

MEXICAN NATIONAL REPORT ON SCIENTIFIC HYDROLOGY (1964-1966)

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INTRODUCTION

Hydrologic research in Mexico is in charge of a number of Federal agencies, viz., the Secretaría de Recursos Hidráulicos (S.R.H. or Ministry of Hydraulic Resources), taking care of the utilization of superficial and ground waters, construction of dams, canals and other public works; the Secretaría de Relaciones Exteriores (S.R.E. or Ministry of Foreign Affairs), through the Comisión Internacional de Límites y Aguas (International Borders and Waters Commission), that supervises the execution of treaties concerning border streams; the Secretaría de Agricultura y Ganadería (S.A.G. or Ministry of Agriculture and Cattle Raising), with respect to the recording and processing of precipitation data and associated phenomena (temperature, winds, etc.); the Comisión Federal de Electricidad (C.F.E. or Federal Commission of Electricity), for the utilization of national waters for the generation of electric power including geothermal energy, and the Departamento del Distrito Federal (or Department of the Federal District). There are also the Institutes of Geology and of Geophysics of the National Autonomous University of Mexico (N.A.U.M.) doing research and studies of fundamental character in various aspects of the hydrologic cycle and publishing their results in a number of publications mentioned in the bibliography, which includes also official serials of the above mentioned agencies of the Federal Government.

ACTIVITIES IN COURSE

SECRETARÍA DE RECURSOS HIDRÁULICOS (Fig. 1)

A network of hydrometric stations to measure superficial water volumes of streams of the country and another of climatologic stations to measure precipitation, temperature and evaporation are operated by this agency; it also

tries to concentrate information from other agencies, and all data are used for the preparation of basic studies of public works for irrigation, water provision for populated centres and flood control, and are also published in hydrometeorological bulletins.

With respect to the world hydric balance, the Ministry of Hydraulic Resources has been elaborating an inventory of superficial and ground hydraulic resources in use and to be used in the Mexican Republic. A census of superficial hydraulic resources has already been prepared (85%) and published (30%) and there is still more to be published (20%). It is estimated that this detailed inventory will be finished by the end of 1967, since preliminary inventories have been elaborated through 40 years of hydraulic policy in Mexico since 1926.

Ground waters have also been inventoried at the same time in a detailed way, with emphasis on those already used in the country, but it is still necessary to plan, establish, operate and preserve a basic ground water network of stations in the Mexican Republic as well as some second order networks. Some of these have been established to study the geohydrologic aspects and the physical, chemical and biological characteristics of ground water, its static and dynamic levels, drilling depths, oscillations, etc. The basic ground water network indicating the underground hydraulic potential and supporting an optimal water utilization program will not be difficult to establish because of the great number of wells in operation in the national territory.

The Ministry of Hydraulic Resources operates large irrigation construction projects with a total of 21 dams covering 84,000 Hs while 39 more that will cover some 125,000 Hs are in construction, and 18 were terminated to cover 352,000 Hs. In the last three years, the total capacity of the larger dams in Mexico increased manifold their water volumes to irrigate now 2,451,000 Hs in the whole country, including new and improved areas. 312 smaller irrigation projects were continued or terminated, and there are still 157 in construction, with a great increase in the total surface irrigated by their waters.

Flood control through conservation work along rivers, including international streams, were continued as well as several hundred public work projects terminated to bring water to almost 1,000,000 inhabitants in diverse areas of Mexico. This is a very important aspect of the program of work of the Ministry of Hydraulic Resources, for example, in the larger cities of the Peninsula of Yucatan where water services had always been insufficient and of low quality. A new development of the Ministry of Hydraulic Resources has consisted in the creation of the General Directorate of Subterranean Waters that will take charge of the inventory of this natural resource and regulate its exploitation, along or in combination with superficial waters as well as to study projects for its utilization in coordination with other divisions of the same Federal agency.

There are also the Special Commissions (of executives or study character) that are in charge of problems of water services, agricultural and cattle raising promotion, coordinating the utilization of hydraulic resources and flood control in the diverser river basins of the country, namely:

SPECIAL EXECUTIVE COMMISSIONS

The COMISION DEL PAPALOAPAN operating dams and canals in the Valley of Tehuacán and in the Cañada Oaxaqueña for a large number of inhabitants and the stimulation of social and economic progress in both areas;

The COMISION DEL RIO BALSAS that has continued the construction of various dams and canals and terminated a dam at El Pejo, Mich., promoting also other developments in cities and villages of its large area;

The COMISION DEL RIO FUERTE that is now enlarging the capacity of the "Miguel Hidalgo" dam and constructing other dams in the States of Sonora and Sinaloa to control and use many hundred millions of cubic meters to irrigate thousands of hectares and improving water services in cities and villages;

The COMISION DEL GRIJALVA in charge of the large "Netzahualcoyotl" dam in the State of Chiapas, to irrigate large tropical agricultural zones of the southern coastal plain of the Gulf of Mexico.

SPECIAL STUDY COMMISSIONS

There are three important Commissions of this type: the HYDROLOGIC COMMISSION OF THE BASIN OF THE VALLEY OF MEXICO, the COMISSIO FOR THE STUDY OF THE LERMA-CHAPALA-SANTIAGO SYSTEM and the COMMISSION FOR THE STUDY OF THE PANUCO RIVER BASIN, each one in charge of specific responsibilities and programs in the areas of their corresponding jurisdictions.

SECRETARÍA DE RELACIONES EXTERIORES

The International Borders and Waters Commission operates some hydrometric stations in the basins of international rivers (Bravo del Norte or Grande, Colorado and Tijuana) between Mexico and USA; recorded data are published in annual bulletins, 35 of which have appeared since 1931. With respect to the southern border, there are two hydrometric stations along the Suchiate river and three along the Usumacinta river, operated by the Ministry of Hydraulic Resources.

SECRETARÍA DE AGRICULTURA Y GANADERÍA

The General Directorate of Geography and Meteorology operates a large number of climatological stations and some meteorological observatories provided with complete recording instruments throughout the country. Every

24 hours weather maps and forecasts are prepared, but for the most part, the utilization of meteorological and climatological data is oriented towards agricultural objectives (see Mexican National Report on Meteorology and Physics of the Atmosphere).

COMISIÓN FEDERAL DE ELECTRICIDAD

The Federal Commission of Electricity operates hydrometric stations in a number of streams of the country where there are adequate conditions for hydroelectric power development. Until now 407 hydrometric stations have been installed, but 207 were dismantled because of change in programs, leaving only 200 stations in operation.

DEPARTAMENTO DEL DISTRITO FEDERAL

Some hydrometric stations are operated in the basin of the Valley of Mexico for the water supply program of the city of Mexico; records of wells are also kept to observe behavior of groundwater levels in some areas.

UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO (Fig. 2)

INSTITUTE OF GEOLOGY

Established on December 17, 1888, by the Federal Congress as the "National Geologic Institute" in continuation of the former "Geologic Commission of Mexico" as a Federal agency under the Secretaría de Fomento. In 1906 it was housed in a new building in one of the suburbs of Mexico City; transferred in 1929 to the National Autonomous University of Mexico under the name of Institute of Geology, and finally accommodated in a new building at Ciudad Universitaria (University campus) in 1960.

The Institute of Geology conducts research including field and laboratory work in various disciplines, and results are published in a number of serials, namely, *Boletín*, *Anales*, *Carta Geológica*, etc.

There is one Department of Hydrogeology carrying out studies in the territory of the Mexican Republic. From 1964 to 1966 some of the following were conducted:

- Hydrology of Mexican deserts.
- Hydrology of the State of San Luis Potosí.
- Hydrology of the State of Tamaulipas.
- Hydrology of the State of Nuevo León.
- Preparation of hydrologic charts for the same states.
- Study of water resources in the Mexican Republic.



Fig. 2. Areas of work of the Institutes of Geology and of Geophysics, U.N.A.M.

INSTITUTE OF GEOPHYSICS

In 1947, Ing. Ricardo Monges López, Director of the Institute of Geology of the N.A.U.M., created the Institute of Geophysics with some departments already in existence and others of new character in various disciplines: gravimetry, magnetometry, seismology, cosmic radiation, etc. In 1954, the Institute of Applied Science was also created by the N.A.U.M., with the cooperation of the UNESCO, to stimulate studies of solar activity, meteorology and physics of the atmosphere, geohydrology and others; these departments were transferred to the Institute of Geophysics by the end of 1962, when the Institute of Applied Science was discontinued. Tide observations and studies in physical oceanography, geodesy and outer space had begun at the Institute of Geophysics of the N.A.U.M., by that time, so that since then a reasonable coverage has been given to most special fields.

The Institute of Geophysics of the N.A.U.M., has also made arrangements with other national and foreign institutions to carry out various geophysical studies, for example, gravimetric measurements in the Central-American Isthmus in collaboration with the Universities of Wisconsin and Hawaii, the Inter-American Geodetic Survey and the Central-American cartographic agencies. Members of the staff of the Institute of Geophysics of the N.A.U.M. have also attended numerous international meetings, specially the General Assemblies of the International Union of Geodesy and Geophysics, Committee for Space Research, and International Hydrologic Decade and joined committees and working groups of national and international character. In 1961, the Mexican Geophysical Union was created under its auspices, and the publication of *Geofísica Internacional* was begun, which in addition to the *Anales del Instituto de Geofísica, U.N.A.M.* (since 1955), the *Monografías del Instituto de Geofísica* (since 1959) and other publications constitute a varied source of information for scientific and technical workers of the world.

To this date the directors of the Institute of Geophysics of the N.A.U.M., have been: Ing. Ricardo Monges López, Dr. Julián Adem and Dr. Ismael Herrera Revilla, and the departments in activity are: Outer Space, Meteorology, Geomagnetism, Geodesy, Gravimetry, Seismology, Geohydrology, Physical Oceanography, Geochemistry and Geochronology and Atmospheric Chemistry and Radiation as well as the Electronic and Maintenance Laboratories, a Library and the administrative services. All departments are distributed in three floors of the Tower of Sciences and of another building (formerly occupied by the Institute of Applied Science) at Ciudad Universitaria, in Mexico City. Seismologic, magnetic (including the Magnetic Observatory at Teoloyucan), and tide gauge stations are distributed throughout the country.

The Department of Geohydrology has achieved between 1964 and 1966 the following tasks:

Geohydrologic studies for water supply; in small communities of the States of Tlaxcala and Puebla.

Preliminary survey of the basin of Conchos River, in the State of Chihuahua (an experimental representative basin of the Mexican National Committee for the International Hydrologic Decade Program).

Coordination of programs for the International Hydrological Decade, including publication of the *Boletín Informativo* (quarterly) since 1965, and of the "Memoria Anual" of the Mexican National Committee (Appendix IV of the *Anales del Instituto de Geofísica, U.N.A.M.*, 1965 and 1966 in preparation).

As one of the International Cooperation Programs of the Institute of Geophysics of the N.A.U.M., the Department of Geohydrology in collaboration with the Pan American Committee of Geophysical Sciences of the P.A.I.G.H., carried out a hydrologic survey of the basin of the Gulf of Fonseca, in Honduras, Central America. In this study, a classification and delimitation of the principal hydrologic subbasins and of their structural, stratigraphic and petrographic traits were tentatively proposed to estimate their hydrological potential. Additionally, maps and photos supplementing the text were presented to conclude with a series of recommendations for the complete planning of the hydric balance in each of the sub-basins of the Honduran part of the Gulf of Fonseca.

UNESCO MISSION

INSTITUTE OF APPLIED SCIENCE (1954-62)

A Technical Assistance project of the UNESCO, in the domain of Applied Science, with special reference to Atmospheric Physics and Hydrology began in Mexico in February 1954 and came to an end in 1962. This program was formalized with the creation of the Institute of Applied Science, by the Federal Government, as a dependency of the National Autonomous University of Mexico.

Before the arrival of the first expert of the UNESCO, the work of the Institute was rather reduced and consisted almost exclusively of some scientific programs related to the problem of artificial rain, and in particular, of Atmospheric Physics and of Hydrology in arid and semi-arid regions. With respect to Atmospheric Physics, that until 1954 had not been methodically investigated in theory nor in practice, the UNESCO experts Wallén, of

Sweden, and Fournier d'Albe, of the United Kingdom, made later on the following studies:

Meteorology and Cloud Physics —

Classification of weather types; study of hygroscopic nuclei; cloud seeding experiments; mechanism of precipitation, etc.

Solar Radiation —

Installation of three observatories, including design and construction of integrators for observations during the International Geophysical Year; conversion of nuclear energy into electric power, etc. (Plate III).

Chemistry of the Atmosphere —

Observations during the International Geophysical Year; study of air pollution in Mexico; air and rain water analysis; etc.

In Hidrology most of the work was oriented towards problems of ground water, which was to be integrated with already existing programs of that type in Mexico in charge of various agencies. The UNESCO experts Iwai (Japan), Loenhberg (Israel), and Stretta (France) carried out reesarch and taught courses with practical application to particular problems, within the following programs;

Arid Zones of Mexico —

Definition of aridity characteristics of Mexico; location and extensión of arid and semi-arid regions; preparation and publication of charts of arid zones of the country, etc.

Methods of research in Hydrology —

Applied Geophysics and the study of aquifers; radioactivity problems in water; superficial and ground water geochemistry; moders geohydrologic methods; preparation of geohydrologic charts, etc. (Plate IV).

Applications of modern methods to concrete problems —

Study of projects for search of potable water; study of hydrothermal springs; study of geotechnical problems (dams, canals, bridges, etc.)

In addition to these essential activities of new character in the National Autonomous University of Mexico, the UNESCO experts and the Mexican staff collaborated in other supplementary tasks:

Training of personnel to organize a group of specialists in the above mentioned disciplines;

Specialized higher teaching; technical lectures; laboratory work and other activities for groups of students of a number of Mexican universities.

Technical assistance to Federal and State agencies, with emphasis on Applied Hydrology, for example, in the basin of San Luis Potosí, where evaporation, experimental precipitation, climatologic studies and other activities were also carried out.

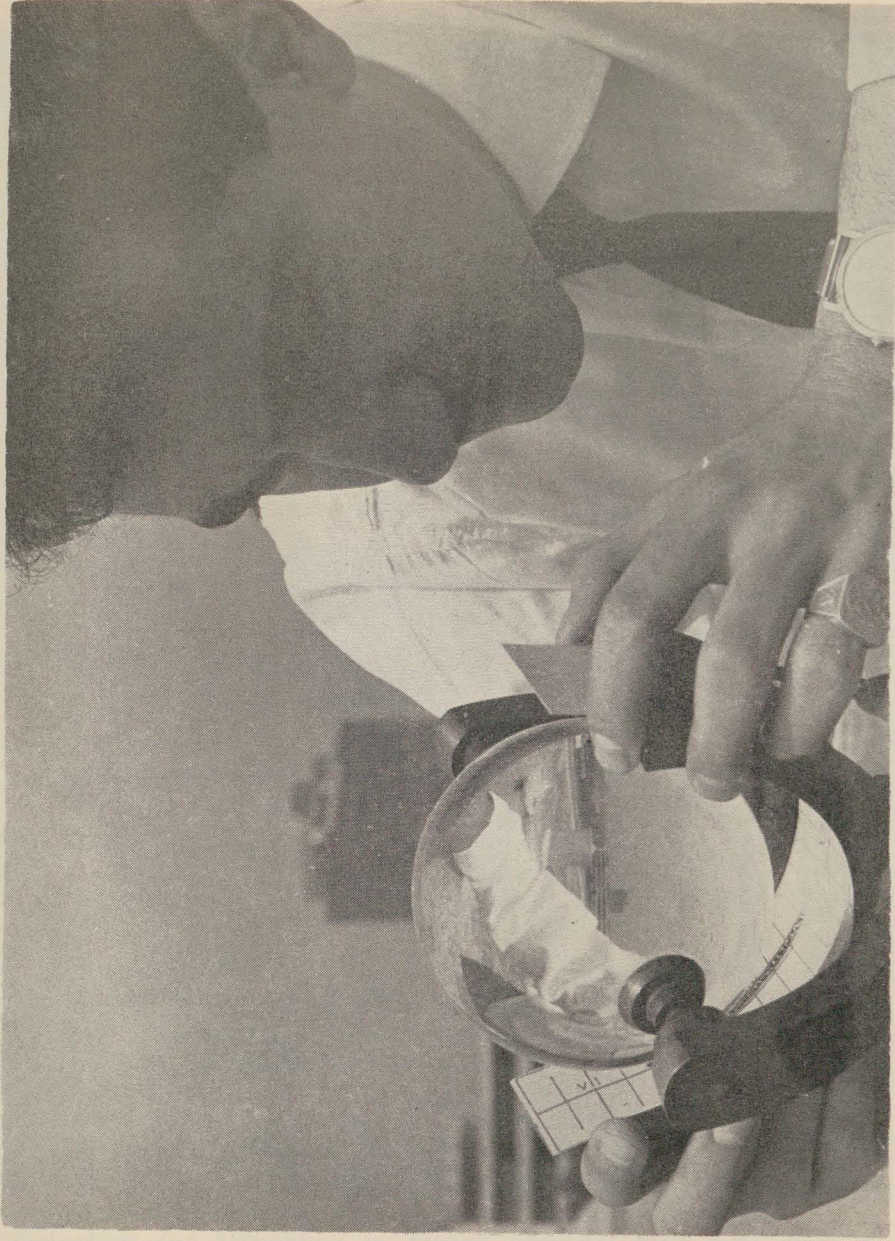
Members of the staff of the Institute of Applied Science participated in national and international meetings and congresses, and results of their work and research were published in a number of scientific journals (more than 30), not counting internal reports of technical interest and/or practical applications transmitted to official or private agencies. Among other products of the Institute of Applied Science, several reports concerning solar radiation, meteorologic and geohydrologic studies were published.

SPECIAL PROGRAMS

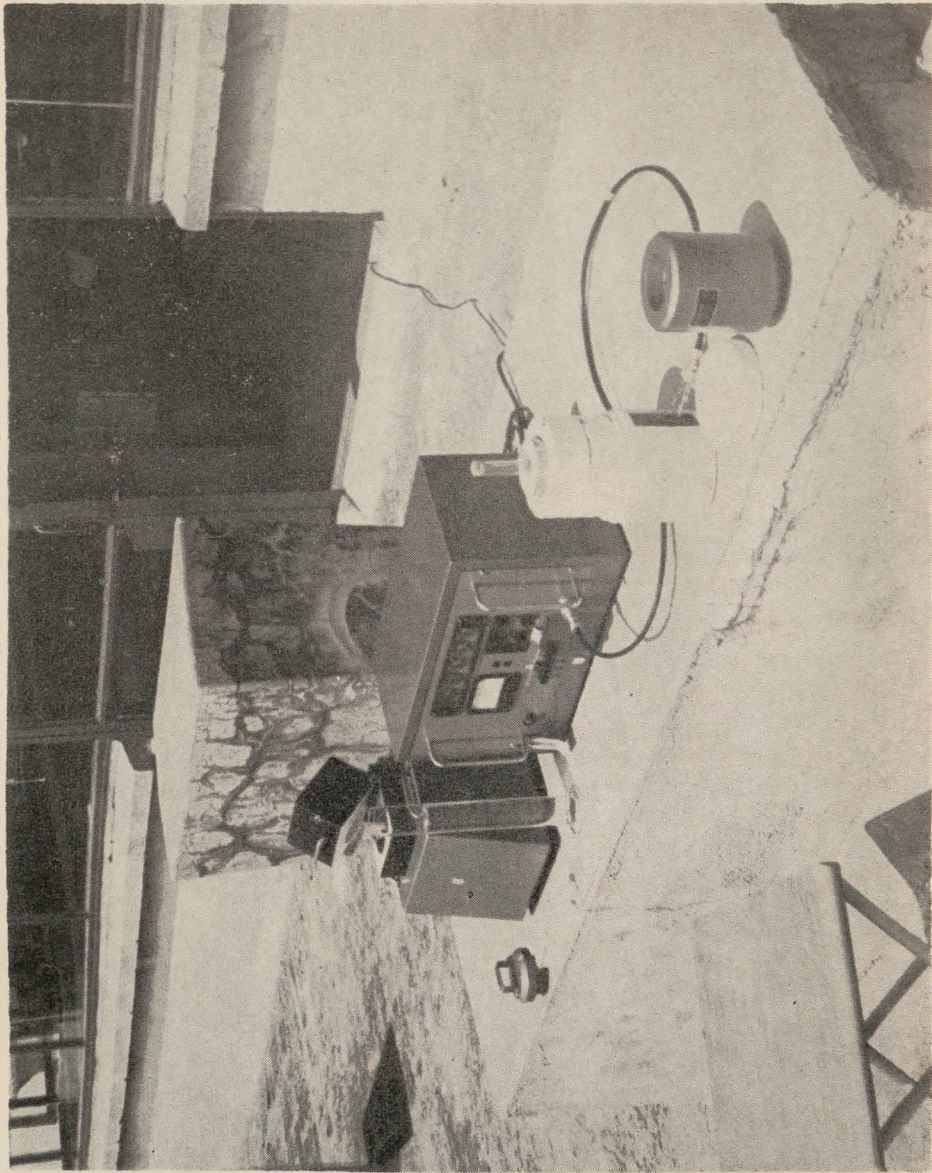
INTERNATIONAL HYDROLOGIC DECADE

ORGANIZATION. The Secretaría de Educación Pública, through the UNESCO National Commission, requested from the Institute of the Geophysics of the N.A.U.M., to prepare, and take charge of, a national program to be carried out in Mexico during the International Hydrologic Decade. This invitation was also supported by the International Associations of Scientific Hydrology and of Hydrogeologists, the International Union of Geodesy and Geophysics and other important organizations interested in having our country contribute to the development of that program. At the time when the invitation was received, Dr. Julián Adem was Director of the Institute of Geophysics, and after consulting with the authorities of the N.A.U.M., appointed Ing. Rodolfo del Arenal C. as Coordinator of the Mexican National Program for the International Hydrologic Decade.

It was distinctly a good opportunity for Mexico to coordinate and expand various programs not only of Federal character, but also of semi-official and/or private scope, according to "Comments and Proposals" of the Preparatory Meeting of Experts in Scientific Hydrology, held at the UNESCO headquarters in Paris, from May 20 to 29, 1963. In the theoretical aspect, there would be opportunities for the detailed analysis of hydrologic data collected and stored in the numerous agencies carrying out such programs; in the practical aspect, there would be a better preparation of plans to evaluate hydrologic resources in Mexico, and of planning their use in



A Campbell-Stokes heliograph in use in Mexico.



Instruments for study of water radiactivity in Mexico.

the light of demographic and economic growth of the country. In order to prepare a Mexican Program it was necessary to create a National Committee with representatives of governmental and private agencies as well as of academic institutions, and this was done at a special meeting in the latter part of 1964, when Dr. Adem and Ing. del Arenal were appointed President and Executive Secretary of the Mexican National Committee for the International Hydrologic Decade, respectively, together with a group of specialists and observers of divers agencies and institutes.

ACTIVITIES. The first year of activities was really employed in organizing the work of the new Committee, both nationally and internationally, selecting methods of study and communication, collecting long series of hydrologic data for statistical and numerical processing, determination of "type" basin in the national territory, etc. A *Boletín del Comité Nacional Mexicano para el Decenio Hidrológico Internacional* was also begun in 1964, and by the end of 1965 enough information and results had been compiled to publish a "Memoria Anual, 1965" (as Appendix V of the *Anales del Instituto de Geofísica, U.N.A.M.*), to be followed in the coming years by similar publications of the Institute of Geophysics.

At present, the Mexican National Committee for the International Hydrologic Decade has Dr. Ismael Herrera Revilla, Director of the Institute of Geophysics, as President, with the rest of members as already mentioned. The yearbook corresponding to 1966 is in preparation, reflecting advances made in the execution of the Mexican Program, and will contain a report on the work of the Secretaría de Recursos Hidráulicos as exposed during the recent International Congress of the UPADI (Unión Panamericana de Asociaciones de Ingenieros), held in Mexico City in October 1966. Other aspects of scientific hydrologic work in Mexico will also be reported upon in that yearbook.

TRAINING AND TEACHING

Hydrology has been traditionally taught in Engineering Schools as part of the training in various specialties, mainly Civil Engineering. With the expansion of program of the Secretaría de Recursos Hidráulicos more attention was given to courses in hydraulic resources, public works and other related subjects; such was also the fate in agricultural courses, and finally, in the geological and mining (as far as usage of water was required) schools. In recent years, the Institute of Geophysics has preceded other institutions in creating a Department of Geohydrology where research is conducted from a geophysical standpoint, viz. flow of fluids through porous media.

Scholarships and fellowships in foreign countries have been given to advanced and graduate students with the cooperation of the UNESCO.

Taking advantage of the International Hydrological Decade, numerous lectures have been given to engineering students, and steps are being taken to create a Division of Hydrologic Engineering, with emphasis on the exploration and exploitation of superficial and ground waters. The curriculum for the Doctorate in Geophysics at the School of Sciences of the N.A.U.M., includes the following courses and seminars for candidates of that degree, if they have the necessary background.

<i>Courses —</i>	<i>Professional Degrees or Diplomas —</i>
Hydraulics	Civil, Mining and Metall. Engineers
Public Health Engineering	Civil, Mining and Metall. Engineers
Soil Mechanics	Civil Engineers
Hydraulic Works	Civil Engineers
Fluid Mechanics	Mechand and Electr. Engineers
Geophysical Methods of Exploration	Petroleum, Geological, Mining and Metall, Engineers
Drilling Methods	Petroleum, Geological and Mining and Metall, Engineers
Geohydrology	Geological Engineers
Hydrology and Hydrometry	Topogr. and Geodet. Engineers
Hydrography	Topogr. and Geodet. Engineers

There is also a Department of Hydraulics, Public Health Engineering, Soil Mechanics and Mathematics in the Division of Higher Studies of the School of Engineering of the N.A.U.M., that has collaborated in the expansion and diversification of scientific hydrologic studies.

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In addition to this list of references, others sources of hydrologic information taken from the report on Meteorology and Physics of the Atmosphere, prepared by Ing. Pedro A. Mosiño Alemán, of the Institute of Geophysics, of the N.A.U.M., for the XIVth General Assembly of the IUGG is appended:

SECRETARÍA DE RECURSOS HIDRÁULICOS.

Dirección General de Hidrometría (Paseo de la Reforma e Ignacio Ramírez, México 1, D. F.)

- Boletín Hidrológico* N° 14 (Upper Río Pánuco)
Boletín Hidrológico N° 15 (Lower Río Pánuco)
Boletín Hidrológico N° 16 (Middle Mexican West Coast; data to 1959)
Boletín Hidrológico N° 17 (Southern Mexico, part 1)
Boletín Hidrológico N° 18 (Southern Mexico, part 2; climatic data)
Boletín Hidrológico N° 19 (Lower Río Pánuco watershed; data to 1961)
Boletín Hidrológico N° 20 (Central Gulf and Valleys of Oriental, Libres and El Seco)
Boletín Hidrológico N° 21 (Northeastern Mexico, part 2; data to 1962)
Boletín Hidrológico N° 22 (Northern Mexico, part 2)
Boletín Hidrológico N° 23 (Lerma-Chapala watershed, part 1, data to 1962)
Boletín Hidrológico N° 24 (Lerma-Chapala watershed, part 2, data to 1962)
Boletín Hidrológico N° 25 (Lerma-Chapala watershed, part 3, data to 1962)
Boletín Hidrológico N° 26 (Northeastern Mexico; compendium for Nayarit State; data to 1966).

UNIVERSIDAD NACIONAL AUTÓNOMA DE MÉXICO.

Instituto de Geofísica (Torre de Ciencias, 3er. piso, Ciudad Universitaria, México 20, D. F.)

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Geofísica Internacional (since 1961).

Instituto de Geografía (Ciudad Universitaria, México 20, D. F.)

- Publicaciones del Instituto de Geografía* (since 1965)
 (other contributions in collaboration with various agencies contain climatological information).

Instituto de Geología (Ciudad Universitaria, México 20, D. F.)

Boletín del Instituto de Geología (since 1886)

Anales del Instituto de Geología (since 1917)

(both serials include meteorological and climatological information on areas of geologic interest).