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the Thai Mineral Resources Department and with joint participation of the Public Works, Irrigation, and Public Health Departments; (2) expanded ground-water exploration and development in the region, with technical guidance from a US AID hydrogeologist advisor; and (3) training of key Thai personnel in ground-water geology and hydrology. The technical findings of Mr. Lamoreaux and his Thai colleagues were published in USGS Water-Supply Paper 1429, which described the general hydrogeologic framework in the Triassic and Jurassic sedimentary rocks of the Khorat Plateau and local ground-water conditions near the larger municipalities in the region.

Following Mr. Lamoreaux's work and recommendations, a joint US-Thai Ground Water Research and Development Project was begun in January 1955 with the assignment of H. F. Haworth, US AID hydrogeologist, as technical advisor to the Thai government. During the ensuing 3 years, 83 exploratory wells totaling 6,200 m in depth were put down in the Khorat Plateau under the direction of a Thai interdepartmental Ground Water Committee with the technical guidance of Mr. Haworth and US AID drilling advisors. With completion of this preliminary exploration, Daniel, Mann, Johnson, and Mendenhall, International (DMJM) under contract to US AID, were engaged to carry out more extensive ground-water exploration as well as training of Thai ground-water scientists, technicians, and drilling personnel. Between April 1958 and May 1961, the DMJM group put down, logged, and tested 411 exploratory and production wells for a total of 51,000 m in depth over an area of some 160,000 km.^{2}

In May 1961, at the request of US AID/Bangkok, Mr. Lamoreaux revisited the Khorat Plateau to review the antecedent work of the DMJM contract and the Thai departments. His administrative report of June 1961 (1) described in detail the history of the first 9 years of continuous ground-water exploration, investigation, and development in the region and the institution building in the Thai departments; and (2) recommended additional investigations and production drilling in selected areas of the plateau.

During the 4 years after Mr. Lamoreaux's review the technical recommendations were carried to fulfillment under the technical guidance of Mr. Haworth with active participation of Thai colleagues. As of project termination in June 1965, 1,527 exploratory wells had been drilled in the Khorat Plateau, and, of this total, 1,242 wells were completed as production wells. The technical findings of the project were published in 1966 as Ground Water Bulletin 2 of the Thai Mineral Resources Department under the authorship of Mr. Haworth and Thai colleagues. The Ground Water Division of the Thai Department of Mineral Resources is now (1970) an active viable organization with a staff of 25 hydrogeologists, hydrochemists, technicians, and support personnel engaged in ground-water exploration and development throughout Thailand.

During July-December 1970, D. A. Phoenix, USGS hydrogeologist, while on assignment to the Mekong Committee, under US AID auspices, reviewed the status of ground-water investigations and development in Thailand. His report of December 1970 proposed renewed bilateral technical assistance to the Thai Ground Water Division and a comprehensive geohydrologic investigation of the Central Valley (Chao Phrya basin) of Thailand.

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TURKEY

Situated at the crossroads of Europe and Asia, the region now occupied by Turkey has figured in pivotal events of human history for more than 3,000 years. The modern Republic of Turkey was founded in 1923 by Musatfa Kemal Ataturk after the collapse of the 600-year old Ottoman Empire at the end of World War I. Since its founding the new republic has made steady progress in modernizing its social and economic institutions in measure with the demands of the 20th century. In support of a long tradition of friendship, the United States furnished Turkey more than $5 billion in loan and grant aid between 1947 and 1968. Because of the Government of Turkey's (GOT) priority concern with full development of its water resources for hydropower, industry, and irrigation as well as for municipal, livestock, and domestic water supply, the U.S. bilateral aid program has given strong emphasis for the past 20 years to the water-resources sector of the economy. As part of U.S. aid, the USGS has provided technical assistance to the GOT both in surface-water and ground-water investigpations, first in

1957, virtually continuously between 1958 and 1965, and intermittently since then.

Surface-Water Investigations, 1957, 1958–62

Based on an agreement signed in March 1957 between the GOT and US ICA/Ankara, K. N. Phillips, USGS surface-water hydrologist, was assigned from April to June 1957 to review the then-current program of streamflow investigations in Turkey and to formulate recommendations for strengthening these investigations in support of national water-resources planning and development. During his stay in Turkey, Mr. Phillips, in company with hydrologists and engineers of the Elektrik Isleri Etud Idaresi (EIEI) or Electrical Power Resources Survey Administration visited numerous stream-gaging stations and water-resources development projects throughout the country; observed stream-gaging instrumentation and techniques; and reviewed methods and procedures for computation, compilation, and publication of streamflow data. His report of September 1957 described the general geographic, climatic, and hydrologic features of Turkey; the history of stream gaging; the then-current EIEI stream-gaging network (244 stations); and field and office procedures and publication of records. The report also identified needs for long-term technical assistance, participant training, and hydrologic equipment support.

Responding to recommendations in Mr. Phillips' report, US ICA/Ankara requested the USGS to provide long-term technical assistance to the Hydrograhic Section of the EIEI in a project known as "Hydrological Data Study and Training." C. C. Yonker, USGS surface-water hydrologist, was assigned to the work, arriving in Ankara in December 1958 and continuing until his return to the United States in April 1961. L. J. Snell, also a USGS hydrologist, succeeded Mr. Yonker in Turkey from June 1961 until December 1962, when the long-term USGS assistance in surface-water hydrology was terminated.

The project objectives included (1) improvement and upgrading methods of collecting, processing, and publishing basic streamflow data for the comprehensive and continuing inventory of the surface-water resources of Turkey; (2) training a cadre of Turkish hydrologists in all phases of surface-water investigations; and (3) establishment of systematic sediment-data collection coupled with regular streamflow observations.

As of the end of the 4-year term (1958–62) of USGS technical assistance, a country-wide network of 290 gaging stations was firmly established, at which 1,800 discharge measurements were being made annually; 50 automatic water-stage recorders were in operation; 23 cableways had been constructed and placed in operation, including a 253-m span across the Euphrates River; and streamflow data were being regularly computed for about 150 streams. Also 9 new EIEI district offices were established throughout Turkey for streamflow data collection and gaging-station operation and maintenance. In addiiton, Messrs. Yonker and Snell assisted in upgrading the EIEI Hydrographic Yearbooks for 1958 through 1961, so that these could serve as models for succeeding years. They also fully trained a cadre of 40 Turkish hydrographers, computers, and observers in field and office methods of streamflow and sediment data collection, compilation, and publication. After completion of the project, Mr. Snell prepared a comprehensive report which was released to the GOT in October 1962. The report presented a summation of work activities and project accomplishments as well as detailed guidelines to the EIEI for future surface-water investigations and training of personnel.

Since the early 1960's, the Devlet Su Isleri (DSI), or State Hydraulic Works, has assumed the lead role in surface-water investigations in Turkey. In 1970, the DSI operated 663 stream-gaging stations, 46 lake-stage stations, 9 snow courses, 386 precipitation stations, 250 sediment stations, and 60 evaporation-temperature stations. On the other hand, EIEI operated 304 stream-gaging stations, 12 lake-stage stations, 10 snow courses, and 65 sediment stations.

Ground-Water Investigations, 1963–65, 1966, 1967

The principal governmental entity in Turkey concerned with ground-water investigations is the Ground Water Division (GWD) in the Devlet Su Isleri (DSI), or State Hydraulic Works. The GWD, which had its beginning in 1952, was organized in five sections, (1) Planning, (2) Geophysics, (3) Investigations, (4) Drilling, and (5) Production and Management. Also, representatives of the GWD were attached to each of the 10 district offices of the DSI throughout Turkey. During the first 10 years of its history, the GWD emphasized hydrogeologic investigations and exploratory drilling to define areas favorable for high-yield wells of moderate depth. Work accomplished during this period (1952–62) included (1) reconnaissance hydrogeological mapping at a scale of 1:100,000 and preparation of individual reports in the Turkish language on 153 ground-water basins totalling 315,540 km^2; (2) drilling of 1,113 exploratory wells aggregating 243,-

962 m of hole; (3) construction of 795 water-supply wells, yielding a total of 7,808 l/s for villages and military garrisons; and (4) coring for dam foundation studies and test drilling related to drainage problems.

Recognizing a need in 1962 to redirect its efforts toward more intensive studies related to ground-water development for irrigation, the DSI requested US AID/Ankara to provide the services of a general ground-water advisor to assist the GWD in the design and execution of its pilot development projects. C. R. Murray, USGS hydrogeologist, assigned to the work, arrived in Ankara in January 1963 and continued until his return to the United States in May 1965. During Mr. Murray's stay in Turkey, pilot ground-water development projects for irrigation were begun in the Konya-Alakova, Elâzig-Ulova, Kayserí, Bolu, Chabuk (Çubak) Esenboga, Merzifon-Gümüshhachköy, Malatya, and Iqdir areas in Anatolia as well as the Maritsa River (Meric) Ergene Nehri (Ergene) and Beyazköy (Beyaz Koy) areas in Turkish Thrace.

Surface resistivity surveys for ground-water exploration were first undertaken by the GWD in 1960 and seismic refraction studies, mainly at damsites, somewhat later. In mid-1963 the DSI requested US AID/Ankara to provide the short-term services of a geophysicist to evaluate the operations of the Geophysics Sections of the GWD and to recommend measures to improve these operations for the needs of ground-water exploration and development in Turkey. W. E. Davis, USGS geophysicist, was assigned to the work from October to December 1963. During this period he examined geophysical reports, field techniques, and interpretation methods of ground-water exploration projects in the Bafra and Samsun deltaic plains on the Black Sea coast and in the Sarayköy and Konya plains of Anatolia. Mr. Davis gave particular attention to surface electrical resistivity surveys for detection of fresh-water salt-water interfaces, location of fresh water-bearing sand and gravel deposits in alluvium and in limestone, and determination of positions of impervious layers. He also reviewed the GWD's seismic reflection work in the Karapinar area of the Konya plain, where surveys were in progress to determine the depth to bedrock beneath a cover of semiconsolidated lacustrine deposits. At the end of his assignment, Mr. Davis directed a 2-week seminar at Ankara for personnel of the Geophysics Section of GWD on applications of geophysical techniques to ground-water exploration in Turkey. The results of Mr. Davis' work in Turkey as well as his recommendations to the GWD for improving its field operations in surface geophysical surveys were described, both in English and in Turkish, in his report of December 1963.

Between May and August 1964, R. L. Cushman, USGS ground-water hydrologist, was assigned to demonstrate the methodology of aquifer tests and applications of quantitative techniquse in pilot GWD ground-water development projects. Mr. Cushman completed special aquifer-evaluation studies in the Konya plain in central Anatolia, in the Mediterranean coastal plain north of Iskenderun, and also in Turkish Thrace. He also directed four 2-week field seminars in applied ground-water hydraulics—each attended by different groups of 20 to 25 DSI scientists, engineers, and technicians—near Konya, Adana-Iskenderun, Lüleburgaz, and Ankara. Mr. Cushman's report of August 1964, later translated into Turkish, presented detailed recommendations to the GWD for improving field determinations and analyses of hydraulic characteristics of aquifers in applications of quantitative techniques in pilot GWD typical Turkish ground-water basins; production-well construction; and collection and interpretation

At the request of the DSI to US AID/Ankara, F. E. Clarke, USGS corrosion expert, visited Turkey briefly in March 1965 to consult with Turkish counterparts on water-well corrosion and encrustation problems in the GWD's pilot ground-water development projects for irrigation. During his stay, Mr. Clarke directed a brief seminar in Ankara attended by GWD chemists, drilling superintendents, ground-water engineers, and hydrologists on well-casing and screen corrosion and encrustation problems in Turkey. He visited several representative well installations in the vicinity of Ankara and Konya for field demonstrations of equipment used to measure on-site water quality and the corrosivity of the metal components of wells and screens. While in Turkey Mr. Clarke also consulted with municipal engineers of Istanbul on corrosion and encrustation problems in pumps, well casings, and screens, and distribution pipelines of the city water supply.

W. E. Davis, USGS geophysicist, returned to Turkey during June and July 1966 to review progress on recommendations made in 1963 with respect to the DSI's geophysical investigations in ground-water exploration for town and village water supplies and for irrigation projects. While in Turkey he reviewed (1) the field operations of seven electrical resistivity survey crews of the GWD's Geophysics Section searching for fresh-water aquifers and two seismic survey crews identifying foundation condi-

tions at the sites of proposed dams and (2) then current (1966) technical reports interpreting the results of field surveys. Mr. Davis concluded in his administrative report of July 1966 that the Geophysics Section had reached a high level of operating efficiency and technical capability.

Electrical logging of the GWD's exploratory wells was first undertaken by the Geophysics Section in 1957. Most of the early logging was done in boreholes less than 500 m deep, mainly in alluvial deposits. The usefulness of electrical loggers in identifying lithologic breaks and in preparing formational logs was soon recognized, and, by 1963, 10 loggers were in operation in DSI's ground-water projects throughout Turkey. Responding to a request from the DSI to US AID/Ankara, P. H. Jones, USGS expert in borehole geophysics and electrical log interpretation, was assigned for 1 month during May-June 1967 to review the GWD's activities in borehole geophysics and to direct a training seminar in electrical log interpretation for GWD professional personnel. Mr. Jones' administrative report of June 1967 described in detail the organization of the DSI's Ground Water Division (GWD) and its activities in borehole geophysics, the results of a field type-area study of the Develi-Yesilhisar Plain, and the content of a 2-week problems seminar in Ankara on borehole geophysics and electrical log interpretation.

The DSI's Ground Water Division in 1970 was an active and viable scientific and technical organization. With a national professional staff of some 125 hydrogeologists, engineers, geophysicists, hydrochemists, and technicians and 1,270 support personnel, the GWD had already completed reconnaissance hydrogeologic investigations and released reports in the Turkish language on 250 ground-water basins aggregating 450,000 km.^{2} The GWD had also embarked on active ground-water development projects for irrigation in 20 of the more promising of these basins that ultimately will have marked benefit to Turkey's agricultural economy. In addition, the GWD was moving ahead rapidly in its well-construction program for the potable water supplies of some 10,000 villages in Turkey that are solely dependent on ground water.

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VIETNAM

The Republic of Vietnam (South Vietnam), located on the eastern bulge of Southeast Asia, was a major recipient of U.S. economic and military aid during most of the 1960's. The USGS participated actively during 1964–70 in the U.S. program and provided technical advisors, both for water-resources appraisals and investigations in the US AID bilateral economic aid and technical assistance program as well as for water-supply problems at U.S. installations in South Vietnam. The scope of this advisory support is described in following sections.

Ground-Water Appraisals and Investigations, 1964–66, 1968–70

In late 1963 the USGS was requested by US AID/Saigon to provide the short-terms services of a USGS specialist to assist in the design of a program for development of safe and adequate water supply, chiefly from ground-water sources, for all hamlets, villages, and small municipalities in South Vietnam. The late W. C. Rasmussen, USGS hydrogeologist, completed this assignment during January-March 1964. In April 1964 Mr. Rasmussen returned to South Vietnam on a 2-year detail to US AID/Saigon as Acting Associate Chief of a newly organized Rural Water Supply Task Force (RUWSTAF) to implement the program. The RUWSTAF was originally set up as an integrated organization of 500 persons, including US AID employees, U.S. Army technicians, U.S. Navy Seabee well drillers, and Vietnamese professional, technical, and support personnel. Six months later some 16 drilling rigs were putting down village supply wells at the rate of 50 a month and surface-