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URBAN WATER MANAGEMENT OF AN INTERNATIONAL RIVER: THE CASE OF EL PASO-JUAREZ*

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Although the difficulties which international rivers present to harmonious water development are well documented, problems associated with international groundwater resources have received comparatively little attention. Indeed, not until the latter 1960's did the International Law Association recommend as a principle of international law an integrated approach to river basin management by coriparian states which would embrace both surface and subsurface waters in an interrelated system.[1]

The experience of the adjacent cities of El Paso, Texas, and Ciudad Juarez, Chihuahua, which are located at the upstream end of the international Rio Grande boundary separating the United States and Mexico (Fig. 1), suggests two kinds of potential problems. First, serious difficulties are inherent in arid land river basin development which does not consider urban water needs when surface water rights are allocated. Second are those difficulties inherent in uncoordinated groundwater appropriation on an international boundary.

This paper begins by reviewing the systems of institutions and laws which guide urban water use in Mexico and the United States. It then considers the critical decisions which determined the degree to which urban water needs were considered in dividing the flow of the Rio Grande between Mexico and the United States and in allocating surface water resources among competing users in each nation. In the next section, existing information on water sources and total reserves, water pricing, and rates of use is compared for both countries. Then international linkages of past municipal groundwater development policies are reviewed. In conclusion, potential lessons from the El Paso-Juarez municipal water supply experience are suggested.

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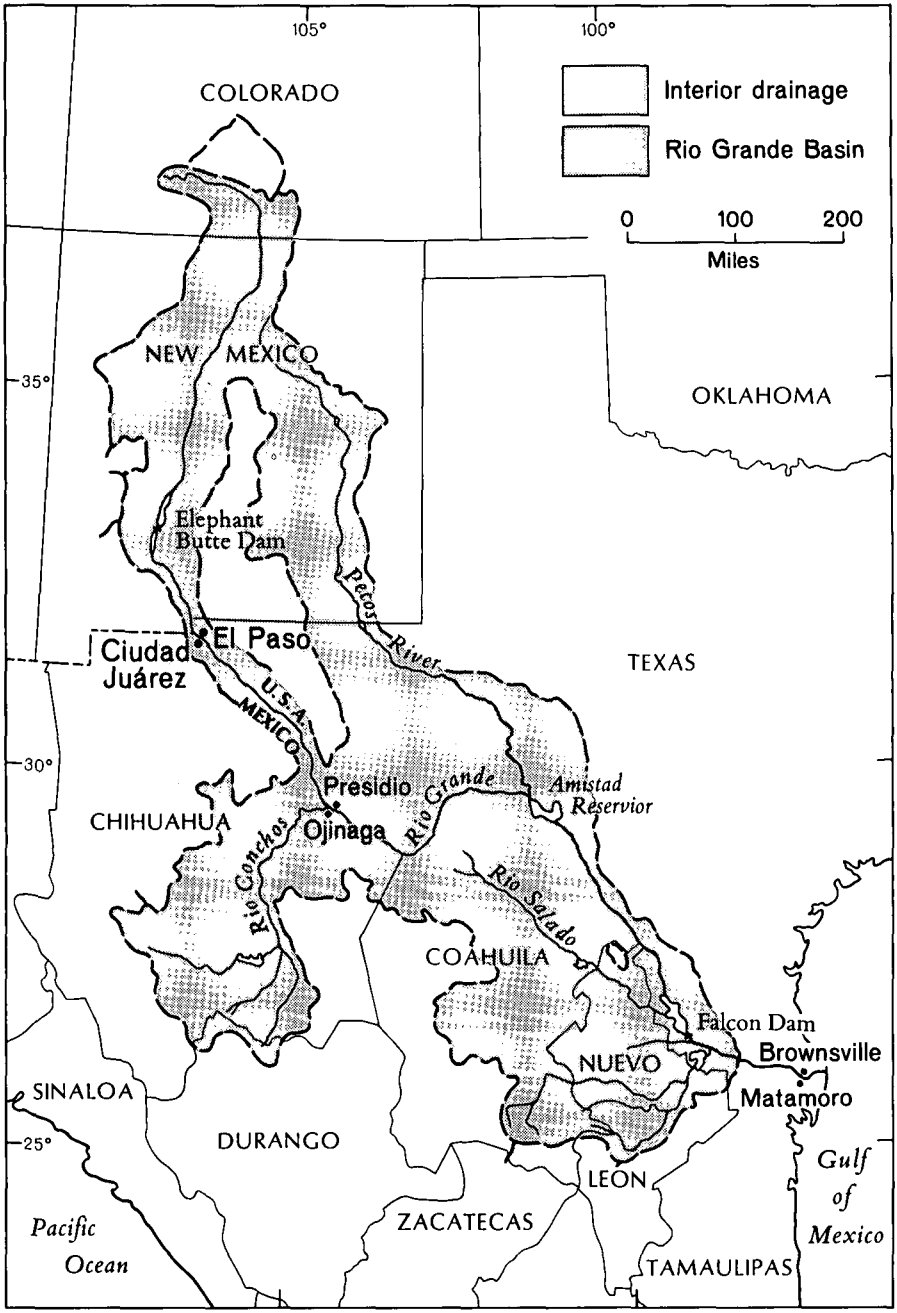
1. The International Law Association, *Report of the Forty-Eighth Conference, New York, 1958* (London: International Law Association, 1959), p. ix.



Source: Comisión Internacional de límites y Aguas, Boletín Hidrométrico, No. 35, 1965.

FIGURE 1

El Paso-Ciudad Juarez in the Rio Grande Basin

WATER MANAGEMENT INSTITUTIONS AND LAWS

The basic divergences between the legal systems adopted in both nations are related principally to two characteristics—allocation of water ownership to the federal government, state governments, or individuals, and delegation of responsibility for water allocation and control to either federal or state administrations.

The United States

In the United States both federal and state governments are vested with the obligation to manage water. However, in spite of the fact that federal agencies are deeply involved in all aspects of water control and use,[2] each state is responsible for establishing water laws to govern surface and groundwater resources within its territory.[3] Groundwater law varies widely among states. Under the Texas system, groundwater is regarded as a resource belonging to individual property owners who are entitled to unlimited pumping without the threat of judicial redress should such action deplete reserves, or impair water quality, of neighboring wells.[4]

In Texas, cities are responsible for providing municipal water service within their incorporated area.[5] Accordingly, in El Paso a Public Service Board was established to supply the city's water needs. The Board is aided in discharging this function by federal and state agencies which cooperate in groundwater data collection.[6]

Mexico

In contrast with the United States, ownership of rivers, streams, lakes, lagoons, and waters of international streams to which Mexico has a lawful right was assigned to the nation by the 1917 Mexican Constitution, following the Agrarian Revolution. Article 27 of the Constitution stated:

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2. The President's Water Resources Policy Commission, Water Resources Law 2 (1950).

3. Interstate water allocation is usually arranged by compacts composed of the states involved and the federal government which mutually determine minimum allowable flows, or quality, or water passing from one reach of the river to the next. Hutchins and Steel, *Basic Water Rights Doctrines and Their Implications for River Basin Development*, 22 Law & Contemp. Prob. 276 (1957).

4. J. T. Thompson, Public Administration of Water Resources in Texas 131-32 (1960).

5. *Id.* at 18.

6. In recent years, financial assistance has been available to stimulate investigation of future water demand and supply. The U.S. Geological Survey and the Texas Water Commission conduct cooperative studies and surveys of groundwater resources with the City of El Paso; The Urban Renewal Administration, U.S. Department of Housing and Urban Development has supported studies of the El Paso water situation as well.

> The ownership of the nation is inalienable and inprescriptible and concessions regarding the utilization of national waters may be granted only by the Federal Government.[7]

Although the necessity for improved Mexican groundwater legislation was not foreseen in 1917, within forty years the nation's groundwater resources were nationalized as well.[8]

Contrary to the United States policy which has proliferated federal, state, and municipal agencies charged with water management, control of all water uses, except hydroelectricity, is delegated to one agency in Mexico. The Ministry of Hydraulic Resources is empowered to plan and control appropriation and use of all surface and subsurface water stocks in the nation as a genetically related resource. It has been through this agency that Mexican water resources have been allocated among urban and rural users since 1947.[9]

All municipal water supply plans in the nation must be approved by the Ministry which normally plans and constructs works where federal subsidies, loans, or guarantees of private loans are involved.[10] Municipal water works are administered by Federal Potable Water Boards composed of Federal representatives of the Ministry and members elected from local populations.[11] Thus, water management institutions and laws vary markedly on opposite sides of the Rio Grande.[12]

PLANNING FOR EL PASO-JUAREZ WATER NEEDS

Massive appropriation of Rio Grande flow by irrigators in Colorado and New Mexico during the late 19th century, combined with prolonged periods of drought, caused severe shortages to irrigators in the El Paso-Juarez area which, in turn, prompted strong Mexican protests.[13] Subsequent negotiations resulted in an international Convention[14] which permanently divided streamflow between the two

7. 5 U.N. GAOR, Legal Problems Relating to the Utilization and Uses of International Rivers 59-60, U.N. Doc. A/5409 (1950).

8. Ramirez, *Aspectos Legales del Agua Subterranea en Mexico,* 21 Ingenieria Hidraulica en Mexico 253 (1967).

9. Anaya, "Mexico and its Water Resources Policy," *International Conference on Water for Peace* 4, Dept. of State Paper 694 (1967).

10. Secretaria de Recursos Hidraulicos, Jefatura de Agua Potable y Alcantarillados, Ley de Ingenieria Sanitaria y Reglamento de Las Juntas Federales de Agua Potable 4-8 (n.d.).

11. *Id.* at 10-11 and 15.

12. Rodriquez Langone, *Evolution of Mexican Water Law,* in International Water Law Along the Mexican-American Border, Committee on Desert and Arid Zones Research, Southwestern and Rocky Mountain Division, American Association for the Advancement of Science Report II 40 (C. S. Knowlton ed. 1968).

13. S. Rep. No. 928, 51st Cong., 1st Sess. Report of the Special Committee on Irrigation and Reclamation of Arid Lands 64 (1890).

14. Proclamation of May 21, 1906, 34 Stat. 2953.

nations[15] without, surprisingly, addressing the question of urban water supplies.

In view of the fact that until the 1890's river water had been the only source of urban water supply for both cities, it is remarkable that the Convention provided only "for the equitable distribution of the . . . Rio Grande for irrigation purposes."[16] All other potentially competitive water uses were ignored. Clearly, determination of rights to Rio Grande flow for municipal uses devolved to the water laws of each nation, for the Mexican and United States Governments had ignored future urban water needs in the settlement.

In the United States all unappropriated Rio Grande water was claimed early in the 20th century by the Reclamation Service[17] prior to constructing the Elephant Butte Dam 125 miles upstream from El Paso-Juarez. This structure provided storage of irrigation water for the Federal Rio Grande Project and the Juarez Valley allocation assigned by the 1907 Convention.

Although the Reclamation Service was permitted to supply municipal water after 1906, this was not done on the Rio Grande Project. On several occasions between 1925 and 1929, the Project Director advised El Paso that water rights on 8,000 acres of undeveloped lands could be claimed by assuming a proportionate share of project construction costs.[18] However, during this period city councils repeatedly refused to consider the Rio Grande as a water source because of its expense. Finally, the council which was elected in 1928 did take an interest in purchasing rights to streamflow. But their action came too late, as a Project Limits Board had already ruled that the United States share of Elephant Butte storage was fully appropriated.[19] Although the city retaliated by taking legal action in an effort to obtain Rio Grande water, for more than a decade El Paso was barred from appropriating water that flowed through its boundaries.[20] Subsequent minor concessions to use the river were only won after costly legal batttles with the Bureau of Reclamation.[21] Thus,

15. For a more detailed explanation of these events, see J. C. Day, *Managing the Lower Rio Grande: An Experience in International River Management,* Department of Geography Research Paper 125 (Chicago: University of Chicago, 1970), pp. 48-58.

16. *Id.* at 3.

17. U.S. Bureau of Reclamation, Data for Committee of Special Advisors on Reclamation of the Department of the Interior, Rio Grande Project, § B-22, January 1924 (on file in the Bureau's Denver Archives).

18. C. Bryson, El Paso Water Supply: Problems and Solutions, 1921-59 at 33 (1959). (Unpublished Master's thesis, Department of History, Texas Western College).

19. *Id.* at 35.

20. See Fig. 2 for a visual portrayal of El Paso's use of Rio Grande water during the 20th century.

21. Interview with Carroll C. Cason, Chief Engineer, Public Services Board, El Paso, Texas, Oct. 1966.

through its ineptness, El Paso was forced to adopt groundwater as the principal input of its water supply system.

During the 1960's, El Paso undertook two new kinds of arrangements to increase its annual river water allocation. Under a 1962 agreement with the Bureau of Reclamation, the city leases water rights on properties of two acres or less within its limits.[22] By September, 1966, 1,200 contracts covering the water rights to 360 acres of land had been secured. Ultimately, 4,000 acres may be acquired under contract although most city landowners used their water allotment in the late 1960's.[23]

In addition, El Paso has been only partially successful in implementing a "wild water" agreement signed with the Bureau of Reclamation in 1949. Although it has never constructed a reservoir to store such water, the city is permitted to capture water in excess of existing irrigation needs which passes down the river from time to time.[24]

The range of choices open to Juarez in selecting its municipal water supply was even more restrictive than that of El Paso. This situation arose because the annual volume of water granted to Mexico in the 1907 Convention was only intended to equal former diversions by irrigators into the Juarez Valley during the 1870's.[25] In effect, prior appropriation rights to the entire Mexican allocation of Rio Grande flow were in existence. Thus before 1930, a complex of international, federal, state, and local decisions in both nations resulted in virtually complete dependence of El Paso and Juarez on groundwater for their municipal water needs.

In the following 35 years, rapid population growth was experienced in the area. During the 1950 to 1960 decade the number of residents in both cities doubled; a similar rate of increase was experienced in Juarez during the previous decade as well. As a consequence of rapidly increasing demand, the major component of El Paso's

22. As well as augmenting El Paso's reserves, this contract provided the solution to a developing municipal problem. Irrigation laterals to individual homes are destroyed commonly during urbanization. Even though river water is not, or may not be used, landowners with water rights must pay annual taxes to the El Paso Irrigation District. Interview with Mr. Phillips, Manager, El Paso County Water Improvement District No. 1, El Paso, Texas, October, 1966.

23. Interview with Mr. Bob Parson, El Paso Water Utilities, El Paso, Texas, October, 1966.

24. Wild water refers to water which enters the Rio Grande downstream from Caballo Dam due to rainfall. Farmers use as much of it as they can, and the remainder escapes downstream. *See* J. T. Hickerson, El Paso's Water Resources (Paper read before a planning seminar, El Paso, Texas, February 8, 1966).

25. Joint International Boundary Commission Report, November 26, 1896, cited in: H. Doc. No. 359, 71st Cong., 2d Sess., 408 (1960).

water reserves underlying the Hueco Bolson had an estimated life of 72 years until exhaustion, based on 1962 pumping rates;[26] water in Bolson observation wells declined to the lowest levels in 29 years of record keeping in late 1967.[27] Projections suggested that the 1970 population of 758,300[28] in the El Paso-Juarez international metropolitan area would increase to 1.1 million in the following 15 years.[29] Although estimates were not available to indicate the adequacy of fresh water reserves for both cities, it is certain that groundwater will be subject to increasingly heavy use in coming decades. In the light of the finite water resource, consumption rates and patterns of use in these cities which have approximately identical numbers of residents are examined below.

URBAN WATER USE CHARACTERISTICS

Demand Schedules

El Paso has steadily increased the capacity of its water supply system in pace with expanding demand. However, the relative proportion of surface flow with respect to total municipal needs has declined since the early 1950's in spite of the city's attempts to increase its allotment of Rio Grande water (Fig. 2). In effect, continually increasing pressure is being placed on groundwater reserves.

The small variation in annual water consumption in Ciudad Juarez is remarkable in view of the magnitude of its recent population increase. No doubt this is a reflection of the double burden of renovating and enlarging the distribution system in the older sections of the city before supplying water to new residents settling on the periphery. When water use is compared across the international border, it is noteworthy that municipal consumption in El Paso was approximately four times greater than in Juarez in 1960, and three times greater in 1970 (Fig. 2).

Marked differences also exist in the annual demand for water. For example, in 1966, El Paso's demand increased significantly during the summer when peak use increased to about three times the winter rate of use. Expansion in the Juarez peak summer requirement over

26. John Carollo Engineers, *Report on the Water System–City of El Paso, Texas* 28 (1963).

27. U.S. Geological Survey and Canada Inland Waters Branch, Water Resources Review (January 1, 1968).

28. Estados Unidos Mexicanos, Secretaria de Industria y Comercio, Direccion General de Estadistica. IX Censo, General de Poblacion: 1970 at 25; City of El Paso, Dept. of Planning and Research, Population and Housing Trends: 1970-72 at 3 (1973).

29. Real Estate Research Corporation, Summary Report, Community Economic Analysis–Chamizal Planning Program, El Paso, tit. 13 (1966).

the winter consumption rate was roughly one half the comparable summer increase experienced in El Paso (Fig. 3).

It is necessary to consider the collective influence of many factors to explain the great absolute and relative annual demand differences in these two cities. Most important is lawn and garden irrigation. For

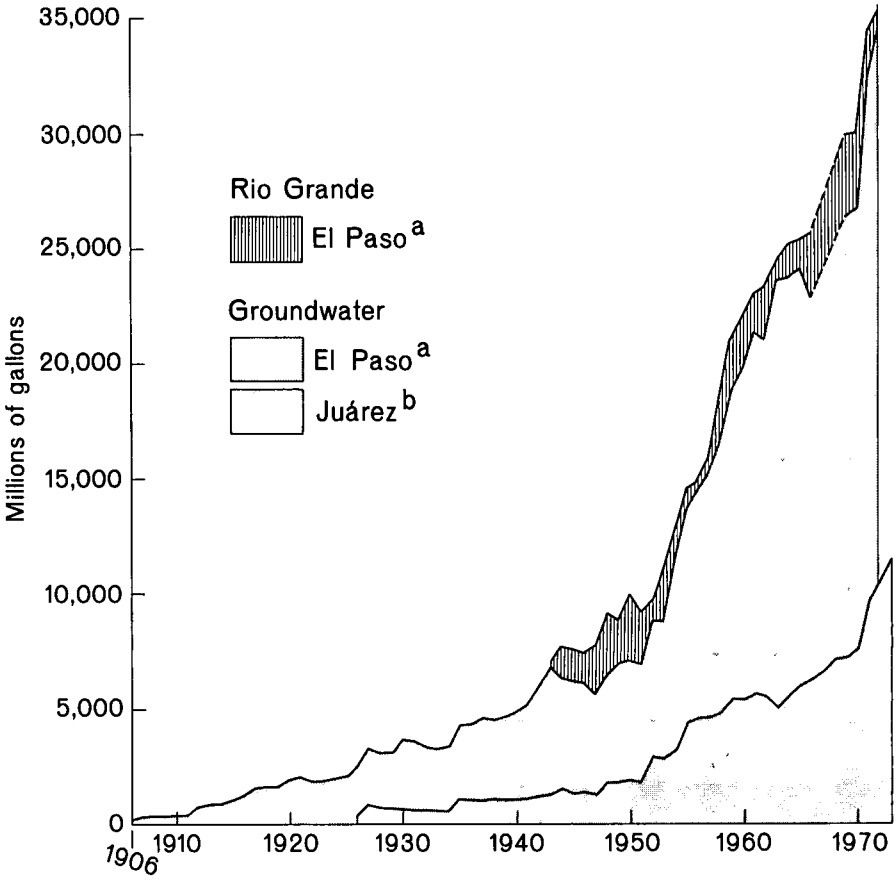

FIGURE 2

El Paso-Juarez municipal water use

[a]Groundwater–U.S., Geological Survey Water Supply, Papers 919 and 1426; Texas, Water Commission, Bulletins 6204 and 6514. Stream diversions–U.S., Department of the Interior, Bureau of Reclamation, "Monthly Water Distribution Reports, Rio Grande Project," 1943-62; Carroll C. Cason and Thomas E. Cliett, El Paso Water Utilities Public Service Board.

[b]M. E. Davis, Geologist, U.S. Geological Survey, El Paso; Junta Municipal de Aguas y Saneamiento, Ciudad Juarez.

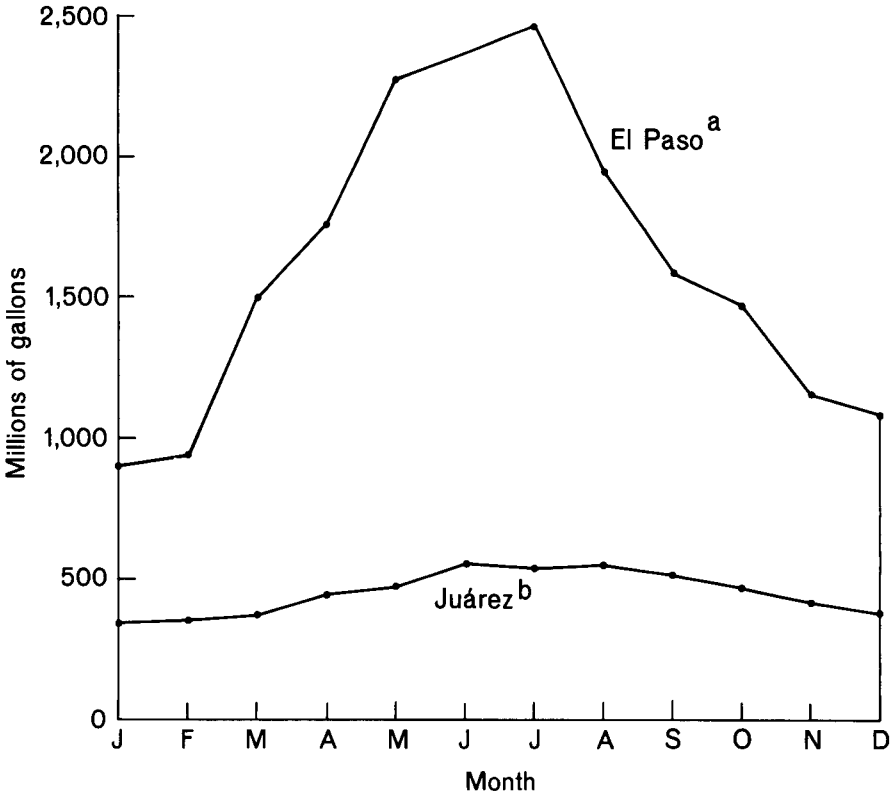

FIGURE 3

Monthly water use: 1966

[a]El Paso, Public Service Board, "Monthly Pumpage and Operation Report"; and Thomas E. Cliett, Geologist.

[b]Ciudad Juarez, Junta Municipal de Aguas y Saneamiento, "Volumenes Bombeados, 1966."

more than thirty years, ending early in the 1970's, El Paso offered a 20 percent summer discount to single family and duplex dwellings in order to create a humid landscape in an arid environment; the program had a deleterious effect on the city's groundwater reserves as the subsidy coincided with the period of maximum evapotranspiration. Of significance as well is the ever-growing number of evaporative coolers. It is estimated that these two uses account for 50 percent of El Paso's water use.[30]

30. Letter from Thomas E. Cliett, Staff Geologist, El Paso Water Utilities Board, El Paso, Texas, March 29, 1974. On file at the University of Western Ontario Department of Geography, London, Ontario.

Although the area of lawns and gardens has not been quantified in Juarez, the architectural style of building houses to the sidewalk which eliminates front lawns is in striking contrast to the El Paso urban landscape. Notwithstanding the many spacious parks and plazas with gardens and grass maintained by Juarez, a smaller acreage of lawns and other water-intensive vegetation covers is maintained vis-a-vis El Paso. This results not only from absence of lawns, or smaller lawns per dwelling unit, but also from a city area many times smaller than El Paso. Similarly, there are fewer evaporative coolers and swimming pools. These differences appear to be major determinants of observed water-use patterns in the two cities.

El Paso residents also possess large numbers of water-intensive appliances such as clothes and dish washing machines, refuse disposal units, and humidifiers, whereas none of these were used as commonly in Juarez in the early 1970's. Other uses, including water for drinking, cooking, and waste removal, were probably similar on both sides of the border.

Comparative Rates of Use

Per capita water consumption variations across the border are striking.[31] The per capita rate of increase in El Paso has diminished slowly since an upward surge between 1940 and 1950 (Fig. 4). Juarez data are not available prior to 1955. Estimates of per capita consumption between 1955 and 1960 indicate an inflection point in the upward trending demand in 1959. Then water use per person diminished until the mid-1960's. Thereafter a rapid increase in per capita consumption occurred.

The anomalous downward trend in the per capita rate of water use in Juarez during the early 1960's was caused by an influx of squatters. This migration continued unabated during those years.[32] In general, newcomers lacked adequate financial resources to acquire accommodations in established residential areas, so they settled on the Juarez Mountain slopes south and west of the city, far from existing water, sewage, and electric services.

Despite a major expansion and renovation program of the city water system between 1959 and 1964, the rate of immigration of

31. Water consumption data discussed in this section reflect water use for small industries and municipal needs as well as domestic consumption. Large industries and government institutions with heavy water demands have their own wells in both cities. For example, privately supplied consumers in El Paso County used 47% as much water as El Paso in 1970. Comparable data were not available for Juarez.

32. E. Orozco, *Sistema de Abastecimiento de Agua Potable y Alcantarillado:* Cd. Juarez, Chih. 22, Secretaria de Recursos Hidraulicos (n.p., n.d.).

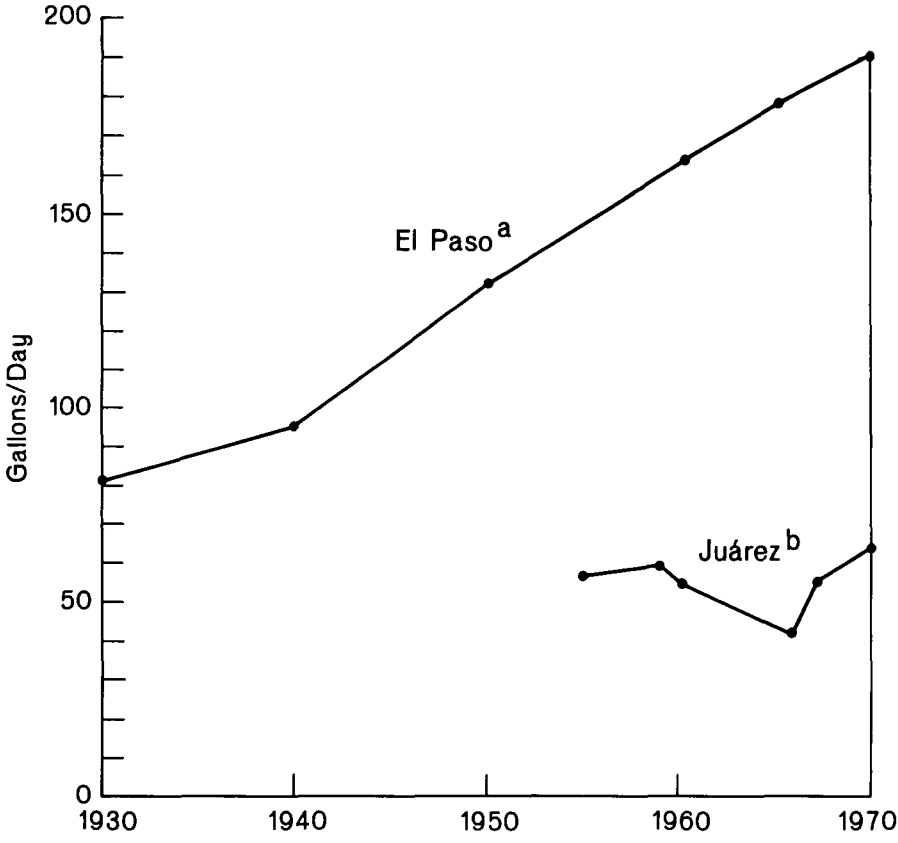

FIGURE 4

Average daily per capita water consumption

[a]Hickerson, "El Paso's Water Resources."

[b]Population figures from: Mexico, Secretaria de Recurso Hidraulicos, Jefatura de Agua Potable y Alcantarillados, *Sistema de abastecimiento de agua potable, Ciudad Juarez,* p. 7.

new residents outstripped gains in delivery capacity during this period. Although the enlarged transmission network was designed to serve 400,000 inhabitants,[33] pipelines had not been extended to dwellings in the broken and rugged terrain above Juarez. Thereafter, an annual program of municipal pipeline extension permitted an increase in the number of Juarez water customers served from 32,350 in 1967 to 52,850 in 1973.[34]

33. *Id.* at 39 and 48.

34. Interview with Ing. Martin Olivas, Jefe de Laboratorio, Junto de Aguas y Saneamiento, Ciudad Juarez, Chihuahua, January 1974.

Notwithstanding the major Juarez municipal water system expansion between 1959 and 1973, rapid immigration to the city during the period outstripped gains in delivery capacity. Approximately 25 percent of the Juarez population living in the rugged terrain above the city did not have piped water service in 1973.[35] A fleet of tank trucks makes daily deliveries vending water which is stored in barrels at each dwelling. Although the city donates water gratis to truckers, rates to consumers in recently settled suburbs are the highest in the El Paso-Juarez area (Table 1).

Water Pricing

The philosophy of water pricing varies dramatically across the international border. In general, the El Paso policy tends to promote water use by decreasing the cost of water per gallon as more water is used. In contrast, Juarez water users generally pay slightly more per gallon as use rises (Fig. 5).

Differences between water rates are examined by comparing the maximum and minimum schedules for Juarez's 6 service rates with the El Paso minimum and the service rate closest to the Juarez maximum (Table 1).

TABLE 1

Comparative Water Costs
El Paso and Juarez, 1973[a]

Type of Water Service	*$U.S./1000 gallons*	*% of Ciudad Juarez Minimum Municipal Domestic Rate*
Juarez		
5,280 gals/month minimum	0.426	100
66,000 gals/month minimum	0.440	103
Tank Trucks	3.154	740
El Paso Meter Size		
3,000 gals/month minimum	0.718	169
74,800 gals/month minimum	0.385	90

[a]Sources: El Paso, Public Service Board; Ciudad Juárez, Junta Municipal de Aguas y Saneamiento.

If the cost to Juarez residential consumers (with sewers) is considered for comparison, neighboring Texas families paid 1.69 times more for water. Conversely, Juarez industries (66,000 gallons/month minimum) paid only slightly more for water (103%) than Juarez residences, while El Paso industries paid 10 percent less than El Paso

35. *Id.*

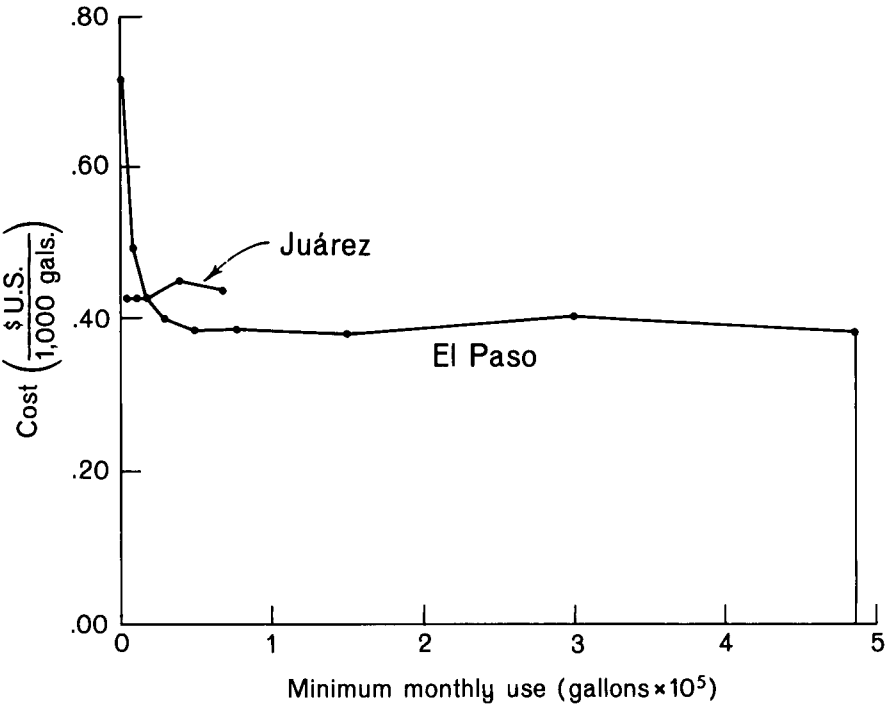

FIGURE 5

El Paso and Juarez water costs, 1973[a]

[a]Data from: El Paso, Public Service Board, "Rules and Regulations No. 5 (Water Service Rates)," Feb. 28, 1969; and Ing. Efren Domingues Torres, Presidente de La Junta Municipal de Aguas y Saneamiento, January, 1974.

residences. But most important, the large numbers of new residents in Juarez beyond the distribution system were doubly disadvantaged in paying 7.4 times more than residents in older sections of the city serviced by pipelines while being forced to provide water storage at their homes.

THE SPATIAL PATTERN OF URBAN GROUNDWATER FIELDS

Marked differences in the location of groundwater fields of Juarez and El Paso in the mid-sixties are related to transnational differences in water laws. In Mexico, the Federal Government controls groundwater exploitation; under Texas law, groundwater rights are a concomitant of land ownership to be used without supervision.

The consequences of these laws are revealed in the pattern of groundwater exploitation. Juarez pumps exclusively from strata beneath the city (Fig. 6). Conversely, El Paso, while producing much of its water from aquifers within its limits, is able to look beyond her boundaries to secure distant groundwater reserves.[36]

The fact that political boundaries exert a strong influence on the present pattern of groundwater development and the consequent sphere of El Paso's producing fields is manifest in Figure 6. Beginning in the early 1950's, El Paso began purchasing land to acquire exclusive subsurface water rights. By 1966, it had amassed 36,000 acres[37] concentrated in the Hueco and Mesa Bolsons. The necessity of protecting known fresh-water reserves made the City of El Paso the largest landholder in El Paso County.

The proximity of the New Mexico boundary effectively blocks attempts by the Texas municipality to extend its producing area north along the Rio Grande in La Mesa Bolson and north along the eastern flanks of the Franklin Mountains in the Hueco Bolson. In 1973, El Paso was exploring the remaining contiguous line of aquifers which lie to the southeast in the Lower Valley Area. Once again, groundwater exploitation will be circumscribed by a boundary, this time the international boundary along the southern edge of the supply corridor.

In addition to political boundaries, El Paso is faced with other difficulties. A large part of the Hueco Bolson (which contains about 90 percent of the fresh water available to El Paso)[38] is owned and used by the U.S. Army (Fig. 6). Thus, in large tracts of land contiguous to the city, El Paso is precluded from pumping. Little technical liaison is maintained between the Army and the Public Service Board of El Paso. While El Paso owns drilling rigs and supervises its own work, the Army contracts drilling to private firms. These landowners did not develop a coordinated pattern of producing wells nor standardize production and construction techniques to ensure maximum productivity of Hueco Bolson water. A coordinated policy integrating exploration, development, and production under the supervision of the largest water user, El Paso, might have been a more efficient arrangement.

36. El Paso protects its water by ordinances which regulate the construction, maintenance, and abandonment of privately owned wells within its boundaries to prevent deterioration of fresh-water aquifers.

37. Hickerson, *supra* note 24 at 7.

38. Davis, *Development of Ground Water in the El Paso District, Texas, 1960-63*, Texas Water Commission Bull. 6514 at 16, 17, 23 and Plate (1965).

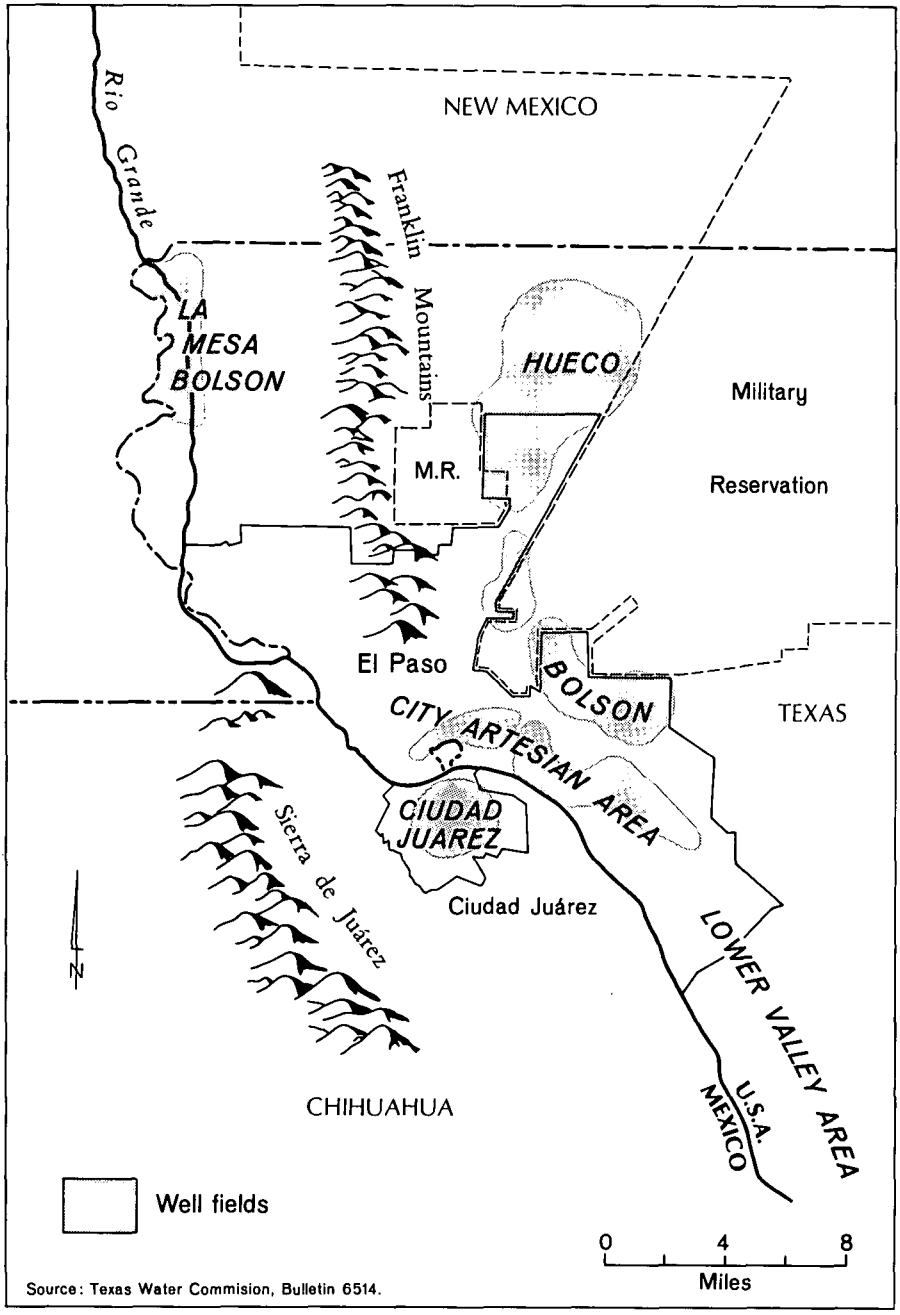

FIGURE 6

Groundwater fields of El Paso and Juarez

INTERNATIONAL GROUNDWATER LINKAGES

Juarez and El Paso developed contiguous groundwater fields in the Rio Grande Valley, separated only by the narrow river. Between 1936 and 1955, most of the water withdrawn by El Paso was produced from the Artesian Field (Fig. 6). During the following nine years, pumping increased in the Artesian Field, but expanded production from other fields reduced the relative proportion taken from the Artesian Field to 30 percent of El Paso's total water supply in 1964[39] and 13 percent in 1972.[40] Of greater relative importance is a contiguous Juarez field which, since 1926, has satisfied all municipal water needs from deep aquifers underlying the city.[41]

Saline water underlies, overlaps, and adjoins fresh-water aquifers of the Texas artesian area.[42] Although a description of the geohydrology on the Mexican side of the valley is not available, there is little doubt that the same aquifer is pumped by both municipalities. The producing horizon occurs approximately 700 to 900 feet below the Rio Grande Valley.[43] Wells must be cased to prevent salt-water encroachment into fresh-water stocks.

Experience in Texas demonstrates that:

> . . . fresh water [in the artesian area] was originally under higher pressure than the saline water, but pumping from the fresh-water sands has caused a reduction in the hydraulic pressure . . . upsetting the original differential balance between the saline and fresh-water bodies. Consequently, the saline water, now under higher pressure, can move into the fresh-water deposits to contaminate the supply.[44]

For this reason, mineral contamination from interformational leakage and leaking well casings is experienced. In El Paso, salinity increased from 250 to 470 parts per million in wells during the quarter century preceding 1963. By the sixties, wells affected by saline contamination were distributed erratically.[45] Similar events occurred in Juarez. When the Ministry of Hydraulic Resources rehabilitated the Juarez well system in 1959, old age and defective

39. Leggat and Davis, *Analog Model Study of the Hueco Bolson Near El Paso, Texas,* Texas Water Development Board Report 28 at 6 (1966).

40. Data supplied by T. E. Cliett, Staff Geologist, El Paso Water Utilities Public Service Board, El Paso, Texas, January, 1974.

41. U.S. Department of the Interior, *Groundwater Resources of the El Paso Area,* Water Supply Paper 919, at 50.

42. Leggat and Davis, *supra* note 39, at 5.

43. Leggat, *Development of Ground Water in the El Paso District, Texas, 1955-60,* Texas Water Commission Bull. 6204, Tables 3 and 4 (1962); Secretaria de Recursos Hidraulicos, Jefatura de Agua Potable y Alcantarillados, *Sistema de abastecimiento de agua potable, Ciudad Juarez,* p. 22.

44. Leggat and Davis, *supra* note 39, at 5.

45. Davis, *supra* note 38 at 18-20.

construction and operation of the twelve city wells were permitting chemical and bacteriological contamination of the deep aquifer. Continued well operation would have resulted in general contamination of the producing horizon.[46]

Another characteristic of the shared aquifer concerns the interrelated nature of water depletion. Between 1937 and 1965, the water level declined under El Paso. Maximum depression of the fresh-water surface by 1965 was 35 feet; a more compact and distinctive cone of depression developed under Juarez approaching 40 feet.[47] This results from the decision to minimize water transmission costs by pumping municipal water from aquifers beneath the Mexican city.[48] When 23 new wells were developed under Juarez between 1959 and 1964, drawdown was induced in the adjacent El Paso artesian aquifer.[49] In spite of the interrelated character of aquifers north and south of the Rio Grande, liaison to permit coordinated groundwater management is not maintained between the municipal water departments, whose offices are less than a mile apart.

Although drawdown has been concentrated in local areas to the present, recent developments in the El Paso-Juarez area point to possible broader consequences of uncoordinated groundwater management and potential international implications. As municipal water use accelerated in recent years, El Paso began exploring for new water supplies in the lower valley (Fig. 5). Concomitantly, the Mexican Ministry of Hydraulic Resources was investigating the possibility of expanding its irrigation water supply by pumping deep and shallow aquifers south of the Rio Grande in the same area of the valley. Not only could rapid pumping in one country potentially affect the water table in the other, but the possibility also exists that land subsidence could be induced if artesian pressure is removed from deep confined aquifers.

CONCLUSIONS

The international character of the common El Paso-Juarez aquifer is not yet a deterrent to development. This is probably because the interrelationship of resource use has not been perceived, or may not readily be demonstrated, as altering the quality, or quantity of water reserves of the coriparian nation. Nevertheless, connectivity of the groundwater fields pumped by each city indicates the need for inter-

46. Secretaria de Recursos Hidraulicos, *supra* note 43, at 16.
47. Leggat and Davis, *supra* note 39, at 8.
48. Interview with Ing. Efren Dominquez Torres, Presidente de la Junta Municipal de Aguas y Saneamiento, Ciudad Juarez, Chihuhua, December 1966.
49. Leggat and Davis, *supra* note 39, at 8.

national liaison to ensure a rational water appropriation policy. Mutually acceptable standards for groundwater protection should be established and enforced. The International Boundary and Water Commission, United States and Mexico, with its long experience in resolving international problems is the logical agency to coordinate such a task.

The El Paso-Ciudad Juarez experience suggests lessons which may be relevant in other international areas with shared groundwater. Where two or more nations pump the same aquifer, the necessity for coordinated groundwater management is apparent. It would be reasonable to establish and enforce a mutually acceptable set of developmental standards and policies to permit maximum aquifer productivity. Such an approach would provide an example of the kind of cooperation encouraged by the United Nations Conference on the Human Environment.[50]

50. United Nations, *Declaration Principles 17, 20, 21, 22, 23, 24, 25,* Report of the United Nations Conference on the Human Environment, at 5, UN Doc. A/Conf. 48/14/Rev. 1 (1972).