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REPORT 10

STUDIES OF PLAYA LAKES IN THE HIGH PLAINS OF TEXAS

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PLAYA LAKE USE AND MODIFICATION IN THE HIGH PLAINS*

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Use of water collecting in the playas dotting the High Plains area was a haphazard thing for many years. Probably the greatest benefit in early times was use as watering places for livestock roaming the range. The shift from ranching to farming eliminated this beneficial use, and for a period of time the playa was considered a nuisance and detriment to the farmer. Usually no crops could be grown in the playa, and the bare soil was an ideal place for dust movement to start when high winds were developing. However, playa areas do remain dry a sufficient number of years to encourage farmers to attempt cultivation. The gamble is great and generally results in long-term loss.

Increased use of underground water following World War II placed a heavy draft on water stored in the aquifer. This was so pronounced by the late 1940's that many wells decreased in production. Old wells were deepened in some cases and new wells were drilled to supplement the existing wells. Progressive people recognized the need for a study of the underground water resource. In the vanguard was the High Plains Underground Water Conservation District No. 1. Calculations of the capacity of the aquifer, and estimates of the pumping rate and natural recharge rate firmly established the fact that water was not being supplied by some distant source. This was contrary to the belief of many High Plains residents. A few are still not convinced that an inexhaustible outside water supply does not exist.

A three-pronged attack was made on the problem. Possibly the most important was education of the people in wise water use. This was to preserve the available water for use in future years. Disseminating information of the true nature of recharge to the aquifer, encouraging more efficient application of pumped water, reduction of waste water, reuse of irrigation runoff, and land preparation for irrigated fields were some of the most important educational projects. Coupled with this program was limitation of the number of wells to be constructed. Guidelines were set up relating spacing and capacity. The third facet was directed toward utilization of surface runoff occurring after intense summer thunderstorms. Estimates were made of the number of playas available to store water and the volume of water available. Early estimates(1) placed the number of playas at about 37,000, and average annual runoff between 1 and 1.5 million acre-feet. Such a large quantity of water needed to be used to the best

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advantage. A study of playas determined that less than 10 percent of this water reached the aquifer by percolation through the soil. More than 90 percent returned to the atmosphere without performing any useful function.

There are essentially three methods by which this flood water can be controlled: 1) land preparation and management to reduce runoff, 2) pumping directly from the playa back to the land, and 3) placing the water into the aquifer by some artificial recharging process. All three have strong and weak points and no method can be considered the correct solution for all situations.

Bench leveling, which can be designed to retain all precipitation except in years of unusually high rainfall, is applicable to light and medium textured soils where the ponded water can percolate through the soil profile rapidly enough so the growing crop is not damaged. Heavy clay soils are not acceptable for this practice. Areas where the topography is made up of steep slopes are not suitable to bench leveling although contour irrigation can be practiced successfully.

Pumping directly from the playa in its natural state is probably the next most feasible practice for utilizing this water resource. There is little investment necessary besides the cost of a pump, power unit, and pipe. A major disadvantage of this procedure is timing. Playas are usually full after a heavy rain or a series of moderate storms and water may not be needed on the field immediately. The common practice is to wait a week or two before starting to pump this water. At this time the surface area of the playa is greatest and the volume of water evaporated per day reaches its peak. Even if a conscientious program is followed, evaporation losses are high.

Two methods of reducing these water losses were apparent. Pumping water at a rate greater than natural recharge had emptied a part of the underground reservoir. Water can be placed in this reservoir by providing access to the aquifer through use of recharge wells. The playa can be modified so the volume of storage is maintained while significantly reducing the surface area.

Recharging the underground formation has been successful in many areas of the world. Two major methods are used for this purpose. Where the overburden is sufficiently permeable and the depth to the aquifer not excessive, spreading the water in surface reservoirs has proven quite advantageous. In areas where the overburden is thick and almost impervious, recharge wells have been used. Local conditions favor the latter method of recharge. The overburden is thick--generally more than 100 feet--and the soil in the bottom of the playa is practically impermeable.

In the January, 1955 issue of "The Cross-Section," news organ of the High Plains Underground Water Conservation District No. 1, Dr. George A. Whetstone(2) of the Civil Engineering Department at Texas Technological College published the first of a series of articles on past accomplishments in the field of replenishing ground water by artificial recharge. Among many projects reviewed, the successful well installations in New York, Louisville, and El Paso were cited as indications that this might be a successful practice in the High Plains of Texas.

A recharge well constructed by the High Plains Underground Water Conservation District No. 1(3) was activated in June, 1955 and a report published the same month in "The Cross-Section." This well started taking water at 1,050 gallons per minute. After 8 days the rate was 200 gallons per minute. Total volume of recharge was 4,200,000 gallons. Rapid and continuous reduction in flow rate showed that turbid runoff water sealed up the pore space in the gravel formation and reduced the recharge rate materially.

Since 1955 several studies have been conducted to determine means of overcoming the problem of sediment plugging the pore space in the formation. The first attempt was to permit turbid water to flow into the well for 22 to 23 hours, followed by shutting off the inflow, starting the pump, and pumping from the aquifer for a period of 1 to 2 hours. It was determined that about 1 hour of pumping removed sufficient sediment to result in discharging water as clear as the recharging water. The rate at which the well accepted water was about the same as at the start of the previous recharge period. This appeared very promising, but a check of the water pumped from the well showed that although a majority (75 percent or more) of the silt was removed(4), only a small portion (7 to 11 percent) of the clay particles was removed. This suggested that, in time, the clay particles would fill up the pore space in the formation. This has happened in many instances with resulting well abandonment.

Attention was turned to means of clearing up the water prior to recharge. Chemical flocculation resulted. Several times wind action was sufficiently strong on succeeding days to cause sediment to be remixed with the water. If another period of runoff followed the treatment process, turbid water mixed with the clear. In either of the cases, a new treatment was required to clarify the water.

To minimize duplication of effort, the Agricultural Engineering Department of Texas Technological College attempted to clarify the turbid water by installing a tile drainage system in the bottom of a playa. The system installation began in 1958 and has provided some recharge water every year since that time. There is no apparent damage to the well which is a gravel-pack structure. Some additional gravel has been required at intervals. Photographs taken below the static water level (summer of 1961) did not reveal any unusual deposits on the well screen. Two faults are evident in this system--turbid water is permitted to reach the well during early stages of recharge, and a rapid drop in filter capacity is noted when the water level in the playa drops below 6 inches. It is necessary to pump sediment from the well for the first day or two of recharging. Near the end of the recharge period a small amount of water remains in the lake to be lost by evaporation. Laboratory studies are being conducted and modifications are being made on the field installation in an effort to eliminate the two inadequacies mentioned above. Prospects are good for obtaining an effective and economical unit by 1968.

Research carried out at the High Plains Research Foundation at Halfway, Texas has closely paralleled early work by the High Plains Underground Water Conservation District No. 1 and has extended into the study of various filtering methods. Reasonable success seems to be evident although a sound evaluation of the progress cannot be made for several years.

Recognition of problems confronting well recharge procedures encouraged additional studies on lake modification to reduce the surface area of the water and increase the depth. One objective of these studies was the reduction of evaporation by decreased surface area. Another objective was the elimination of shallow water areas that provided a breeding place for mosquitoes. The mosquitoes multiplying in playas are carriers of viruses that cause encephalitis (sleeping sickness), and have caused several severe outbreaks of the disease on the High Plains.

In 1962 a cooperative project was started by the High Plains Underground Water Conservation District No. 1, Texas Technological College, Lubbock City-County Health Unit, the Texas Water Commission, and the U.S. Public Health Service. Ten Lubbock County lakes were selected for this study. Topographic maps were made and an elevation-volume curve developed for each lake. Rain gages, staff gages, and automatic water-level recorders were installed. Based on information received in 1962, three lakes were modified during 1963 and two more during 1964. Information gathered showed that water losses were reduced to less than one-sixth(5) that experienced before modification. In the modification an average of 10.5 acres(6) was reclaimed for crop use. Some crops will, with proper management, thrive in the modified lake soils and produce as good or better yields than on surrounding land. To date, the volume of this water used for irrigation has been minimal with no record of the quantity pumped.

Cost of modifying these lakes ranged from about $3,000 to $9,000. A more complete description of plans and specifications for each lake modified is given in "Multipurpose Modification of Playa Sinks," second and third annual reports of the above mentioned cooperative project. Pertinent information is found on pages 18 to 22 in the second annual report and on page 37 of the third annual report. On a basis of acres of land reclaimed, this may be more economical than the purchase of new land(7). The same objective may be reached in many cases by use of a recharge well. A lower cost may be possible by the recharge method.

Many playas in the High Plains area have received minor modification so that water will be concentrated where a pump installation can pick up the water. The number of these lake pump installations 10 years ago was small. Replies to our recent questionnaire(8) show 284 known modifications, with 156 having pump installations (Table 1). It is certain that there are many others not listed in the returned questionnaire. In reporting playa modifications and recharge wells the County Agent and Work Unit Conservationist were asked to report only those which could be positively identified. The figures received were conservative and did not include systems that the reporter may have noticed, but for which he did not know the owner or operator of the system. Checking with several local irrigation supply organizations revealed centrifugal pump sales considerably above the reported figure for lake pumps. The total number of lakes pumped has been estimated at about 2,000. In Table 2, the number of playas pumped includes the playas modified by major concentration. Some of the playas were developed primarily for livestock water use and are not pumped.

In addition to the counties recorded in Table 1 inquiries were sent to Borden, Mitchell, and Scurry Counties. No replies were received. Replies for the fringe areas in Childress, Collingsworth, Hall, Hemphill, Lipscomb, and Wheeler Counties indicated no playa modifications or recharge wells. No questionnaire was sent to determine the number of playas existing. The number of playas missed was negligible in the large total number in counties that were thoroughly covered.

A portion of this study involved estimating the number of playa modifications and recharge well installations that would be completed at 10-year intervals until the year 2020. This projection is presented in Table 2. The projected figures are based on the assumption that a significant number of the playas will be modified only to the extent necessary for pump installation. Almost all playas modified to concentrate water and reduce evaporation will be used as a source of irrigation water and, therefore, are included in the total used for pumping.

Table 1.--Summary of data received from lake modification and recharge questionnaire, 1965

County	Lakes	Lake acreage		Lakes modified	Lakes pumped	Recharge wells		
		Total	Average			Active	Inactive	Total
Andrews[1]	298	--	--	0	0	0	0	0
Armstrong[1]	1,348	16,580	12.3	0	7	0	0	0
Bailey[1]	629	5,221	8.3	0	2	2	0	2
Briscoe[1]	348	14,900	38.8	6	7	0	0	0
Carson[1]	575	16,860	29	0	9	0	0	0
Castro[1]	525	15,750	30	0	1	3	4	7
Childress	--	--	--	0	0	0	0	0
Cochran[1]	407	2,003	4.9	0	0	1	0	1
Collingsworth	--	--	--	0	0	0	0	0
Crosby[3]	1,269	18,466	15	0	10	2	0	2
Dallam[2]	179	3,043	17	2	0	0	0	0
Dawson[1]	910	8,110	8.9	0	1	5	0	5
Deaf Smith[1]	364	12,012	33	3	6	4	0	4
Dickens	--	--	--	0	0	0	0	0
Donley	5	--	--	0	5	0	0	0
Floyd[1]	367	7,707	21	11	5	7	0	7
Gaines[1]	127	--	--	0	0	0	0	0
Garza[1]	337	3,723	11	0	2	0	0	0
Gray[2]	458	2,291	5	0	0	0	0	0
Hale[1]	1,181	16,416	13.9	1	6	21	0	21
Hansford[1]	352	6,867	19	50	6	0	0	0
Hall	--	--	--	0	0	0	0	0
Hartley[2]	214	3,872	18	0	0	0	0	0
Hemphill	--	--	--	0	0	0	0	0
Hockley[1]	2,344	12,900	5.5	0	1	4	2	6
Howard[1]	140	1,500	10.7	1	0	6	0	6
Hutchinson[2]	95	976	10.2	0	4	0	0	0
Lamb[1]	1,245	14,069	11.3	24	1	13	1	14
Lipscomb	--	--	--	0	0	0	0	0
Lubbock[1]	1,500	14,908	9.9	2	22	17	3	20
Lynn[1]	870	10,000	11.5	4	5	2	0	2
Martin[1]	319	6,700	21	0	0	2	0	2
Moore[1]	122	1,806	14.8	0	13	0	0	0
Ochiltree[3]	110	4,600	41.8	0	8	0	0	0
Oldham[3]	75	3,000	40	0	0	0	0	0
Parmer[1]	393	12,576	32	0	33	0	0	0
Potter[1]	69	4,900	71	--	--	--	--	--
Randall[1]	394	13,669	34.2	0	2	0	0	0
Roberts[2]	20	100	5	15	0	0	0	0
Sherman[2]	419	7,123	17	0	0	0	0	0
Swisher[1]	584	36,000	61.6	0	0	0	0	0
Terry[1]	575	3,267	6.8	9	0	0	0	0
Wheeler	--	--	--	0	0	0	0	0
Yoakum[1]	38	270	7.1	0	0	0	0	0
Total	19,241	339,685	--	128	156	90	10	100

[1] Actual count by personnel from the Agricultural Engineering Department using aerial photographs of the entire county.
[2] Count supplied by U.S. Soil Conservation Service Work Unit Conservationist or North Plains Underground Water Conservation District representatives.
[3] Sample maps selected, lakes counted and planimetered, and then projected to the total area of the county.

Table 2.--Projections of playa modification and well recharge, 1965-2020

	1965[1]	1970	1980	1990	2000	2010	2020
Lake Modifications							
By pumping	2,000	6,000	8,500	10,000	11,000	12,000	13,000
By water concentration	128	300	3,500	5,500	6,500	7,400	8,000
Recharge Wells							
Without NAWAPA	100	200	800	1,600	2,400	3,000	3,500
With NAWAPA[2]	100	200	1,000	6,000	7,500	8,000	10,000

[1] The figure 2,000 is based on a sampling of centrifugal pump sales made by irrigation equipment firms. The other values for 1965 were obtained by use of a questionnaire sent to County Agents and Work Unit Conservationists in the counties of the High Plains.

[2] An outside influence such as the North American Water and Power Alliance concept would alter the situation to quite an extent and must be considered in the study.

Recharge wells are not going to be accepted rapidly. The reluctance to accept recharge wells under present conditions is evidenced by the High Plains irrigation surveys prepared by D. W. Sherrill(9, 10, 11). In 1962 this report showed 181 recharge wells. By 1964 this had decreased to 164, and the number reported by those responding to our questionnaire in 1965 was 100 of which 10 are inactive. Although new recharge wells are being installed, those abandoned are apparently of a greater number. Why these are being abandoned is not fully known. One operator cited the well as a source of Johnson grass infestation. Seed entering the well with the recharge water was distributed to other portions of his property.

The need for utilizing every drop of water possible in areas that do not lend themselves to proper land preparation or to utilization of lake pumps will encourage the installation of recharge systems. Some lake pump installations without an expensive water concentration modification may shift to recharge as the more economical of the two methods and possibly as the most efficient in reducing evaporation losses.

A much different situation will be presented if the NAWAPA (North American Water and Power Alliance) concept develops. In this case it is conceivable that water will be recharged into the aquifer whenever it is not being used directly for irrigation. Water delivery may be on a 365 day a year basis, while irrigation would be carried out only about 100 to 150 days of the year. To accomplish this it seems that one recharge well for every four to five production wells would be adequate. This, coupled with other methods of recharge that can be practiced in certain areas, should gradually build up the ground-water resource to maximum capacity and provide a stable supply of irrigation water.

Even with maximum utilization, a small percentage of the playas will not be used by any of the above methods. It would be overly optimistic to expect that more than 85 percent will be developed by either of the two major methods considered. Some playas will be eliminated by land preparation.

The number of playas which accumulate water and the total acreage involved is an important feature in this study. It provides a guide to the scope of the problem of maximum water utilization. The number of pumps that will be required, the number of recharge wells to be constructed, and the amount of earth movement to be done can be estimated. Equally as important is the amount of water involved in the project. A recent calculation by the High Plains Underground Water Conservation District No. 1 places the average annual runoff at 3 million acre-feet per year. This is a significant percentage of the average yearly irrigation requirements and, if properly handled, salvaged water can contribute to the extended irrigation life of the High Plains. If 70 percent of the runoff water can be salvaged a major step in water conservation will have been accomplished, contributing 2.1 million acre-feet to the irrigation economy of the High Plains.

SUMMARY

Realization of the importance of irrigation water to the High Plains of Texas brought forth action on the part of community leaders late in the decade 1940 to 1950. Playing a leading role in this action was the High Plains Underground Water Conservation District No. 1 at Lubbock, Texas. Among the many agencies cooperating in this program were the Texas Board of Water Engineers, U.S. Soil Conservation Service, Texas Agricultural Experiment Station, Texas Agricultural Extension Service, and local and regional groups.

Education in efficient use of irrigation water was an early part of the program and continues to be an important part of the conservation program. Research in more efficient practices has aided in the water use program. It was not long after heavy irrigation pumping started that people realized the underground water supply was exhaustible and efforts were begun to reduce the use of this depletable resource and make more use of the recurring resource--natural rainfall. Estimates were made of the number of playas available and the volume of runoff that accumulated in these lakes. Then means were sought to utilize this water. Placing this water in the gravel formations was one of the early plans and still has many promising features. Land preparation came into prominence--both as a means of improved irrigation efficiency and for rainfall conservation. More recently lake modification to reduce the water surface area and its accompanying evaporation losses has come to the fore. This is another practice that appears to be a practical solution to reduce water losses.

This somewhat localized problem has come to be a part of the much greater picture. Not only does it become part of the water problem of Texas, but is of concern in National and Continental water plans. A recent directive from Governor Connally required a much closer look at the Texas water situation. In keeping with this directive, Texas Technological College participated in a more detailed study of the lake modification activity and recharge well construction on the High Plains of Texas. A lake by lake count was made for 27 counties on the High Plains. Samples were drawn from three counties and projected to the total area. U.S. Soil Conservation Service personnel provided count for six counties. Playas in these counties under study numbered 19,241. Active recharge wells totaled 90. An estimated average of 3 million acre-feet of runoff water accumulates annually in these lakes. Considering unavoidable losses, 2.1 million acre-feet of this water should be available for productive agricultural uses.

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PUBLIC HEALTH ASPECTS OF HIGH PLAINS WATER*

By Ellis W. Huddleston[1] and Virginia C. Riggs[2]

INTRODUCTION

Information for this report was collected from many sources. Although there are some published data, most of the information concerning public health in the High Plains exists as unpublished field reports and mimeographed reports by workers from the U.S. Public Health Service, Texas State Department of Health, local health units, and Texas Technological College.

HISTORY OF ENCEPHALITIS IN THE AREA

Three main types of encephalitis exist in the United States. These are eastern equine encephalitis (EEE), western equine encephalitis (WEE), and St. Louis encephalitis (SLE). Since the virtual elimination of malaria and yellow fever, the arthropod-borne viral encephalitides have become the most important group of mosquito-transmitted diseases of man in the United States(1). Arboencephalitis also is considered to be the major health problem associated with High Plains surface water, since mosquito breeding is directly associated with surface water.

More than 90 percent of the Texas High Plains drains into small, intermittent lakes or playas which range in diameter from a few feet to almost a mile and in depth from a few inches to several feet. The playas are usually dry during the winter months, but fill during the growing season by surface runoff and irrigation waste water. More than 70 percent of the mosquitoes in the High Plains are produced from these playas(2).

Epidemics of arboencephalitis occur at irregular intervals when weather conditions and prevalence of virus become optimum during the same year. Table 1 gives the cases of encephalitis by county in the Southern High Plains from 1957 to 1964.

These data are often misleading in that many suspect cases are not reported, and thus confirmation of total incidence often is not possible.

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Table 1.--Encephalitis cases (human) in the Southern High Plains, reported to the Texas State Department of Health

County	1957	1958	1959	1960	1961	1962	1963	1964
Bailey	0	1	2	9	0	2	0	0
Briscoe	0	1	0	0	0	0	0	0
Castro	0	0	3	4	0	0	1	0
Cochran	0	0	0	0	0	0	0	0
Crosby	0	0	7	0	1	0	4	1
Dickens	0	0	0	0	0	0	0	0
Floyd	0	2	0	0	0	0	1	0
Garza	0	2	1	1	0	0	0	0
Hale	0	12	1	14	6	1	26	13
Hall	0	1	0	0	0	0	0	0
Hockley	0	0	0	1	1	0	0	0
Kent	0	0	0	0	0	0	0	0
Lamb	0	0	5	3	1	0	3	0
Lubbock	0	5	7	8	8	3	5	3
Lynn	0	0	0	0	0	0	1	0
Motley	0	0	0	0	0	0	0	0
Parmer	0	0	0	1	0	0	0	0
Swisher	0	0	4	1	0	0	1	2
Terry	0	0	0	0	0	0	0	0
Yoakum	0	0	0	0	0	0	0	0
Total	0	24	30	42	17	6	42	19

Arboencephalitis is especially prevalent in the younger age groups where it may readily be confused with various childhood diseases. Table 2 gives the data of the age distribution for encephalitis cases in Texas.

Table 2.--Age distribution of encephalitis cases in Texas in 1956
(Reproduced from Pigford[3], 1957.)

Age	Number of cases	Percent of total cases
0-12 months (19 cases)	--	--
1-9 years (54 cases)	73	27.4
10-19 years	35	13.2
20-29 years	37	13.9
30-39 years	34	12.9
40-49 years	22	8.3
50-59 years	31	11.6
60-69 years	20	7.5
70-79 years	10	3.7
80-89 years	4	1.5
Total	266	100.0

THE VIRUSES AND THEIR VECTORS

All three main virus types causing human encephalitis are present in Texas, and two of these, SLE and WEE, are endemic in Lubbock[3].

Prior to 1938, transmission of these diseases was thought to be from man-or-horse to mosquito to man-or-horse. Since Ten-Broeck's work in 1938, viruses have been isolated from domestic fowl, Redwing Blackbird, pheasants, pigeons, and other birds[4]. Present opinion is that the viruses are maintained locally in a natural reservoir of birds and possibly small mammals. The viruses appear to be asymptomatic or subclinical in the birds but are pathogenic when transferred to man or horse. Man and horses are considered to be dead-end hosts in that mosquitoes are unable to transmit the virus from man or horse to another host. Figure 1 shows the cycle of arboencephalitis virus transmission.

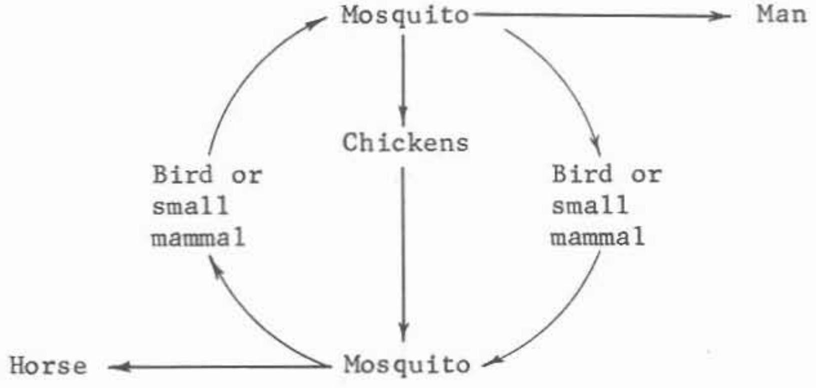

Figure 1.--Cycle of Arboencephalitis Virus Transmission
(Redrawn from U.S. Public Health Service Communicable Disease Center)

Virus isolation from groups of 50 individual mosquitoes, called a pool, are routinely conducted by the U.S. Public Health Service and Texas State Department of Health.

The following mosquito species that have been found to harbor EEE, WEE, or SLE are found on the High Plains of Texas(5): Culex tarsalis Coquillett, Culex quinquefasciatus Say, Culesita inornata (Williston), Aedes dorsalis (Meigen), and Aedes nigromaculis (Ludlow).

Other mosquito species found on the High Plains have been shown experimentally to be capable of transmitting these viruses(6). Table 3 gives examples of virus isolations from mosquito pools collected in the High Plains.

Table 3.--Arboencephalitis virus isolations from mosquito pools in the High Plains[1]

Lab	Year	Species	Pools tested	Virus isolates				
				WEE	HP[2]	TUR[2]	SLE	Other
DEC	1964	Culex tarsalis	208	73	15	2	1	11
TSDH	1964	do	56	10	0	0	0	1
TSDH	1964	Aedes nigromaculis	1	1	0	0	0	1

[1] Data obtained from Dr. John S. Wiseman, Texas State Dept. Public Health.

[2] Other arboviruses not of primary importance.

Culex tarsalis, the main vector, becomes most numerous in late summer, corresponding with the peak of human cases of arboencephalitides. Table 4 gives the reported cases of human encephalitis on the High Plains from July 1 to December 29, 1956, and Table 5 gives light-trap records of Culex tarsalis from July 3 to December 10, 1962.

Table 4.--Reported cases of encephalitis by week of onset from July 1 to December 29, 1956. (Reprinted from Pigford(3), 1957.)

Week ending	Reported cases
July 14, 1956	0
July 21, 1956	2
July 28, 1956	1
August 4, 1956	6
August 11, 1956	13
August 18, 1956	21
August 25, 1956	24
September 1, 1956	44
September 8, 1956	32
September 15, 1956	14
September 22, 1956	45
September 29, 1956	12
October 6, 1956	31
October 13 to December 29, 1956	17

Table 5.--Numbers of Culex tarsalis per light-trap night from July 3 to December 10, 1962. (Data from Huddleston(8), 1962.)

Date	Number per light-trap night
July 3, 1962	--
July 9, 1962	1
July 16, 1962	3
July 23, 1962	33
July 30, 1962	45
August 6, 1962	53
August 13, 1962	330
August 20, 1962	250
August 27, 1962	220
September 4, 1962	100
September 11, 1962	144
September 19, 1962	45
September 26, 1962	40
October 2, 1962	30
October 8, 1962	29
October 15, 1962	6
October 22, 1962	11
October 29, 1962	17
November 6, 1962	3.4
November 12 to December 10, 1962	7.3

Culex tarsalis prefer the warm weed-and-grass-choked shallow waters of the playa lakes as breeding sites. Breeding conditions become more favorable toward the end of the summer, and this fact, together with the adult mosquitoes over-wintering in small numbers, leads to the gradual increase in population density from June to early August. From early August until September numbers of Culex tarsalis increase at a "compound interest" rate, reaching very large numbers before the advent of cooler weather slows rates of reproduction and development.

PEST MOSQUITOES

Large numbers of other species of mosquitoes are present during the summer months, especially in years of above-normal rainfall. These mosquitoes, although at present not thought to cause significant health problems, seriously interfere with outdoor recreational and work activities in the late afternoon and evening.

The four main species of mosquitoes associated with playa lakes, in order of relative abundance, are Culex tarsalis Coquillett; Aedes nigromaculis (Ludlow); Psorophora signipennis (Coquillett); and Aedes vexans (Meigen).

Other species found in the area are given in the following tabulation[7]:

Aedes thelcter Dyar	Anopheles pseudopunctipennis Theobald
Aedes dorsalis (Meigen)	Anopheles quadrimaculatus Say
Aedes sollicitans (Walker)	Psorophora ciliata (Fabricius)
Culex quinquefasciatus Say	Psorophora ionfinnis (Lynch Arribalzga)
Culex coronator Dyar and Knob	Psorophora cyanescens (Coquillett)
Culex erraticus (Dyar and Knob)	Psorophora discolor (Coquillett)
Culex restuans Theobald	Ursanotaenia lowii Theobald
Culex erythrothorax Dyar	Ursanotaenia sapphirina (Osten Sacken)
Culiseta inornata (Williston)	Ursanotaenia syntheta Dyar and Shannon
Culiseta incidens (Thomson)	

Mosquitoes of the genera Aedes and Psorophora are usually termed floodwater mosquitoes, indicating that eggs are laid at the shoreline of stationary or declining water levels, and are hatched when the water rises at a later date. Not all eggs will hatch at the first flooding but will remain viable and hatch after later floodings. Eggs are known to remain viable for a year or more[4]. In the playa lake environment the highest water level often is successively lower in each year of a 2 or 3 year period, followed by a year when the high-water level exceeds any of the recent past years. In this situation, tremendous numbers of mosquitoes emerge from 1, 2, and 3-year-old eggs.

The genus Culex differs from the Aedes and Psorophora in that eggs are laid on the surface of the water. The shallow, warm, weed-choked playa is a perfect breeding site for Culex.

The normal pattern is to have large numbers of Aedes and Psorophora following the heavy rains of June or July, followed by increasing numbers of Culex as the emergent vegetation increases in the playa. The number of arboencephalitis cases increases in the same pattern, with both mosquitoes and arboencephalitis reaching a peak in mid-September.

OTHER NUISANCE INSECTS

Very few, if any, other arthropod vectors of disease are associated with the surface waters of the High Plains. A few horse flies breed in the limited canyon-bottom habitat, while feedlots and other concentrations of animals provide food and breeding sites for horn flies and stable flies.

The lack of cultivation of the playa lakes, and hence the weeds and grass that grow profusely, offers an important overwintering site for several important insect pests of the area, such as the cotton fleahopper and thrips. In addition to overwintering, many of these pests pass one or two early generations in and around the playa and serve as loci for infestations of cropland.

CONTROL MATERIALS AND METHODS

Insecticides are available that will adequately control mosquitoes in playa lakes. Several problems exist, however, that make chemical control impractical. First, it is only a matter of time before mosquitoes will become resistant to any given insecticide, and perhaps acquire at the same time a cross-resistance to another insecticide. Second, chemical control requires several applications per season. Work at Texas Technological College has shown that season-long control is impossible with presently available insecticides. Third, the large numbers of lakes, borrow-pits and railroad rights-of-way prevent the treating of all breeding sources within the short time interval between flooding and emergence of adult mosquitoes. When the heavy clay soils of the playa are wet, it is impossible to get spray machinery close enough to treat the water. Fourth, for Lubbock County alone, with 1,000 playas averaging about 10 acres each, the cost of a chemical for control would be in excess of $50,000 per year.

Based on experience from a study of mosquito breeding in playa lakes, there appears to be insufficient naturally occurring biological control organisms to meet public health standards of mosquito suppression. Studies with the mosquito minnow, *Gambusia affinnis affinnis* have not given the level of control needed.

The physical modification of playas, as presently being studied by the personnel of the project "Multipurpose Modification of Playa Sinks," has virtually eliminated mosquito breeding while producing permanent bodies of water. Preliminary indications are that modifications of this nature will be economically feasible for many of the playas of the area[8, 9, 10].

PESTICIDE CONTAMINATION AND OTHER POLLUTION OF IMPOUNDED AND RECHARGED WATER

The large amount of pesticides used in agricultural production on the watershed of the playa, together with the pesticides necessary for mosquito control, present several possible contamination problems. If this water is involved in the recharge of the underground aquifer, still more problems loom in the future. The exact status of this problem has not been investigated, but funds for a project to study this problem have been requested from the U.S. Public Health Service.

Sewage and other waste-product contamination is limited to the few watercourses in the area. Since each playa is the terminal accumulation basin for its watershed, and only 10 percent of the area does not drain into a playa, the scope of the contamination problem is limited.

PROJECTIONS TO THE YEAR 2020

Arboencephalitis has been endemic in the High Plains of Texas for many years; therefore, there is no reason to anticipate any change in the past pattern of irregular epidemics, with attack rates as high as 2.6 per 1,000 population, unless certain changes occur. Factors influencing mosquito breeding, and thus encephalitis epidemics, include irrigation, cultural practices, mosquito control, human population density, and the possible development of effective immunizations.

The decrease in available irrigation water should lead to more effective utilization of available water, with a consequent reduction in the amount of waste water allowed to flow into the sinks, thus providing mosquito-breeding sites. In addition, more and more, direct utilization of playa lake water for irrigation can be foreseen; hence a direct reduction in duration and size of mosquito-breeding habitats. Cultural practices, especially bench leveling and terracing, should significantly reduce runoff from farmlands into the playa sinks.

The accelerated use of parks, outdoor recreation sites, and suburban homesites, as population density increases, will place more and more people in positions of increased exposure to encephalitis vectors. Other vectors, either present and unrecognized or introduced from other areas into the playa lake environment, together with new or unidentified viruses, as previously mentioned, could pose new health threats.

Entomologists and officials involved with public health problems recognize that the most effective and efficient method of mosquito control is the Mosquito Abatement District approach. Far-thinking State Legislators have already provided the legislative basis for the establishment of these tax-supported districts in any area of the State.

If, by the year 2020, an educated public has learned to more effectively use underground and surface water, and has established efficiently operated mosquito abatement districts, mosquitoes and encephalitis should be a lesser problem than at the present time.

FOREWORD

The High Plains of Texas is unique in having thousands of shallow depressions, or playas, in an otherwise level plain that have no regular outlets and normally hold most surface runoff.

These playas furnish catchment for a considerable amount of water, providing opportunity for its salvage for beneficial use. At the same time, the preponderance of these areas presents problems, particularly of a health nature, that can become serious if not controlled through proper development and management of the playas.

This volume contains two reports that deal, respectively, with the utilization and public health aspects of the playa lakes. These reports were prepared under provisions of the General Research Agreement between Texas Technological College and the Texas Water Development Board. They are two of five reports by various members of the Texas Technological College staff arranged for as a direct contribution to the development of a State Water Plan. The Texas Water Development Board gratefully acknowledges the cooperation extended and the staff time and expense incurred by Texas Technological College in developing this information. The Board also thanks the authors for providing valuable and useful data important to water planning.

Texas Water Development Board

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