1591-A, 42 p., 5 figs., 2 tables, 67 references.

The continuing growth and concentration of population and industry in urban and suburban areas has caused a complex merging of social, economic, and physical problems. As urban man changes an area from one of field and forest to one of buildings and streets, he covers land where water once entered the soil and thus creates or aggravates problems of drainage, including storm-water runoff. As he requires increasing amounts of water for home and factory, he drills deeper wells and builds longer aquaducts and larger dams and reservoirs. As he disposes of unwanted waste materials, he either treats them by using water or pollutes the receiving body of water. As he dredges and deepens coastal streams carrying salt water, and as he pumps greater quantities of water from wells in coastal areas, he increases the likelihood of salt-water contamination.

Descriptors: Rainfall-runoff relationships, sediment yield, land use, saline water intrusion, groundwater.

463 Sawyer, C. N.
1947. Fertilization of lakes by agricultural and urban drainage: Jour. New England Water Works Assoc., v. 61, no. 2, p. 109–127, 5 figs., 6 tables, 6 references.

Agricultural drainage near Madison, Wis., contributes annually about 4,500 pounds of nitrogen and 255 pounds of phosphorus per square mile of the watershed. Treated sewage supplies annually approximately 6.0 pounds of nitrogen and 1.2 pounds of phosphorus per capita, thus equating 1 square mile of agricultural drainage to 750 persons for nitrogen and 212 persons for phosphorus. In 1946, lakes on the outskirts of Madison received approximately 1,300 tons of nitrogen and 215 tons of phosphorus. The lakes retained from 30 to 60 percent of nitrogen received. The phosphorus concentration in Lakes Waubesa and Kegonsa attained above 0.25 parts per million as compared with 0.01–0.02 ppm concentration found in less polluted lakes of southern Wisconsin. Microcystis aeruginosa was a particularly obnoxious by-product of eutrophication.—W70-02787.

Descriptors: Water pollution sources, water pollution effects, lakes, eutrophication, Madison (Wis.).

464 Sawyer, R. M.

1963. Effect of urbanization on storm discharge and ground-water recharge in Nassau County, New York: U.S. Geol. Survey Prof. Paper 475-C, p. C185–C187, 1 map, 2 tables, 1 reference.

Nassau County, N.Y., on Long Island, is one of the fastest growing counties in the Nation. The large expansion of housing and highway construction, with the replacement of permeable surfaces by impervious ones, has reduced infiltration of precipitation. This rapid urbanization causes problems of loss of replenishment of underground water supplies and collection and disposal of storm waters. Some of the storm runoff is carried through short sewer lines to recharge basins. Recharge basins may be used in the interior of the island where the depth to water table is as much as 200 feet. Near the south shore, however, the water table is very shallow. In the near shore areas there is at present no other recourse than to discharge storm-water runoff into streams or into Great South Bay. This loss of recharge during the period 1952–60 was about 63,000 gallons per day.

Descriptors: Groundwater depletion, recharge, storm runoff, water balance, Long Island (N.Y.), Nassau County (N.Y.).

465 Schaake, J. C., Jr.

1963. Progress report of the storm drainage research project, July 1, 1962 to June 30, 1963: Johns Hopkins Univ., Dept. of Sanitary Eng. and Water Resources, Storm Drainage Research Proj. Rept. XI, 55 p., 16 figs., 9 tables, 2 references.

The rational method of computing design peak runoff rates is reviewed, and improvements in its use are suggested. The frequency of occurrence of the computed design peak runoff rate is assumed to be the same as the frequency of occurrence of the selected rainfall intensity. The constant values of C (runoff coefficient) and t (time of concentration) can be selected so that this assumption is approximately correct for the range of rainfall intensities commonly considered in design practice in the Baltimore area. Equations were developed to estimate C and t from physical characterisitcs of the drainage area. These relationships should provide good estimates when using the rational method to select design capacities for urban drainage systems.—W69-01894.

Descriptors: Rational formula, rainfall-runoff relationships, Baltimore (Md.), peak discharge.

466 Schaake, J. C., Jr.

1968. Response characteristics of urban water resource data systems: Am. Soc. Civil Engineers, Urban Water Resources Research Program, Tech. Memo. 3, 57 p., 10 figs., 15 tables, 8 references.

The characteristics of rainfall-runoff data and instrumental response are analyzed in a cost-effectiveness study of urban hydrology data-collection systems. Rainfall data characteristics are subdivided into rainfall measurement error, measurement criteria, and response of tipping bucket rain gages. A stochastic model of rainfall predicts rain-gage network response. Coefficients of variation of the ratio of measured intensity to average intensity at several gages in the Baltimore area are tabulated. The best gaging system uses Parshall flumes. Measurement errors are analyzed, and data from Northwood, a well-instrumented area in Baltimore, are tabulated and discussed. Rainfall and runoff data are analyzed by regression and spectral analyses and shown by hyetographs and hydrographs. Water quality measuring and sampling systems are discussed and analyzed for optimum design. Economic and operations research approaches are outlined and recommended for optimization of urban hydrologic data systems.—W69-03509.

Descriptors: Rainfall-runoff relationships, stream gages, rain gages, data collections, instrumentation, hydrologic data.

467 Schaake, J. C., Jr.

1969. A summary of the Hopkins storm drainage research project: its objectives, its accomplishments, and its relation to future problems in urban hdyrology; *in* The Progress of Hydrology, vol. 2, 1st Internat. Seminar for Hydrology Professors, Illinois Univ., Urbana, July 13–25, 1969, Proc.: Urbana, Illinois Univ., 28 p., 8 figs., 12 references.

Since its initiation in 1949, the Hopkins storm drainage research project had the following primary objectives: development of the principles of hydraulic behavior of storm-water inlets and application to design practice; development of instruments for measuring and recording rainfall and storm runoff and collection of data; and development of the relationship between rainfall and runoff and application to storm-sewer design. During the period 1949–67, 52 locations were gaged. Some of the gaged catchments were sewered, but 29 of them were inlet areas. A computer model of the rainfall-runoff process was developed to predict runoff; it is based on physical principles, and runoff data are not required for its application.—W71-01823.

Descriptors: Rainfall-runoff relationships, storm runoff, model studies, data collections, Baltimore (Md.), hydrologic data.

468 Schaake, J. C., Jr.

1971. Modeling urban runoff as a deterministic process, *in* Treatise on urban water systems, Albertson, M. L., Tucker, L. S. and Taylor, D. C., eds.: Fort Collins, Colorado State Univ., p. 343–349, 2 references.

A model of a hydrologic system is an abstraction, a simplified representation of the system and not a complete or exact duplication of it. Natural hydrologic systems are complex, so any model must neglect at least some aspects of the natural systems. One of the most promising approaches to nonlinear modeling of hydrologic systems is to use the differential equations that describe hydrologic phenomena. Much progress has been made in applying the equations for unsteady flow in open channels to describe surface runoff and streamflow. Flow in streams and sewers may be described by the unsteady flow equations. If the kernel of linear system is known, calculations of the system response is simply evaluating the correlation integral. The calculations are inherently stable, and no numerical difficulties are encountered. The response of the system to many different inputs may be obtained using little computer time, even for distributed parameter models. In comparison, nonlinear models based on the kinematic wave equations may require computer time one or more orders of magnitude longer than a linear model.

Descriptors: Mathematical models, storm runoff, unsteady flow, rainfall-runoff relationships.

469 Schaake, J. C., Jr.

1971. A general rationale for modeling urban runoff, *in* Treatise on urban water systems, Albertson, M. L., Tucker, L. S., and Taylor, D. C. eds.: Fort Collins, Colorado State Univ., p. 350–356, 4 references.

A general rationale for modeling urban runoff is proposed. Fundamentally there are seven basic steps that should be followed in any modeling procedure. These are: (1) carefully identify and evaluate the objectives; (2) select criteria for meeting these objectives; (3) seek the best of all possible models that satisfy these criteria; (4) estimate model parameters; (5) establish the adequacy of the model; (6) design appropriate input and output systems for the model; and (7) use the model according to the objectives.

Descriptors: Mathematical models, storm runoff, rainfall-runoff relationships, runoff.

470 Schaake, J. C., Jr.

1971. Deterministic urban runoff model, *in* Treatise on urban water systems, Albertson, M. L., Tucker, L. S., and Taylor, D. C., eds.: Fort Collins, Colorado State Univ., p. 357–383, 11 figs., 1 table.

A deterministic model is described for computing storm runoff from rainfall in urban areas. It is based on theoretical motion of kinematic waves in uniform channels with both lateral and upstream inflows. Kinematic wave theory is applied to urban catchments by decomposing the catchment into segments. The resulting model is a conceptual or hypothetical model of the real catchment. It is a deterministic model because all of the input data are given functions of time or are related uniquely to the physical properties of the catchment. The general system for creating deterministic models of any urban catchment is given as a FORTRAN program. This program requires data input which describes the physical features of the catchment and which describes the

occurrence of a storm as it is distributed both temporally and spatially over the catchment. The program prints out the outflow hydrographs at selected points throughout the catchment. Runoff data are not required to use this model. All parameters can be estimated on the basis of physical features alone. However, if runoff data are available, they can be used to adjust parameter values to improve the fit of the model to the catchment.

Descriptors: Mathematical models, computer programs, storm runoff, rainfall-runoff relationships, routing, kinematic wave theory.

471 Schaake, J. C., Jr.; Geyer, J. C.; Knapp, J. W.
1967. Experimental examination of the rational method: Am. Soc. Civil Engineers Proc., Paper 5607, Jour. Hydraulics Div., v. 93, no. HY 6, p. 353–370, 10 figs., 5 tables, 5 references.

Rainfall and runoff data collected in Baltimore, Md., from 20 gaged urban drainage areas as large as 150 acres were used in a study of the rational method. The frequency of occurrence of computed design peak runoff is the same as the frequency of occurrence of rainfall intensity, if the appropriate value of the runoff coefficient is selected. In accordance with their usual design procedures, five storm drainage designers used the rational method to estimate 5-year design peak runoff rates for six gaged drainage areas. These values are compared with runoff values from runoff frequency curves for these gaged areas.—W69-02259.

Descriptors: Rainfall-runoff relationships, rainfall intensity, storm runoff, data collections, Baltimore (Md.), peak discharge.

472 Scheidt, M. E.
1967. Environmental effects of highways: Am. Soc. Civil Engineers Proc., Paper 5509, Jour. Sanitary Eng. Div., v. 93, no. SA 5, p. 17–25, 16 references.

The polluting effects of highways on the environment are discussed. Erosion of soil exposed during construction results in substantial sedimentation damage downstream from the construction area. Sediment loads and damages are described for localized conditions in Maryland and Virginia. Provisions for controlling the pollution effects of highway construction are required by Federal and local governments. Roadside litter requires stronger action than presently enforced penalties. The use of chemicals in highway maintenance and spillage in the transportation of chemicals also have damaging effects on the environment. A center for reporting of highway accidents involving spillage of hazardous commodities should be established.—W69-01854.

Descriptors: Water pollution sources, sediment yield, soil erosion, deicers, highways.

473 Schicht, R. J.; Moench, A. F.
1971. Future demands on ground water in northeastern Illinois: Ground Water, v. 9, no. 2, p. 21–28, 2 figs., 5 maps, 3 tables, 11 references.

Future water demands are estimated for each 10-year interval from 1980 to the year 2020 for areas in the Chicago region dependent upon ground water as a source of supply. Demands are compared with ground-water availability to define water-deficient areas. Two approaches were considered in developing the ground-water resource. The first approach limits ground-water withdrawals to the maximum rate of natural ground-water recharge that can be induced by pumping. The second approach allows withdrawals to exceed natural recharge. When limiting ground-water withdrawals to recharge, a large part of the region will require importation of water as early as 1980. With proper pumpage distribution, it is possible that there is sufficient water that can be withdrawn (mined) in excess of natural recharge to meet demands through the year 2020.—W71-0700

Descriptors: Water resources development, groundwater, water yield, Chicago (Ill.).

474 Schmidt, K. D.
1972. Nitrate in ground water of the Fresno-Clovis metropolitan area, California: Ground water, v. 10, no. 1, p. 50–61, 9 figs., 10 references.

Natural concentrations of nitrate are quite low in most ground waters in the eastern part of the San Joaquin Valley. High nitrate contents are related to sewage effluent percolation ponds, septic tank disposal systems, industrial waste waters, and agricultural fertilizers. Nitrate is stratified in the aquifer beneath unsewered metropolitan areas, and highest contents occur in the upper 50 or 60 feet. Water quality hydrographs show long and

short-term trends in nitrate. Chloride and nitrate hydrographs, trilinear diagrams, the distribution of other constituents, and hydrologic data delineate sources of nitrate in areas where numerous potential sources are present.

Descriptors: Water pollution sources, nitrates, groundwater, pollution, Fresno (Calif.).

475 Schneider, W. J.

1968. Water data for metropolitan areas, a summary of data from 222 areas in the United States: U.S. Geol. Survey Water-Supply Paper 1871, 397 p., 1 fig., 5 tables, 2 maps, 1,332 references.

The hydrologic data available by states and for each standard metropolitan area in the United States are cited, and references to their sources are given. Such data are prerequisite for planning and engineering design of urban environments. For each of the 222 areas, the information given consists of: data on size and population, a short description of the hydrology of the area, a tabulation of current data-collection activities and data available in the area, a list of current U.S. Geological Survey investigational projects in the area, and a bibliography of reports on the hydrology of the area.—W68-01027.

Descriptors: Data collections, hydrologic data, water resources development, planning, bibliographies.

476 Schneider, W. J.

1969. The U.S. Geological Survey urban water program, *in* Effects of watershed changes on streamflow, Moore, W. L., and Morgan, C. W., eds., Water Resources Symposium No. 2, Austin, Tex., Oct. 1968: Austin, Tex., Univ. Press, p. 165–168.

The Water Resources Division of the U.S. Geological Survey is currently expanding its role in urban hydrology to meet new demands. Since the first stream-gaging stations were established more than 80 years ago, data have been collected in urban areas. Today data are available for the 222 standard metropolitan areas in the United States. The Water Resources Division has also conducted studies within and including urban areas. In recent years, the emphasis of these studies has been on the assessment of changes in water resources caused by urbanization. Storm drainage today is still largely designed on the basis of the rational formula using rainfall intensity modified by a coefficient of runoff. Greater knowledge of the part of the hydrologic cycle involving rainfall-runoff relations in urban environments is needed. A study under way considers the data needs for urban runoff studies, instrumentation, and networks for collection of these data.—W70-04573.

Descriptors: Data collections, water resources research, rainfall-runoff relationships, U.S. Geological Survey (Washington, D.C.).

477 Schneider, W. J.

1970. Hydrologic implications of solid-waste disposal: U.S. Geol. Survey Circ. 601-F, 10 p., 2 figs., 2 tables, 7 references.

The disposal of more than 1,400 million pounds of solid waste in the United States each day is a major problem. Four disposal methods—open dumps, sanitary landfill, incineration, and on-site disposal—carry an inherent potential for pollution of water resources. Seepage of rainwater through the wastes leaches undesirable constituents which reach ground water. This leachate is generally both biologically and chemically contaminated. Pollution potential is highest in permeable areas with a shallow water table where the wastes are in direct contact with the ground water. Site selection for disposal of solid wastes must be based on adequate information if pollution is to be minimized. This will require regional as well as localized data on the water resources of the area. Only through such an approach can adequate protection be afforded.—W71-05094.

Descriptors: Water pollution sources, hydrogeology, garbage dumps, landfills, groundwater pollution.

478 Schneider, W. J.

1971. Hydrologic data for storm drainage design: Am. Soc. Civil Engineers, Pre-print no. 1328, 12 p., 7 references.

Public comfort and safety requires that storm water be removed rapidly from urban areas to prevent serious flooding. Despite the tremendous investment in storm drainage facilities in the United States, the criteria for design are among the oldest and most poorly defined of all criteria used by the engineering profession. The current practices emphasize that not enough knowledge of storm runoff is available for optimum design. Most storm drainage design is based upon the "rational formula." There are wide variations in the interpretation and application of this formula in practice. Perhaps the strongest criticism that can be made of it is that it provides an estimate of only the flood peak. As emphasis shifts from simple removal of storm runoff to its management, estimates of the entire runoff hydrograph will be needed. Recently, consideration has been given to rainfall-runoff relationships. New methods are evolving slowly because sound hydrologic data necessary for their development are lacking. More and better data on rainfall, runoff, and water quality must be collected for proper management of urban storm runoff.

Descriptors: Storm drains, storm runoff, water yield, model studies, rainfall-runoff relationships.

479 Schneider, W. J.; Rickert, D. A.; Spieker, A. M.

1972. The role of water in urban planning and management: U.S. Geol. Survey Circ. 601-H, 31 p., 3 figs., 1 table.

The concentration of people in urban areas has modified the natural landscape, bringing about water problems. The deleterious effects can be minimized or corrected by comprehensive planning and management. Urban planners are not generally able to identify the data that are needed. To help satisfy the need, a water-resources evaluation matrix was developed. The graphic matrix provides a means for organizing the relative importance of water-related problems and for identifying the data needed to evaluate these problems. The matrix lists nine subject categories in which water-related urban problems may occur. The matrix also lists 51 possible data inputs for evaluation of the problem areas. The inputs include standard basic hydrologic data as well as information based on interpretation and analysis of these data. The list also includes the factors of climate, land, and culture.

Descriptors: Hydrologic data, planning, rainfall-runoff relationships, water quality, water management (applied).

480 Schneider, W. J.; Spieker, A. M.

1969. Water for the cities—the outlook: U.S. Geol. Survey Circ. 601-A, p. A1–A6, 4 references.

Except perhaps for the arid Southwest, water resources are generally sufficient to meet the needs of cities for the foreseeable future. Cities will continue to expand, and additional rural areas will be converted to urban and suburban complexes. Demands for urban water will continue to rise, and this will place a heavy strain on existing systems. Most city water problems have not been the result of shortages of sources of water but rather the result of overtaxed collection, storage, and distribution systems. This is verified by the experience of the Northeast during the recent prolonged drought. Pollution abatement, recreation, wildlife conservation, and aesthetics are demands now recognized by both rural and urban areas. Future development of water resources must consider regional demands and resources. Only in this way can our reasonably abundant water resources meet the severe demands imposed by our rapidly expanding urban areas.

Descriptors: Water demand, water management (applied), water resources development, public utilities.

481 Schraufnagel, F. H.

1967. Pollution aspects associated with chemical deicing: Natl. Research Council, Highway Research Board, Highway Research Record no. 193, p. 22–33, 4 tables, 37 references.

The use of rock salt and calcium chloride in Wisconsin for winter road maintenance dates back about 20 years. Calcium chloride can lower the freezing point more than salt, and in addition heat is evolved as it goes into solution. In the Madison area, samples were taken of street runoff at various locations including Lake Wingra and Murphy Creek, which connects Lake Wingra to Lake Monona. The maximum chloride concentration found in runoff was 3,275 mg per liter. A large amount of sand and silt is also washed off the streets. The maximum suspended solids concentration found was 3,852 mg per liter. Most BOD (biochemical oxygen demand) values were in the range of 20 to 30 mg per liter, although three were about 100 mg per liter. Samples of melt from a large snow pile along Lake Monona had chloride concentrations of 77.5 and 1,130 mg per liter. A sample of runoff from another snow pile had a chloride content of 285 mg per liter. In 1960, five wells were affected by leaching from a sand-salt stockpile. The area involved is underlain with limestone, and ground waters used for supplies normally have less than 12 mg per liter of chloride.

Descriptors: Deicers, highway deicing, water pollution sources, water pollution effects, snow removal, groundwater pollution.

482 Schulz, E. F.; Pinkayan, Subin; Komsarta, Chumporn

1971. Comparison of dimensionless unit hydrographs in Thailand and Taiwan: Nordic Hydrology, v. 2, no. 1, p. 23–46, 16 figs., 2 tables, 21 references.

To estimate peak flow for street planning, sewer design, and road drainage, the characteristics of dimensionless unit hydrographs were derived from floods from watersheds smaller than 1,000 square kilometers in Thailand. These dimensionless unit hydrographs were compared with similar unit hydrographs derived from floods on Taiwan and with the unit hydrographs derived from a mathematical model using the theory of the instantaneous unit hydrograph. The unit hydrographs derived from the Thai watersheds had much longer base length and much longer time to peak than similar unit hydrographs derived from floods on Taiwan. This increase in length of response time is attributed to a larger component of subsurface runoff in the floods from tropical watersheds.

Descriptors: Storm runoff, unit hydrographs, rainfall-runoff relationships, Thailand, Taiwan.

483 Schwob, H. H.

1970. Flood profile study, Morgan Creek, Linn County, Iowa: U.S. Geol. Survey open-file rept., 16 p., 5 figs., 6 maps, 3 references, 1 app.

Profiles were computed for a large flood of Morgan Creek, Iowa, under existing conditions and for two assumed changes of encroachment by the Cedar Rapids urban area. Morgan Creek is a small right-bank tributary of the Cedar River near the northwestern part of Cedar Rapids. The area drained at the mouth is 18.9 square miles. The land in the basin is gently rolling and is now virtually all used for agricultural purposes. Standard methods of step-backwater computation were used to define water-surface profiles for the larger flood discharge that defines the inundation level.—W70-08247.

Descriptors: Floods, stage-discharge relations, river basin development, Cedar Rapids (Iowa).

484 Schwob, H. H.

1970. Flood profile study, Hoosier Creek, Linn County, Iowa: U.S. Geol. Survey open-file rept., 18 p., 8 figs., 1 map, 2 references, 1 app.

A flood profile study was made for Hoosier Creek and its tributary, South Hoosier Creek, Linn County, Iowa. The reaches studied extend from near the south Linn County line upstream to U.S. Highway 218 on Hoosier Creek, and from the mouth to U.S. Highway 218 on South Hoosier Creek. A total of about 11 miles of stream is included in the two reaches. The profiles shown in the report are computed for a very large flood under existing valley conditions and for a smaller flood under two assumed changes of encroachment. This information can be used to supplement the existing county zoning ordinances for flood plains and to aid in future flood-plain management when part or all of the area, adjacent to the south limit of the city of Cedar Rapids, is urbanized.—W71-03932.

Descriptors: Stage-discharge relations, river basin development, Cedar Rapids (Iowa), floods.

485 Scott, K. M.

1971. Origin and sedimentology of 1969 debris flows near Glendora, California: U.S. Geol. Survey Prof. Paper 750-C, p. C242–C247, 3 figs., 2 tables, 7 references.

Watersheds near Glendora, Calif., yielded catastrophic volumes of debris slurry during the record-breaking storms of 1969. Erosion rates sufficient to reduce the entire land surface by more than 2 inches occurred in several steep mountain-front basins which had suffered brush fires in 1968. The most concentrated damage from debris flows occurred among homes built directly at the mouth of a basin with a drainage area of 0.09 square mile and a relief of 1,400 feet. Triggered in part by surficial slope failures, the debris flows mobilized channel-bed material and scoured channels to bedrock. This mechanism is probably the most common means of coarse-sediment transport in these and similar basins. Channel oaks were of considerable value in retaining debris and reducing the number and size of hillslope failures of the type which triggered the flows.—W71-13468.

Descriptors: Mudflows, floods, sedimentation, Glendora (Calif.).

486 Seabrook, C. S.

1964. Storm sewer design factors: Am. City, v. 79, no. 7, p. 76–78, 2 figs., 3 photos.

An approach to the determination of design discharges for storm sewers in Puyallup, Wash., is discussed. The runoff coefficient to be used and the actual contributing area within the given drainage area are determined by actual flow measurements to curb inlet and rainfall intensities. Only the street rights of way are regarded as the contributing drainage area, and a runoff coeffieient of 0.9 is assigned to this area for purposes of design discharge calculations. Such examination of actual runoff conditions, as opposed to the arbitrary selection of a runoff coefficient times a total contributing drainage area, saved the city some 20 percent on a million dollar storm sewer project.—W69-02195.

Descriptors: Rainfall-runoff relationships, storm runoff, rational formula, storm drains.

487 Seaburn, G. E.

1969. Effects of urban development on direct runoff to East Meadow Brook, Nassau County, Long Island, New York: U.S. Geol Survey Prof. Paper 627-B, p. B1–B14, 3 figs., 2 maps, 8 tables, 18 references.

The effects of intensive urban development on runoff to East Meadow Brook, in central Nassau County, Long Island, N.Y., during the period 1937–66, are described. The objectives of the study were to relate urban development to increases in the runoff to the stream, to compare hydrographs at different periods during the transition from rural to urban conditions, and to compare the rainfall-runoff relations for periods before and after urban development. Periods of housing and street construction correspond to three distinct periods of increased runoff. During each period the runoff increased because of an increase in the area served by storm sewers. The amount of land served by sewers increased from about 570 acres in 1943 to about 3,600 acres in 1962, or about 530 percent. During this same period, the average annual direct runoff increased from about 920 acre-feet per year to about 3,400 acre-feet per year, or about 270 percent.—W70-05712.

Descriptors: Rainfall-runoff relationships, storm runoff, storm drains, Nassau County (N.Y.), impervious area.

488 Seaburn, G. E.

1970. Preliminary analysis of rate of movement of storm runoff through the zone of aeration beneath a recharge basin on Long Island, New York: U.S. Geol. Prof. Paper 700-B, p. B196–B198, 3 figs., 1 table, 2 references.

A study of recharge basins on Long Island, N.Y., provided information on the rate of movement of water through the zone of aeration. Data were collected during 38 storms from a basin in central Nassau County, where the depth to the water table is 35 feet below the bottom of the basin. In this basin the apparent downward rate of movement averaged 5.0 feet per hour; it varied from an average of 3.0 feet per hour for storms in November through March to an average of 6.0 feet per hour for storms in April through October.—W70-08486.

Descriptors: Artificial recharge, infiltration, storm runoff, Long Island (N.Y.), Nassau County (N.Y.).

489 Seaburn, G. E.

1970. Preliminary results of hydrologic studies at two recharge basins on Long Island, New York: U.S. Geol. Survey Prof. Paper 627-C, p. C1–C17, 7 figs., 1 map, 2 photos., 1 table.

More than 2,000 recharge basins on Long Island are used to dispose of storm runoff from residential and industrial areas and highways. Two of these basins have been instrumented to measure the response time of runoff generated from a rainfall event and to study inflow patterns and infiltration rates. The time lag recorded at the Westbury test basin from the start of rainfall to the start of inflow varied from 5 to 20 minutes. The time lag from the start of rainfall to the initial rise in the water table was between 2 and 8 hours. The average ratio of storm-water inflow to rainfall closely approximates the ratio of paved street area to total drainage area of both basins. The estimated recharge in 1967 was 7.5 acre-feet for the Westbury recharge basin and 10 acre-feet for the Syosset recharge basin. The average infiltration rate at the Westbury basin for 12 storms during the summer and fall of 1967 was 211 gallons per day per square foot.—W70-05711.

Descriptors: Artificial recharge, storm runoff, Long Island (N.Y.).

490 Seaburn, G. E.

1971. Method of rating flow in a storm sewer: U.S. Geol. Survey Prof. Paper 750-D, p. D219–D223, 5 figs., 3 references.

Accurate flow measurements in storm-sewer systems are required for many hydrologic studies and are generally difficult to obtain. One approach is to use a theoretical rating curve between stage and discharge. This rating curve is developed by using the critical-flow relationship and the Bernoulli equation. To verify the theoretical curve, a measure rating curve was developed in an instrumented storm-sewer system. Three methods were used to measure flow: volumetric, current-meter, and critical-flow measurements. The measured rating curve and the theoretical rating curve are nearly identical for the range of the field tests. Instantaneous discharges exceeding the field rating curve were evaluated by using the extension of the theoretical rating curve.

Descriptors: Storm drains, discharge measurement, Long Island (N.Y.), artificial recharge.

491 Seaburn, G. E.; Aronson, D. A.

1971. Catalog of recharge basins on Long Island, N.Y.: U.S. Geol. Survey open-file rept., 28 p., 2 figs., 10 tables, 10 references.

Basic data are compiled for 2,124 recharge basins in operation in 1969 on Long Island, N.Y. These data consist of the basin location, date of construction, capacity to store water, maximum infiltration area, size, bottom altitude, overflow altitude, land-surface altitude, water-table altitude, drainage area, clogging or lack of clogging, use, geologic environment, and soil environment. Tables summarizing the data and a cross reference are included. One of the major methods of disposing of storm runoff from urban and suburban areas on Long Island is to divert the water into recharge basins. This method of disposal, begun in 1935, helps to augment and conserve water in Long Island's ground-water reservoir, the sole source of fresh water for nearly 3 million people in Nassau and Suffolk Counties. Most of the recharge basins are unlined open pits that dispose of storm runoff from residential, commercial, and industrial areas, as well as from highways.

Descriptors: Recharge, storm runoff, artificial recharge, surface-groundwater relationships, Long Island (N.Y.), Nassau County (N.Y.), Suffolk County (N.Y.).

492 Seaburn, G. E.; Laushey, L. M.

1967. Velocities of culvert jets for incipient erosion, *in* Erosion and local scour downstream from hydraulic structures, Internat. Assoc. Hydraulic Research Congress, 12th, Ft. Collins, Sept. 11–14, 1967, Proc.: v. 3, Colorado State Univ., p. C1-1 to C1-8, 4 figs.

High capacity roads too often cause streambed erosion at their drainage outlets. Stilling basins designed to reduce erosion are too expensive and seldom justified for small culverts. Studies were undertaken of using loose

stones to prevent erosion at the outlet of small culverts. The critical velocity that will initiate erosion was found by trials under full-pipe and partially full-pipe flows. In the full-pipe flow, the critical momentum was proportional to the cube of the stone size. Further, a larger velocity was required to scour spheres than to scour stones, because spheres have a smaller drag coefficient and a better hydrodynamic shape. The pipe diameter is not a useful parameter in calculating scour potential in partially full-pipe flow.—W70-07912.

Descriptors: Scour, culverts, erosion.

493 Seward, L. B.; Vandertulip, J. J.
1969. Informational needs on changes in rural watersheds and their relationships to planning activities, *in* Effects of watershed changes on streamflow, Moore, W. L. and Morgan, C. W., eds., Water Resources Symposium No. 2, Austin, Tex., Oct. 1968: Austin, Texas Univ. Press, p. 37–43, 1 fig.

Studies for the Texas water plan must include computations to determine runoff accurately under all conditions. Present depletions by man of the various river basins of the State must be evaluated. Accurate data are necessary on domestic, industrial, and agricultural water use. Depletions at sites of use must be computed and then routed downstream to determine channel losses resulting from manmade depletions. Inflow-outflow hydrologic studies must be conducted to analyze reaches of streams and rivers.—W70-04724.

Descriptors: Data collections, water resources development, Texas, planning.

494 Shadegg, S. C.
1969. Century one, 1869–1969, one hundred years of water development in the Salt River Valley; the story of man's progress in central Arizona: Phoenix, Ariz., Salt River Project, Community Relations, 48 p., 3 figs., 3 maps, 103 photos.

The basic history of irrigated agriculture in the Phoenix area is outlined. The Salt River project is the major interest of the history, which covers in detail irrigation in the Salt River Valley, passage of the National Reclamation Act of 1902, organization of the Salt River Valley Water Users Association in 1903, and growth to the present. Changes in orientation toward urban and industrial water use and the influence of the project on the economic development of Arizona are discussed.—W70-06807.

Descriptors: Irrigation, dams, Salt River (Ariz.), water resources development.

495 Sharp, R. W.
1971. Road salt as a polluting element, *in* Street salting, urban water quality workshop, Syracuse, N.Y., May 5–6, 1971, Symposium Proc.: Syracuse, N.Y., Syracuse Univ., College of Forestry, p. 70–73, 5 references.

The use of salt for snow and ice control on streets and highways has grown rapidly. In the winter of 1964–65, Milwaukee, Wis., used 33,000 tons of sodium chloride and 200 tons of calcium chloride. The Wisconsin highway department used 160,000 tons, or 15.8 tons per mile. The chlorides are carried by runoff to lakes and streams. Effects appear to be localized near urban centers and along heavily used routes. Diamond Lake, in Hennepin County, Wis., which receives the discharge of a major storm sewer now has a chloride content of 2,270 ppm. Bluegills will tolerate 10,000 ppm sodium chloride. Studies show a substantial build-up in chloride content of domestic wells located adjacent to highways. Chloride levels exceeding the potable water supply standard of 250 ppm have been found in many states as a result of road salt.

Descriptors: Water pollution sources, deicers, highway deicing, sodium chloride, groundwater pollution.

496 Sheaffer, J. R.; Oelberg, Emil; Hackett, J. E.
1968. Water resource management in Mt. Prospect—a survey of the environment, problems, and opportunities: Wheaton, Ill., John R. Sheaffer and Associates, 30 p., 9 figs., 1 table, 2 references.

A series of chronic water problems in northern Illinois included sewer backup, flooding, pollution of streams, and falling water levels in municipal wells. A drainage and clean streams commission was organized to correct the problems and to examine the water resource opportunities available to Mt. Prospect. Urbanization has altered to a large extent the physical environment in the Mt. Prospect area. The most significant effects of urbanization have been caused by the sewerage and drainage system and by urban development in flood-prone

areas. A comprehensive program of water-resource management should be based upon structural and non-structural alternatives and should be compatible with programs of municipalities and regional agencies. Recommendations include: flood plain management; water use management; flood water storage; construction of multiple-purpose lakes as detention reservoirs; and an increase in the flow potential of Weller Creek, one of Mt. Prospect's natural drainage outlets.—W69-03168.

Descriptors: Water management (applied), Mt. Prospect (Ill.), planning, floods, groundwater depletion, water pollution sources.

497 Sheaffer, J. R.; Zeizel, A. J.
1966. The water resource in northeastern Illinois; planning its use: Chicago, Ill., Northeastern Illinois Metropolitan Area Planning Comm., Tech. Rept. 4, 182 p., 55 figs., 40 tables, 96 references.

The potentials of the various water sources available in northern Illinois are assessed. Water management and the balance of supply against demands under various types of management are evaluated. Legislation related to water management is analyzed, and recommendations are advanced for legal areas where changes are desirable. Pollution of surface and ground water, falling water levels in wells, damaging floods alternating with periods of inadequate stream flow, the growing shortage of water-oriented recreational facilities, and the general overall laxity in applying known management techniques are all serious problems in the area. Recommended management measures include storage of surface water, interbasin transfer, management of the withdrawal and replenishment of ground water, conjunctive use of surface and ground water, water quality management, and management of water use.—W68-00843.

Descriptors: Water management (applied), water resources development, Chicago (Ill.), planning, groundwater depletion.

498 Shigorin, Georgii G.
1956. Problems in the pollution of urban surface runoff: Vodosnabzhenie i Sanitarnaia Tekhnika, no. 2, p. 19–20, 1 table.

Quality of storm water and street-washing water in sewers and gutters of the Leningrad sewerage system were studied by the Leningrad Scientific Research Institute of the Academy of Municipal Economy. Storm-water flow in gutters of uncongested cobblestone streets contained an average of 14,541 mg of suspended matter per liter. Oxidation potential of the water was 56.5 mg per liter, and 5-day and 20-day biochemical oxygen demand values were 36.2 mg per liter and 63 mg per liter, respectively. The concentration of suspended matter from cobblestone streets was 1.1–1.3 times less than that from heavily traveled asphalt roads.

Descriptors: Water pollution sources, storm runoff, Leningrad (USSR).

499 Simpson, L. D.
1969. Summary report, storms of 1969: Los Angeles County Flood Control District, California, Summary Report, 55 p., 30 photos., 1 plate, 3 tables.

Data on flood-producing storms of 1969 in Los Angeles County, Calif., are tabulated. During the months of January and February of 1969, storms over the southern California area were of such a magnitude as to tax the capacities of a number of the facilities of the district and to cause significant damage to public and private property in those areas where complete flood protection had not yet been attained. These storms began with a two-phase storm which occurred between January 18 and 26, 1969, followed by a storm which occurred between February 23 and 25, 1969.—W70-06542.

Descriptors: Floods, storm runoff, Los Angeles (Calif.), drainage (urban).

500 Smith, R. E.; Johnson, S. L.
1966. Urban hydrology, Houston metropolitan area, Texas, 1964: Austin, Tex., U.S. Geol. Survey basic-data rept., 18 p., 11 figs., 3 tables.

The purpose of this report is to outline the progress made in a cooperative program between the city of Houston, Tex., and the U.S. Geological Survey to determine the changes in magnitude of floodflow and runoff

caused by urbanization at selected stream-gaging sites. The records collected will provide data on floodflow magnitude and frequency at the gaging sites and can be used in predicting floodflow from ungaged areas. The network of streamflow and precipitation data collection sites determined to be needed for adequate sampling consists of seven continuous rainfall and runoff sites, 15 flood-hydrograph partial-record sites, and six recording rain gages. Instruments used at flood-hydrograph stations will also furnish a continuous record of rainfall of sufficient accuracy to supplement other rainfall records during significant storm periods. The drainage areas selected for sampling range in size from less than 1 square mile to 19.5 square miles. They are well distributed throughout the metropolitan area to obtain data from areas of varying stages of development and from areas of different types of cover, shape, and topography.

Descriptors: Storm runoff, Houston (Tex.), stream gages, rainfall-runoff relationships, data collections, hydrologic data.

501 Smith, R. L.

1968. General observations relating to analytical needs in urban hydrology, *in* Urban water resources research; systematic study and development of long-range programs of urban water resources research, first year report: New York, Am. Soc. Civil Engineers, app. A, chap. 1, p. A6–A14, 1 table, 15 references.

Urban hydrologic problems can be studied by approaches including: direct field measurements; scale and analog models; and analysis and synthesis utilizing electronic computers. System simulation techniques include deterministic methods and stochastic methods. Deterministic models attempt to develop relationships among measured physical parameters and processes involved in the hydrologic cycle. These relationships are then used to generate or to predict non-recorded hydrologic sequences. The principal input function is rainfall, and the principal output function is runoff. In the case of quality models, the input requires magnitude and location of system loads, and the output is the time distribution of concentration.

Descriptors: Rainfall-runoff relationships, mathematical models, simulation analysis, statistical models, model studies, data collections.

502 Smith, R. L.

1968. Application of models in urban hydrology, *in* Urban water resources research; systematic study and development of long-range programs of urban water resources research, first year report: New York, Am. Soc. Civil Engineers, app. A, chap. 2, p. A15–A21, 7 references.

Urban hydrology model development should be coordinated with associated basic data and research activities. In order to test the transfer capability of the models, 3 to 5 years of data sufficient to provide an appropriate range of input variables should be collected. Most existing models, owing to limitations in available data, utilize limited climatic input; usually this consists of low-density precipitation coverage plus evaporation (or temperature). Similarly, watershed parameters are usually limited to readily identifiable factors such as slope, surface characteristics, and channel conveyance characteristics. Measured output is normally limited to surface flow. Perfection of adequate modeling techniques would be of great assistance to public works administrators in appraising the adequacy of their existing storm drainage systems.

Descriptors: Rainfall-runoff relationships, mathematical models, simulation analysis, statistical models, model studies, data collections.

503 Smith, R. L.; O'Brien, W. J.; Le Feuvre, A. R.; Pogge, E. C.

1967. Development and evaluation of a mathematical model of the lower reaches of the Kansas River drainage system: Lawrence, Kansas Univ., Center for Research, Inc., Eng. Sci. Div., 96 p., 34 figs., 25 references, 5 app.

A mathematical model simulates the distribution of the conservative and the nonconservative water qaulity of the lower Kansas River system. The model consists of three digital computer programs and considers both quasi-steady-state and dynamic hydrologic boundary conditions. The hydrologic and conservative portion of the

model was tested for verification with discharge records for 6 time periods of from 4 to 6 weeks in length. The completed model is capable of simulating the hydrologic behavior of the river system, predicting the history and distribution of conservative and nonconservative pollutants throughout the river system, and predicting the location of critical areas of pollution under various types of river-basin development.

Descriptors: Water pollution effects, path of pollutants, mathematical models, Kansas River (Kans.).

504 Smoot, G. F.

1971. Data collection for real-time systems, *in* Treatise on urban water systems, Albertson, M. L., Tucker, L. S., and Taylor, D. C., eds.: Fort Collins, Colorado State Univ., p. 499–508, 1 table, 6 references.

Existing devices and methods which might be used in data-collection systems for metropolitan areas are reviewed and evaluated. The discussion includes devices for measurement of precipitation, surface runoff, sewers, open channels, water quality, and systems for transmitting and logging of data. A data-collection system for a metropolitan area must collect data from the network on a common-time base. The use of a mixed-time base would result in chaos, confusion, and loss of records. A computer-based control data-logging system would provide not only the required precise time correlation but also the real-time data required for the urban operational and management service. Such a system would permit programming to record only storm events, thus avoiding an excessive quantity of data that would otherwise result. Real-time data collection also provides a means for effective surveillance of the operating condition of instrumentation.

Descriptors: Data collections, storm runoff, instrumentation, telemetry, rainfall-runoff relationships.

505 Snyder, F. F.

1958. Synthetic flood frequency; Am. Soc. Civil Engineers Proc., Paper 1808, Jour. Hydraulics Div., v. 84, no. HY 5, pt. 1, p. 1808-1 to 1808-22, 5 figs., 3 tables, 10 references, 2 app.

A procedure is developed for computing the flood discharge probability associated with a given rainfall-duration-frequency pattern on natural drainage basins, overland flow areas with storm sewer drainage. The method uses basin characteristics of area, length, slope, friction, and shape. The approach is patterned after the rational method and utilizes the time-of-concentration concept with unit hydrographs but evaluates the effect of storage in channels or conduits and uses an average rainfall-runoff relation. The variables were evaluated for application in the vicinity of Washington, D.C.

Descriptors: Rainfall-runoff relationships, rational formula, depth-area-duration analysis, flood frequency, Washington (D.C.).

506 Snyder, W. M.

1967. Simplified versus optimum unit hydrographs, one comparison: Water Resources Research, v. 3, no. 4, p. 947–948, 2 tables, 4 references.

A unit hydrograph derived from a record storm previously analyzed for the optimum, realizable unit hydrograph was improved by simplified curve-fitting procedures. This produced a more rational-appearing unit hydrograph. An urban rainfall-runoff event using a segmented linear form for a 2-minute unit hydrograph illustrates the procedure.—W69-01052.

Descriptors: Rainfall-runoff relationships, storm runoff, unit hydrographs.

507 Soderlund, G.; Lehtinen, H.; Friberg, S.

1971. Physiochemical and microbiological properties of urban storm water runoff, *in* Internat. Conf. on Water Pollution Research, 5th, San Francisco, Calif., July 26 to Aug. 1, 1970, Proc.: Internat. Assoc. on Water Pollution Research, Preprint Paper I-2, 8 p., 18 figs.

In Sweden today storm and sanitary sewers are usually separated. This avoids discharging mixed storm water and waste water into streams and inland waters. Discharge of snowmelt from heavily trafficked areas into streams and inland waters contributes oil and heavy metals to pollution. Storm water from roads is contaminated with oil not only from traffic but also from industrial areas. The use of cutting oils and emulsions, dry cleaning liquids, and industrial cleaning liquids is increasing, and the problem of collection and destroying such waste liquids must be solved. Nearly 50 percent of the dry residue obtained from warm-water runoff is volatile material, asphalt, rubber, and oil. Other constituents measured are chloride, pH, nitrogen, phosphorus, coliforms, carbohydrates, and BOD (biochemical oxygen demand).—W70-10398.

Descriptors: Storm runoff, water pollution sources, Sweden, runoff.

508 Soil Conservation Society of America.

1970. Frontiers in conservation, 24th Annual Meeting, Soil Conserv. Soc. America, Colorado State Univ., Ft. Collins, Aug. 10–13, 1969, Proc.: Ankeny, Iowa, Soil Conserv. Soc. America, 162 p., 55 figs., 13 tables, 1 photo., 92 references.

Forty-four papers presented at the 24th annual meeting of the Soil Conservation Society of America are included in this volume. Major topics include: soil and land management to meet conservation goals; water resources utilization and management; wastes in relation to agriculture and forestry; outdoor recreational and natural beauty needs and opportunities; urban-suburban conservation; and utilization of land to meet future needs. Portions of the meeting included college student sessions and technical study committee sessions.—W71-06129.

Descriptors: Conferences, land management, flood control, sedimentation.

509 Soren, Julian

1971. Ground-water and geohydrologic conditions in Queens County, Long Island, New York: U.S. Geol. Survey Water-Supply Paper 2001-A, p. A1–A39, 4 figs., 2 maps, 1 table, 19 references.

Queens County is a heavily populated borough of New York City at the western end of Long Island, N.Y. Large amounts of ground water are used, mostly for public supply. The county's aquifers consist of sand and gravel in a wedge-shaped reservoir lying on a southeastward-sloping floor of bedrock. Withdrawal averaged about 60 mgd from about 1900 to 1967. The county has been extensively paved, and storm and sanitary sewers divert water which formerly entered the ground to discharge points outside the area. Natural recharge is about one-half of the natural rate and is below the withdrawal rate. Ground-water levels have declined more than 40 feet. The water table is below sea level in much of the county. The aquifers are contaminated by salty ground water. Thermal pollution of the ground water has occurred locally where ground water pumped for cooling uses is returned hot to the aquifer through recharge wells.

Descriptors: Drawdown, groundwater, New York City, Queens County (N.Y.), recharge, groundwater depletion.

510 Spieker, A. M.

1968. Some observation of streamflow and water quality in the urban environment, *in* Am. Water Resources Conf., 4th, New York, N.Y., Nov. 18–22, 1968, Proc.: Am. Water Resources Assoc., p. 742–753, 7 figs., 3 maps, 4 references.

The effects of urbanization on the hydrologic regimen are studied through observation of the Salt Creek basin in Illinois from 1940 to 1965. The effects of urbanization on low flows may be significant. Discharge of sewage from the local drainage basin by affiliation with the Metropolitan Sanitary District of greater Chicago may reduce flow almost completely during dry periods. Where a community operates its own treatment plant, increased population brings about increased sewage effluent discharge. Where treatment is good, DO (dissolved oxygen) and BOD (biochemical oxygen demand) readings at several locations show favorable conditions during

the flooding period. Exceptions result from untreated discharge from combined sewer systems. Dissolved solids concentrations are much higher at low flow. Coliform bacterial counts are higher during high flows in areas with combined sewers or accumulated sludge in streambeds.—W71-00318.

Descriptors: Water pollution sources, rainfall-runoff relationships, Salt Creek Basin (Ill.).

511 Spieker, A. M.

1969. Urbanization and the water balance, *in* Symposium on Water Balance in North America, Banff, Alberta, Canada, June 23–26, 1969, Proc.: Am. Water Resources Assoc., p. 182–187, 2 figs., 8 references.

Urbanization modifies the hydrologic balance by causing changes in the distribution and quality of water in time and place. The overall quantity of water, however, remains essentially unchanged. In extreme cases, the lack of adequate management measures can result in catastrophic events. In 1969 floods in Southern California were intensified by uncontrolled urban sprawl in alluvial fans and canyons. Sewering of urbanized areas on Long Island has caused an increase in direct runoff and flood peaks and a lowering of ground-water levels. In Fairfax County, Va., urbanization in small watersheds increases peak flow by 2 to 3 times and shortens the lag time by about 8 times. Construction in urbanizing areas can result in increased sediment loads in streams and lakes. Chemical and bacterial quality of water are also affected. Studies of Salt Creek, a small stream in suburban Chicago, indicate high coliform and BOD (biochemical oxygen demand) levels at both low and high flows. Coliform counts are greater at high flows, resulting from combined sewer overflows.—W70-08990.

Descriptors: Rainfall-runoff relationships, water pollution sources, sediment load, peak discharge, sedimentation, combined sewers.

512 Spieker, A. M.

1970. Water in urban planning, Salt Creek basin, Illinois: U.S. Geol. Survey Water-Supply Paper 2002, 147 p., 30 figs., 22 maps, 5 photos., 5 tables, 31 references.

This report concentrates on problems of ground-water recharge, water quality, management of flood plains, and flood-control measures in the Salt Creek basin in Cook and Du Page Counties, part of the rapidly developing Chicago metropolitan area. Salt Creek basin has a drainage area of 150 square miles. It is flat to gently rolling terrain, underlain by glacial drift as much as 200 feet thick which covers a dolomite aquifer. In 1964, the population of the basin was about 400,000, and 40 percent of the land was in urban development. The population is expected to number 550,000–650,000 by 1990, and most of the land will be taken by urban development.—W70-10070.

Descriptors: Water quality, groundwater, water pollution sources, water management (applied), recharge, flood control, Salt Creek basin (Ill.).

513 Stall, J. B.

1970. Runoff from an urban basin by the British Road Research Laboratory method, *in* Annual Midwestern States Flood Control and Water Resources Conf., 25th, Chicago, Ill., Sept. 3–4, 1970, Proc.: 12 p., 2 figs., 2 tables, 3 references.

A design method for urban storm runoff developed by the Road Research Laboratory of the Ministry of Transport of the British Government is reviewed. Starting more than 20 years ago, a study was made of existing hydrologic methods, and a research program was devised. Twelve basins were selected in urbanized areas of Great Britain; equipment for measuring streamflow and rainfall was devised, installed, and was operated from 1950 to 1959. Measurements of storm rainfall and storm runoff from 286 storms were collected and analyzed, and results of the rational method and the unit hydrograph method were compared. As a first step in using the RRL method, the total paved area of the basin is mapped. A map of travel time in minutes from each portion of the basin is computed. The areas covered with grass or with paved areas which are not directly connected to the storm-drainage system are all excluded from the analysis. In practice, a particular rainfall event is mapped from

the rain gages. The rainstorm values are applied to each of the areas. This virtual inflow hydrograph is routed to account for storage within the storm-drainage system. This routing process provides the actual streamflow hydrograph at the outlet.

Descriptors: Storm runoff, rainfall-runoff relationships, Road Research Laboratory method, hydrograph analysis.

514 Stall, J. B.; Huff, F. A.

1971. The structure of thunderstorm rainfall—National Water Resources Eng. Meeting, Phoenix, Ariz., Jan. 11–15, 1971: Am. Soc. Civil Engineers, Preprint no. 1330, 30 p., 12 figs., 7 tables, 17 references.

In the Midwest, heavy storm rainfall occurs most frequently from thunderstorm cells. The average rain cell has a diameter of 3 to 6 miles, moves at a velocity of 20 to 30 miles per hour, and has a duration of 30 to 60 minutes. Most of the rainfall occurs during the first 10 minutes; it occurs in two to four bursts; and two or three cells usually occur together. The resulting dynamic rainfall input onto an urban basin is represented by a matrix in six dimensions of depth, area, duration, frequency, sequence, and place. Illustrations are given of five traditional, two-dimensional plots dealing with various pairs of these six parameters or dimensions. Using point rainfall data for north-central Illinois, the Road Research Laboratory hydroeffect method is used for an urban basin in Chicago to show the effect of rainfall variability on the resulting flood runoff hydrograph.—W71-07924.

Descriptors: Storm runoff, thunderstorms, rainfall disposition, Chicago (Ill.), depth-area-duration analysis, Road Research Laboratory method.

515 Stall, J. B.; Terstriep, M. L.; Huff, F. A.

1970. Some effects of urbanization on floods: Natl. Water Resources Meeting, Am. Soc. Civil Engineers, Memphis, Tenn., Jan. 26–30, 1970, Preprint 1130, 29 p., 11 figs., 10 tables, 22 references.

A better definition of the effects of urbanization on floods was attempted by using information available in Illinois on storm rainfall structure and frequency and translating this into the resulting effect on the flood-frequency curve by using a set of empirical equations developed at the University of Texas. The Texas equations were used as a transfer function from storm rainfall to flood peak. A model 2-hour rainstorm was developed for various recurrence intervals and applied to the completely urbanized 3.5-square-mile drainage area of Boneyard Creek at Urbana, Ill. Equations seem adequate to produce a 30-minute unit hydrograph for the Boneyard basin, and it checks favorably with actual unit hydrographs. The complete transformation of a 3.5-square-mile rural basin, in east-central Illinois, to an intensely urbanized basin would quadruple the flood peak for the 50-year recurrence interval; the mean annual flood would increase by about 8 times.—W71-01336.

Descriptors: Storm runoff, rainfall-runoff relationships, peak discharge, Illinois, flood frequency, unit hydrographs.

516 Stankowski, S. J.

1972. Population density as an indirect indicator of urban and suburban land-surface modifications: U.S. Geol. Survey Prof. Paper 800-B, p. B219–B224, 2 figs., 2 tables, 11 references.

A new method was developed for determining a quantitative index of urban and suburban land-use characteristics for application in regional water-resources analyses. Population density is the only independent variable needed to estimate empirically the proportion of impervious area resulting from urban and suburban development. This formulation is based on correlations between population density and the proportions of land area in each of six urban and suburban land-use categories. The proportions of land use are weighted by the average percentage of impervious area found in each land-use category. The method is illustrated using county land-use and population-density data for New Jersey. The procedure, though limited by the averaging process, is an inexpensive and rapid technique for generating quantitative indices of land-surface development for use in preliminary and general hydrologic studies and projections.

Descriptors: Land use, rainfall-runoff relationships, peak discharge, population density, impervious area.

517 Stetson, C. L.; Meffler, R. W.; McIntyre, V. B.; and others.

1965. Fresno-Clovis metropolitan area water quality investigation: California, Dept. of Water Resources, Bull. 143-3, 42 p., 7 tables, 11 plates, 15 references, 4 app.

In general, the quality of ground and surface water in the Fresno-Clovis metropolitan area in California is excellent. Effluents from waste disposal systems in the metropolitan area are discharged on or under the land surface for percolation, evaporation, and utilization by crops. Lower quality ground water was found in the vicinity of the Fresno sewage treatment plant. Nitrate concentrations near and above the U.S. Public Health Service's maximum limit of 45 ppm were found in some locations throughout the metropolitan area. Nitrate contents are high in waters from shallow wells in an unsewered region southwest of the Fresno air terminal. Lowering of the ground-water table under the heart of Fresno's downtown area and ground-water recharge by land disposal of effluent from the Fresno sewage treatment plant have caused a change in the slope of the water table near the plant. If this continues, ground water could flow from the vicinity of the sewage treatment plant toward the heart of Fresno.

Descriptors: Water pollution sources, groundwater pollution, groundwater depletion, Fresno (Calif.).

518 Steytler, R. B.

1960. Simplified sewer design: Public Works, v. 91, no. 6, p. 102–104, 2 figs.

The sewer system of the city of Erie, Pa., should be enlarged to serve growth in population and expansion of the urbanized area. A simplified sewer design method was developed for use in extending and modifying the storm and sanitary sewer systems. The method consists of equating area to quantity of both sanitary and storm flow, and superimposing the information on any one of a number of sewer design charts available. In this case a diagram based on Kutter's formula (N=0.013) was selected. Drainage areas for both sanitary and storm drainage are plotted on the sewer design chart opposite the corresponding quantities of sewer flow. The sanitary portion of the chart was designed strictly on a population basis, with a sufficient safety factor to lead to an over-design.—W69-02198.

Descriptors: Storm runoff, rainfall intensity, storm drains, Erie (Pa.), planning, drainage systems.

519 Stout, G. E.

1962. Some observations of cloud initiation in industrial areas, *in* Air over Cities: Environmental Protection Agency, Robert A. Taft Sanitary Eng. Center, Cincinnati, Ohio, SEC Tech. Rept. A62-5, p. 147–153, 2 figs., 7 references.

A petro-chemical industry located in the rural areas of central Illinois was observed to initiate clouds. At least five cases are partially documented by surface, airborne, or radar observations. On one occasion a cumulus congestus cloud formed and produced tornado funnels. No other clouds were present in the area. Other cases are discussed, and the available data are presented. Preliminary observations suggest that this industrial source could be used for an interesting research study of the possible influence of industrial pollution on cloud formations.

Descriptors: Clouds, climatology, weather patterns, air pollution effects.

520 Stout, G. E.; Huff, F. A.

1962. Studies of severe rainstorms in Illinois: Am. Soc. Civil Engineers Proc., Paper 3202, Jour. Hydraulics Div., v. 88, no. HY 4, p. 129–146, 7 figs., 8 tables, 14 references.

A network of 10 recording rain gages on a 10-square-mile urban area was used to study distribution characteristics of heavy rainstorms over urban watersheds for a 10-year period. Twice as many excessive quantities occur within a 10-square-mile area as occur at any specific point within the area. The proportion of the area experiencing excessive rainfall increases with increasing storm duration. The majority of the excessive quantities of

rainfall lasting from 30 minutes to 24 hours occur in the same storms. Although a single rain gage records only a portion of the excessive rate occurrences in 10 square miles, a point rainfall record is satisfactory index of frequency distribution of areal mean rainfall. Urban influences, if present, are not of practical significance in the distribution of excessive quantities.—W69-01896.

Descriptors: Weather patterns, storm runoff, rain gages, hydrologic data, data collections.

521 Struzeski, E. J., Jr.
1971. Environmental impact of highway deicing, *in* Street salting, urban water quality workshop, Syracuse, N.Y., May 5–6, 1971, Proc.: Syracuse, N.Y., Syracuse Univ., College of Forestry, p. 14–19.

The effect of highway deicing on the environment is reviewed. Current annual use of highway deicers is around 9 million tons of sodium chloride, about one-third million tons of calcium chloride, and about 8 million tons of abrasives. Leading states in deicer use are Pennsylvania, Ohio, New York, Michigan, and Minnesota. Serious ground-water pollution has occurred in many locations due to the heavy application of salts onto highways. The State of New Hampshire up to 1965 had replaced more than 200 roadside wells due to contamination by road salts. Some of these wells contained chlorides in excess of 3,500 mg per liter. Tastes and odors in domestic water supplies in Connecticut have been traced to chlorides and sodium ferrocyanide originating from salt storage areas. Within Massachusetts, salt increases have been noted in the water supplies of some 63 communities, and various supplies have been abandoned due in part to road salting and salt storage piles.—W71-13434.

Descriptors: Water pollution sources, deicers, highway deicing.

522 Struzeski, E. J., Jr.
1971. Environmental impact of highway deicing: Environmental Protection Agency, Water Quality Office, Water Pollution Control Research Series 11040-GKK-06/71, 120 p., 43 figs., 9 tables, 147 references.

See Environmental Protection Agency, Water Quality Office Rept., Water Pollution Control Research Series 11040-GKK-06/71.

523 Sugiki, A.; Matsuo, T.; Tanaka, K.
1969. Water resources studies in the Ara Valley, *in* Advances in water pollution research, Internat. Conf. on Water Pollution Research, 4th, Prague, Czechoslovakia, Apr. 21–25, 1969, Proc.: Internat. Assoc. on Water Pollution Research, p. 107–119, 5 figs., 8 tables, 5 references, 2 app.

Water pollution control of rivers in Japan requires careful study because of the many problems created by the rapid pace of urbanization and industrialization. In 1985 about 80 percent of Japan's population will dwell in urban areas, and industrial production will be 7–8 times greater than at present. With these drastic developments it is necessary to determine how rivers may be maintained free of pollution. A plan proposed for water conservation in Japan is illustrated by the Ara River, a typical polluted river in the Tokyo metropolitan area, as a case study. A general description is given of the present and future conditions of the Ara River basin. Future water demands and pollution loads are predicted. Regulation of industrial development is proposed as a regional planning approach. A systems analytical method is applied to obtain an economically and technically optimum water conservation plan.—W70-08635.

Descriptors: Water resources development, planning, water pollution control, Tokyo (Japan).

524 Sundborg, Ake
1951. Climatological studies in Uppsala with special regard to the temperature conditions in the urban area: Geographica, no. 22, 111 p., 21 figs., 13 maps, 10 tables, 66 references.

A compact city area (Uppsala, Sweden) with its mass of houses, industrial structures, streets, and parks constitutes a pronounced interruption in the natural formation of the landscape. The changes in the surface configuration alone are sufficient to produce a modification of the climatological elements. More significant, however, are the consequences of commercial and industrial activity. Combustion processes and other transformations of energy make cities act as heat generators of great magnitude. These processes are simultaneously attended by a

considerable production of dust particles which surround the city like a cloud and influence the radiation balance. Not only is the radiation climate peculiar in a city, but other climatological elements as well, such as temperature, humidity, wind, and precipitation, all differ from those of the surrounding countryside. Local differences are not of great importance in normal weather situations or with strong wind velocities. In extreme situations, especially in clear weather and weak wind, very significant differences appear.

Descriptors: Climatology, microclimate, air pollution effects, weather patterns, precipitation (atmosphere), Uppsala (Sweden).

525 Suter, Russell

1937. Engineering report on the water supplies of Long Island: New York State Water Power and Control Comm., Bull. GW-2, 64 p., 35 figs., 7 references.

Long Island ground waters are part of the water supply resources of the city of New York. The amount available cannot exceed the amount of rainfall and, as a matter of practical development, can never exceed a fraction of that rainfall. This resource was being destroyed in 1937 by unregulated exploitation. The beds under Brooklyn were nearly gone, those under Queens were going, and those under Nassau were adversely affected. Overpumping destroys the value of the aquifers by causing saline water intrusion. Demands for water in the city of New York in 1937 exceeded the safe capacity of the water works systems.

Descriptors: Groundwater depletion, saline water intrusion, New York City, Long Island (N.Y.).

526 Sutherland, G. A.

1967. Progress to date and current works at Glenrothes New Town: Inst. Municipal Engineers Jour., v. 94, no. 10, p. 325–329, 3 figs.

Glenrothes, the second new town in Scotland, was designated to contain an area of 5,730 acres and a target population of 32,000. The complete system of foul and surface water catchments is gravity-operated, and it has not been necessary to resort to either pumping or tunneling to maintain the gravity system. Two catchments, one draining the northern portion of the town (3,550 acres) and one draining the southern portion (2,180 acres), are described. A once-in-ten-year storm which should produce bankfull conditions and flooding has been provided for by 20 acres of balancing pond capacity based on an average water depth of 3 feet. The trunk surface water sewer was designed by the Road Research Laboratory's unit hydrograph method for a once-per-year storm. Subsidiary sewers were designed using the rational method and Bilham's once-per-year storm. Continuing rainfall observation is expected to establish a rainfall intensity curve for the area.—W69-02199.

Descriptors: Storm drains, drainage (urban), Glenrothes (Scotland), flood control.

527 Swallow, L. A.; Petersen, R. G.; Searles, G. H.

1971. Flood of March 1968 on the Charles River, Massachusetts: U.S. Geol. Survey Hydrol. Inv. Atlas HA-419, 2 sheets, scale 1:12,000, 4 figs., 2 photos, 1 table, 4 references.

This two-sheet hydrologic atlas presents six photomosaics which show areas inundated along the Charles River during the record flood of March 1968. Flood data for the gaging stations in the basin illustrate the magnitude of the 1968 flood and should assist State and local planners in making decisions pertaining to flood-plain zoning and flood prevention. The flood of March 1968 on the Charles River was caused by an intense 3-day storm which began on March 17. The rain, totaling from 5 to 6 inches in 36 hours, fell on ground already saturated by snowmelt and 1½ to 2 inches of precipitation on March 12–13. The peak discharge was 3,220 cfs for March 21–22, 1968.

Descriptors: Floods, storm runoff, Charles River (Mass.), planning.

528 Swarzenski, W. V.

1963. Hydrogeology of northwestern Nassau and northeastern Queens Counties Long Island, New York: U.S. Geol. Survey Water-Supply Paper 1657, 90 p., 14 figs., 13 plates, 10 tables, 27 references.

The geology and ground-water occurrence in northwestern Nassau and northeastern Queens Counties, N.Y., are described. Unconsolidated sediments, 200 to 800 feet thick, constitute the ground-water reservoir. In general,

ground-water supplies in sufficient quantity and of excellent quality can be obtained from the three aquifers underlying northwestern Nassau and northeastern Queens Counties, N.Y. Ground-water withdrawals for public supply have increased with population growth and expanded use from an average of about 10 mgd in 1940 to 30 mgd in 1957. In addition, about 10 mgd of water is pumped for other uses. Much of the water pumped by industry is returned to the ground by diffusion wells and recharge basins. However, an increasing amount of water is lost from the ground-water reservoir due to the expanding network of sewer systems discharging directly into the ocean. Excessive pumping has caused sea-water encroachment.

Descriptors: Hydrogeology, Long Island (N.Y.), groundwater, Nassau County (N.Y.), Queens County (N.Y.).

529 Sylvester, R. O.; Anderson, G. C.
1964. A lake's response to its environment: Am. Soc. Civil Engineers Proc., Paper 3786, Jour. Sanitary Eng. Div., v. 90, no. SA 1, pt. 1, p. 1–22, 4 figs., 1 photo, 6 tables, 19 references, 1 app.

Green Lake in Seattle, Wash., was studied to find the causes underlying its heavy algae blooms and pollution so that its recreational potential might be realized. Data were obtained on urban runoff, lakeshore runoff, subsurface inflow, algae populations, waterfowl, composition of sediments, effect of wind-induced currents on water quality, and requirements of competing recreational water uses. Water and nutrient budgets are presented. Nutrient additions sustain heavy algae blooms throughout most of the year. Bacterial contamination is directly related to waterfowl populations. Changes in physical and chemical water quality are caused largely by algal growth and decay. Recommendations are given for the addition of low-nutrient city water for dilution purposes, for dredging, and for shoreline improvements. It is recommended that increased quantities of storm water not be added.—W69-02217.

Descriptors: Water pollution sources, lakes, storm runoff, drainage (urban), Seattle (Wash.), eutrophication, water pollution control.

530 Symons, J. M.
1970. Urban sources of nitrate: 12th Sanitary Eng. Conf., Illinois Univ., Urbana, Feb. 11–12, 1970, Proc., p. 78–83, 3 tables, 11 references.

Urban sources of nitrate, nitrite, ammonia, and organic nitrogen are discussed. The sources of urban nitrogen include human wastes from individual and central sewage systems, runoff from separate and combined storm-water systems, rainfall, and industrial wastes. These sources are discussed in terms of the quantities and concentrations of readily biologically oxidizable nitrogen they contribute and the degree of dilution each has to undergo to meet the requirements for nitrate in drinking water supplies.—W71-09959.

Descriptors: Water pollution sources, nitrates, runoff, water quality.

531 Robert A. Taft Sanitary Engineering Center.
1961. Algae and metropolitan wastes: Seminar on algae and metropolitan wastes, Cincinnati, Ohio, Apr. 27–29, 1960, Trans.: Robert A. Taft Sanitary Eng. Center, Tech. Rept. W61-3, 162 p.

In April 1960, a seminar met in Cincinnati, Ohio, to consider the problems of algae and metropolitan wastes. Discussions at the seminar were limited to prevention and control of objectionable algal blooms arising from enrichment by urban and other wastes. The conference was organized into panel discussions as follows: statement of the problem, growth characteristics of algae, sources of nutrients, methods of prevention or control. Specific problems in lakes, rivers, algal nutrition, measurement of productivity, land drainage, limnological relationships, nutrient limitation, and algicide use were the topics discussed.—W70-04506.

Descriptors: Conferences, eutrophication, water pollution effects.

532 Telford, J. W.
1960. Freezing nuclei from industrial processes: Jour. of Meteorology, v. 17, p. 676–679, 2 maps, 1 photo, 5 references.

Some of the freezing nuclei in the urban atmosphere come from industrial activity. The smoke from a steel furnace in Sydney, Australia, was identified as a prolific source. Counts of the natural freezing nuclei should be

made at remote locations or in aircraft flying well above the smoke layers. Measurements were taken at 24 degrees C, and about 10 crystals were usually sampled, thus avoiding inaccuracies of very small samples. Since most natural clouds are already nucleated at 24 degrees C, the effect of these nucleus concentrations on rainfall depends on the relationship between counts at warmer temperatures than those observed. If concentrations are larger at warmer temperatures, it seems reasonable to expect more rain downwind from industrial concerns than would otherwise fall if the smoke were entirely inactive.

Descriptors: Air pollution effects, precipitation (atmospheric), clouds, Sydney (Australia).

533 Terjung, W. H.; and others.
1971. The effect of a cyclonic storm on the energy fluxes at the urban interface—a preliminary experiment: Archiv Meteorologie, Geophysik, und Bioklimatologie, Series B, No. 19, p. 367–416, 37 figs., 4 tables, 33 references.

The spatial and temporal variations of the energy and moisture budgets of a megalopolis (Los Angeles basin) were examined during a frontal passage in February and during an extremely clear day in March in order to determine the possible seasonal extremes. The frontal passage caused a reduction of 92 percent of the absorbed solar radiation as compared to the clear day. Infrared components of the budget were much less affected. An increase of 18 percent was observed in atmospheric counterradiation, while net radiation declined by 93 percent. An inverse spatial relationship existed between incoming solar radiation and precipitation. The albedo of the urban surface changed with the position of the cold front. Wet impermeable surfaces have a mirror effect in reflecting proportionally greater amounts of radiation.

Descriptors: Climatology, heat balance, meteorology, storms, Los Angeles (Calif.).

534 Terstreip, M. L.; Stall, J. B.
1969. Urban runoff by road research laboratory method: Am. Soc. Civil Engineers Proc., Paper 6878, Jour. Hydraulics Div., v. 95, no. HY 6, p. 1809–1834, 19 figs., 6 tables, 19 references, 2 app.

A simple mathematical model of an urban basin presented in 1962 by the British Road Research Laboratory was tested on three urban watersheds of very different sizes in the United States. The basins are located in Baltimore, Md., and Chicago and Champaign, Ill. They contain 0.395, 12.5, and 2,290 acres, respectively. The model produces a runoff hydrograph by applying rainfall to only the directly connected impervious area of the basin. The basin is described by a time-area diagram and a discharge-storage relationship. The peak discharges of actual and predicted hydrographs are compared for 39 storms, and complete hydrographs are shown for 8 of these. To apply the model to a basin, the pattern of impervious areas must be known in detail, as well as the slopes and sizes of all surface and subsurface drains.—W70-02467.

Descriptors: Storm runoff, mathematical models, rainfall-runoff relationships, Road Research Laboratory method.

535 Tholin, A. L.
1962. The sewerage and drainage problem, *in* Environmental Engineering and Metropolitan Planning, Logan, J. A., Oppermann, Paul, Tucker, N. E., eds.: Evanston, Ill., Northwestern Univ. Press, p. 91–109.

Urban liquid-waste pollution control planning includes the necessity for thinking and acting on a metropolitan-wide basis, the need to encourage and support research for the solution of metropolitan-wide problems, and the need for extensive public relations work to encourage public support for necessary projects. Various methods for fulfilling these needs were proposed. If any plan or research program is to be successfully applied, it must have strong public backing, especially financial. To this end, planners and engineers should present to the public an accurate picture of the conditions actually existing in their community or metropolitan area and the reasons why a given plan is necessary for their own individual protection and benefit.—W70-04431.

Descriptors: Water pollution control, water pollution sources, planning.

536 Tholin, A. L.; Keifer, C. J.

1959. The hydrology of urban runoff: Am. Soc. Civil Engineers Proc., Paper 1984, Jour. Sanitary Eng. Div., v. 85, no. SA 2, pt. 1, p. 47–106, 28 figs., 8 tables, 6 references. [Am. Soc. Civil Engineers, Trans., v. 125, Paper 3061, p. 1308–1353, 1960.]

A detailed study of rainfall-runoff relationships in urban areas is based upon a design storm for 3 hours' duration. Several types of uniform land use with various values of ground slope and depression pondage were studied. Based on the sewer hydrographs, a series of easy-to-use design charts are presented.—W69-01897.

Descriptors: Rainfall-runoff relationships, design storm, hydrographs analysis, land use.

537 Thomas, H. E.

1969. Water as a resource and as a nuisance: Highway Research Rec. no. 271 [entitled] Planning; conservation of the physical environment, p. 17–28, 17 references.

Consumptive uses reduce the quantity, and nonconsumptive uses may impair the quality of water available for use by others; various laws protect the rights of individuals in water use. Water may constitute a nuisance if it harms development of land resources and invades recognized property rights. Conversely, development of land resources may have effects that interfere with the water rights of others, causing a nuisance. In urban areas, water as a resource becomes increasingly inadequate to meet requirements of the population and must be imported, along with food, fuel, and other materials. Generally in urban areas, water supply and disposal of used water have become public responsibilities. Urbanization changes the hydrology of an area in total runoff, peak flow characterisitcs, water quality, and appearance of lakes, streams, and valleys. To predict, ameliorate, or otherwise cope with these changes, urgent need exists for additional research in urban hydrology.—W70-02959.

Descriptors: Water management (applied), water resources development, storm runoff, planning.

538 Thomas, H. E.; Schneider, W. L.

1970. Water as an urban resource and nuisance: U.S. Geol. Survey Circ. 601-D, p. D1–D9, 15 references.

The development and use of water may create nuisances if they adversely affect the use of resources and invade recognized property rights. Conversely, the development and use of the land resources may have effects on water that interfere with the rights of others and thus cause nuisances. In urbanized areas, water as a resource becomes increasingly inadequate to meet the requirements of the concentrated population and industry; it must be imported from other areas. Buildings and pavements inhibit ground-water recharge and promote rapid runoff from storms. Increased flood peaks cause erosion and sediment transport, as do various construction activities. Vulnerability to floods is increased by urban encroachment upon flood plains. The urban water problem can be solved, but only if a complete understanding of the role of water in the urban environment is realized. Such understanding can be achieved through the proper interpretation of adequate data.—W70-09129.

Descriptors: Water resources development, water management (applied), storm runoff, planning.

539 Thomasell, Albert, Jr.

1968. Considerations for characterizing the time and space distributions of metropolitan storm rainfall, *in* Urban water resources research; systematic study and development of long-range programs of urban water resources research, first year report: New York, Am. Soc. Civil Engineers, app. B, p. B1–B12, 3 figs., 10 references.

A research program should be conducted in parallel with runoff model development and data acquisition to lead to assessment of the time and space variability of precipitation in a form that is useful both for the daily operation of urban water drainage systems and for the design of new systems. To make the program economically feasible, emphasis should be placed on making the results transferable to as many locations as possible.

Descriptors: Rainfall disposition, rainfall patterns, variability, data collections.

540 Thompson, G.

1966. The use of balancing reservoirs and flow regulating reservoirs in dealing with run-offs from urban areas, *in* River engineering and water conservation works, Thorn, R. B., ed.: London, England, Butterworths, p. 132–141, 5 figs., 1 aerial photo., 5 references.

Urban development and the installation of surface water drainage often cause increased runoff in rivers. Such a problem ensues wherever paved areas are directly connected by sewers to a river. As a solution, flow balancing entails passing the flow through a natural or artificial lake with a restricted outflow. These plans can be economical, and they reduce peak flows and channel sizes farther downstream. General design factors for implementing flow balancing and regulation are discussed; and a scheme combining the two principles, which was applied to the River Cray, is described. Flow balancing is possible in new or undeveloped towns, but it cannot usually be implemented in a built-up area unless lakes or disused mine workings are available. In such urban areas, flow regulation is readily applicable.—W71-06772.

Descriptors: Storm runoff, flow control, flood control, reservoirs.

541 Thompson, J. R.

1970. Soil erosion in the Detroit metropolitan area: Jour. Soil and Water Conserv., v. 25, no. 1, p. 8–10, 3 figs., 4 tables, 4 references.

A study was made in the Detroit metropolitan area to evaluate the rates and amounts of erosion from urban construction sites. In the summer of 1968, 2.1 percent of the study area was under development. This zone produced about the same amount of eroded soil material as the remaining 97.9 percent of the area. Erosion from the developing areas averaged 69 tons per acre per year, compared with an overall average erosion rate for the metropolitan area of about 3.0 tons per acre per year and an overall average erosion rate for southeast Michigan of 2.6 tons per acre per year.—W70-04557.

Descriptors: Soil erosion, sediment yield, construction, Detroit (Mich.).

542 Timberman, C. W.

1970. Discussion of some aspects of urban hydrology methodology, *in* Seminar on Urban Hydrology, Davis, Calif., Sept. 1–3, 1970, Proc.: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, Paper no. 7, 48 p., 24 figs., 5 tables, 31 references, 3 app.

The distinctive hydrologic characteristic of urban hydrology is the change in runoff response of an area as a function of its development. The unit hydrograph mathematical modeling procedure appears to be a suitable method of analyzing urban-area runoff. The unit hydrograph characteristics, including time to peak, peak discharge, and recession factor, can be correlated to physical basin characteristics such as slope, basin shape, basin storage, and channel and overland flow efficiency. Loss rates, or runoff factors, can be determined with sufficient accuracy and properly related to rainfall duration, season, and rainfall intensity. The recommended methodology can be related to specific design criteria, it is relatively easy to apply, it provides a basis for evaluating basin storage effects, and it allows determination of optimum design discharge.

Descriptors: Unit hydrographs, rainfall-runoff relationships, storm runoff, depth-area-duration analysis.

543 Todd, D. K.

1960. Salt water intrusion of coastal aquifers in the United States: Internat. Assoc. Sci. Hydrology Pub. 52, p. 452–461, 1 fig., 20 references.

Salt water intrusion originates from connate or oceanic sources in coastal aquifers of the United States. The present status of intrusion in the 23 coastal states is reviewed. Areas, causes, effects, remedial measures, and future possibilities of intrusion are discussed. Advances in knowledge of intrusion and current research are reported. An understanding of the hydrodynamics of the phenomenon is developing. Particularly significant is progress in analysis of the formation and maintenance of the interfacial transition zone.

Descriptors: Saline water intrusion, coastal aquifers, water pollution sources.

544 Tucker, L. S.

1968. Northwood gaging installation, Baltimore, instrumentation and data: Am. Soc. Civil Engineers, Urban water resources research program, Tech. Memo. 1, 36 p., 4 figs., 2 maps, 21 tables, 5 photos., 3 app.

Northwood in Baltimore, Md., is one of the few sewered catchments in the United States that is gaged with flumes. The 47.4-acre drainage area is about 4 miles north of downtown Baltimore in a residential suburban area. It contains a 17.4-acre shopping center and 30 acres of residential development. Buildings in the residential area are very uniformly grouped houses with three to four houses per group. The average imperviousness of the drainage area is 68 percent. Ground slopes average 3 percent. A rain gage and a Parshall flume were installed in 1959. Runoff is estimated to be within 5 percent of actual flow 95 percent of the time for flume depths over 4 inches. Reduced rainfall and runoff data for 14 storms, hourly precipitation, and daily pan evaporation data are tabulated. Hyetographs and hydrographs illustrate the rapid response of the drainage area.—W69-03507.

Descriptors: Rainfall-runoff relationships, data collections, storm runoff, Baltimore (Md.), hydrologic data, instrumentation.

545 Tucker, L. S.

1968. Oakdale Avenue gaging installation, Chicago, instrumentation and data: Am. Soc. Civil Engineers, Urban Water Resources Research Program, Tech. Memo. 2, 76 p., 34 figs., 1 map, 2 photos., 2 app.

A 12.9-acre urban drainage area was instrumented in Chicago, Ill. Rainfall and runoff data for storms for which data are reliable are tabulated and presented. The area is 2½ blocks long by 1 block wide and consists entirely of detached family dwellings. The drainage system is a 30-inch combined sewer draining into a 10.5-foot-square concrete trunk sewer. Runoff is measured by a parabolic flume in an underground vault. A tipping bucket rain gage is located about 1 block north of the drainage area. The rain and flume gages are connected to recorders by telephone lines. Rainfall and runoff records from storms are shown in tables, hyetographs, and hydrographs. Copies of some of the original recorder charts are included.—W69-03508.

Descriptors: Data collections, storm runoff, rainfall-runoff relationships, Chicago (Ill.), hydrologic data, instrumentation.

546 Tucker, L. S.

1969. Availability of rainfall-runoff data for sewered drainage catchments: Am. Soc. Civil Engineers, Urban Water Resources Research Program, Tech. Memo. 8, 93 p., 8 figs., 3 maps, 3 photos., 5 tables, 9 references, 1 app.

Data on the availability of rainfall-runoff data from gaged, sewered urban catchments are compiled. Only 13 completely sewered catchments in the United States are gaged. Runoff is measured by flume in Northwood, Gray Haven, and Swansea, all in Baltimore, Md. Reduced data from 29 Gray Haven storms are tabulated. The 13 catchments are summarized in a table giving name, size, data collected, type of flowmeter, type of storm sewer, data available, operator of the installation, location, and period of operation. Each installation and catchment is described in detail. Baltimore has three gaged catchments; Cincinnatti, Ohio, has one; St. Louis, Mo., has three; Chicago, Ill., has one; Philadelphia, Pa., has one; New York City has four; and Washington, D.C., has one.—W69-07484.

Descriptors: Data collections, gaging stations, rainfall-runoff relationships, hydrologic data, cities.

547 Tucker, L. S.

1969. Raingage networks in the largest cities: Am. Soc. Civil Engineers, Urban Water Resources Research Program, Tech. Memo. 9, 90 p., 6 figs., 17 maps, 28 tables, 2 photos., 10 references.

The extent of rain-gage networks in the 20 largest cities in the United States is described, and the history of available data is given. Recording rain gages are operated and maintained in and around 15 of the 20 largest

cities. These cities are Baltimore, Chicago, Cleveland, Dallas, Detroit, Houston, Los Angeles, Milwaukee, New Orleans, Philadelphia, St. Louis, San Antonio, San Diego, Seattle, and Washington, D.C. Information on the number, type, location, and history of the gages and on the form, use, and availability of rainfall data for these 15 cities is presented. The metropolitan area with the largest network of recording rain gages is Los Angeles, where 162 rain gages are operated. Seattle has a unique method for recording, reducing, and processing rainfall data which was put in operation in early 1965. Rainfall data are recorded on tapes, translated to computer cards, and processed through a computer. Chicago has the greatest amount of reduced historical data. A summary of the rain-gage network information for 15 of the 20 largest cities is tabulated.—W69-07485.

Descriptors: Data collections, hydrologic data, rain gages, instrumentation, storm runoff, rainfall-runoff relationship.

548 Tucker, L. S.

1969. Sewered drainage catchments in major cities: Am. Soc. Civil Engineers, Urban Water Resources Research Program, Tech. Memo. 10, 71 p., 34 figs., 4 tables, 13 references.

The size, distribution, and number of sewered drainage catchments in San Francisco, Washington, D.C., Milwaukee, Houston, and Philadelphia are summarized to provide data for urban rainfall-runoff water quality studies. The four cities are in four distinctly different regions of the United States and are different topographically. The sizes of all sewered drainage catchments are tabulated, maps show catchment boundaries, and summary discussions are presented. The distribution of sewered drainage catchment size is unique for each city. The number of catchments varies from 42 in San Francisco to 1,283 in Houston. The size of the largest catchment in each city ranges from 1,820 acres in Milwaukee to 6,180 acres in Washington, D.C. The average catchment size ranges from 65 acres in Houston to 560 acres in San Francisco.—W69-07486.

Descriptors: Rainfall-runoff relationships, storm drains, storm runoff, San Francisco Bay Area (Calif.), Washington (D.C.), Milwaukee (Wis.), Houston (Tex.), Philadelphia (Pa.), data collections, hydrologic data.

549 Tucker, L. S.

1970. Availability of rainfall-runoff data for partly sewered urban drainage catchments: Am. Soc. Civil Engineers, Urban Water Resources Research Program, Tech. Memo. 13, 156 p., 4 figs., 16 maps, 3 photos., 15 tables, 49 references, 1 app.

Available rainfall-runoff data for partially sewered urban drainage catchments are identified to facilitate development of model studies. Information on the availability of rainfall-runoff data from 64 developed, partially sewered urban drainage catchments in the United States and eight in Japan is summarized. The 64 catchments in the United States are concentrated in eight States, and the locations of these instrumented catchments are shown by a map. Rainfall-runoff data are available for most of the catchments. Information on the 64 instrumented, highly developed, partially sewered urban drainage catchments in the United States is summarized. Additional details such as availability of data, how to obtain further information about catchments, and data, gage locations, and maps of catchments are presented.—W70-06573.

Descriptors: Data collections, hydrologic data, rainfall-runoff relationships, storm runoff, Japan, instrumentation.

550 Tucker, L. S.

1970. Non-metropolitan dense raingage networks: Am. Soc. Civil Engineers, Urban Water Resources Research Program, Tech. Memo. 11, 51 p., 15 figs., 8 tables, 19 references.

Information on 13 dense recording rain-gage networks located in non-metropolitan areas of the United States is summarized. The 13 networks are located in eight States. Data are reduced and recorded on punch cards or magnetic tape for most of the networks. Rainfall data for all networks are available. Only six of 13 networks are still in operation. Locations of 15 of the 20 largest U.S. cities operating rain gages are shown on a map. Information on the 13 dense rain-gage networks is tabulated.

Descriptors: Rain gages, rainfall-runoff relationships, data collections, hydrologic data.

551 Turner, A. K.

1963. The control of roadside erosion: Great Britain, Dept. of Sci. and Indus. Research, Road Research Lab., Overseas Bull. 17, 56 p., 20 figs., 2 tables, 12 references, 7 app.

In most tropical and subtropical countries the erosion of soil at roadsides presents serious problems. The building of a road frequently interferes with natural drainage paths. In these areas, where rainfall intensities may sometimes exceed 4 inches per hour, the sudden concentration of water in roadside drains may do serious damage to the road structure and to the surrounding ground. In the location of roads there are two main problems when considered in the light of possible water erosion. They concern roads in or adjacent to watercourses and roads on steep gradients. Generally the lower lands of valleys are cleared before the hill country. Often routes are adjacent to the main watercourse. Continuing erosion in these watercourses deepens and widens them to form gullies. As a result, the road pavement often becomes endangered by undermining due to the lateral erosion of the gully. An added problem results from tributary scours that head back from the main watercourse towards culverts under the road, necessitating works at the outlet ends of the culverts.

Descriptors: Erosion control, soil erosion.

552 United Nations Educational, Scientific and Cultural Organization.

1969. Influence of man on the hydrological cycle, guide to policies for the safe development of land and water resources, *in* Internat. Conf. on the Practical and Scientific Results of the Internat. Hydrological Decade and on Internat. Co-operation in Hydrology, Paris, Dec. 8–16, 1969, Proc.: UNESCO, Food and Agriculture Organization of the United Nations, p. 1–55.

The sciences and technologies involved in measuring hydrological results of changes in land use are reviewed. Large-scale catchment studies of experimental changes in land use are scarce. Subjects discussed include forest lands, grasslands, arable lands, irrigation, salinity, swamp drainage, urbanization, water pollution, and landslides. Water pollution control is achieved only at high cost and with the support of strong public opinion. In developing countries, rapid increases of population result in unplanned growth of subsistence agriculture, without the discipline to protect vegetation, soils, and water. Provision of fertilizers and improved seeds, their local distribution, and provision of financial credit to permit their use are recommended to combat soil erosion. Discipline in the use of water resources for irrigation and their protection from pollution is advised.—W70-06370.

Descriptors: Land use, water resources development, erosion, water pollution control.

553 U.S. Army Corps of Engineers.

1968. State Road and Ebner Coulees, Wisconsin: U.S. 90th Cong., 2d Sess., House Doc. 360, 57 p., 3 plates, 6 tables, 1 app.

Floods on State Road and Ebner Coulees, LaCrosse, Wis., were studied, and control measures are suggested. The floods are caused by high rates of runoff from rugged terrain in upper reaches of the watersheds. Predicted damages are $351,700 in 1970 and $578,000 in 2020 without control. The suggested plan includes channel improvements and diversion works leading from Ebner Coulee to the LaCrosse River. The estimated first cost is $4,495,000, and annual costs are $192,000. The benefit-cost ratio is 1.36.—W69-00440.

Descriptors: Flood control, LaCrosse (Wis.).

554 U.S. Army Corps of Engineers.

1968. Flood plain information, City of Alexandria and Arlington County, Virginia: Baltimore Dist., Md., U.S. Army Corps of Engineers, Flood Plain Rept., 38 p., 11 figs., 7 tables.

Flooding was studied on the lower 3 miles of Fourmile Run, a floodway draining 18.5 square miles that flows 9 miles through Arlington County, along the northern boundary of Alexandria, Va. During the largest flood of

record, in August 1963, damage to business properties in a four-block stretch of Arlandria was estimated at more than one million dollars. Estimates are made of the maximum velocities, discharge rates, and flood depths that would result from a flood having a 100-year average recurrence interval, and from the maximum probable flood that could ever be anticipated in the area. This latter flood would top the flood depth of record by 10.3 feet on Mount Vernon Avenue in Arlandria and discharge 25,000 cfs at its peak. The report is intended to provide the basis for further study and planning by Arlington County and Alexandria to develop solutions.—W71-02285.

Descriptors: Flood forecasting, storm runoff, flood control, Arlington County (Va.).

555 U.S. Army Corps of Engineers.
1969. Special flood hazard information report, Barton Creek, Austin, Texas: Fort Worth, Tex., U.S. Army Corps of Engineers, 7 p., 2 maps, 2 charts.

Flooding of Barton Creek, Austin, Tex., is described in a report of flood-plain problems based on records of rainfall, runoff, and historical and present flood heights. Maps, photographs, and profiles indicate the extent of flooding that has occurred and which may be expected to occur in the future. The information is for use in study and planning ways to minimize vulnerability to flood damages.—W70-07374.

Descriptors: Austin (Tex.), floods, storm runoff.

556 U.S. Army Corps of Engineers.
1970. Flood plain information, Albuquerque arroyos, Albuquerque, New Mexico: Albuquerque Dist., N. Mex., Flood Plain Rept., pt. 1, 34 p., 5 figs., 11 plates, 1 table.

Flooding along the numerous arroyo channels in or adjacent to the city of Albuquerque, N. Mex., is described to aid in solving local flood problems and in planning the best utilization of flood-prone lands. Maps, profiles, cross sections, and other material relating the extent of past flooding to floods which might occur in the future are based on available records of rainfall, runoff, historical flood heights, and other technical data. Application of loss rates used in the design of the Albuquerque north diversion channel to the critical distribution of 100-year rainfall amounts will produce a total runoff of 1.92 inches over a 6-hour period; rainfall losses would be 0.50 inches for the first hour and 0.16 inches per hour for subsequent periods. For study purposes, all mesa areas were assumed to be developed.—W71-09846.

Descriptors: Floods, flood control, Albuquerque (N. Mex.).

557 U.S. Army Corps of Engineers.
1970. Proceedings of a siminar on urban hydrology, Davis, California, September 1–3, 1970: Davis, Calif., U.S. Army Corps of Engineers, Hydrologic Eng. Center, 287 p., 85 figs., 21 tables, 53 references, 4 app.

Problems associated with runoff in urban areas derive not only from the necessity to handle runoff that enters the area from natural watersheds but also from the necessity to evaluate the effects of urbanization on the actual runoff process. In general, the creation of impervious sections of the drainage area causes an increase in the total volume of runoff and in the peak rates of runoff. Furthermore, the drainage of natural ponding areas, the improvement of natural channels, and the realignment of drainage patterns can greatly increase the peak rates of runoff. Runoff from urban areas has increasingly become a quality problem in the receiving rivers. When rainfall washes the cities and surrounding areas, the resulting runoff can contribute to river pollution. Many cities have combined sewers, and overflows often contribute seriously to river pollution.

Descriptors: Conferences, water pollution sources, storm runoff, rainfall-runoff relationships.

558 U.S. Department of Agriculture; U.S. Department of Housing and Urban Development.
1968. Soil, water and suburbia, Natl. Conf. on Soil, Water and Suburbia, Washington, D.C., June 15–16, 1967, Proc.: Washington, D.C., U.S. Govt. Printing Office, 160 p., 106 figs., 67 references.

The National Conference on Soil, Water and Suburbia was held in Washington, D.C. on June 15–16, 1967. The purpose of the conference was to examine soil and water problems and opportunities that occur as land shifts from rural to suburban and urban uses; to exchange information on soil and water management assistance; to

explore the economics of land-use changes, devices for reserving land for recreation, methods for maintaining natural beauty and reducing land damage and water pollution; and to discuss community action in planning. The broad subject areas covered included land in transition, the suburban land resource and its use, knowledge in transition, and community action. Multidisciplinary approaches in planning, design, development, and construction are emphasized.—W70-09188.

Descriptors: Land use, water management (applied), erosion control, water pollution control, planning, conferences.

559 U.S. Department of Housing and Urban Development.
1970. National conference on sediment control, Washington, D.C., Sept. 14–16, 1969, Proc.: Washington, D.C., U.S. Dept. of Housing and Urban Devel., Environmental Planning Div., 54 p., 4 references.

The National Conference on Sediment Control was convened in Washington, D.C., on September 14, 1969, to bring together representatives of State, regional, and local agencies, in order to explore ways of combating soil erosion and sediment problems in urban and suburban areas. A major task of the conference was the development of a final version of "Community Action Guidebook for Soil Erosion and Sediment Control." More than 4,000 acres a day are disturbed to build real estate developments, suburban facilities, highways, and industries. Sediment yields from some of these activities are 500 times greater than from rural soil erosion, and urban drainage from concrete surfaces provides another substantial source of sediment deposits. Nine papers are printed in the proceedings; they describe policies and programs for federal, State and local officials to obtain more effective sediment controls in urban and suburban areas.—W71-02425.

Descriptors: Sedimentation, erosion, conferences, erosion control, sediment control, water pollution sources, planning.

560 U.S. Department of the Interior.
1968. Considerations for modeling urban rainfall-runoff-quality processes, *in* Urban water resources research; systematic study and development of long-range programs of urban water resources research, first year report: Washington, D.C., U.S. Dept. of Interior, Office of Water Resources Research, p. A1–A124, 25 figs., 8 tables, 151 references.

Current assessments of urban drainage construction requirements and current estimates of damage from urban storm water indicate a need for a research effort on urban rainfall-runoff-quality relationships. Mathematical modeling is the method most useful for defining such relationships. Standard statistical techniques for analyzing data are inadequate because of the lack of a data base. There is a considerable body of knowledge available for analyzing the hydrology of natural basins. Much of this knowledge is transferable to the urban environment. More urban hydrologic data are needed. Data which exist now or will be collected should be made readily available for calibrating and testing mathematical models of urban hydrology. Research must be conducted both in the fields of model building and model assessment and in the way in which urban conditions affect the natural hydrologic environment.

Descriptors: Rainfall-runoff relationships, water quality, data collections, mathematical models, storm runoff, planning.

561 U.S. Department of the Interior.
1971. National conference on urban water research, Georgia Inst. of Technology, Atlanta, Mar. 17–19, 1970: Washington, D.C., U.S. Govt. Printing Office, 31 p., 2 app.

This report contains the keynote and plenary session papers presented at the National Conference on Urban Water Research, sponsored by the Office of Water Resources Research. Contents include: introductory remarks, keynote address, resource development in the urban environment, the social consequences of natural resource development in urban regions, the economic consequences of natural resource development in urban regions, and engineering alternatives in natural resource development in urban regions.—W71-09468.

Descriptors: Conferences, planning, water resources development, water resources research.

562 U.S. Department of the Interior.
1971. A national urban water resources research program: Washington, D.C., U.S. Govt. Printing Office, 54 p., 1 app.

On August 1, 1969, the Office of Water Resources Research submitted a proposed program of urban and metropolitan water resources research and recommended convening a conference of water resources practitioners to review the proposed program. A National Urban Water Resources Conference was convened at the Georgia Institute of Technology on March 17, 1970. Sixty-one individuals participated in the conference, including academic researchers, consulting engineers, participants from business and industrial firms, and representatives from federal, State, and local government agencies. The speakers directed the conference to the social, economic, political, legal, ecological, and water resource engineering problems of major significance in urban regions. Most critical needs are at interfaces, linkages, and interrelationships with physical, administrative, financial, social, political, and legal elements of urban systems.

Descriptors: Water Resources Research Act, water management (applied), conferences, planning.

563 U.S. Department of the Interior.
1969. Environmental impact of the Big Cypress Swamp jetport: Washington, D.C., U.S. Govt. Printing Office, 153 p., 19 figs., 4 tables.

Development of the proposed Big Cypress Swamp Jetport, Fla., and attendant facilities will lead to land drainage and development for agriculture, industry, housing, transportation, and services in the swamp. This will destroy the south Florida ecosystem and Everglades National Park. Construction of each training strip will destroy about 400 acres of natural habitat. Air pollutants from engine exhausts will be substantial. There will be frequent high-level noise intrusion on the wilderness. A severe bird-strike problem may develop. Interference with overland flow will be negligible. The combination of bird strikes, pest insect problems, and incidence of small animals on runways will probably lead to drainage of at least part of the jetport property. Construction and imminent operation of the first training strip have elevated surrounding land prices and sales. Economic and social pressures for further development within and without the port property will mount rapidly. Land development and drainage will be accompanied by increased nutrients in the water, will alter the hydroperiod, and will promote eutrophication.—W70-08596.

Descriptors: Ecology, swamps, airports, Florida jetport, Big Cypress Swamp; Everglades National Park (Fla.), conservation, land use.

564 U.S. Geological Survey.
1966. Basic data for urban hydrology study, Dallas, Texas, 1966: U.S. Geol. Survey open-file rept., 203 p., 3 figs., 1 table.

Basic hydrologic data compiled for the study of urban hydrology in Dallas, Tex., include data from rain gages, stream gages, and flood-profile partial-record stations. Hydrographs and mass curves are given for major storms at each station.—W69-08056.

Descriptors: Rainfall-runoff relationships, data collections, hydrologic data, streamflow, Dallas (Tex.), floods.

565 U.S. Geological Survey.
1968. Compilation of hydrologic data, Waller and Wilbarger Creeks, Colorado River basin, Texas, 1966: U.S. Geol. Survey open-file rept., 31 p., 3 figs., 1 table, 1 app.

Streamflow data are compiled for comparison of Waller Creek, an entirely urban stream in Austin, Tex., and Wilbarger Creek, in a geologically and topographically similar setting in a rural area, for urban hydrological studies. Data are tabulated on a regular daily basis and for individual storms for the water year 1966. Each stream-gaging-station record includes location, drainage area, availability of records, gage type, extreme flow events, remarks, and daily gage records for the year. Hydrographs are used to show storm rainfall-runoff relationships.—W69-04599.

Descriptors: Data collections, streamflow, rainfall-runoff relationships, Austin, (Tex.), hydrologic data.

566 U.S. Geological Survey.

1969. Basic data for urban hydrology study, Dallas, Texas, 1967: U.S. Geol. Survey open-file rept., 80 p., 3 figs., 1 table, 6 references, 1 app.

This report presents the basic hydrologic data collected in Dallas, Tex., during the 1967 water year (October 1, 1966 to September 30, 1967). Basic data were collected for urban hydrology studies to determine, on the basis of historical data and hydrologic analyses, the magnitude, frequency, and areal extent of flooding, to document and define floods of greater-than-ordinary magnitude, and to determine the effect of urban development on flood peaks and volume on small streams.—W70-05500.

Descriptors: Floods, data collections, rainfall-runoff relationships, hydrologic data, Dallas (Tex.).

567 U.S. Geological Survey.

1969. Basic data for urban hydrology study, Austin, Texas, 1967: Austin, Tex., U.S. Geol. Survey basic-data rept., 59 p., 3 figs., 1 table, 1 app.

Basic data of the hydrology of the urban Waller Creek and the rural Wilbarger Creek, Austin, Tex., are compiled to compare the watersheds as the Waller Creek basin becomes more urban. Each gaging-station record includes location, drainage area, gage type and history, average discharge, extremes, remarks, daily discharge, total discharge, mean discharge, annual maximum and mean discharges, and peak discharges. Runoff and rainfall are computed for each drainage basin, and hydrographs and mass curves are drawn. The objectives are to determine the effects of progressive urbanization on infiltration, rates of peak discharge, and rainfall-runoff relations in the Waller Creek watershed; to provide rainfall and runoff data from the rural Wilbarger Creek watershed to be used for comparative purposes in determining the effects of urbanization in the Waller Creek watershed; and to provide applied research facilities for studies at the University of Texas at Austin. The Waller Creek drainage area lies entirely within the city of Austin, with the headwaters in the northern part of the city. The Wilbarger Creek drainage area is 15 miles north of Austin. The principal land use of this rural watershed is farming and ranching.

Descriptors: Storm runoff, rainfall-runoff relationships, Austin (Tex.), data collections, hydrologic data.

568 U.S. Geological Survey.

1970. Compilation of hydrologic data, Austin, Texas, 1968: U.S. Geol. Survey open-file rept., 68 p., 3 figs., 1 table.

Rainfall and runoff data compiled in this report for the 1968 water year (October 1967 to September 1968) from the urban Waller Creek watershed in Austin, Tex., and the rural Wilbarger Creek watershed in Travis County are primarily for comparative purposes in determining the effects and progressive urbanization in the Waller Creek watershed. Also included are average stream discharge values, discharge extremes, and weighted-mean rainfall data for several years of record in both watersheds.—W71-00041.

Descriptors: Data collections, discharge measurement, Waller Creek Watershed (Austin, Tex.), rainfall-runoff relationships, hydrologic data.

569 U.S. Geological Survey.

1970. Basic data for urban hydrology study, Dallas, Texas, 1968: Austin, Tex., U.S. Geological Survey basic-data rept., 103 p., 3 figs., 6 references.

Basic data of the urban hydrology of Dallas, Tex., are compiled. Surface-water records are from gaging stations, crest-stage partial-record stations, rain gages, and miscellaneous sites. Each gaging-station record includes location, drainage area, gage type and history, average discharge, extremes, remarks, daily discharge, total discharge, mean discharge, annual maximum and mean discharges, and peak discharges. Runoff and rainfall are computed for each drainage basin, and hydrographs and mass curves are drawn. The objectives are to provide

basic runoff data for small urban drainage areas which differ in topography, soil, vegetation, tributaries, basin shape, and degree of urbanization; to provide related rainfall data with consideration of variation in intensity and location; and to provide data showing the effects of progressive urbanization on flood peaks and volume. Six storm periods were selected for detailed analysis. The analyses for these storms include a tabulation of incremental rainfall and discharge data, as well as hydrographs and mass curves.

Descriptors: Dallas (Tex.), storm runoff, data collections, hydrologic data.

570 U.S. Public Health Service.
1964. Pollutional effects of stormwater and overflows from combined sewer systems, a preliminary appraisal: U.S. Public Health Service Pub. 1246, 39 p., 19 tables, 25 references.

Data on storm water and combined sewer overflows were studied in regard to pollutional effects, and existing and possible corrective measures were investigated. The sources of data include more than 50 engineering reports and completed questionnaires regarding sewer systems and sewage treatment, reports of detailed studies of water quality data and storm-water separations, and interviews with municipal sanitation representatives. These sources provide information on quantity and quality of combined sewer overflows; effects on streams, water uses, and users; adverse effects and existing or suggested control measures and their effectiveness; and costs necessary for control.—W69-01795.

Descriptors: Combined sewers, water pollution sources, storm runoff, water pollution control.

571 U.S. Public Health Service.
1965. Activities report, July 1, 1964 to June 30, 1965: Washington, D.C., U.S. Public Health Service, Div. of Water Supply and Pollution Control, 53 p., 1 fig., 9 photos., 7 tables, 59 references.

This report reviews research carried out from 1964 to 1965 to determine causes and methods of control of water pollution. The work includes studies on the chemical and microbiological analysis of wastes; the polluting effects of urban and rural runoff; the persistence of organic chemicals in surface waters and their biological degradation; the effects of pollution on aquatic life and on municipal water use; methods of waste treatment, including advanced treatment of sewage; and control of surface-water quality by dilution and by removal of nutrients from effluents. A list of papers published during the year is appended.—W69-01794.

Descriptors: Storm runoff, water pollution sources, drainage (urban), water pollution control.

572 U.S. Soil Conservation Service.
1970. Controlling erosion on construction sites: U.S. Dept. of Agriculture, Soil Conserv. Service, Agriculture Inf. Bull. 347, 31 p., 36 photos.

Each year more than a million acres of land in the United States are converted from agricultural use to urban use. Erosion on land going into urban uses is about 10 times greater than on land in row crops, 200 times greater than on land in pasture, and 2,000 times greater than on land in timber. The trend toward large developments has left large cleared and graded areas exposed to erosion for long periods. Erosion and sedimentation can be controlled effectively and at reasonable cost. The principles of erosion control are: using soils that are suited for development; leaving the soil bare for the shortest time possible; reducing the velocity and flow of runoff; detaining runoff on the site to trap sediment; and releasing runoff safely. In applying these principles, the following practices are effective: selecting land favorable for the intended use; fitting the development to the site and providing for erosion control; using for open space and recreation those areas not well suited for urban development; developing large tracts in small units so that large areas are not left bare; grading at a minimum and removing few trees; controlling runoff; protecting soil with mulch, cover crops, and with mechanical measures; constructing sediment basins; and establishing permanent vegetation and erosion-control structures.

Descriptors: Erosion control, sediment yield, soil erosion.

573 Updegraff, G. E.

1971. The economics of sewage disposal in a coastal urban area, a case study of the Monterey Peninsula, California: Natural Resources Jour., v. 11, no. 2, p. 373–389, 10 references.

A case study is presented of the water pollution problem of Monterey Peninsula, between Monterey Bay and Carmel Bay, 120 miles south of San Francisco. The bays are noted as recreational attractions for California and out-of-State visitors. Several communities and a few military installations (total population 162,000) and 15,000 visitors each year discharge nearly all their sewage into the bays. Of this sewage, 4 percent is raw, 49 percent receives primary treatment, and 47 percent receives secondary treatment. An evaluation is made of the actions of the State under the Porter-Cologne Water Quality Control Act (1970), and the results are summarized. Two changes are suggested with respect to powers and duties of the State under the Act: (1) operationally, pollution should be monitored at the source and (2) the Act should be extended to explicitly encompass the tasks of ranking coastal water areas and to set standards in accordance with this ranking.

Descriptors: Water pollution control, estuaries, bays, recreation, Monterey Peninsula (Calif.).

574 Ursic, S. J.

1969. Hydrologic effects of prescribed burning on abandoned fields in northern Mississippi: U.S. Forest Service Research Paper SO-46, 20 p.

Results of a 3-year prescribed burn on two small watersheds supporting a cover of native grass are given. Comparisons were against an unburned control watershed. Variables included stormflows, overland flows, peak discharges, and sediment yields.—W70-02207.

Descriptors: Burning, storm runoff, accelerated erosion, sediment yield, rainfall-runoff relationships.

575 Van Sickle, D. R.

1968. Interior drainage for hurricane protection projects: Am. Soc. Civil Engineers Proc., Paper 5858, Jour. Hydraulics Div., v. 94, no. HY 2, p. 455–480, 13 figs., 8 tables, 19 references.

Problems of interior drainage in hurricane protection projects are illustrated, and methods of analysis and the solutions obtained are discussed, based upon studies made in the Port Arthur area, Tex. Engineering of the drainage systems involves study of rainfall and tides, urban hydrology, synthetic hydrographs, and reservoir routing. These procedures are applied to interior drainage design in the low elevations and flat slopes of the gulf coast. Development of design criteria is described, including hydrograph characteristics, rainfall, tides, and ponding levels. Design procedures, including selection of pump-station capacities, gravity outlet sizes, and other project features are summarized.—W68-00090.

Descriptors: Drainage engineering, hurricanes, flood protection, rainfall-runoff relationships, drainage systems, Port Arthur (Tex.).

576 Van Sickle, D. R.

1969. Experience with the evaluation of urban effects for drainage design, *in* Effects of watershed changes on streamflow, Moore, W. L. and Morgan, C. W., eds., Water Resources Symposium No. 2, Austin, Tex., Oct. 1968: Austin, Texas Univ. Press, p. 229–254, 17 figs., 11 tables, 17 references.

The Houston metropolitan area, one of the most rapidly urbanizing areas in the United States, was used to establish and test new urban runoff criteria. The following procedures are followed: mean basin length and mean basin slope values are developed from topographic maps; the degree of development anticipated in the watershed is estimated for the period of design; drainage density is estimated for each of the areas of use; the drainage density is multiplied by the area for each type of land use to get total channel length; the basin factor is determined; the time to peak and the unit hydrograph peak are determined for the degree of development

involved; and the unit hydrograph is developed. Empirical curves of drainage area versus discharge are of specific use only in the urban area and for the storm frequencies for which they are designed. Synthetic unit hydrographs were prepared and tested for about 50 drainage areas in Houston.—W70-04578.

Descriptors: Rainfall-runoff relationships, rational formula, storm runoff, Houston (Tex.), unit hydrographs, impervious area.

577 VanZandt, J. K.

1972. Annual compilation and analysis of hydrologic data for urban studies in the Austin, Texas metropolitan area, 1970: Austin, Texas, U.S. Geol. Survey basic-data rept., 70 p., 3 figs., 1 table, app.

Rainfall and runoff data are presented for Waller Creek (Austin, Tex.) for the 1970 water year. The Waller Creek drainage area lies entirely within the city of Austin, with the headwaters in the northern part of the city. The creek flows south for 6.6 miles to the Colorado River. Storm sewers and street gutters divert runoff both into and out of the natural drainage area. The headwaters of Wilbarger Creek, a rural creek used for comparison, originate about 15 miles north of the city of Austin. The weighted-mean rainfall upstream from 38th Street was 35.82 inches, 10 percent above the mean annual rainfall for Austin of 32.58 inches. Mean daily discharge was 1.65 cfs; annual runoff was 9.68 inches, or 27 percent of rainfall. The weighted-mean rainfall upstream from 23rd Street was 34.95 inches, 7 percent above the mean annual rainfall for Austin. Mean daily discharge was 3.24 cfs; annual runoff was 10.66 inches, or 30 percent of rainfall. Rainfall-runoff data for 4 storms are summarized.

Descriptors: Rainfall-runoff relationships, hydrologic data, storm runoff, Austin (Tex.), data collections.

578 Veldkamp, F. B.

1963. Problems of water discharge in urban areas: Nederlandse Centrale Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek, Commissie voor Hydrologisch Onderzoek T.N.O., Verslagen en Mededelingen no. 9, Verslag van de technische bijeenkomst 18, p. 73–94, 8 figs., 4 photos. [In Dutch]

Urban discharge is usually calculated starting from rainfall, assuming that impervious surface has a runoff of 100 percent. Impervious area consists of the area of roofs, streets, sidewalks, as well as paved backyards connected to the sewer system. Sewer systems with a design capacity of 60 liters per second per hectare in flat areas are able to discharge design storms with a frequency of one per year. In steeper areas difficulties might arise where steep slopes change into flatter slopes. When flooding occurs, water does not stay in one spot but flows down along the street. For this reason in steeper areas a design capacity of 90 liters per second per hectare is preferred. Storage basins are calculated using storms with a lower frequency than one per year.—W69-01899.

Descriptors: Storm drains, rainfall-runoff relationships, design storm, drainage (urban), impervious area.

579 Vice, R. B.; Ferguson, G. E.; Guy, H. P.

1968. Erosion from suburban highway construction: Am. Soc. Civil Engineers Proc., Paper 5742. Jour. Hydraulics Div., v. 94, no. HY 1, p. 347–348, 1 table.

The extent of erosion and transportation of earth materials exposed in highway work was studied in a 4.54 square mile drainage basin in Fairfax County, Va., in 1961 and 1964. About 11 percent of the basin was disturbed. Sediment yield was measured for 88 storm events representing the overland runoff from 1961 to 1964. The mean concentration of sediment in the flow increased as the flow increased. Sediment concentrations in mid-summer flow were about double these of mid-winter flow. Variability of concentration and yield was considerable, depending on exposure and remedial measures. About 179 acres of construction contributed 94 percent of the 37,000 tons transported from the basin during the 3.4 years of record. About 85 percent of the total sand eroded and 29 percent of the silt were redeposited in the basin. Precipitation was 13 percent below average; there would have been about 22 percent more erosion, or 139 tons per acre per year, with average precipitation. That is 10 times normal cultivated-land erosion and 500 times that of pasture or forest.—W69-00423.

Descriptors: Erosion, road construction, sediment yield, Fairfax County (Va.).

580 Vice, R. B.; Guy, H. P.; Ferguson, G. E.

1969. Sediment movement in an area of suburban highway construction, Scott Run basin, Fairfax County, Virginia, 1961–1964: U.S. Geol. Survey Water-Supply Paper 1591-E, p. E1–E41, 13 figs., 11 tables, 10 references.

Movement of sediment during a period of intensive highway construction was studied in the Scott Run basin, Fairfax County, Va., from 1961 to 1964. The 4.54 square-mile drainage basin was the scene of highway construction covering 11 percent of the basin. Sediment was measured at the gaging station by a system of representative samples. The sediment yield for 88 storm events represents the period's entire overland runoff. The 88 events accounted for 37 percent of the runoff and 99 percent of the sediment movement in 3 percent of the time. The highway construction areas, varying from less than 1 to more than 10 percent of the basin at a given time, contributed 85 percent of the sediment. Thirty-eight percent of the sediment movement occurred during April, May, and June, and only 11 percent occurred during July, August, and September. The amount of sediment eroded from areas of construction was about twice that transported from the basin. Sediment yield is about 10 times that normally expected from cultivated land, 200 times that expected from grassland, and 2,000 times that expected from forest land.—W69-09683.

Descriptors: Sediment yield, road construction, soil erosion, Fairfax County (Va.).

581 Viessman, Warren, Jr.

1966. The hydrology of small impervious areas: Water Resources Research, v. 2, no. 3, p. 405–412, 6 figs., 3 tables, 7 references.

A method for computing storm-water runoff from small, impervious urban areas is described in which consecutive 1-minute unit hydrographs are determined for a storm and summed to provide a total outflow hydrograph. Calculations are based on the assumption that such areas behave as linear reservoirs and take account of the drainage-area lag time and losses due to depression storage. Good agreement was obtained between actual and computed hydrographs, and peak discharges for 30 storms were predicted with an average absolute error of 9 percent.—W69-01901.

Descriptors: Storm runoff, hydrograph analysis, rainfall-runoff relationships, drainage (urban), impervious area, peak discharge.

582 Viessman, Warren, Jr.

1968. Runoff estimation for very small drainage areas: Water Resources Research, v. 4, no. 1, p. 87–93, 7 figs., 3 tables, 9 references.

Analyses of hydrologic data from high-intensity short-duration storms on several very small drainage areas with different physical characteristics show that a 1-minute unit hydrograph can be used as the basis for generating runoff from an effective rainstorm input. The single parameter of the unit hydrograph (time constant K) is related to the physical characteristics of the drainage area. No evidence of the correlation between K and the storm pattern was discovered. Procedures are given for estimating net storm inputs.—W69-01900.

Descriptors: Storm runoff, rainfall-runoff relationships, unit hydrographs.

583 Viessman, Warren, Jr.

1968. Modeling of water quality inputs from urbanized areas, *in* Urban water resources research; systematic study and development of long-range programs of urban water resources research, first year report: New York, Am. Soc. Civil Engineers, app. A, p. A79–A103, 3 figs., 1 table, 42 references.

As a result of the neglect of water quality considerations, only a few efforts have been made to identify the water quality constituents of urban runoff. This paper summarizes the data which have been obtained, the outlook for future data collection, the water quality models which have been used on large water courses and which could be adapted to urban drainage area, the manner in which the urban drainage system relates to the larger regional drainage complex, the kinds of quality components which need to be considered in a generalized urban runoff water quality model, and a general orientation for developing useful water quality models for urban drainage systems.

Descriptors: Water pollution sources, storm runoff, sediment yield, water quality, data collections.

584 Viessman, Warren, Jr.

1969. Assessing the quality of urban drainage: Public Works, v. 100, no. 10, p. 89–92, 1 fig., 1 table, 23 references.

Recommendations are made for study in identifying sources and constituents of urban runoff through the development and testing of urban water quality models and through the national collection of urban water quality data. Possible sources of pollutants and constituents of storm-water runoff are described with emphasis on sediment. Approaches to the development of water quality models are discussed.—W71-06575.

Descriptors: Water pollution sources, storm runoff, sediment yield, data collections.

585 Viessman, Warren, Jr.; Geyer, J. C.

1962. Characteristics of the inlet hydrograph: Am. Soc. Civil Engineers Proc., Paper 3285, Jour. Hydraulics Div., v. 88, no. HY 5, pt. 1, p. 245–268, 10 figs., 6 tables, 13 references.

A study was made of the relationship between rainfall and runoff for impervious inlet areas. As many significant variables as possible were included. Antecedent rainfall, storm intensity and pattern, and size, slope, and roughness of the inlet areas and data were obtained from records on impervious areas in Baltimore, Md., Newark, Del., and Hertfordshire, England. Equations for peak rates of runoff, rise of hydrograph, and method are proposed for predicting shape of simple hydrograph.—W69-02275.

Descriptors: Rainfall-runoff relationships, storm runoff, drainage (urban), impervious area, hydrograph analysis, Baltimore (Md.), Newark (Del.), Hertfordshire (England).

586 Viessman, Warren, Jr.; Keating, W. R.; Srinivasa, K. N.

1970. Urban storm runoff relations: Water Resources Research, v. 6, no. 1, p. 275–279, 3 figs., 1 table, 7 references.

A model incorporating the hydrologic and hydraulic phases of storm-water flows to estimate the runoff from a 23-acre residential area has prediction errors that are generally less than 10 percent when the peak flow is used as the criterion for comparison. The runoff process of the Gray Haven area, Baltimore, is simulated by a linear reservoir, linear channel model. A sequence of 1-minute effective rainfall intensities serves as the input. The effective precipitation is computed directly from the gaged storm pattern by applying one of the loss functions. Depression storage and infiltration are considered to be the primary loss components of the Gray Haven area. The analysis shows that a separate consideration of pervious and impervious surfaces in runoff computations for relatively small urban areas might be important.—W70-05684.

Descriptors: Storm runoff, rainfall-runoff relationships, peak discharge, mathematical models, Baltimore (Md.), impervious area.

587 Vines, W. R.

1970. Surface waters, submerged lands, and waterfront lands: Naples, Fla., Vines and Associates, Inc., 182 p., 11 figs., 108 references.

The values of the surface waters, submerged lands, and waterfront land resources of Palm Beach County, Fla., depend upon the capability of the county's waters to provide pleasant experiences. Urbanization has resulted in value-reducing physical and biological damages to water resources. The principal damages include ocean beach erosion, undesirable ecological modification, and waterfront land misuse. Physical and biological damages to inshore waters and submerged lands have caused a severe reduction in the number of native gamefish. Damage to inland marine waters and submerged lands results directly from modification of the amount and manner of fresh-water flow, from pollutant materials, and from physical modification (typically by dredging and filling) of submerged lands and shorelines. Turbidity of inshore marine waters results from an unfiltered flow to tidewater of waterborne pollutant materials. Water management projects, agricultural practices, and urban development projects have modified the physical configuration of the natural fresh-water bodies in the county, have modified the rate and range of fluctuation of fresh-water surface levels, have modified the conditions which collectively comprise fresh-water game and fish habitat, and have loaded these waters with increasing volumes of pollutant materials.

Descriptors: Water pollution sources, land use, recreation, Palm Beach County (Fla.).

588 **Waananen, A. O.**

1961. Hydrologic effects of urban growth—some characteristics of urban runoff: U.S. Geol. Survey Prof. Paper 424-C, p. C353–C356, 2 figs., 3 references.

The timing, intensity, and distribution of runoff and the shape of the flood hydrograph are affected when natural areas are urbanized. The sharp peak at the Temple Street gage, Syracuse, N.Y., which precedes the usual flood peak from upstream, illustrates a significant characteristic of urban runoff. Short-duration, high-intensity summer storms may in urban areas cause sharp flood peaks that are considerably higher than flood peaks generally in the basin. In August 1953, an urban flood peak was 860 cfs, as contrasted to only 132 cfs from upstream flows. The average of 16 peaks of urban runoff in Syracuse was nearly 3 times greater than the average of peaks of natural storm runoff. Although total annual runoff from developed areas should not differ much from that occurring before development, the timetable for runoff differs significantly. A substantial part of the flow from urban areas occurs during a short period following the storm. The quick runoff reduces evaporation and transpiration opportunity, as well as infiltration and percolation.—W69-01903.

Descriptors: Rainfall-runoff relationships, storm runoff, peak discharge, Syracuse (N.Y.).

589 **Waananen, A. O.**

1969. Urban effects on water yield, *in* Effects of watershed changes on streamflow, Moore, W. L. and Morgan, C. W., eds., Water Resources Symposium No. 2, Austin, Tex., Oct. 1968: Austin, Texas Univ. Press, p. 169–182, 6 figs., 11 tables, 16 references.

Urban development has a significant impact on hydrologic relations. These effects include: increase in total yield from stormflow and in annual discharge; decrease in base flow; modification of low flow of streams influenced by the importation of water and the discharge of waste water; decrease in recharge to the underlying ground-water basins; and increase in precipitation in urban areas and corresponding increase in yield. The principal effect of urban development on yield is an increase in direct runoff. The cumulative effect of increase in stormflow from urban areas, particularly in regions of strip cities and the megalopolitan complexes developing in several areas, may be substantial on downstream receiving channels.—W70-04574.

Descriptors: Rainfall-runoff relationships, storm runoff, peak discharge, water yield.

590 **Walker, W. H.**

1969. Illinois ground water pollution: Am. Water Works Assoc. Jour., v. 61, no. 1, p. 31–40, 9 figs., 2 maps, 16 references.

The ground-water pollution presently occurring in Illinois is discussed, and precautionary measures to prevent more contamination in the future are described and recommended. Contamination hazard of consolidated and unconsolidated aquifers in the State is shown by maps which can be used to guide planning of locations of wells, oil wells, and garbage-disposal sites. Hazards are highest in highly permeable glacial outwash and in outcropping cavernous carbonate rocks, and they are lowest in buried consolidated fine sandstones. Cross sections and maps show typical sources and paths of contamination in several discussed cases of ground-water pollution by hot water, organic wastes, and water of inferior chemical quality.

Descriptors: Water well contamination, groundwater pollution, hydrogeology, water pollution sources, Illinois.

591 **Wallace, D. A.**

1969. An ecological study of the Twin Cities metropolitan area: Minneapolis, Minn., Twin Cities Metropolitan Council, Rept., 127 p., 41 tables, 3 app.

An ecological survey was made of the Minneapolis-St. Paul area of Minnesota to be used in urban planning. Each of the major categories of geology (historical and surficial), physiography, hydrology, (ground and surface

water), soils, plant ecology, and wildlife habitats (terrestrial and aquatic) are mapped. Ecological phenomena such as rock types, slopes, rivers, lakes, streams, aquifers, soil types, forest associations, wildlife habitats, and scenic, scientific and historic values are mapped. These data are discussed in relation to the major prospective land uses.—W70-06764.

Descriptors: Ecology, land use, water resources development, Minneapolis and St. Paul (Minn.).

592 Wallace, J. R.
1971. The effects of land use change on the hydrology of an urban watershed: Atlanta, Georgia Inst. of Technology, Environmental Resources Center, Rept. ERC-0871, 66 p., 30 figs., 3 tables, 25 references.

Analysis of the relative utility of alternative flood plain management techniques must include examination of urban flooding. The hydrologic aspects of floods are influenced by land-use patterns, and land-use patterns are a reflection of social values and economic needs. The development of the Peachtree Creek watershed in Atlanta, Ga., was traced for 10 years, and the influence of the development on streamflow was analyzed. The watershed surface covered by impervious area increased from 17.13 percent to 31.21 percent, or about 12,000 acres. During the period 1949–55 dense development occurred primarily on ridge lines. During the period 1955–68 changes were near interstate highways, which paralleled one of the major forks of the creek, often in the flood plain. The average storm runoff yield in August and September for the period of 1963–69 was approximately 3 times that which occurred for the period 1959–63; however, the wet-season base flow from the nonurbanized control watershed was 1.46 times as great as the base flow from Peachtree Creek. In the urban watershed, storm runoff has increased in the dry months, base flow has decreased in the wet months, and peak runoff from summer storms has greatly increased. Such a trend could result in an extended "flood season" in which large flood peaks could become as common in the summer as they have historically been in the winter and spring.—W72-04126.

Descriptors: Floods, Atlanta (Ga.), storm runoff, land use, hydrograph analysis.

593 Walling, D. E.; Gregory, K. J.
1970. The measurement of the effects of building construction on drainage basin dynamics: Jour. Hydrology, v. 11, no. 2, p. 129–144, 8 figs., 21 references.

The impact of building activity upon suspended sediment concentrations may be assessed by comparing samples obtained simultaneously at different points within one catchment or by comparing samples derived from two adjacent small watersheds. The suspended sediment concentrations are between 2 and 10 times, and occasionally up to 100 times, greater than the concentrations obtained from undisturbed conditions. To assess the yields over time, streamflow and sediment records are required. A small catchment was instrumented for this purpose on the margin of Exeter, Devon, England. The catchment was calibrated for a period of 17 months prior to building activity by deriving multiple regression equations relating peak flow, runoff amount, and runoff percentage to precipitation characteristics at different times of the year, by evaluating unit hydrographs, by establishing suspended sediment rating curves, and by using two adjacent catchments as controls.—W71-00592.

Descriptors: Sediment yield, storm runoff, construction, instrumentation, Exeter (England), data collections, unit hydrographs, peak discharge.

594 Walton, W. C.
1964. Future water-level declines in deep sandstone wells in the Chicago region: Ground Water, v. 2, no. 1, p. 13–20, 8 figs., 3 tables, 5 references.

Severe water-level declines have occurred in deep wells penetrating the most highly developed aquifer for large ground-water supplies in the Chicago region. The Cambrian-Ordovician aquifer is encountered at an average depth of 500 feet below the land surface at Chicago; it has an average thickness of 1,000 feet and is composed chiefly of sandstones and dolomites. A mathematical model provides a means of evaluating the sustained yield and of predicting future water-level declines. Pumpage from deep sandstone wells concentrated in six pumping centers has increased from 200,000 gpd in 1864 to 96.5 mgd in 1961. As a result of heavy pumping, water levels

in deep sandstone wells declined more than 650 feet between 1864 and 1961. Pumping water levels in most pumping centers will be at critical stages a few feet above the top of the lowermost and most productive unit of the aquifer by the year 2010.

Descriptors: Water levels, drawdown, Chicago (Ill.), groundwater depletion.

595 Warg, Gunter

1966. The effect of delayed discharge on the calculation of storm-sewage overflows: Gas und Wasserfach (GWS), v. 107, no. 3, p. 85–89, 8 figs., 2 tables, 3 references.

The effect of delayed discharge of rain water on the design calculations and measurements of storm-sewage overflows is discussed. Measurements were carried out in the sewerage system at Munich to evaluate the effects on discharge capacity, intensity and duration of discharge, load on the receiving water, and dimension of the sewerage system. A specially developed hydrograph system may be used to calculate and allow for changes in permeability at peak flows and to assess the maximum area likely to be covered during rainstorms. Tables and nomographs are included to be used to calculate the effects of delay on design calculations for storm-sewage plants and flood-retention basins.—W69-02120.

Descriptors: Storm runoff, hydrograph analysis, impervious area, water pollution sources, combined sewers.

596 Wark, J. W.; Keller, F. J.

1963. Preliminary study of sediment sources and transport in the Potomac River basin: Washington, D.C., Interstate Comm. on the Potomac River basin, Tech. Bull. 1963-11, 28 p., 11 figs., 2 tables, 11 references, 3 app.

A 2-year sediment study was made on the Potomac River basin to determine the magnitude of sediment loads of streams and the sources of sediment. Also studied were environmental factors affecting sediment yield. Computed average annual sediment discharge varies from 21 to 2,300 tons per square mile and can be attributed chiefly to variations in land use. Drainage basins with a high percentage of forest cover have low sediment yields. Areas undergoing urbanization near Washington, D.C., have the highest yields.

Descriptors: Sediment yield, erosion, sedimentation, Potomac River basin, Washington (D.C.).

597 Wasson, B. E.

1969. Floods of July 2, 1968, in Jackson, Mississippi: U.S. Geol. Survey open-file rept., 10 p., 4 figs.

An urbanized belt along Woodrow Wilson Avenue in northwestern Jackson, Miss., received more than 4 inches of rain during a 5-hour period July 2, 1968. About 3 inches of the rain fell during 1 hour. The recurrence interval of this rainfall is in excess of 10 years. Severe flooding occurred on streams in the central part of the Town Creek basin. West Branch Town Creek at Derrick Street had the highest stage since 1953. The 1953 flood was much more severe than the July 2, 1968 flood, except in a small area upstream from the mouth of West Branch Town Creek. Town Creek at Gallatin Street and Lynch Creek at Valley Street had floods representing 3-year recurrence intervals, and Eubanks Creek at Wood Dale Drive has a 2-year recurrence interval.—W69-10101.

Descriptors: Floods, rainfall-runoff relationships, Jackson (Miss.).

598 Wasson, B. E.

1972. Effects of urbanization on timing of flood peaks on Town Creek in Jackson, Mississippi: U.S. Geol. Survey open-file rept., 3 p., 3 figs., 1 table, 3 references.

The abnormal sequence of flood peaks observed during two low-order floods on Town Creek in Jackson, Miss., is attributed to spot urbanization. Flooding after general rains in March and April 1969 crested at downtown Gallatin Street before crests occurred at upstream measuring sites. Heavy urbanization in the downstream part

of the basin caused an abnormal flood-peak sequence. Floodflow at Gallatin Street is spread over a greater time span than flows in the lightly urbanized area upstream in the northwest parts of the city. Rapid runoff from the lower heavily urbanized part of the basin flows past the gage before runoff from the lightly urbanized parts of the basin arrives. During floods caused by rainfall of longer duration than those described, the effects of nonuniform urbanization probably will be less pronounced.

Descriptors: Storm runoff, peak discharge, time of concentration, Jackson (Miss.), floods.

599 Wastes Engineering.

1962. What to do about pollution from storm sewage overflows: Wastes Eng., v. 33, no. 8, p. 401 and 429.

In a symposium on the treatment of storm sewage overflows held in New York and presented by the Sanitary Engineering Division, Metropolitan Section, American Society of Civil Engineers, the subjects discussed were frequency and composition of storm-sewage overflows; the effect of storm-water outfalls on waters around New York City; techniques of analyzing and classifying harbor water; sewage and storm-water chlorination; treatment of storm-sewage overflows with ozone; design of facilities for chlorinating storm water; and design and operation of sewage systems to minimize pollution.—W69-01504.

Descriptors: Water pollution control, reviews, storm runoff, drainage (urban), conferences.

600 Water Resources Engineers.

1968. Comprehensive system engineering analysis of all aspects of urban water, a prefeasibility study: Walnut Creek, Calif., Water Resources Engineers, Inc., 121 p., 13 figs., 74 references.

It is possible to describe a given urban region by its boundaries and boundary conditions, to develop systems analysis techniques to describe this region's subsystems, and to model this system's operation under specified loads or inputs. It is not possible and probably will not become possible to write one program that will describe any urban area's complete water situation. Its ultimate goal should be to support the decision-making process through optimization analysis that indicates which alternative project is best, and hence, the one to adopt.

Descriptors: Systems analysis, water resources development, computer programs, planning, water management (applied).

601 Watkins, L. H.

1962. The design of urban sewer systems; research into the relation between rate of rainfall and the rate of flow in sewers: Great Britain, Dept. of Sci. and Indus. Research, Road Research Lab., Tech. Paper 55, 96 p., 47 figs., 12 tables, 36 references, 5 app.

Research was carried out by the Road Research Laboratory, United Kingdom, on the relation between the rate of rainfall and the rate of runoff from urban areas, principally intended to lead to a method for calculating the rate of runoff in sewerage systems. Rainfall and runoff were recorded at 12 experimental catchment areas, representing a wide range of sizes, types of development, locality, and other variables; and the rates of runoff calculated from the recorded rates of rainfall by five differenct methods were compared with the recorded rates of runoff. A total of 286 storms were analyzed, and it was concluded that the rational (Lloyd-Davies) tangent and modified tangent methods for calculating runoff were unreliable for use in the design of sewerage systems. The usual unit hydrograph method was also unsuitable. The Road Research Laboratory therefore devised a new hydrograph method which is reliable under all conditions, to be used with an electronic digital computer. In calculations for the design of sewers, the whole area of paved surface should be considered impermeable, and the unpaved areas should be considered completely pervious.—W69-01905.

Descriptors: Rainfall-runoff relationships, instrumentation, hydrograph analysis, drainage (urban), Road Research Laboratory method.

602 Watkins, L. H.

1963. Research on surface-water drainage: Inst. Civil Engineers Proc., London, v. 24, Paper 6638, p. 305–330, 14 figs., 4 tables, 9 references.

The Road Research Laboratory studies the relation between the rate of rainfall and the rate of runoff from urban areas. The object of the research was a method of calculating the rates of storm runoff in sewer systems that would be accurate and reliable under as wide a range of conditions as possible. The method is accurate and reliable for the calculation of runoff hydrographs for all the urban areas studied. The method known as the R.R.L. hydrograph method is based on broadly the same principles as the unit hydrograph method. A program for an electronic computer was developed to use the method simply and economically for designing sewer systems.

Descriptors: Rainfall-runoff relationships, storm runoff, Road Research Laboratory method, hydrograph analysis.

603 Watkins, L. H.

1963. Design of storm sewer systems: Chartered Municipal Engineers, v. 90, no. 11, p. 337–341, 5 figs., 3 tables, 6 references.

Research into the relation between the rate of rainfall and rate of runoff from urban areas led to development of a new method of calculating sewer sizes. Programs for electronic digital computers enable the method to be used simply and economically for designing new sewer systems and examining and redesigning existing systems.—W69-02204.

Descriptors: Rainfall-runoff relationships, computer programs, drainage (urban).

604 Watkins, L. H.

1966. Runoff from combined rural and urban areas, *in* River engineering and water conservation works, Thorn, R. B., ed.: London, England, Butterworths, p. 111–121, 5 figs., 4 tables, 4 references.

Hydrologic principles of the calculation of runoff from rural areas are also applicable to urban and combined rural and urban catchments. Urban runoff calculated by a variation of the rational formula is reliable only for very small urban catchments, and it is being replaced by the Road Research Laboratory hydrograph method. This hydrograph method is based on climatic conditions in Great Britain; for application elsewhere, suitable rainfall data must be employed and adequate allowance made for increased impermeability of natural surfaces, particularly under conditions of tropical rainfall.—W71-06774.

Descriptors: Rainfall-runoff relationships, rational formula, Great Britain, Road Research Laboratory method.

605 Weibel, S. R.

1969. Urban drainage as a factor in eutrophication, *in* Eutrophication, causes, consequences, correctives; proceedings of a symposium: Washington, D.C., Natl. Acad. Sci., Natl. Research Council, p. 383–403, 2 figs., 9 tables, 31 references.

Storm-water runoff and combined-sewer overflows as sources of water pollution, including nutrient contributions, are reviewed as an area of study where much work is needed. Urbanization means that more people, more demands for water for all purposes, more wastes, more storm-water runoff, all are impressed upon existing time, space, facilities, and habits already representing huge investments. About 1,920 U.S. communities (18 percent of the communities with identifiable systems) are partly or wholly sewered by combined-type sewer systems. Many of our older and larger cities are served by combined sewers. The geographic distribution is also of interest; 98 percent of the communities having combined systems are in a band of States across the northern part of the country and the West Coast.

Descriptors: Storm runoff, storm drains, water pollution sources, eutrophication, combined sewers.

606 Weibel, S. R.; Anderson, R. J.; Woodward, R. L.

1964. Urban land run-off as a factor in stream pollution: Water Pollution Control Federation Jour., v. 36, no. 7, p. 914–924, 9 figs., 5 tables, 11 references.

A runoff study was carried out in part of Cincinnati, where about 37 percent of the total drainage area is impermeable, the remainder being lawns, parks, and gardens. The runoff had an average BOD (biochemical oxygen demand) of 19 mg per liter, a chemical oxygen demand of 99 mg per liter, a suspended-solids content of 210 mg per liter, a turbidity of 170 units, and a color of 81 units. The runoff also contained organic chlorides, which could be derived from pesticides, and large numbers of bacteria, indicating predominantly nonhuman pollution. The highest concentrations of all contaminants occurred within the first 15 minutes of the start of runoff. These results confirm that runoff should be taken into consideration when estimating waste loadings from urban sources.—W69-02223.

Descriptors: Storm runoff, water pollution sources, impervious area.

607 Weibel, S. R.; Weidner, R. B.; Christianson, A. G.; Anderson, R. J.

1967. Characterization, treatment, and disposal of urban stormwater, *in* Advances in Water Pollution Research, Third Internat. Conf., Munich, Germany, Sept. 1966, Proc.: v. 1, Washington, D.C., Water Pollution Control Federation, Paper 15, p. 329–352, 1 fig., 6 tables, 29 references.

Because of the increasing needs for conservation and effective use of all available water resources, urban storm water must play an important role as a readily available raw-water resource. In many cases this water may require treatment before it is acceptable for many uses. Storm-water runoff from a 27-acre residential and light commercial urban area had the following constituent averages: suspended solids, 227 mg per liter; volatile suspended solids, 57 mg per liter; COD (chemical oxygen demand), 111 mg per liter; inorganic nitrogen, 1.0 mg per liter; total hydrolyzable phosphate, 1.1 mg per liter; and inorganic chlorine, 1.70 microgram per liter. Suspended solids discharged annually in the runoff equal 160 percent of those produced as sanitary sewage; COD, 33 percent; BOD (biochemical oxygen demand), 7 percent; total hydrolyzable phosphate, 5 percent; and total nitrogen, 14 percent. Coliform densities were greater than 2,900 per 100 ml in 90 percent of the samples, exceeding the 1,000 per 100 ml criterion for swimming water quality.

Descriptors: Water pollution sources, storm runoff, water quality, water resources research, water pollution control.

608 Weidner, R. B.; Weibel, S. R.; Robeck, G. G.

1968. Automatic mobile sampling and gaging unit: Public Works, v. 99, no.1, p. 78–80, 2 photos.

Equipment for sampling storm-water runoff from various environments on time-proportioned or flow-proportioned basis was developed to facilitate urban storm-water runoff studies. Operation of the sampler is controlled by sufficient rainfall to start electrical and cooling systems, and a predetermined amount of runoff activates the sampling section.—W69-02088.

Descriptors: Storm runoff, sampling, instrumentation, data collections.

609 Weigle, J. M.

1967. Groundwater contamination by highway salting: Natl. Research Council, Highway Research Board, Highway Research Record no. 193, p. 34.

Of the salt applied to highways, a part eventually lodges in or on nearby soil. Subsequent rainfall and snowmelt that enter the ground carry some salt down to the water table. In the saturated zone, the salt moves laterally along with the ground water, which ultimately discharges into surface streams. In shallow unconfined aquifers, the chloride concentrations in ground water near salted highways fluctuate strongly, reflecting the interplay between surges of salty water carried down from the soil above the continuous flushing and dilution by laterally

moving ground water in the zone of saturation. Under these conditions, the fluctuations are cyclic annually, and generally the chloride content increases only until a balance is reached between salt recharge and continuous dilution by ground water. Generally the chloride concentration is less than 250 ppm during the entire year, but in some places it exceeds that figure at peak times throughout the year.

Descriptors: Deicers, highway deicing, water pollution sources, water pollution effects, groundwater pollution.

610 Weller, L. W.; Nelson, M. K.

1963. A study of stormwater infiltration into sanitary sewers: Water Pollution Control Federation Jour., v. 35, no. 6, p. 762–776, 2 figs., 9 tables, 1 reference.

In the metropolitan area of Kansas City, Mo., a surface drainage survey of selected areas and a surface inspection of the main sewers were made to find if conditions promote the entry of surface water into sanitary sewers. A total sewer flow of 104.33 mgd is developed during large rainstorms. Even during periods of moderate precipitation most of the flow is from sources other than waste water from the residences and public buildings within the district. During these periods the major source of sewer flow is ground water, presumably from foundation drains used throughout the district. Additional local factors influencing sewer flow are reviewed.—W69-02177.

Descriptors: Storm runoff, combined sewers, Kansas City (Mo.).

611 Wells, D. M.; Austin, T. A.; Cook, B. C.

1971. Project completion report, variation of urban runoff with duration and intensity of storms: Lubbock, Texas Tech. Univ., Water Resources Center, Report WRC-71-5, 139 p., 30 figs., 24 tables, 37 references, 2 app.

A simulation model describes the quantitative and qualitative regimes of storm-water runoff from urban watersheds. The urban runoff system consists of three basic subsystems: Precipitation, runoff, and quality. The model assumes that short-duration precipitation events are random and governed by a stationary probability distribution function. A bivariate log-normal distribution function fits the observed rainfall depths and durations for Lubbock, Tex. The runoff process is modeled by using the British Road Research Laboratory method, which assumes that all runoff is derived from interconnected impervious areas. The total pollutant load is predicted by a multiple regression involving the storm characteristics and the antecedent conditions. A one-step lag regression model is used to predict the pollutant concentrations.

Descriptors: Rainfall-runoff relationships, water quality, routing, Road Research Laboratory method, simulation analysis, mathematical models, Lubbock (Tex.)., storm runoff.

612 Welsch, W. F.

1955. Ground water pollution from industrial wastes: Sewage and Indus. Wastes, v. 27, no. 9, p. 1065–1072, 5 figs., 1 table, 6 references.

Growth in the population of Nassau County, Long Island, N.Y., coupled with rapid industrial expansion has created a problem in protecting the ground water of the county from pollution. Industrial wastes from the many light industries in the area have caused a critical situation in some sections. Chromium wastes are disposed of by recharging to the ground water through artificial recharge basins. This practice contaminated a large volume of ground water before the deleterious effects were detected. Water from one of the public water-supply wells near a contaminated area was found to contain over 1 ppm of hexavalent chromium. In an area immediately south of an aircraft company's seepage basin, chromium concentrations as high as 40 ppm were discovered. The contaminated water affected an area 600 feet wide by 3,600 feet long. Field investigations made in cooperation with the Nassau County Department of Public Works included several series test wells on lines perpendicular to the direction of ground-water flow just south of the recharge basins in question. The east and west limits of the contaminated section are nearly parallel as the cadmium travels southward under the influence of the ground-water flow.

Descriptors: Path of pollutants, groundwater pollution, industrial wastes, Long Island (N.Y.).

613 Wentz, D. A.; Lee, G. F.
1969. Sedimentary phosphorus in lake cores, observations on depositional pattern in Lake Mendota: Environmental Sci. and Technology, v. 3, no. 8, p. 754–759, 5 figs., 1 table, 20 references.

Available phosphorus is an operationally defined fraction of lake sediments available for plant growth. A core from the deepest part of eutrophic Lake Mendota, Wis., was analyzed for available phosphorus. Deposition rate of available P was constant in marl layers, increased with a change from marl to sludge, was maximal about 30 centimeters below sediment-water interface, and decreased gradually from that stratum to the surface. Initial increases may correspond with man's appearance in the watershed. Decrease may correspond with cessation of input of Madison's sewage effluents in 1899. Available phosphorus is probably associated with the carbonate portion of the sediments, and changes in its deposition correlate with events influencing the eutrophication of the lake.

Descriptors: Lakes, phosphorus, lake sediments, water pollution sources, Lake Mendota (Wis.), eutrophication, Madison (Wis.).

614 Wenzel, H. G.
1968. A critical review of methods of measuring discharge within a sewer pipe: Am. Soc. Civil Engineers, Urban Water Resource Research Program, Tech. Memo. 4, 20 p., 11 figs., 11 references.

Existing methods of measuring discharge of sewers are discussed with respect to the requirements and physical limitations imposed by their use in an urban study area. Rating curves are given for a suggested critical flow device with recommendations for design research. The gage must have an output in the form of an electrical signal for recording, be automatically turned on and off, and need no attendant. Desired accuracy is 5 percent in discharge measurement over a large range of flow. The device must be capable of installation in any existing sewer at reasonable cost. Weirs, depth gages, and velocity meters all have serious disadvantages and are not recommended. Tracer dilution methods as well as venturi flumes and other critical-flow devices are suggested for development. A pipe section with a narrow throat acts as a venturi flume for open flow and as a venturi meter for full flow. Plans and theoretical rating curves for such a device are shown.—W69-03510.

Descriptors: Stream gages, flow measurement (sewers), data collections, venturi meters.

615 Whipple, William, Jr.
1969. Summary—Water and metropolitan man, Conf. on Urban Water Resources Research, 2d, Andover, N. H., Aug. 12–16, 1968, Proc.: Am. Soc. Civil Engineers, Urban Hydrology Research Council, p. 11–14.

A multidisciplinary approach to urban water resources development poses problems, including conflicts in the role and the status of the engineer. There is a need to codify much of the common law relating to water. The systems approach to metropolitan water resources development is suggested as a method of achieving progress. Different objectives cause tensions because of the varying degree to which persons are benefited. Rational criteria for selection of projects is necessary; these criteria require the quantification and identification of impacts, direct and indirect. Determining the desires of society is often complicated by the fact that there are multiple interests. Reconciliation of these often conflicting needs requires the development of a sophisticated methodology for measuring values and needs.—W69-08629.

Descriptors: Social aspects, systems analysis, water resources development.

616 White, G. F.
1960. Strategic aspects of urban flood plain occupance: Am. Soc. Civil Engineers Trans., Paper 3092, v. 126, pt. 1, p. 63–75 and Am. Soc. Civil Engineers Proc., Paper 2376, Jour. Hydraulics Div., v. 86, no. HY 2, pt. 1, p. 89–102, 6 figs., 7 references.

Studies of seventeen selected urban areas having flood problems reveal a general and persistent encroachment of urban structures upon the flood plains during the period 1936–57, even in areas in which there was net decrease in total population. Highway construction and flood-control works are major stimulants to growth. The situations at Boulder and Denver, Colo., illustrate some of the major findings. Perhaps of greater importance is the difference in number of large and infrequent floods. Probably the most important reason for the rising trend in

flood losses is to be found in the continuing encroachment of human occupance upon flood plains. New structures and changes in the intensity of existing structures reduce the hydraulic efficiency of valley sections and increase the hazard in affected reaches of the stream.

Descriptors: Storm runoff, flood plain use, flood hazard, flood plains, Boulder (Colo.), Denver (Colo.), floods.

617 Wiitala, S. W.

1961. Some aspects of the effect of urban and suburban development upon runoff: U.S. Geol. Survey open-file rept., 28 p., 3 maps, 2 tables, 5 charts.

Selected storms and the resulting runoff were studied for two small drainage basins near Detroit, Mich. One basin, Red Run, covering an area of 36.5 square miles, is urban and completely sewered. The other, Plum Brook, covering an area of 2.9 square miles, is relatively free of urban and suburban development. The time of concentration for the urban basin is about 3 hours, while that for the natural basin is about 12 hours. Flood peaks on the urban basin are about 3 times the magnitude of those for natural basins of comparable size. There is no appreciable difference in the total volume of storm runoff for the two basins.

Descriptors: Rainfall-runoff relationships, storm runoff, time of concentration, peak discharge.

618 Wiitala, S. W.; Jetter, K. R.; Sommerville, A. J.

1961. Hydraulic and hydrologic aspects of flood-plain planning: U.S. Geol. Survey Water-Supply Paper 1526, 69 p., 30 figs., 4 plates, 7 tables.

Hydraulic and hydrologic data concerning the flood regimen of a stream can be used in appraising its flood potential and the risk inherent in occupation of its flood plain. The approach involves the study of flood magnitudes, flood frequencies, stage-discharge relations, flood profiles, and flood-zone maps. Urbanized areas, because of their large proportion of impervious catchment, intensify runoff. Where development is extensive on two or more tributaries and the concentrated flow from these tributaries arrives at about the same time, flood conditions will be aggravated. A concentrated inflow from a built-up area entering at the upper reaches of a steep tributary could make conditions worse by dangerously augmenting the stream velocity.

Descriptors: Floods, storm runoff, flood plain planning.

619 Wilkinson, R.

1956. The quality of rainfall run-off water from a housing estate: Inst. of Public Health Engineers Jour., v. 55, pt. 2, p. 70–84, 4 figs., 3 tables, 1 reference.

In many recently developed housing estates in England the separate system of drainage is used. An investigation of the quality of runoff waters was made at a typical modern estate including houses, schools, and shops with some undeveloped land and woodland and with a housing density of about eight houses per acre. The total paved area of the catchment area is 121 acres. In most storms there is a first flush of water which was more polluting than the rest of the storm. The time of concentration is about 20 minutes, and between 20 and 30 minutes from the start of most storms the concentration of polluting matter passes its peak. The volume of the early flush is 55,000 gallons, which is 250 gallons per impervious acre and 450 gallons per paved acre. The first flushes contain concentrations of polluting matter roughly twice as great as subsequent flow. The polluting matter discharged in the runoff water tended to increase with the period of dry weather which preceded the storm. The estimated total weight of polluting matter is equivalent in BOD (biochemical oxygen demand) to 12.5 million gallons of sewage effluent per year and in suspended matter to 209 million gallons of sewage effluent per year.

Descriptors: Storm runoff, London (England), water pollution sources.

620 Willeke, G. E.

1966. Time in urban hydrology: Am. Soc. Civil Engineers Proc., Paper 4615, Jour. Hydraulics Div., v. 92, no. HY 1, p. 13–29, 4 figs., 4 tables, 6 references, 1 app.

Analysis of lag time (defined as time between centroids of effective precipitation and runoff) from nine small urban watersheds shows that lag time variability is small and that lag time is not correlated with storm intensity.

Effective precipitation can be routed through storage by the Muskingum method to accurately reproduce the observed runoff hydrograph. Precipitation loss on watershed is closely represented by a linear relationship between total storm precipitation and total storm runoff.—W69-01906.

Descriptors: Rainfall-runoff relationships, rainfall intensity, time lag, routing.

621 Wilson, K. V.
1966. Flood-frequency of streams in Jackson, Mississippi: U.S. Geol. Survey open-file rept., 6 p., 3 figs., 1 map.

Individual flood-frequency curves were drawn for Eubanks, Town, and Lynch Creeks, Jackson, Miss., based on annual maximum floods during the period 1952–66. The Three Mile Creek curve was based on a shorter period of annual peaks, 1962–66. The 50-year flood is only about twice the magnitude of the mean annual flood. This is quite different from larger rural areas whose 50-year floods are about 3 times the mean annual flood. The difference is accredited to the storm sewers, gutters, and ditches which function well during low-order floods but are overtaxed during extreme floods. The mean annual floods for each of the four gaged sites were from 2 to 3½ times the values for rural streams. The mean annual flood for a basin with 100 percent of its area containing storm sewers and improved channels is about 4½ times that of a rural stream.

Descriptors: Floods, storm runoff, Jackson (Miss.).

622 Wilson, K. V.
1967. Preliminary study of effect of urbanization on floods in Jackson, Mississippi: U.S. Geol. Survey Prof. Paper 575-D, p. D259–D261, 3 figs., 1 map, 1 reference.

Comparison of flood-frequency curves for three streams near Jackson, Miss., based on annual maximum floods for the period 1953 to 1966 and for another stream for a shorter period indicates that mean annual flood for a totally urbanized basin is about 4½ times that of a similar rural stream. The 50-year flood for an urbanized basin is about 3 times that of a rural stream.—W69-01907.

Descriptors: Flood frequency, storm runoff, peak discharge, Jackson (Miss.), floods.

623 Wilson, K. V.
1968. Floods of June 1, 1967 in southwestern Jackson, Mississippi: U.S. Geol. Survey open-file rept., 22 p., 6 figs., 1 table, 2 references.

An intense rainfall of 2 to 4 inches on June 1, 1967, most of it falling within 1 hour, caused unusual flooding in southwestern Jackson, Miss. The frequency of this rainfall exceeded 25 years for periods less than 1½ hours. The frequency flooding of Hardy Creek was greater than 50 years at McDowell Road and dissipated to about 10 years at Terry Road. The frequency of flooding of Cany Creek exceeded once in 50 years at Raymond Road but was only a 10-year flood at Cooper and Terry Roads. Baker Creek, which drains from the extreme western part of Jackson, flooded Spring Ridge Road to considerable depths. The frequency of this flood on Baker Creek was about 17 years.—W70-02477.

Descriptors: Storm runoff, stage-discharge relations, Jackson (Miss.), floods.

624 Winslow, A. G.; Doyel, W. W.; Wood, L. A.
1957. Salt water and its relation to fresh ground water in Harris County, Texas: U.S. Geol. Survey Water-Supply Paper 1360-F, 32 p., 15 figs., 2 plates, 2 maps, 53 references.

Harris County, in the West Gulf Coastal Plain in southeastern Texas, has one of the heaviest concentrations of ground-water withdrawal in the United States. Large quantities of water are pumped to meet the requirements of the rapidly growing city population, of industry, and of rice irrigation. The water is pumped from artesian

wells which tap a thick series of sands. The base of the fresh-water sands ranges in depths from about 100 feet to more than 3,000 feet. Before large-scale ground-water withdrawals were begun, the hydraulic gradient sloped gently toward the coast. Then, as large quantities of water were withdrawn, a large cone of depression was established, the hydraulic gradient was reversed, and salt water began to move slowly toward the centers of pumping.

Descriptors: Saline water intrusion, municipal water, groundwater depletion, Texas, groundwater pollution.

625 Wischmeier, W. H.; Johnson, C. B.; Cross, B. V.
1971. A soil erodibility nomograph for farmland and construction sites: Jour. Soil and Water Conserv., v. 26, no. 5, p. 189–193, 2 figs., 1 table, 7 references.

A new soil particle-size parameter was found and used to derive a convenient erodibility equation that is valid for exposed subsoils as well as farmland. A simple nomograph provides quick solutions to the equation. Only five soil parameters need to be known: percent silt; percent sand; organic matter content; structure; and permeability. This new technique for computing soil erodibility can greatly facilitate evaluation of the erodibility factor for hundreds of soils throughout the country. It perhaps can be of even greater value in planning sediment-control measures for construction sites and other disturbed areas. With onsite values of the erodibility factor K available, a contractor can use the universal soil-loss equation to compute probable sediment yields for the area that he plans to develop.—W71-13910.

Descriptors: Soil erosion, construction, particle size, soil erodibility, sediment yield.

626 Wolfson, J. B.
1971. Graphic analysis of roadway runoff: Civil Eng. v. 41, no. 6, p. 64–65, 2 figs.

The drainage design of highways requires computation of the storm-water runoff for various widths, lengths, and slopes of roadway at variable times of concentration. Curves are derived to give a graphic analysis for determining the rates of storm-water runoff that will occur for storms of various sizes. To accomplish this, the rainfall, surface area of the roadway, and time of concentration are related to various slopes of roadway. The chart gives a picture of the flow that can be expected as the length of the pavement or the time of concentration varies by the addition of a lag time or roof-to-gutter time.

Descriptors: Rainfall-runoff relationships, storm runoff, hydrograph analysis, time of concentration.

627 Wolman, M. G.
1967. A cycle of sedimentation and erosion in urban river channels: Geografiska Annaler, v. 49A, no. 2–4, p. 385–395, 7 figs., 10 photos., 1 table, 11 references.

Historical evidence and contemporary measurements in the Piedmont of Maryland show successive changes in land use accompanied by changes in sediment yield and in the behavior of river channels. Sediment yields from forested areas in the prefarming area appear to have been less than 100 tons per square mile per year. Yields from agricultural lands in the same region at a later time range from 300 to 800 tons per square mile on large drainage areas. Areas exposed during construction can produce sediment loads in excess of 100,000 tons per square mile per year. Increased runoff from urban areas, coupled with a decline in sediment yields to values on the order of 50 to 100 tons per square mile, promote continued bank erosion and channel widening. Raw banks adjacent to coarse cobble bars and widespread deposits of flotsam and debris attest to the flood regimen of urban rivers. Canalization in concrete does not eliminate such debris nor does it eliminate deposition of sediment.

Descriptors: Sedimentation, erosion, construction, Maryland, land use, sediment yield.

628 Wolman, M. G.; Schick, A. P.
1967. Effects of construction on fluvial sediment, urban and suburban areas of Maryland: Water Resources Research, v. 3, no. 2, p. 451–464, 3 figs., 5 tables, 29 refeerences.

Construction and urbanization affect sediment loads of streams in the Washington, D.C., and Baltimore, Md., urban and suburban areas. Annual precipitation is 42 inches, evenly distributed areally, and with high summer intensities. Average sediment yield is 200–500 tons per square mile per year. Construction areas yield as much

as 140,000 tons per square mile per year with sediment concentrations of 3,000 to over 150,000 ppm, while natural and farm area yields are not over 2,000 ppm. The increased sediment loads in streams cause channel bar deposition, bank erosion, flow obstruction, flooding, changing channel morphology, blanketing of bottom flora and fauna, and changes in patterns of fish species. Building permits show that 50 percent of sites were open 8 months, 60 percent for 9, and 25 percent over 1 year. Activity is almost constant through the year. Average site size is 14,400 square feet. A minimum of 7.2 square miles is open at any one time. Housing accounts for 5.7 square miles and highways for 1.5 square miles. Sediment yield is 700–1,800 tons per 1,000 increase in population.—W69-03227.

Descriptors: Sediment yield, construction, Maryland, District of Columbia, land use.

629 Wood, I. R.

1959. A method of urban drainage design for regions of high rainfall intensity: Australia, Inst. of Engineers, Civil Eng. Trans., v. CE1, no. 1, p. 38–46, 13 figs., 3 tables, 24 references.

The rational method is unsuitable for the design of suburban drainage systems in regions where the design intensity is so high that runoff occurs not only from the impervious area but also from the pervious area, such as lawns and gardens. A better method would be to determine a design storm pattern, subtract a loss-rate curve, and translate the excess rain into hydrograph form using overland flow equations. The application of the method to conditions in Canberra, Australia, is described. Approximations are suggested to make it possible to use the procedure for routine design.—W69-01910.

Descriptors: Rainfall intensity, rational formula, storm runoff, design storm, Canberra (Australia), hydrograph analysis.

630 Woodward, L.

1961. Ground water contamination in the Minneapolis and St. Paul suburbs, *in* Ground Water Contamination: Cincinnati, Ohio, Environmental Protection Agency, Robert A. Taft Sanitary Eng. Center, Tech. Rept. W61-5, p. 66–71, 1 fig., 3 tables.

The ground water in the suburbs of Minneapolis and St. Paul from 1959–61 was extensively contaminated by sewage. Individual household wells serve a relatively large population in the area. Perhaps the most important cause of the problem was the lack of control of platting. Ground water is readily available throughout most of the area, at depths of 20 to 70 feet, so that a developer could justify individual wells instead of community water systems that would involve him in operation of a utility. Also soil conditions are generally favorable for the absorption of waste liquids. In younger (postwar) communities 10 to 20 percent of the wells most seriously affected by sewage chemicals were also contaminated bacteriologically, and in older communities as many as 50 percent of all wells were affected. Factors found to affect the occurrence of ground-water contamination are: well depth, character of soil, population, and rate and direction of ground-water movement.

Descriptors: Water pollution sources, water pollution effects, groundwater pollution, Minneapolis-St. Paul (Minn.).

631 Woolhiser, D. A.; Liggett, J. A.

1967. Unsteady, one-dimensional flow over a plane—the rising hydrograph: Water Resources Research, v. 3, no. 3, p. 753–771, 9 figs., 23 references.

The equations describing overland flow, in three non-dimensional forms, are solved for the rising hydrograph by finite-difference integration of the characteristic equations utilizing a characteristic net. A dry channel was used as an initial condition; the upstream and downstream boundary conditions were zero inflow and critical depth. In general, there is no unique dimensionless rising hydrograph for overland flow, but for most hydrologically

significant causes the kinematic wave solution gives very accurate results. A single dimensionless parameter was found to be a suitable criterion for choice between the complete equations or the kinematic-wave approximation.

Descriptors: Mathematical models, unsteady flow, overland flow, rainfall-runoff relationships, hydrograph analysis, kinematic wave theory.

632 Woollum, C. A.; Canfield, N. L.

1968. Washington metropolitan area precipitation and temperature patterns: U.S. Weather Bureau, Tech. Memo. WBTM-ER-28, 32 p., 22 maps, 1 graph, 12 references, 1 app.

Around Washington, D.C., systematic mapping of monthly weather data on a metropolitan area basis began in January 1946. A relative minimum of annual precipitation extends upstream along the Potomac River, while greater precipitation is associated with higher terrain to the west and north of the District of Columbia. The mean annual snowfall ranges from about 16 inches in the center of the city to nearly 22 inches over higher terrain in the northwestern and eastern suburbs. The urban heat island, along with elevation, is a factor in the pattern of long-term snowfall totals. In all seasons, the centers of the isotherm patterns are in similar locations. In early morning, the center of the urban heat island is rather consistently between the center of the District and a point 2–4 miles to the southeast. In the afternoon, however, two heat centers are evident several miles upstream along each of the rivers. The gradients of maximum and minimum temperature from the center of the city to the suburbs seem to be similar in all seasons.

Descriptors: Climatology, weather data, precipitation (atmospheric), heat islands, Washington (D.C.).

633 World Meteorological Organization.

1970. Urban Climates, v. 1: Geneva, Switzerland, Secretariat of the World Meteorological Organization, Tech. Note 108, WMO-no.254.TP.141, 390 p., 131 figs., 3 photos., 28 tables, 216 references.

In 1968 a symposium was held on urban climates and building climatology. Mesoscale airflow systems above urban areas are important not only in themselves but also to other aspects of urban climatology, such as to the temperature and pollution fields. Sharp marginal temperature gradients, especially on the leeward side of towns, may be partly owing to centripetal winds. Urban temperatures, like other measures, are clearly closely related to very local conditions, especially on calm, clear nights. In highly polluted areas adsorption by gases and aerosols can probably result in heating rates in excess of 5 degrees centigrade per day which could not be compensated by stronger infrared cooling. In consequence, there could be a loss, beneath polluted city atmospheres, of up to one-half of all visible radiation and two-thirds of ultraviolet radiation. Three main factors may be the cause of urban changes in precipitation. These are additional condensation nuclei, increased turbulence because of increased surface roughness, and thermal convection resulting from higher temperatures. Because of these influences, a number of cities have more rain days, more thunderstorms, and more total precipiation than the country areas around them.

Descriptors: Climatology, heat islands, conferences, precipitation (atmospheric).

634 Wright, K. R.

1967. Harvard Gulch flood control project: Am. Soc. Civil Engineers Proc., Paper 5132, Jour. Irrigation Drainage Div., v. 93, no. IR 1, p. 15–32, 15 figs., 3 tables, 7 references.

Planning, design, and construction of a major urban flood control project is discussed. Emphasis is placed on flood hydrology investigations used for sizing of culverts, open channels, and structures. Techniques for designing open channels, both concrete and grass-lined, are described. Underflow pipes are used to carry normal low flows.—W69-01911.

Descriptors: Flood control, storm runoff, model studies.

635 Wright-McLaughlin Engineers.

1969. Urban storm drainage criteria manual: (2 volumes), Denver, Colo., Wright-McLaughlin Engineers, v. 1, 388 p., 69 figs., 10 maps, 31 tables, 80 references; v. 2, 143 p., 60 figs., 8 tables, 88 references.

A storm-drainage criteria manual was developed by the Denver Regional Council of Governments to provide uniform guidelines and technical design information for those involved with storm-water drainage. The overall approach taken is based on two separate drainage systems: the initial, or convenience, system for regularly occurring flows (return frequency of once in 2 to 10 years) and the major system for relatively infrequent flows. The design of streets receives extensive coverage, with allowable drainage capacity related to traffic volume. Storm-sewer design is based entirely on hydraulics, replacing rule-of-thumb procedures for head loss at manholes. Hydrological design is based on a modified rational method, in which the summation of flows is used for areas under 200 acres, and on a hydrograph analysis for larger areas.—W70-03148. PB-185–262 and PB-185-263.

Descriptors: Rainfall-runoff relationships, storm runoff, rational formula, hydrograph analysis.

636 Yamamoto, Teruo; Anderson, H. W.

1967. Erodibility indices for wildland soils of Oahu, Hawaii, as related to soil forming factors: Water Resources Research, v. 3, no. 3, p. 785–798, 2 figs., 10 tables, 38 references.

Urbanization is invading Hawaii's forest lands. Soil characterisitcs help determine the extent of allowable disturbance and the kind of intensity of conservation practices needed. Indices of soil erodibility of Oahu's wildland soils were obtained by principal component analysis of seven characteristics which can be determined from maps and aerial photographs: geologic rock type, rainfall, elevation, vegetation type, slope, aspect, and zone. Parent rock is the most important factor in erodibility of wildland soils in Hawaii. Planting of trees which favor development of less erodible soils is recommended. A generalized map of the erodibility of soils in Oahu was combined with a rainfall map, indicating where care in management might be most needed.—W69-08482.

Descriptors: Hawaii, sediment yield, erosion control.

637 Yevjevich, V.; Barnes, A. H.

1970. Flood routing through storm drains, pt. I, solution of problems of unsteady free surface flow in storm drains: Fort Collins, Colorado State Univ., Hydrology Papers, no. 43, 107 p., 44 figs., 36 tables, 23 references, 5 app.

Flood routing through storm drains was studied physically in a storm conduit (3 feet in diameter and 822 feet long) and theoretically in terms of unsteady free-surface flow. The method of characteristics was selected for the practical integration procedure whenever the complete differential equations were used. Experimental and analytical investigations of the geometric and hydraulic parameters that define the coefficients of the two differential equations are summarized. The initial and boundary conditions are expressed mathematically for the numerical solutions. The analytically computed waves are then compared with the experimentally observed waves by using the same initial and boundary conditions. Qualitative and quantitative comparisons are given for depth hydrographs at different positions, for depth wave profiles at different instants in time, and for the peak-depth versus both position and time. From a practical point of view, good agreement is indicated by these comparisons.—W71-04890.

Descriptors: Routing, storm drains, mathematical models, storm runoff.

638 Yevjevich, V.; Barnes, A. H.

1970. Flood routing through storm drains, pt. II, physical facilities and experiments: Fort Collins, Colorado State Univ., Hydrology Papers, no. 44, 43 p., 49 figs., 13 tables, 13 references.

Experimental storm-drain routing research facilities and experiments at Colorado State University are described. A large conduit, 3 feet in diameter and 822 feet long, was constructed to accurately measure geometric and hydraulic characteristics and the propagation of flood waves. The calibration of the instruments has been carried

out to the point where there are relatively small errors. The data recording system was designed and constructed so that the output could be put either on cards or paper tapes and provide a direct input for computations on a digital computer.—W71-04891.

Descriptors: Storm drains, hydraulic models, routing, storm runoff.

639 Yevjevich, V.; Barnes, A. H.

1970. Flood routing through storm drains, pt. III, evaluation of geometric and hydraulic parameters: Fort Collins, Colorado State Univ., Hydrology Papers, no. 45, 37 p., 24 figs., 12 tables, 10 references.

Results are given of investigation of the geometric and hydraulic parameters of an experimental storm-drain routing facility. The errors in cross-section geometric parameters were analyzed using a conduit not ideally circular but approximated by an elliptical shape; errors are also analyzed when the undulations in the longitudinal slope of the conduit affect the predicted water-surface profiles and thus the geometric parameters for a given water depth. The variation of hydraulic resistance, expressed by the Darcy-Weisbach friction factor, was experimentally determined with its theoretical relation to Reynolds number. Energy losses in a 90-degree junction box were studied. The velocity distribution coefficients vary with the Darcy-Weisbach friction factor and consequently with the depth of flow. Boundary conditions for both controlled and free outfall were experimentally determined and approximated by power functions.—W71-04892.

Descriptors: Storm drains, hydraulic models, unsteady flow, routing.

640 Yevjevich, V.; Barnes, A. H.

1970. Flood routing through storm drains, pt. IV, numerical computer methods of solution: Fort Collins, Colorado State Univ., Hydrology Papers, no. 46, 47 p., 16 figs., 4 tables, 6 references, 3 app.

Computer-oriented numerical methods are given for solving the Saint-Venant quasi-linear hyperbolic partial differential equations of gradually varied free-surface unsteady flow for storm drains. Various numerical finite-difference schemes, including explicit schemes based on the two partial differential equations, unstable-diffusing schemes, upstream differencing schemes, leap frog schemes, the Lax-Wendroff method, and the specified intervals scheme are analyzed. The specified intervals scheme (derived from the method of characteristics), the Lax-Wendroff method, and the diffusing scheme are compared. Flow charts and computer programs for these various numerical methods are given.—W71-05376.

Descriptors: Computer programs, storm drains, numerical analysis, routing, unsteady flow, mathematical models.

641 Yorke, T. H.; Davis, W. J.

1971. Effects of urbanization on sediment transport in Bel Pre Creek basin, Maryland: U.S. Geol. Survey Prof. Paper 750-B, p. B218–B223, 5 figs., 2 tables, 8 references.

The effect of urban expansion on the sediment yield of a 1.7-square-mile drainage basin in Maryland is described. Streamflow and sediment data were collected at a gaging station on Bel Pre Creek in Montgomery County, Md., between 1963 and 1967. Prior to March 1965, the drainage area was used for pasture and woodland; however, between March 1965 and August 1967, part of the basin was developed for garden apartments and townhouses. A graphical regression analysis indicated that the storm runoff increased 30 percent and the sediment yield was 14 times greater as a result of urban construction on about 15 percent of the drainage basin. The sediment yield from the construction site was 90 times greater than the yield expected from the area with the original land-use conditions.

Descriptors: Sedimentation, sediment yield, construction, Montgomery County, (Md.).

642 **Yorke, T. H.; Davis, W. J.**
1972. Sediment yield of urban construction sources, Montgomery County, Maryland, a progress report, Rock Creek-Anacostia River basins: U.S. Geol. Survey open-file rept., 39 p., 16 figs., 8 tables, 15 references.

In three streams in the Rock Creek-Anacostia River basin, Md., sediment load increases significantly as urban construction increases. In Bel Pre Creek, suspended-sediment discharge increased 14-fold as a result of urban construction on about 15 percent of the basin during the first 30-month period of the study. Sediment-water-discharge curves and graphic regression analysis indicate that a direct relation exists between the sediment yield of a basin and the area of land under construction, the season of year, slope of land at construction sites, and proximity of construction sites to stream channels.

Descriptors: Sediment yield, storm runoff, construction, Montgomery County (Md.).

643 **Young, L. H.**
1970. Mean annual rainfall-runoff relationship: Inst. Water Engineers Jour., v. 24, no. 7, p. 423–430, 1 fig., 3 tables.

Worldwide data are analyzed to investigate the relationship between the mean annual runoff, rainfall, and temperature of cities. Other parameters have little independent effect. For nonarid climates, the relationship is a straight line for which the slope is unity for 50 degrees F, steeper for lower temperatures, and flatter for higher temperatures. Water loss is independent of rainfall only in the region of 50 degrees F. A general runoff formula is developed for the overseas data, and a separate formula is available for the British Isles.—W71-07512.

Descriptors: Rainfall-runoff relationships, climatology, precipitation (atmospheric).

644 **Yu, Y. S.; McNown, J. S.**
1963. Runoff from impervious surfaces: Lawrence, Kansas Univ., Contract Research Rept., 17 p., 13 figs., 9 references. [Also published in Jour. of Hydraulic Research, v. 2, no. 1, p. 3–24, 6 figs., 10 references.]

Runoff of rain falling on an impervious surface can be predicted by means of numerical computations. For the small slopes and depths which occur on highways or airstrips, the nonuniform flow is quasi-steady. The calculation proceeds by steps in the direction of flow, beginning at the upstream end of the reach and at the onset of rainfall; repeated computations provide predictions of depths and velocities at subsequent times. Because most of the rain falling is stored on the surface initially, the flow approaches equilibrium quite rapidly. The anomalous increase in discharge which often followed the cessation of rain in field tests is a consequence of turbulent flow becoming laminar when the battering of rain ceases.

Descriptors: Rainfall-runoff relationships, numerical analysis, street runoff.

646 **Zabik, M. J.; Pape, B. E.; Bedford, J. W.**
1971. Effect of urban and agricultural pesticide use on residue levels in the Red Cedar River: Pesticides Monitoring Jour., v. 5, no. 3, p. 301–308, 12 figs., 3 references.

Analysis of 1,549 water and bottom samples show high levels of DDT and its metabolites (TDE and DDE) in the Red Cedar River, Mich. The river becomes progressively more contaminated in downstream direction and shows seasonal variations. The concentration of pesticides in bottom samples gives a good indication of long-term contamination, whereas levels in the suspended matter indicate the amount of pesticide carried on a short term basis. The largest amount of pesticide contamination entering the Red Cedar River comes from the waste-water treatment plants of the three cities in the sampled part of the stream.

Descriptors: Pesticide residues, water pollution sources, sediment load.

647 **Zanoni, A. E.**
1972. Ground-water pollution and sanitary landfills, a critical review: Ground Water, v. 10, no. 1, p. 3–13, 61 references.

Studies concerned with the ground-water pollution potential from sanitary landfills and dump grounds were conducted in California, South Dakota, Illinois, and England. These studies all demonstrate that leachates are

highly pollutional, but once they pass into the surrounding soil regime, the attenuation mechanisms of dilution, adsorption, and microbial degradation tend to reduce their impact on ground water. A survey of practice in 21 States in the United States regarding ground-water pollution from landfill operation shows that not much new research is underway; there is much variation in the code and laws dealing with ground-water pollution; and distances from landfill to water wells varied from 50 to 1,000 feet. Based on the literature finding plus the result of State surveys, recommendations are offered to minimize ground-water pollution problems stemming from landfill operations.

Descriptors: Reviews, landfills, water pollution sources, garbage dumps, groundwater pollution.

648 Zelazny, L. W.; Blaser, R. E.
1970. Effects of de-icing salts on roadside soils and vegetation: Natl. Research Council, Highway Research Board, Highway Research Record no. 335, p. 9–12, 1 table.

Deicing salts applied to roads may be carried by surface runoff into streams and waterways or they may infiltrate into the soil bordering the highway. These salts may be carried to ground waters, remain in soil solution, or become adsorbed by soils. Therefore, salts are potential pollutants of water supplies and soils in the highway environment. Plant damage can decrease property value, interfere with highway beautification programs, and increase the cost of highway maintenance. The distribution and movement of deicing salt were studied in soil bordering the highway at a site in Vermont, and the role of these salts in causing an extensive silver maple decline in this highway environment was determined. Deterioration of the silver maples increases with exposure of the trees to roadside drainage. Highway salting increased the concentrations of sodium and chloride and the specific conductance in the soil on the east side of the highway at the site examined. This was manifested in an extensive silver maple decline on the east side of the road, while healthy trees were growing on the west side of the road.

Descriptors: Deicers, water pollution sources, water pollution effects, Vermont.

ADDENDUM

At the time this bibliography was printed, copies of these entries had not been received for abstracting:

650 Hydrocomp International, Inc.
1971. Studies in the application of digital simulation to urban hydrology: Palo Alto, Calif., Hydrocomp Internat., Inc., prepared for Office of Water Resources Research, U.S. Dept. Interior.

651 March, F. and Eagleson, P. S.
1965. Approaches to linear synthesis of urban runoff systems: Cambridge, Massachusetts Inst. of Technology, Hydrodynamics Lab., rept. 85.

GEOGRAPHIC INDEX

LIST OF HEADINGS USED IN MAJOR-SUBJECT CLASSIFICATIONS OF THE SUBJECT INDEX

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  - Nitrates
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  - Phosphates
  - Phosphorus
  - Saline water intruston
  - Storm runoff—quality
  - Waste disposal wells

SUBJECT INDEX

Note: Terms in this index are compounded in the same manner as the descriptors in the *Water resources thesaurus* (U.S. Department of the Interior, Office of Water Resources Research, 1972), including the single nonhyphenated usage of *groundwater* as a noun or as a modifier.

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