AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

1. SUBJECT CLASSIFICATION

A. PRIMARY: Agriculture — AP10-0000-G510

B. SECONDARY: Water resources and management--Argentina

2. TITLE AND SUBTITLE

Preliminary assessment of some problems of the hydrogeology of the dry pampas in Buenos Aires Province,Argentina,trip report

3. AUTHOR(S)

Davis,S.N.; Winslow,J.D.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1970	15p.	ARC AR551.35.D264

7. REFERENCE ORGANIZATION NAME AND ADDRESS

NAS

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

9. ABSTRACT

10. CONTROL NUMBER

PN-RAB-168

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Argentina
Buenos Aires Province
Hydrogeology
Project planning
Water quality

13. PROJECT NUMBER

14. CONTRACT NUMBER

CSD-2584 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

PRELIMINARY ASSESSMENT OF SOME PROBLEMS OF THE HYDROGEOLOGY OF THE DRY PAMPAS IN BUENOS AIRES PROVINCE, ARGENTINA

Trip Report
(September 1970)

by

Dr. Stanley Davis

Dr. John Winslow

Under the Auspices of the
National Academy of Sciences
and
Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina)

In fulfillment of
Agency for International Development Contract csd-2584
Task Order #3

Preliminary Assessment of Some Problems of the Hydrogeology of the Dry Pampas in Buenos Aires Province, Argentina

Introduction

This report describes a preliminary assessment of some problems of the hydrogeology of an area of the dry Pampas (Pampa Semiarida) of western Buenos Aires Province, Argentina made by the authors in September 1970. The trip was made in accordance with an agreement between the U.S. National Academy of Sciences (NAS) and the Argentine Consejo Nacional de Investigaciones Científicas y Técnicas (CONICT) and was financed in part by the U.S. Agency for International Development (AID). The report is based upon 1) data and information made available by Argentine hydrogeologists, particularly the group working under Dr. Luis E. Arigós, 2) conferences with Ing. José S. Gandolfo and Drs. Oscar Ruiz Huidobro, Amilcar Galván and Dr. Luis E. Arigós, 3) a short, but highly informative, trip to the Pampa taken August 25 through 28, 1970 and 4) discussions held during the 1969 Argentine-U.S. Workshop on Science and Technology in Economic Development held in Mar del Plata, Argentina.

Background Information on the Pampa Semiarida

The area visited is in the cattle-raising region of the dry Pampa in the western part of the Province of Buenos Aires, roughly between longitude 61-63 west and latitude 34-36 south. The problems of water supply are representative of those in much of the Pampean region of central

Argentina.

The area is virtually flat and without evidence of surficial drainage. In the southern part, in the vicinity of Trenque Lauquen, low sand dunes provide local relief of a few meters. In the northern part, relief is seldom discernable. In all of the area the slight depressions are points of ground-water discharge by evaporation, and these are marked by small playas or salt-crusted soils. The southeast regional gradient is so slight (about one foot per mile) that ground-water movement is principally in response to local factors such as pumping, ground-water recharge from precipitation and discharge by evapotranspiration.

Water supply for domestic and stock use is from wells except for precipitation collected from the roofs of buildings and stored in cisterns (aljives) for human consumption. Storage volumes of the aljives commonly exceed 50,000 liters but the fresh water supply is often depleted during periods of drought.

The aquifer consists principally of silt and sand of Pleistocene age. It ranges from 20 to 70 meters in thickness, with an average thickness of about 50 meters. The surficial materials are at least in part the result of eolian action. The underlying clays of Tertiary age are reported to be about 500 meters in thickness, and are not a source of water to wells.

Water in the aquifer is generally saline, being progressively more saline with depth. However, in some local areas the water in the upper part of the aquifer is of sufficiently low salinity to be acceptable for human and/or stock consumption. In a small area of sand dunes southwest

of Trenque Lauquen, the aquifer zone containing acceptable water is about 50 meters thick, but generally such potable water zones are much thinner. In one area near the northern boundary of Buenos Aires Province, the water produced by windmill-powered wells becomes too saline for use after about two days pumping, but if the wells are then turned off for several days, the water is of more acceptable quality on the resumption of pumping. This indicates either lateral movement of saline water as a result of pumping or, most likely, that more saline water moves up from lower zones. It has also been observed that if a given amount of water is produced by a number of very shallow wells, rather than a single well, the quality of water deteriorates more slowly Scavenger wells have been considered impractical because of lack of areas to place scavenged saline water.

Water generally is considered potable for human consumption when the dissolved-solids concentration is less than 2,000 mg/l (milligrams per liter), and for cattle when less than 4,000 mg/l; however, much of the water used exceeds these limits. The ionic constituents in the water are principally sodium, calcium, sulfate, chloride and carbonate, but it also contains nitrate, fluoride and arsenic in significant amounts.

Recharge to the aquifer is from precipitation which averages about 800 mm per year. The range in annual precipitation is from about 500 mm to about 1,100 mm (Trenque Lauquen). Winter is the dry season. Evaporation is about twice the average precipitation. Over most of the area the water table is within a few meters of the surface so that ground-water discharge

is by evapotranspiration from the water table as well as from evaporation and playas and other low areas. Because of the delicate balance between recharge and discharge and the shallow water table, importation of water will require similar exportation of saline water.

Municipalities initially presumably developed in areas of the more potable water. Generally water supply is from individual shallow wells and sewage disposal by means of individual septic tanks. The quality of the water probably has deteriorated with time. In about 18 months, Trenque Lauquen (population about 30,000) will receive water from supply wells from a potable-water area southeast of town. However, if present sewage disposal methods continue without pumping, water levels beneath the town should rise. Water supply for cattle generally is pumped from shallow wells by windmills into open-topped storage tanks from which it is metered into watering troughs by float valves. Attempts have been made to locate these wells in areas of potable water, but many yield water of marginal utility, or water which is virtually unusable. Unfortunately, cattle-watering troughs generally are close to wells so that it is possible for animal wastes to percolate to the water table and pollute the aquifer, thereby worsening an already difficult situation. One cattle-raising area near the boundary between the provinces of Buenos Aires and Santa Fe previously was supplied by seven wells which in time became too saline for use. Now water is piped in from an area nearby. The deterioration in quality of the initially acceptable water may have been caused either by pollution or by removal (mining) of potable

water in the upper part of the aquifer.

The method of finding areas where the upper part of the aquifer contains water of unusable quality has become largely a matter of trial. Over the years, the inhabitants have learned to recognize that certain types of areas are better than average for finding potable water. Relatively higher areas, especially in stabilized sand dunes, are favored for exploration. Here, the depth to water is slightly greater and discharge of ground-water by evapotranspiration is probably slightly less than average. Perhaps, also the infiltration capacity of the soils is better than average in the higher areas. A second favored location is near roads where the manner of road construction favors better-than-average ground-water recharge. The roads generally are built slightly above the general land level, and are flanked by ditches. Apparently, a fair proportion of the water that stands in the ditches after a rain percolates to the water table. In other places the presence of potable water areas has no easy explanation on the basis of present data.

A large amount of data on the ground-water resources of the Pampean region has been collected by Argentine scientists. Thousands of wells have been inventoried for water level and construction details; thousands of water samples have been analyzed. Test wells have been drilled to study aquifer materials and the change of water quality with depth. Electrical resistivity surveys have been made in certain areas with some apparent success in delineating areas of potable water. Grouped together, these

studies provide a large body of information from which plans can be developed for further investigation of the ground-water resources of the area as well as for further development of the water resources.

Proposed Study of the Pampa Semiarida

The authors recommend a study of the hydrogeology of the Pampa Semiarida 1) to elucidate specific immediate steps which must be taken to maintain and, if possible, increase the agricultural productivity of the region and 2) to provide more basic data for a clearer understanding of scientific questions underlying ground-water resources in the area.

The objectives of the proposed study will be to 1) determine as accurately as possible the origin of waters of both low and high salinities, 2) determine the hydrogeologic controls which serve to localize waters of various qualities, 3) determine the origin of minor and trace constituents that occur in the water in unusual amounts and 4) develop exploration criteria which will enable future studies of water quality to progress more rapidly over a wide area. Despite the lack of specific practical objectives, data needed for the theoretical work will allow parallel or later studies to develop answers to problems of well construction, estimation of the quantity of available fresh water, economics of salt-water conversion and construction of drainage systems which are necessary with all water importation and/or recharge projects.

Proposed Procedure

The following procedure is offered only as a starting point for future discussions. The program should always be as flexible as possible to take advantage of new knowledge as it becomes available. An emphasis is placed on investigations which will yield a maximum amount of information for the time and money invested. Although of some potential use, caution should be exercised in embarking on costly analog models, full-scale geophysical exploration, and the like before full use is made of inexpensive procedures which are commonly more productive from a scientific standpoint.

Needless to say, all available data should first be collected and analyzed. We understand that the Direccion Nacional de Geología y Minería has made some preliminary studies of the fresh water-salt water problems of portions of the Pampa Semiarida. Although these studies are not as extensive as needed, every effort should be made to incorporate the data into the proposed research program. Likewise, a comprehensive literature search of studies in other areas of the world having similar fresh water-saline water problems should be made to incorporate whatever findings may be judged useful to the Pampa Semiarida.

Four test areas should be selected for intensive investigation in Argentina. The selection should be based on hydrogeological variations which are present. As an example, one area could be a region of sand dunes, another a region with salt-water lakes or ponds, another of extremely poor water but without surface topography, and the last region might be on the

eastern boundary of the Pampa Semiarida. About 100 km^2 might be a convenient size. The exact boundaries should be determined by hydrogeologic considerations together with existing boundaries of estancias rather than making the areas conform to latitude and longitude lines.

The bulk of the work will involve drilling and sampling shallow test holes and placing semi-permanent casing in the holes. A limited number of deeper holes, perhaps 100 to 200 meters deep, should be drilled in order to sample areas in which unusually high or unusually low salinities are encountered.

The excellent inventory and survey already accomplished by Dr. Arigós will form a good basis for provisional selection of test areas. As Drs. Huidobro, Arigós, and others have emphasized, however, the probability exists that many wells which have been sampled may be contaminated by humans, and to a larger degree by cattle. Much of the contamination will be localized around watering points which are also near the wells that have been sampled. The need for new test holes at least 300 m, preferably up gradient, from existing or abandoned wells cannot be emphasized too strongly. The exact number of test holes needed will vary from one locality to another, depending on the variability of water quality between sampling points. One hole per km^2 might be a reasonable suggestion for planning purposes.

Work to be Accomplished

The following list gives the actual work which should be accomplished

after the test areas have been selected. The list is given in the approximate order of importance but not in chronological order. A preliminary work chart is also included which gives some indication of the sequence which might be followed. Again, it should be emphasized that this list is intended to promote discussion and an exchange of ideas rather than serve as a basis for final planning.

1. Inventory existing wells within the test area and collect water samples for laboratory analyses. This will serve to pinpoint changes which may have occurred since the last inventory. Estancia owners and foremen should be interviewed in order to determine location of abandoned wells and areas which have had human or animal concentrations in the past. Such areas should be noted as areas of possible artificial contamination.

2. Auger test and observation wells, collect geologic and water samples, install casing, measure water levels, and make short-term pumping tests. A poor alternative would be to make slug tests. Although slug tests are not very reliable, a comparative value can be obtained provided the design and construction of the wells are standarized. If time and money are available, low discharge aquifer tests should be made of all test holes.

3. Make laboratory analyses of water and sediment samples. Particular attention should be paid to trace constituents in the water and to stratigraphic markers in the sediments. A number of determinations should be made of H^3 and C^{14} concentrations in the water samples.

4. Make leaching tests of surface soil and auger samples. Make chemical analyses of leachate.

5. Run second-order level lines to all observation wells. Owing to the low gradients, as much precision as possible should be achieved in order to determine local ground-water gradients.

6. Drill deep wells in areas of fresh and saline water. Water and sediment samples to be processed the same as samples from auger holes. If rotary drilling is used, special care should be taken to obtain good samples. This is particularly difficult under most circumstances unless special coring tubes and packers are available. Rotary drilling has the advantage, nevertheless, of allowing electrical logging as well as a number of other "wire-line" methods.

7. Establish several automatic as well as manual monitoring stations. Some items to measure are water levels, salinity, air and water temperatures, rainfall, soil moisture at various depths, and evapotranspiration. This phase of the work will probably take at least two years.

8. Continue and expand study of exising air photographs. Details obtained in test areas may be correlated with features shown on photographs.

9. Establish programs to study special techniques for surveying fresh and salty water. Such programs might include low-cost surface geophysics as well as false-color, near infrared photography. If remote sensing programs are planned by other Argentine agencies, it may be possible to have the test areas surveyed at little or no extra cost.

10. Write final report. It is essential that enough money be budgeted so the final report can be finished, printed and widely distributed. The work will most likely uncover new facts and principles which will be of wide interest in the scientific community as a whole.

Related Studies

Hydrogeologic studies already planned and underway in the Province of Buenos Aires should be continued and perhaps expanded. This work is an important complement to the research proposed for the test areas.

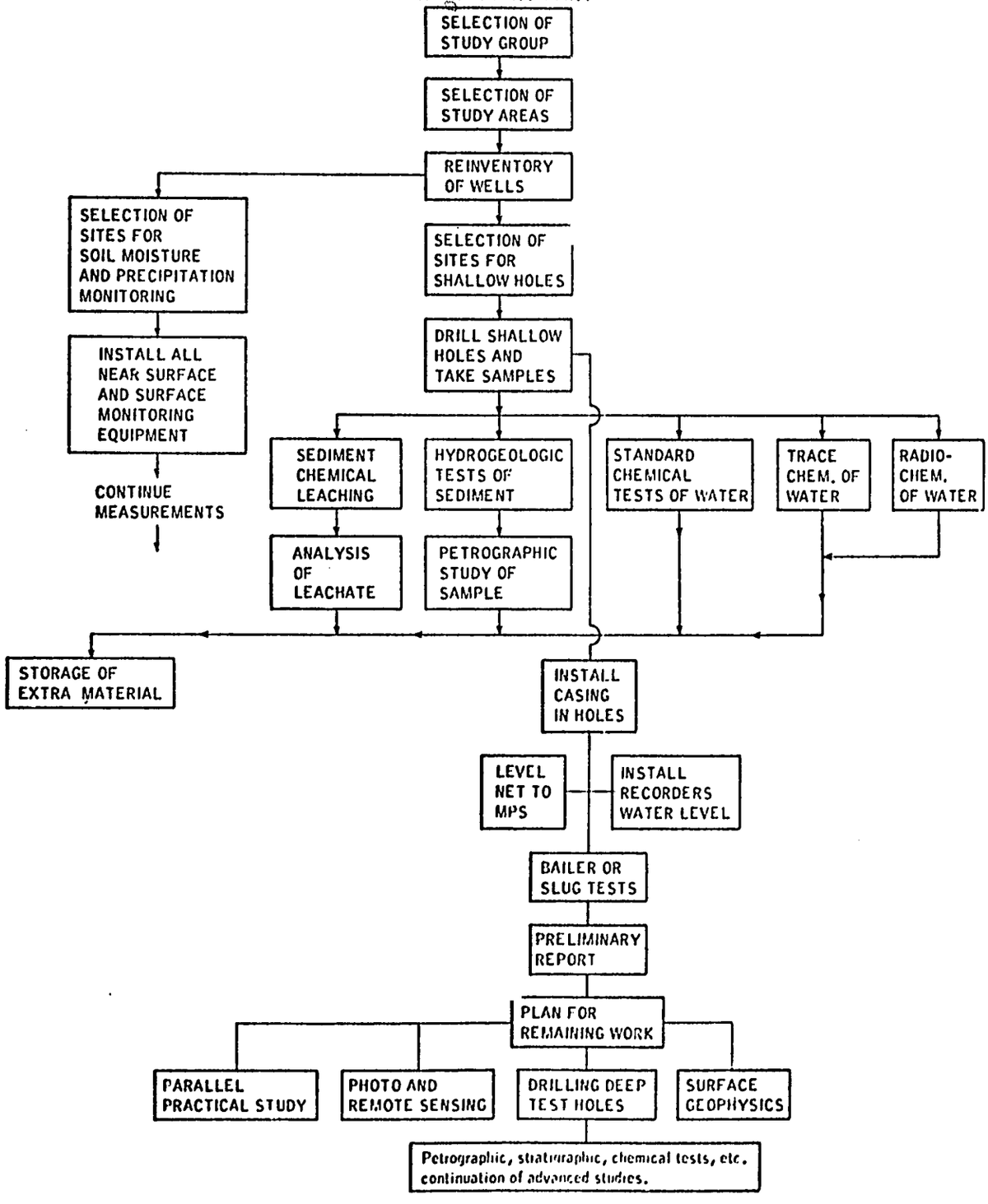
Selected studies of a more practical nature could also be started before the test-area research is completed. Effects of water importation, methods of determining the "safe yield" of an area, well-design problems, and many other items must be considered before water supplies of the Pampa region are fully developed.

Non-hydrogeologic topics also need investigation. Argentine scientists interested in the water-supply problems have all emphasized the need for a thorough review of existing information on the relation of water quality to growth of cattle. If the existing information is not sufficient, as appears likely, field tests under careful statistical controls should be made. Water-supply utilization cannot be planned intelligently unless the above information is available.

Selection of Personnel

As visualized in this report, the research will be carried out by

TIME SEQUENCE
IN
WATER QUALITY RESEARCH
PRELIMINARY PART



Argentine scientists who will be selected by the proper local agency. Conferences and reports will involve other Argentine researchers as well as people from outside the country. In addition, the NAS of the United States may establish a more formal basis of cooperation and exchange of information between selected specialists in Argentina and their counterparts in the United States. If so, the NAS will undoubted consult with the appropriate Argentine agency (presumably the CONICT) concerning individuals under consideration.

Types of specialists to be considered include:

1. A general hydrogeologist with Latin American experience who is interested in research as well as practical applications of scientific work.

2. A hydrogeochemist who is acquainted with analytical technique as well as theoretical physical chemistry. Perhaps two men will be needed in this category.

3. A geophysicist who is familiar with the broad problems of ground-water exploration. This man will be needed about midway through the project.

4. An expert in remote sensing if some activity in this field is contemplated.

Problems of Financing

Financing the proposed project is of great concern to the Argentina scientists. Although much of the basic equipment is available for the

survey work, the following are some of the items which may need to be purchased:

1. Special coring tubes.
2. Soil moisture measuring equipment, possibly a neutron probe.
3. Water-level recorders.
4. Inexpensive rain gages.
5. Special chemical equipment for field measurement of pH, iron, and bicarbonate.
6. Temperature probes and read-out equipment.
7. Special equipment for trace constituent analyses.
8. Plastic casing for observation wells.

If technical assistance of foreign scientists is deemed desirable, the expenses of these persons should be included in the cost estimate.

Conclusions

Argentine hydrogeologists are interested in a research project in the Pampa Semiarida where quality of ground-water is of great practical importance as well as theoretical interest. A brief reconnaissance has indicated that such a project is feasible through an intensive investigation of a small number of test areas that typify the hydrogeologic variations of the region. Staffing and financial problems need to be resolved, but the importance of the project suggests that sufficient governmental interest will be developed to insure success.

APPENDIX A

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