paper 2

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problems of conflicting demands for water in el salvador

1. INTRODUCTION

The firm of Wallace Evans & Partners were commissioned by the Overseas Development Administration of the Foreign and Commonwealth Office of the British Government at the request of the Government of El Salvador under the Technical Assistance Agreement between Great Britain and El Salvador to carry out a Technical and Economic Feasibility Study with the following aims:

a) To establish for the period up to 1995 proposals for the provision of additional water supplies to the city of San Salvador.

b) To prepare proposals for the development of the sewerage system and treatment of sewage from the city.

c) To investigate the general problem of pollution in rivers and lakes throughout the country with a view to recommending a programme for future control and abatement.

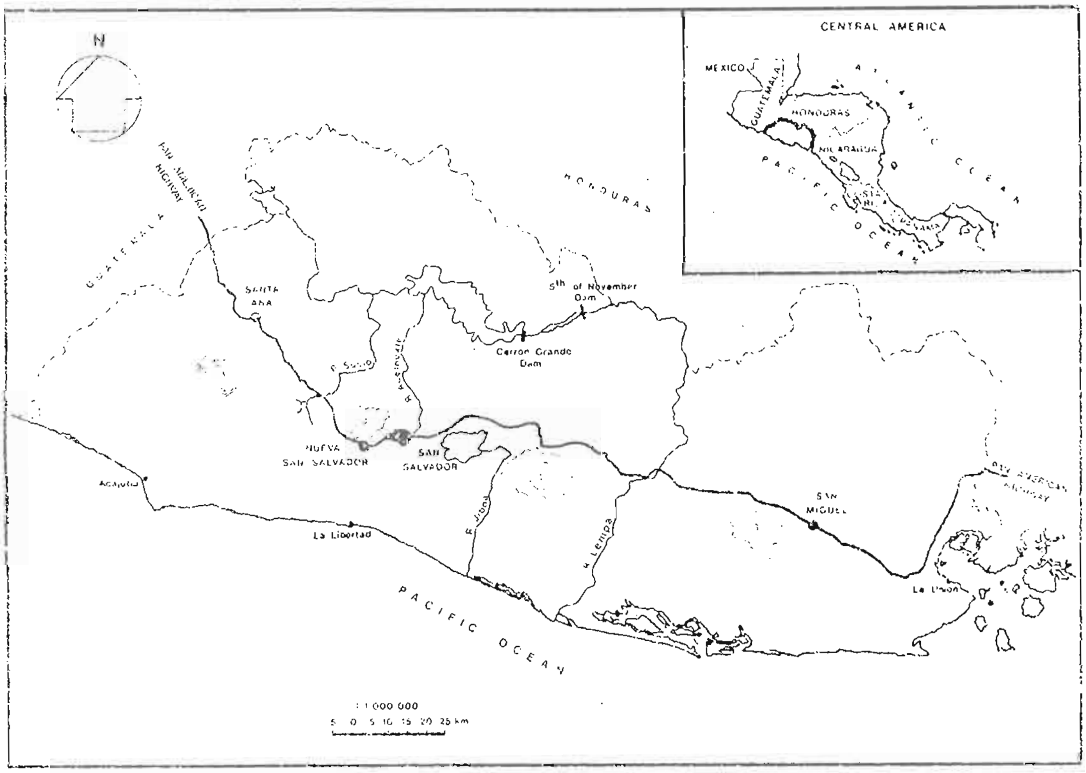
The study was undertaken for the Administracion Nacional de Acueductos Y Alcantarillados (ANDA) the authority responsible for the provision of water supply and sewerage services throughout El Salvador. It followed a United Nations Development Project investigation into possible sources of water for the City of San Salvador (1967-1972)(1) and a study of the city's water distribution system by Messrs. Black and Veatch Consulting Engineers carried out in 1967(2).

This discussion sets out to describe the conflicts of water demand which arose due to the requirement to provide additional water supplies for the city of San Salvador and emphasises the need for an overall control of water resources in a small crowded country.

2. BACKGROUND

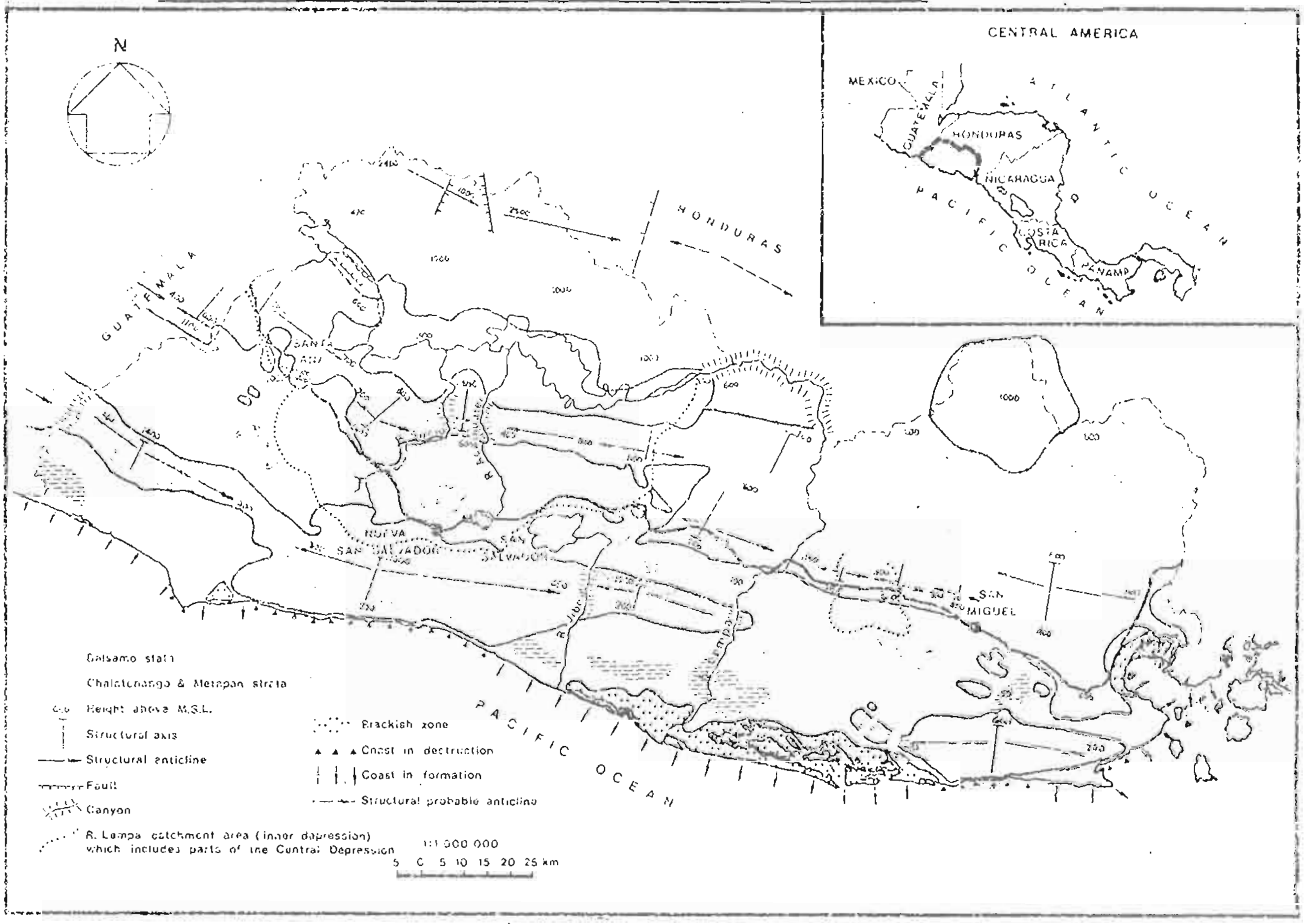
El Salvador is a small Central American Republic, bounded to the North by Guatemala and Honduras, and has the Pacific Ocean as its southern seaboard. The country is long and narrow in shape being some 270 km in length with a total area of 21 000 km^2. The present population is some 3.5 million. Of this 60% can be classified as rural and 40% urban though there is an increasing trend towards urbanisation. There are three main urban areas: San Salvador (570 000 population), Santa Ana (96 000) and San Miguel (60 000). Figure 1 shows the location of El Salvador and the locations of these principal urban areas.

FIGURE 1: El Salvador



The country is dominated by volcanoes and crater lakes and shows the characteristics of recent geological activity with very rugged terrain and steep, young rivers which carry large amounts of sediment from recent volcanic deposits. (An estimated 7 million cubic metres of sediment annually is transported by the River Lempa to Cerron Grande Dam Site(3), where the average annual river flow is 5300 million cubic metres.) The main geographical feature of the area is the trough or "graben" sometimes known as the Nicaraguan depression which passes through Costa Rica, Nicaragua, El Salvador and Guatemala running roughly parallel to the coast. This "graben" zone is one of intense and continuing tectonic activity which has resulted in complex and disordered geological formations. The country has a chain of volcanoes stretching along its full length parallel with the coastline but some 25-30 km inland. A range of hills (El Balsamo) also lies parallel between the volcanic chain and the seaboard. These hills are geologically "older" and have a great influence on the groundwater drainage of the country (figure 2).

FIGURE 2: Pliocene rocks and their influence on groundwater flow



The river systems draining the country can be considered as consisting of two main elements. An internal drainage basin running roughly from west to east which is drained by the River Lempa and a series of short, steep rivers rising in the southerly slopes of the El Balsamo hills which flow due south to the sea. The River Lempa is the most important river in the country and accounts for 72% of the country's hydraulic resources. It has an international river basin of some 18 000 km^2 rising in Guatemala and flowing through part of Honduras. 10 000 km^2 of the river basin are in El Salvador. (This represents 48% of the national territory). The river has great hydro-electric potential and is being developed for this purpose(4).

3. RAINFALL AND THE HYDROLOGICAL CYCLE

El Salvador has two distinct seasons; wet (May to October) and dry (November to April). The rainfall generally occurs in the form of local short duration high-density electric storms which are more intensive over the higher terrain. The volcanoes and hills in the country therefore have great influence on the hydrological resources of the country. This is particularly so of the volcanoes which, due to the nature of the quaternary volcanic material of which they are formed, allow much of the precipitation to infiltrate below ground (in some favourable areas up to 60% of the total rainfall). This in turn recharges the aquiferous volcanic and alluvial sediments in the country's valleys and plains. This groundwater storage mechanism has the effect of maintaining flows in the rivers throughout the dry season.

The average annual rainfall in El Salvador is high - some 1865 mm, but so are the losses due to evapo-transpiration(5). The annual hydrological balance for the period 1968-1972 is given in Table 1.

TABLE 1: Hydrological balance for the period 1968-1972

	Annual volume $m^3 \times 10^6$	Percentage	
Rainfall	39 488.7	100	
Run off	14 507.7	37	
Evapo-transpiration (real)	24 365.0	62	
Change in storage	616.0	1	(1)

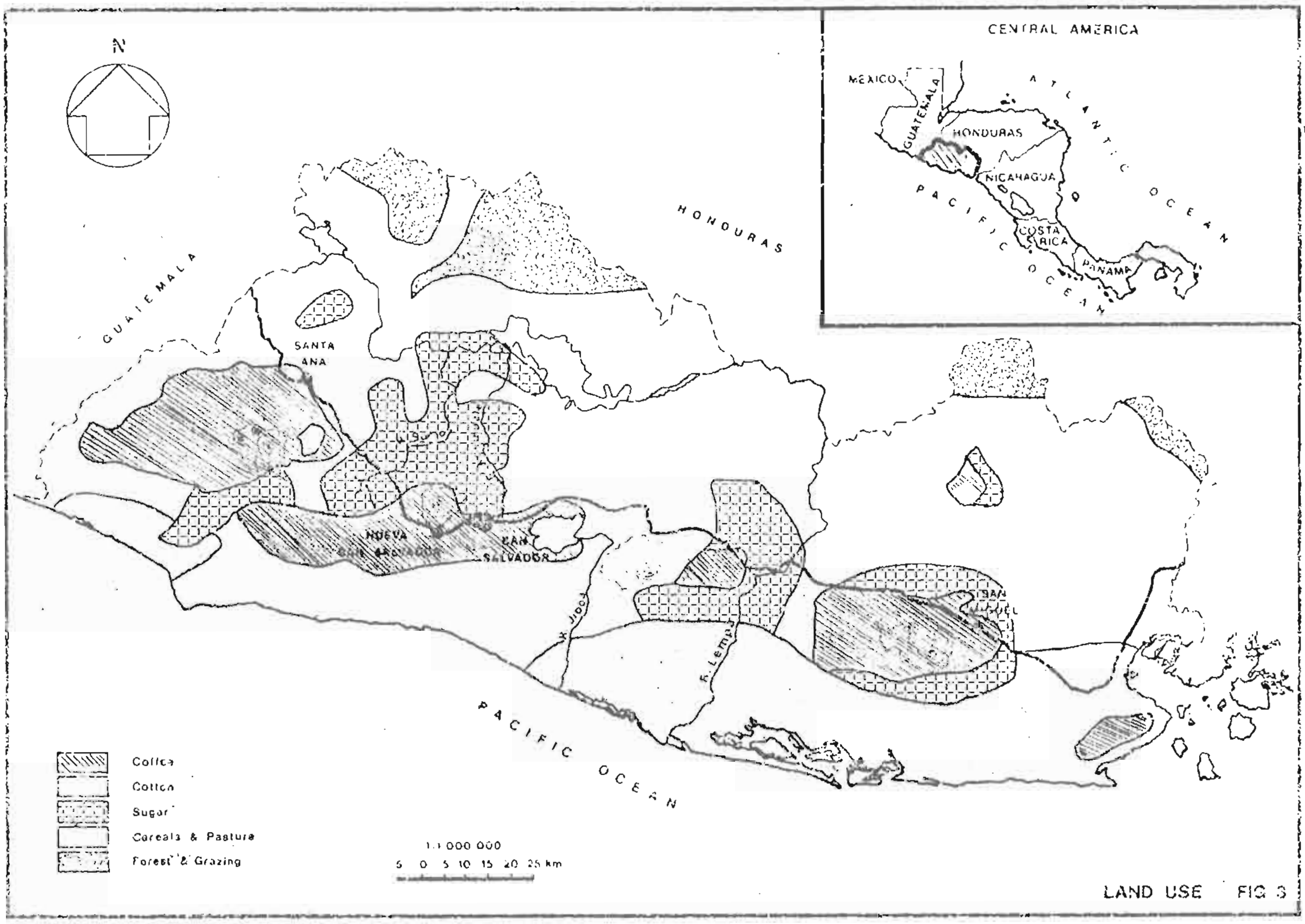
4. POPULATION AND LAND USE

The main centres of population, San Salvador, Santa Ana and San Miguel, were established during Spanish colonial rule, and were trading centres for the production of indigo dye and the cultivation of cocoa beans. These crops are no longer grown, and coffee is now the prime crop on the volcanic slopes near these urban centres. The presence of plentiful water resources obviously has had a considerable influence in the location and growth of these centres. During a slump in world coffee prices some twenty years ago cotton growing was successfully introduced in El Salvador on the coastal plains where it was found that the high ambient temperatures suit the plant. The main cotton growing area is on the coastal plain stretching between the ports of La Libertad and La Union but a smaller cotton growing region also exists on the plain surrounding the port of Acajutla. Sugar is grown in the central plains of the country. Figure 3 shows the present main agricultural divisions of the land and the present land uses are tabulated in Table 2. Sisal growing is mainly confined to the eastern area of the country centred around San Miguel. In addition to these crops which are exported, maize and other crops are grown for internal consumption. Also cattle ranching takes place in a number of small areas and there are a number of intensive chicken and pig production units utilising home grown agricultural foodstuffs.

TABLE 2: Present land uses

Use	Hectares	Total Hectares	Percentage	
Permanent cultivation		163 881	8.19	
Coffee	141 606			
Others	22 275			
Semi-permanent cultivation		33 584	1.68	
Sugar cane	14 885			
Others	18 699			
Annual crops		429 846	21.49	
Cotton	55 860			
Cereals	227 663			
Others	146 323			
Pastures		619 181	30.96	
Natural	514 205			
Seeded	104 976			
Forest		50 000	2.50	
Mountains		189 955	9.50	
Areas without agriculture		513 553	25.68	
	TOTAL	2 000 000	100.00	(3)

FIGURE 3: Land use



El Salvador is a small and crowded country, having a population density of 170 persons per km^2, with a current population growth rate of about 3.5% per annum. It is anticipated that the country's population will reach 7.2 million by the year 2000. There is obviously a great need to develop the agricultural resources of the country as far as possible in order to support this high population density.

The gross national product for 1970 was colon/2500 m (= US$ 1000 m).

TABLE 3: Division of gross national product

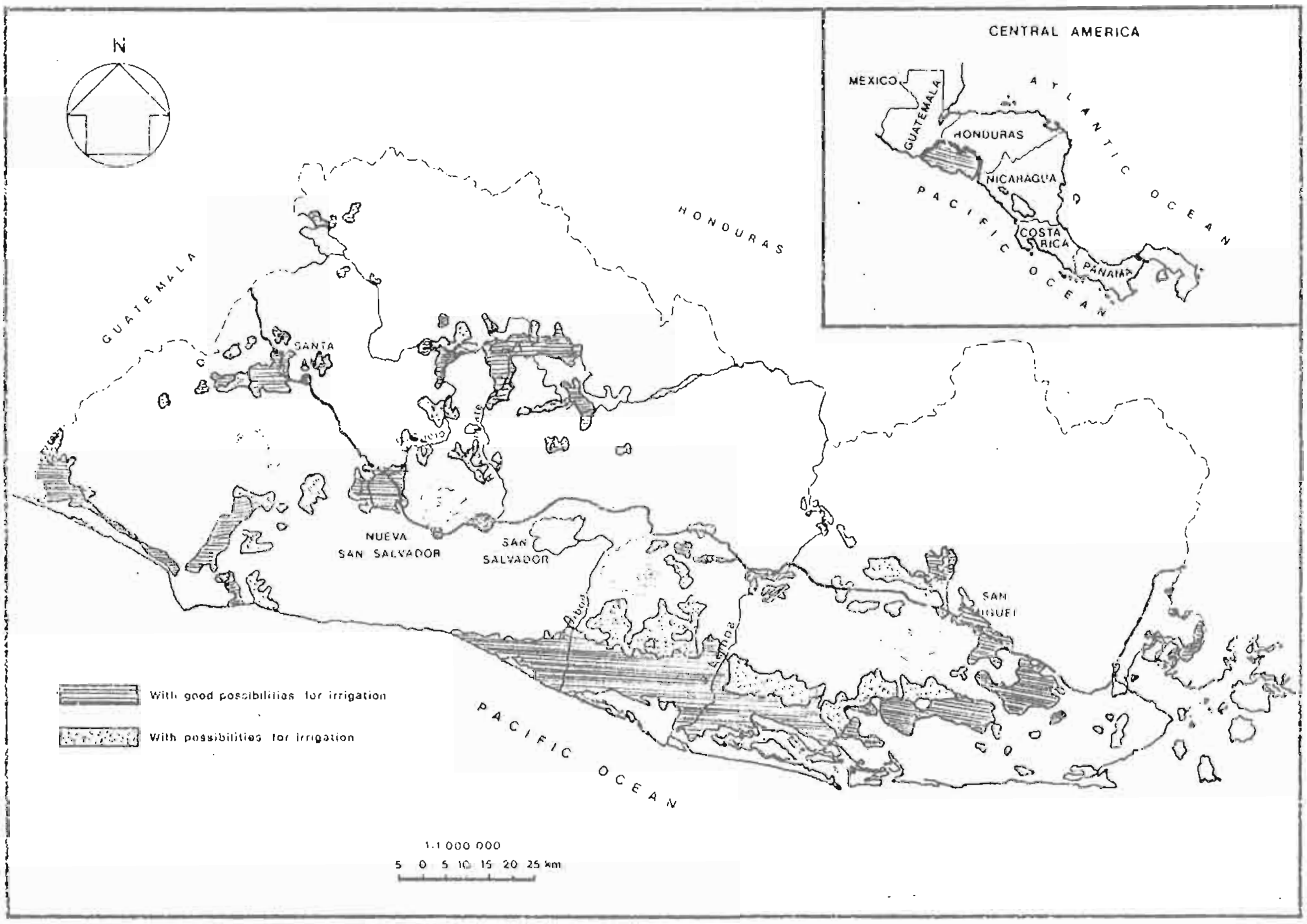
Activity	Percentage
Agriculture	27.2
Commerce	21.8
Industry	19.4
Others	31.6

(6)

These figures indicate the important role which agriculture plays in El Salvador.

It has been estimated by the Ministry of Agriculture that some 327 110 hectares of the terrain in El Salvador would be suitable for intensive cultivation using irrigation. The areas which have been designated as being suitable for irrigation are shown in figure 4. These areas form the main plains of the country. At present only about 23 750 hectares are irrigated (an area in the Zapotitan valley near San Salvador and the San Miguel Plain) so that there is a large potential for agricultural development if the country's water resources can be developed for irrigation purposes(3). Irrigation of land will allow two harvests a year.

FIGURE 4: Land suitable for irrigation

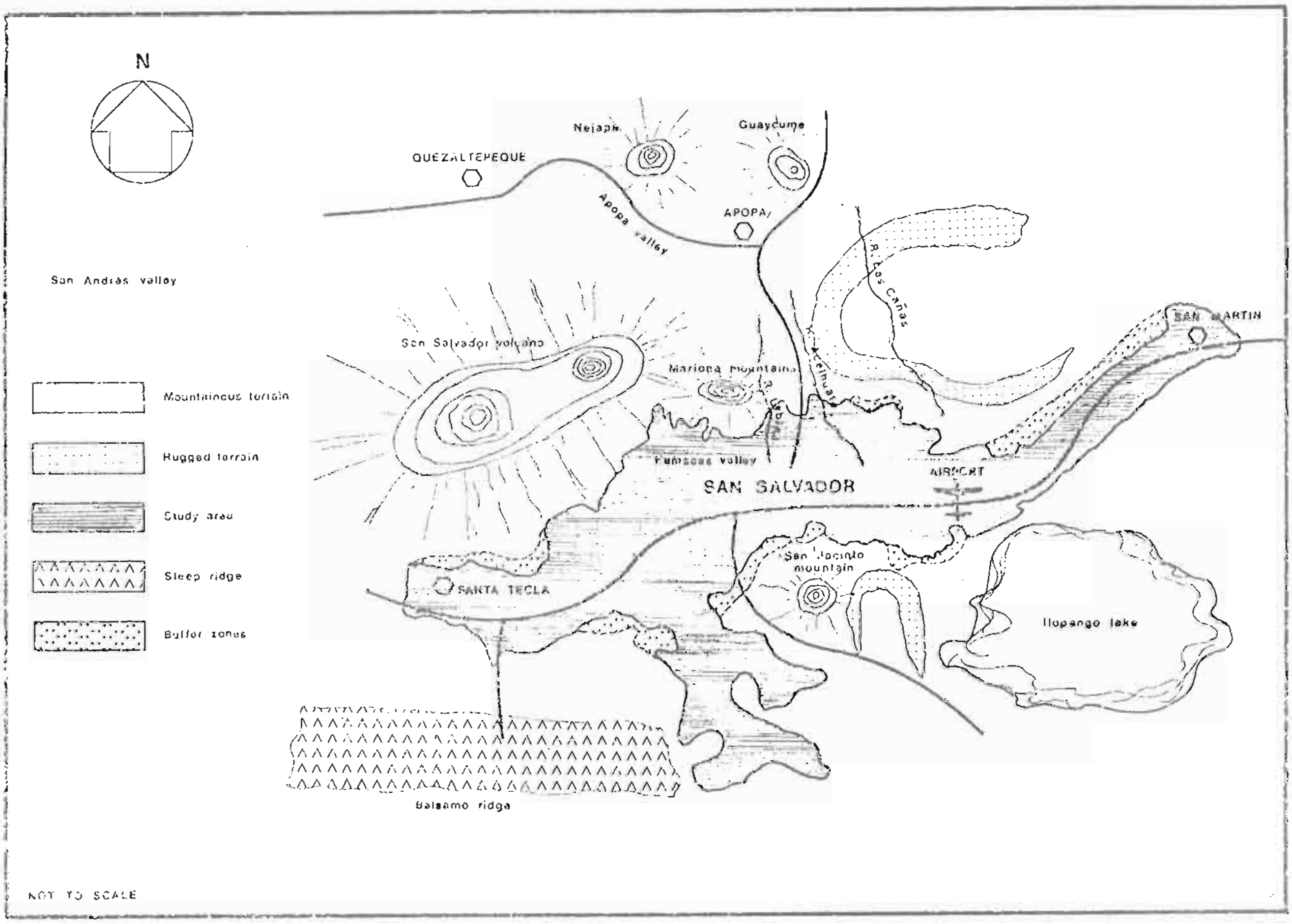


The mineral resources of the country are minimal, and at the present time there are only two small mining operations in existence, one being for silver and one for gold. Cement is also manufactured near Metapan.

5. THE CITY OF SAN SALVADOR

San Salvador lies between 600 metres and 900 metres above sea level and is some 40 km from the coast (see figure 5). It is situated on the eastern slope of the El Boqueron Volcano. There is a volcanic crater lake to the east of the city. The Balsamo range of hills rise immediately to the south of San Salvador and forms a physical barrier between the city and the coast. Immediately to the north of San Salvador a ridge of hills, the Cerros de Mariona, forms the northern limit of the city. To the west of the city there is a narrow gorge some 10 km long. Thus the city has

FIGURE 5: Diagram of natural barriers to urban development



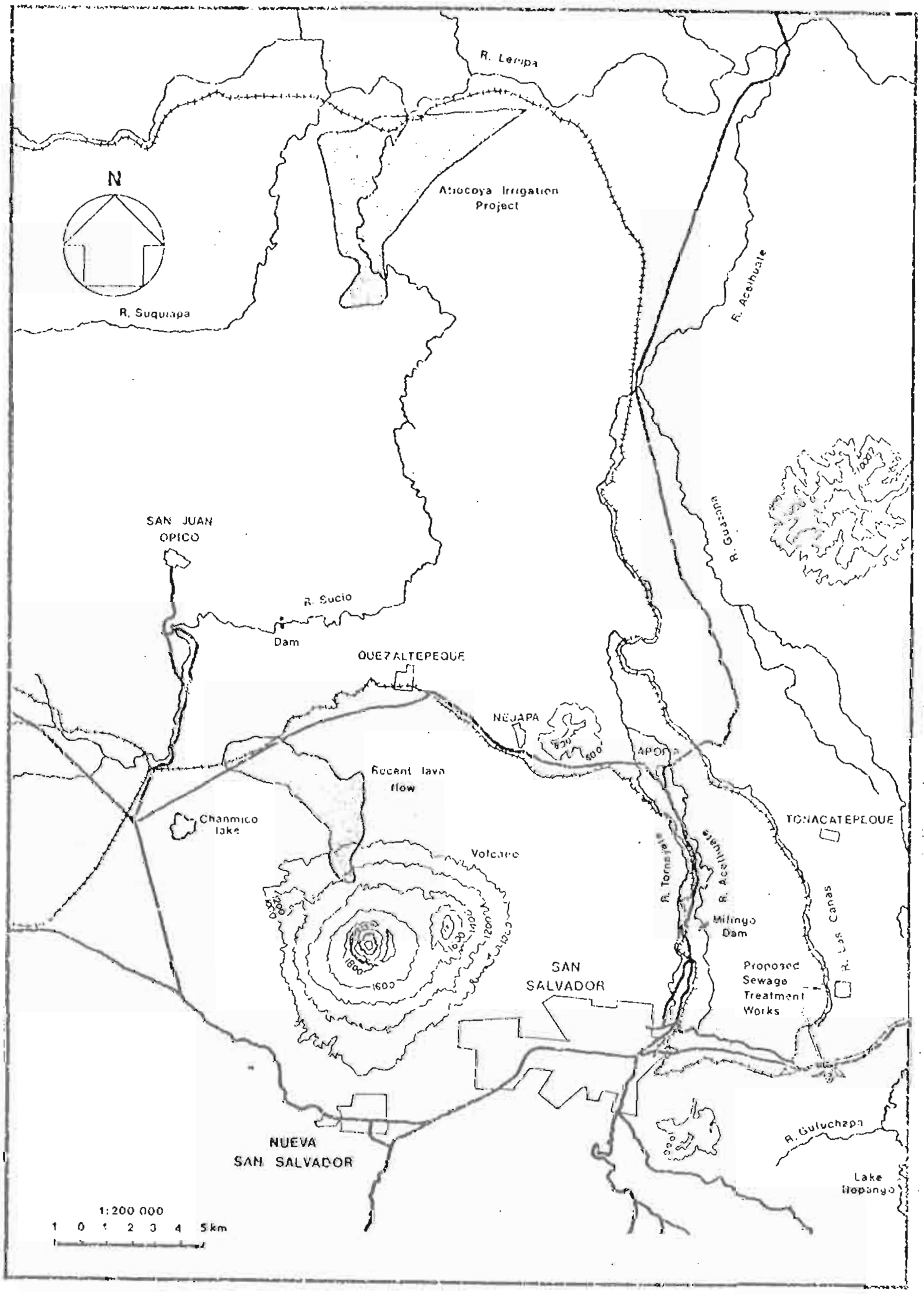
geographical features surrounding it which will constrain its ultimate development. Two river systems, the River Sucio and the River Acelhuate, originate on the west and east sides of the El Boqueron and flow northwards to the River Lempa (see figure 6).

The city lies on the Nicaraguan depression and is in an area of severe seismic activity and earthquakes of greater than force 8 in the Mercalli-Sieberg scale can be expected. Earthquakes of this magnitude have occurred frequently in the past. It was completely destroyed by an earthquake in 1854 and was extensively damaged in the 1917 and 1919 earthquakes. The 1917 earthquake was accompanied by a major eruption of lava from El Boqueron volcano but fortunately the lava flows were emitted down the north-west slope of the volcano on the opposite side to the city. Faulting is predominantly in an east-west direction parallel to the direction of the "graben". A secondary direction of faulting is north-north-west - south-south-east, being roughly in the direction of the northward flowing rivers. The valley of the River Las Canas to the east of the city is aligned along one of these faults.

The climate in the region of San Salvador can be described as salubrious although the seasonal rains from May to September may induce very humid conditions. Figure 7 shows the meteorological data from the San Salvador Meteorological Station.

Most of the rainfall in San Salvador (approximately 70%) occurs between 18.00 and 0.600 hours in the form of short squalls which appear to be influenced by local breezes. The mass of the San Salvador volcano has a

FIGURE 6: River Sucio and River Acelhuate

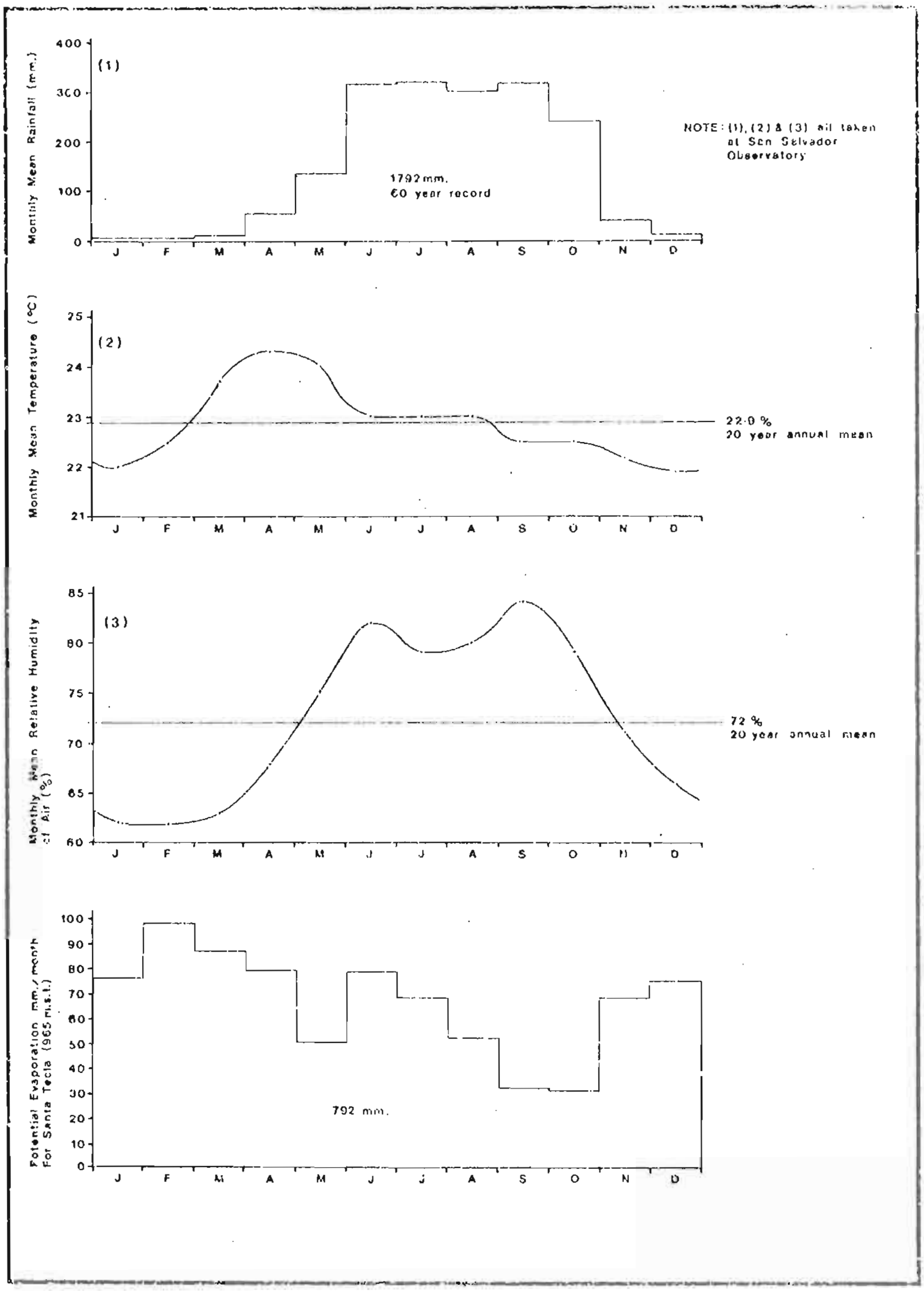


marked effect on the local climatic conditions and is the major factor in determining the magnitude of precipitation to the head of the Rivers Sucio and Acelhuate. These river basins were studied in detail during the UNDP investigation and Table 4 shows the flows for these rivers averaged over the four years. (Records were taken 1967-1971). The measurements were made at El Jocote on the Sucio and at the confluence with the Lempa on the Acelhuate.

TABLE 4: Mean monthly flows in m^3/sec.

River	Maximum (September)	Minimum (March)	Mean
River Sucio at El Jocote (Catchment area 724 km^2)	23.34	4.96	11.02
River Acelhuate at Guayapa (Catchment area 713 km^2)	27.53	4.10	11.26

FIGURE 7: Meteorological data: San Salvador



It should be mentioned that the flows given in Table 4 for the River Acelhuate include sewage flows from the city estimated at 1.3 m^3/sec. In the upper reaches of the river within the city limits, the river flow can be considered as undiluted sewage as natural water flows are virtually non-existent.

At present the city obtains its industrial and domestic water supplies from an aquifer underneath the city. The aquifer extends over 126 km^2 and is located on the south-east slopes of the San Salvador volcano. The surface slope of volcanic ash, tuffs and lava which form the aquifer material varies from 1 in 3 at 1500 m above sea level to 1 in 25 at 600 m. The isofreatic levels vary across the city from about 150 m depth at 900 m contour level to emerge as springs at the Acelhuate River around 600 m. Extensive logging of existing boreholes in San Salvador has established a decrease in ground-water levels of something like 1 m a year. Allowing for some future building development and consequent reduction in the recharge area available, it has been estimated that the reliable yield of the aquifer is 1.3 m^3/sec but the present abstraction rate is nearer 2 m^3/sec.

6. FUTURE WATER DEMANDS

A department of the Ministry of Public Works, Dirección General de Urbanismo y Arquitectura, are responsible for planning within the city. This department recognised the geographical constraints and have produced a planning map with population densities at saturation level when the whole of the area which can be built on has been developed. These are reproduced in Table 5 and show a population density at saturation of 1 830 000.

TABLE 5: City area - land use and population densities at saturation

Land use	Area (ha)	Population density (persons/ha)	Population
Low density housing	1726.63	125	215 829
Medium density housing	2370.45	250	592 613
High/medium density housing	1141.08	375	427 905
High density housing	278.08	500	139 040
*I.V.U. housing	519.88	375	194 955
Institutional	567.89	100	56 789
Institutional	308.81	NA but allow:	2000
Institutional	36.91	nil	nil
Industry	914.13	nil	nil
Light industry	353.41	50	17 670
Possible development zone	2245.01	50	112 250
Commercial	280.98	50	14 049
Commercial	138.43	nil	nil
"Buffer zone"	1076.97	50	53 849
Green zone	203.42	nil	nil
TOTALS:	12 162.08		1 826 949

* Instituto de Vivienda Urbana (Government Department responsible for low-cost housing).

The anticipated population densities for the various zones given in the above Table are very high by American standards. However El Salvador is a densely populated country and standards of housing tend to be lower than in a developed country. The forecast of population for the study area in the city is given in Table 6.

TABLE 6: Population forecast for study area

Year	Population
1975	700 000
1980	900 000
1985	1 100 000
1990	1 450 000
1995	1 700 000
Saturation	1 830 000

Table 7 shows typical population densities for other countries for comparison.

TABLE 7: Typical population densities

Country	Area (km^2)	Present population (m)	Density (p.p. km^2)	City	Density of city (pp.Ha)
Guatemala	108 889	5.2	48	Guatemala	80
Dominican Republic	48 734	4.0	82	Santo Domingo	96*
Costa Rica	50 900	1.8	35	San Jose	25
El Salvador	21 350	3.6	170	San Salvador	47

*Forecast for 1975

Metering carried out on all sources during the study indicated that the gross mean production rate was about 2 m^3/sec. This represents a gross consumption (including waste) of some 300 litres per person per day based on a population of 570 000. In the report prepared by Black and Veatch Consulting Engineers in 1967 they arrived at a gross consumption of 267 litres per person per day based on an estimated population of 480 000. These estimates were made on metred water consumption in periods when there was no short-fall of water in the metropolitan area of San Salvador and can therefore be considered reasonably realistic. For comparison water production statistics for other countries in Latin America and the West Indies are given in Table 8.

The Black and Veatch Report suggested that the unaccounted for water amounted to something like 39% of the water produced. During this later study efforts were made to corroborate this figure by leak detection methods but the results were inconclusive, though a figure of around 30% was considered the right order.

From the figures of unit production given in Table 8 it appears that the gross demand is increasing by some 5 litres per head per day every year. It was assumed during the study that some improvement in the wastage will be achieved and the following unit water production figures were taken as shown in Table 9.

TABLE 8: Water production characteristics in 1969

Country	City	Water production l/p/d	Population	GNP/person US$	Average revenue m^3/US$	Percentage unaccountable water
Brazil	Sao Paula	310	5 900 000	250	0.05	36
Colombia	Bogota	315	2 520 000	310	0.07	25
Colombia	Cali	295	920 000	310	0.04	22
Colombia	Palmira	295	140 000	310	0.02	30
Jamaica	Kingston	235	600 000	460	0.08	23
Nicaragua	Managua	250	340 000	360	0.09	18
Venezuela	Caracas	280	2 000 000	950	0.13	32

TABLE 9: Future water production (litres/person/day)

Year	Production
1972	300
1975	282*
1980	310
1985	337
1990	365
1995	392

*Assumed some improvement in wastage figure

The design water production figures necessary to meet the future water demands for the City of San Salvador are shown below.

TABLE 10: Projected mean water production (m^3/sec.)

1975	2.3
1980	3.2
1985	4.3
1990	6.1
1995	7.7
Saturation	10.0

7. SOURCES IDENTIFIED

Figure 8 shows the locations of sources which were identified during the study to meet the water demand for the City of San Salvador up to the year 1995. The staging of the development of these sources is shown in Figure 9. A short description of each source follows.

FIGURE 8: Location of water sources for the city of San Salvador

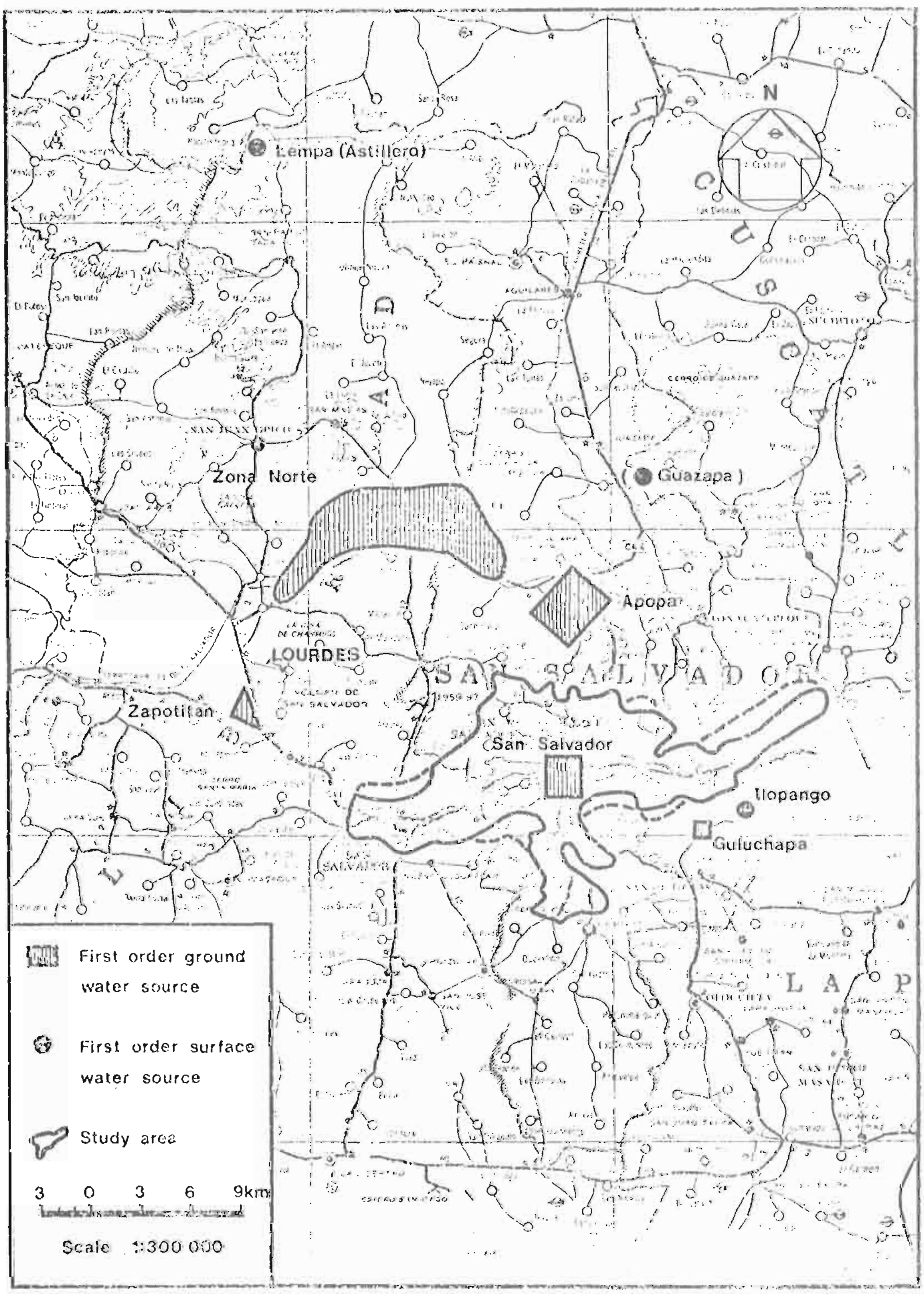
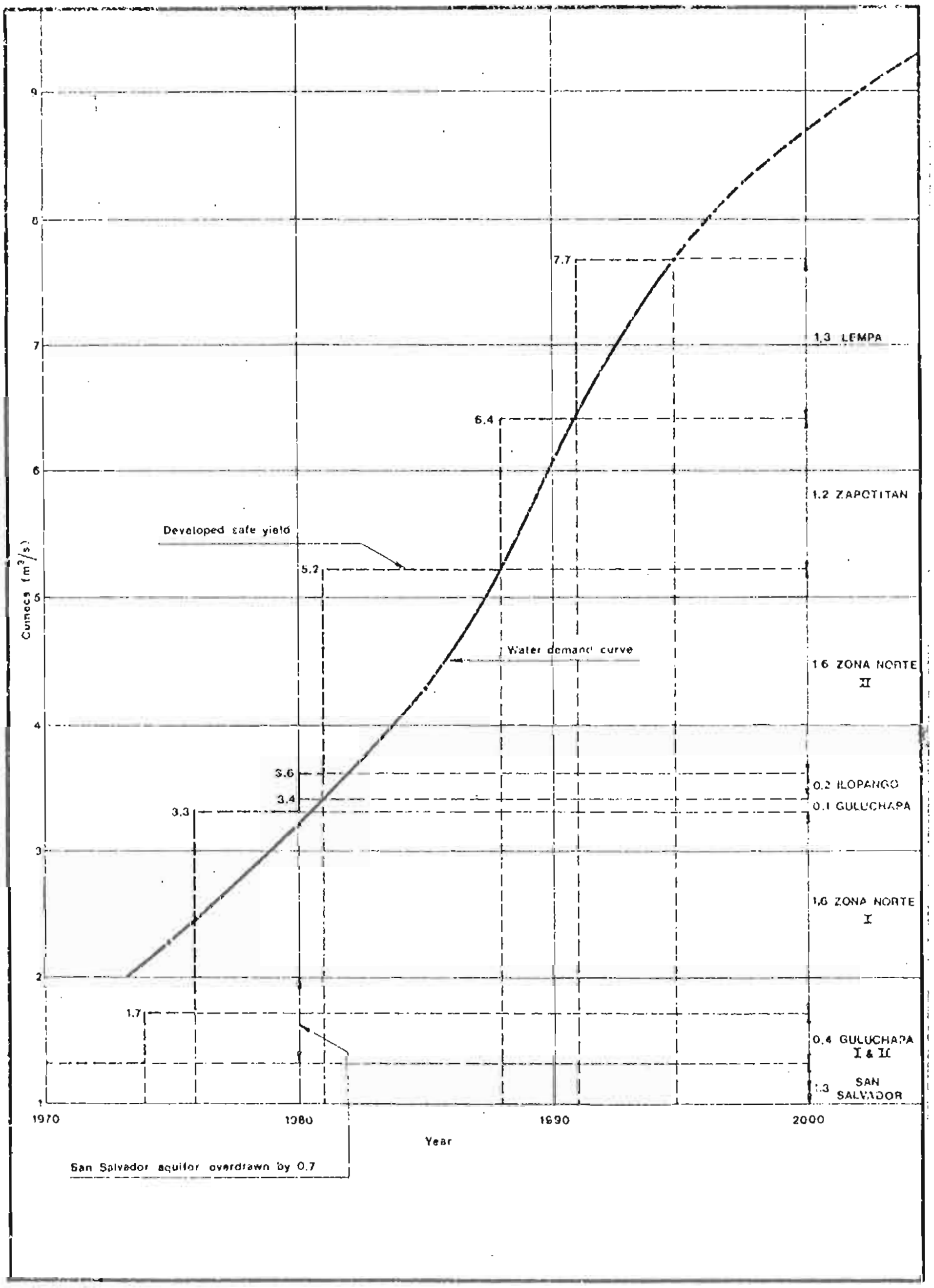


FIGURE 9: Phasing of proposed water supply schemes



Guluchapa has a catchment area of 38 km^2 and is a sub-basin of Lake Ilopango. The basin is formed of re-deposited materials, principally sands, tuffs and clays and generally exhibits good hydrological properties. The water table at the valley floor of this basin is at ground level and there is every possibility that when the valley is developed by borewells and the table lowered, further recharge water will enter.

Zona Norte Groundwater. The area lies to the north and north-west of the San Salvador volcano and the following possible sources were identified by the UNDP project team which they estimated could provide 3.2 m^3/sec for the city of San Salvador. These are summarised in Table 11.

TABLE 11: Zone Norte potential sources

Locations	Springs m^3/sec	Wells m^3/sec	Total m^3/sec
Recent lava flows in Quezaltepeque and Sitio del Nino	1.10	1.20	2.30
El Angel, Los Luceros, Nejapa	0.45	0.25	0.70
La Junta, north of Apopa	-	0.20	0.20
TOTAL			3.20

The UNDP report states that these estimates are conservative and their recommendations were accepted and work commenced early in 1973 on the detailed design of works for the Zona Norte Stage I scheme which will provide 1.6 m^3/sec for the City of San Salvador.

Zapotitan groundwater. The Zapotitan groundwater basin is part of a large flat fertile plain in the headwaters of the River Sucio to the west of the San Salvador volcano. This basin is extensively used for agriculture. The mean annual basin yield as assessed by the UNDP team is estimated at 4.3 m^3/sec. The Zapotitan basin is largely made up of pyroclastic deposits much of which are secondarily deposited by the rivers and have very variable distribution creating within a short distance aquifers, aquitards and aquicludes. The central portion of the valley has low transmissibility values. However, the UNDP team did identify an area in the south-east corner of the basin where good transmissibility values were obtained and they recommended that this should be developed for the City of San Salvador with an average annual yield of 1.2 m^3/sec.

Lake Ilopango. Lake Ilopango is a collapsed volcano crater lake of 72 km^2 in area and is only 10 km from San Salvador. In places it is 240 m deep and has a total catchment to the lake outlet of 200 km^2. The large available storage per unit depth so close to the city makes the lake a very attractive potential source. However the presence of 10 mg/l of boron salts (measured as boron) in the lake water means that the water is toxic to certain plants and is not very suitable as a source for the City except in admix with other water. It is suggested that when the Guluchapa source has been developed to its full potential of 0.5 m^3/sec that 0.2 m^3/sec should be extracted from Lake Ilopango and mixed with groundwater from Guluchapa.

River Lempa. The River Lempa is located 50 km north of San Salvador at its nearest point to the city. The Rivers Acelhuate, Sucio and Suquiapa all drain high polluting loads into the Lempa so that abstraction from the river for water supply should take place upstream of the highest polluted tributary, namely the Suquiapa. Initial estimates of the reliable run of river yield at Astillero upstream of the Suquiapa suggest a figure 10 m^3/sec so that in the long term the water supplies for the City of San Salvador are reasonably assured (see figure 8).

7. CONFLICT OF WATER DEMAND

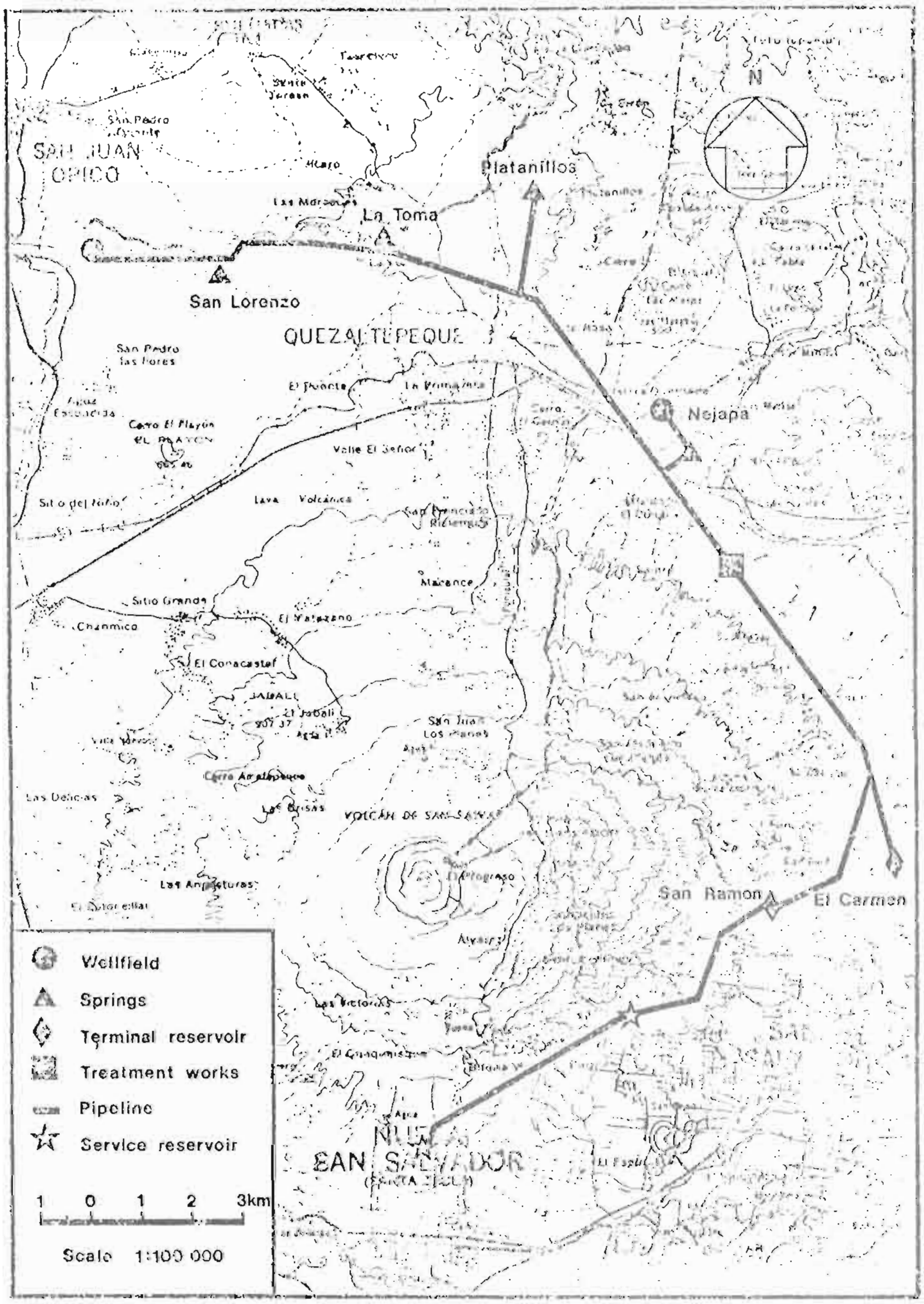
When considering new water sources for a city it is inevitable that the requirements of the city will conflict with other present and future uses. The United Nations project team report adopted the theme that the water supplies for the City of San Salvador should have priority over other considerations. This philosophy would seem logical in the light of the current rapid increase in the population of the city (4.6% per annum). The rate of growth of the city is very much greater than that of the country as a whole (3.5%) due to migration of rural population. This migration is creating an ever increasing problem for the city authorities and is being tackled by a rapidly expanding programme of low-cost housing. Also the World Bank is financing schemes to provide sites with services so that self-build schemes can be implemented. Obviously it would be a better solution if alternative foci of urban development could be established, but at present all the new industrial development in the country is centred at San Salvador. It will need strong government action/interference to reverse the present trends.

The first major scheme to be implemented will be the Zona Norte Water Supply Scheme which will supply an extra 138 million litres/day to the city. This scheme has now been designed and construction is about to commence, financed by Inter-American Development Bank funds. The scheme is shown diagrammatically on Figure 10 and involves the pumping of spring and borehole supplies into a common trunk main varying in size from 450 mm to 1200 mm diameter discharging to a water treatment plant. After treatment water is raised to the city by means of a high lift pumping station via a 1200 mm diameter steel main 15 km long against a head of some 300 mm. This station delivers to two separate control reservoirs. Distribution works in the city will include the construction of two major re-lift pumping stations, 40 km of ductile iron water mains varying from 1200 mm to 300 mm diameter and eleven service reservoirs varying in capacity from 20 000 to 4000 m^3.

In the River Sucio basin there are many conflicting requirements for water which will suffer when the Zona Norte Scheme is constructed. The Ministry of Agriculture are implementing a scheme to abstract irrigation water from the Rivers Sucio and Suquiapa to irrigate an area of some 4200 hectares in the Atiocoya region near the confluence of the Sucio and the River Lempa. During the most critical months this irrigation project will require irrigation water at the rate of 2.9 m^3/sec and it is proposed to extract 2.0 m^3/sec from the River Sucio and the balance of 0.9 m^3/sec from the Suquiapa. The minimum stream flows in the River Sucio once both stages of the Zona Norte Scheme have been implemented wil be very low and this scheme will not be feasible, and no special allowance was made to ensure a minimum flow in the River Sucio as it is considered a logical step to reserve the better quality water sources near to San Salvador to satisfy the future water demands of the city. The irrigation scheme could anyway be served directly from the River Lempa. It should be noted that one of the conclusions reached in the Sewerage and Sewage Treatment section of our study was that all sewage flows from the city should be transferred to the valley of the River Las Canas so that the Zona Norte water will not be returned to the River Sucio if this proposal is implemented. Figure 6 also shows the location of a small hydro-electric station on the Sucio (2500 kw, owned and operated by Caess). Its use will have to be discontinued when the Zona Norte Scheme is implemented.

The spring source at San Lorenzo has a small dam and diversion channel to take water over the River Sucio to a sugar-growing area. This irrigation facility will be lost to the local land owner when the Zona Norte Scheme is implemented.

FIGURE 10: Zona Norte supply scheme



At La Toma the spring water has been dammed to form a large swimming pool (1500 m^3). The area surrounding the swimming pool is at present being developed as a major tourist attraction by the Ministry of Tourism without recognising the fact that the considerable flows of spring water through the pool will be diminished when the supplies are requisitioned for the city and inevitably the water quality in the pool will suffer. It was felt that the risk would be too great to collect water downstream from the pool and the proposal is for capture works upstream with a provision of a small pump flow to the pool (50 l/sec). Proposals for providing a filtration plant for a pool of this size would obviously be very expensive.

Spring waters in the Apopa/Nejapa areas are used for power generation and cooling at sugar cane processing plants and for village clothes washing and these facilities will be lost when the Zona Norte Scheme is implemented.

The Guluchapa valley scheme which is being developed by ANDA at present will deplete flows in the Guluchapa River which is currently being used to irrigate vegetable crops.

When the Zapotitan source is developed this will have an inhibiting effect on the Ministry of Agriculture's long term plans for the development of irrigation schemes. The proximity of the valley to the metropolitan area and good possibilities of irrigation of the fertile soil have led to its development to supply agricultural produce, mainly root vegetables, corn and sugar cane. An area of 7000 hectares has been quoted in a report by the Ministry of Agriculture as being suitable for irrigation and a project is currently being developed to irrigate 4000 hectares[7]. The irrigation demand for the 4000 hectares at present under development has been assessed as follows: surface water demand - 1.8 m^3/sec; maximum groundwater demand - 1.0 m^3/sec. Of this up to 45% would be non-consumptive use and the excess would drain back to the River Sucio. There are plans for a new town to be developed at Lourdes (see figure 6) in the Zapotitan basin which ultimately will accommodate a population of some 180 000 and the utilisation of the mean annual yield of the basin could be as shown below but future irrigation projects would have to be curtailed unless treated sewage effluent from Lourdes new town were used.

TABLE 12: Proposed utilisation of mean annual yield in Zapotitan Basin

Irrigation of 4000 hectares	2.1 m^3/sec
Future water requirement Lourdes New Town	1.0 m^3/sec
Available for San Salvador	1.2 m^3/sec
Total	4.3 m^3/sec

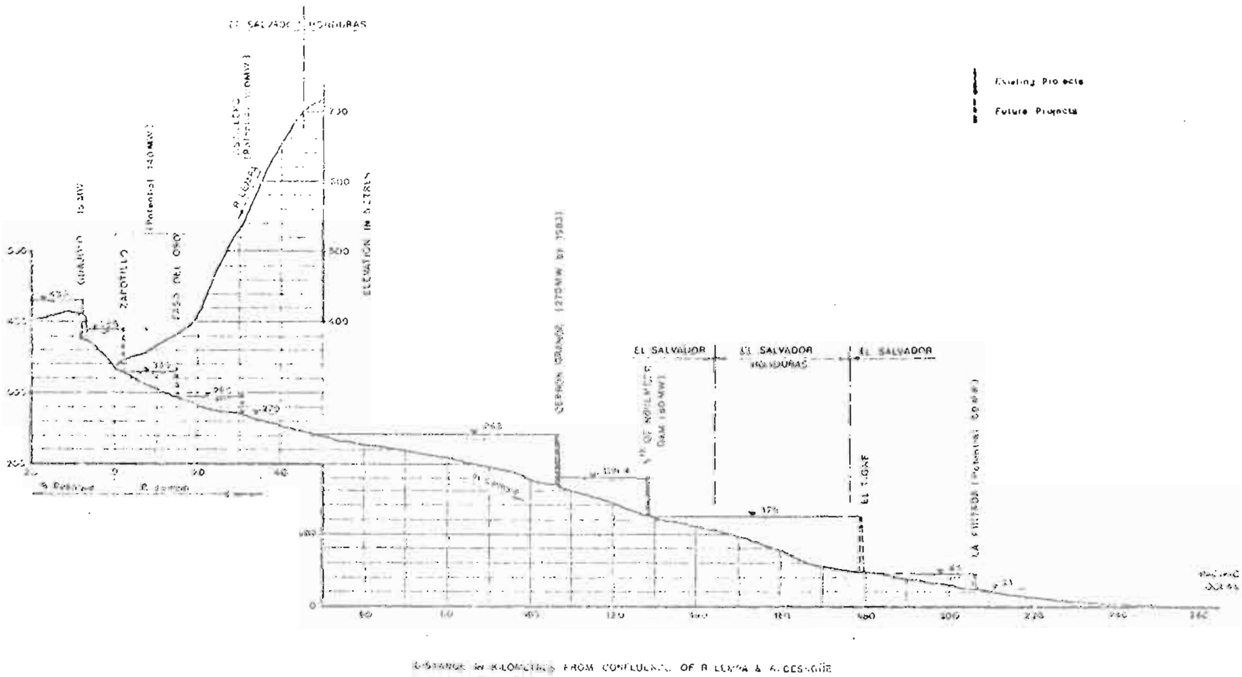
9. NEED FOR CONTROL OF WATER RESOURCES IN EL SALVADOR

The Government of El Salvador have been active in a policy of trying to provide job opportunities in San Salvador and have attracted many light industrial concerns to the city. The conditions are made particularly favourable for industrial investment in the city due to tax concessions and cheap and good labour resources. Industrialists have also been allowed to develop their own borewell water sources within the San Salvador aquifer without any control on abstraction. This has contributed to the over drawing taking place in the aquifer and has led to some of the existing wells supplying the city drying up at certain times of the year.

Again there has been no control on industrial discharges to sewers or watercourses and there are very great pollution problems in the country. For instance five-day BOD values as high as 400 ppm were obtained for river water samples taken from the River Suquiapa during December when coffee cherries are being processed to extract the coffee beans. Generally, coffee, sugar and sisal processing plants are sited adjacent to rivers and water is used and water is polluted indiscriminately without any effective control.

The River Lempa is the country's most important river and has already been developed at three sites for hydro-electric power generation[3], (see figure 11). The river passes through fertile valleys which could be irrigated but at the price of reducing flows available for power generation. This river has a portion of its catchment in Honduras so that flows available to El Salvador now cannot be guaranteed in perpetuity.

FIGURE 11: Development of hydro-electric power on River Lempa



An additional problem for the water resources of the country is the rate at which de-afforestation has taken place and due to the nature of the volcanic ash the natural terrain erodes creating even greater silt loads in rivers and producing infertile conditions on hillsides.

The need for control of the country's water resources was recognised in the United Nations project's report and reiterated in the Wallace Evans and Partners study[8] in which a National Council of Water Resources is suggested. The main task will be to establish a legal framework to allow such a council to be effective in deciding priorities for water use and control of pollution.

The above sounds very like the arguments used to bring about the Water Reorganisation in the U.K. One justification for this reorganisation was that the estimated consumption of 14.1 x 10^6 m^3 of water a day in England and Wales will increase to $2\frac{3}{4}$ x 10^6 m^3 of water a day[9]. These estimates assumed an increasing population and continued growth of industrial consumption. Already it looks as though our population is stabilising and in the last few years the growth in industry has not lived up to expectations due to the economic climate.

In the City of San Salvador the dangers of predicting future demands are far greater. One of the main causes of high per capita water consumption in the dry season is garden watering. It is arguable that as the city develops land which at present has properties with large gardens will be redeveloped to a higher housing density and the per capita water consumption could decrease. Also it is difficult to believe that the extremely rapid rate of expansion of the city will be maintained. Already a "low key" birth control programme is being implemented and a change in Government policy could well divert future industrial development to an alternative area. It is therefore likely that the development programme outlined in figure 9 will be considerably stretched. Leak detection is difficult in San Salvador as leaks do not show on the surface due to the porous nature of the subsoil. Due to low pressures in water mains domestic properties tend to have low level water storage tanks which fill over 24 hours so that night detection methods would not give a true picture. However, as new mains are laid and the distribution system improved waste should be reduced which again could affect the timing of implementation of future schemes.

The development of water schemes is also influenced by the cost of borrowing money. The Zona Norte Scheme is to be financed by a "soft" loan from the IADB and there may be some justification in buying as much water (and time) as the opportunity arises.

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