Border Demographic Impacts on The Urban Environment and Sustainable Development of Imperial County, California, and Mexicali Municipio, Mexico

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Chapter 1

Introduction

1. Introduction

This project has as its goal to analyze recent population, economic, energy, and water trends for Imperial County, California, and Mexicali, Baja California, in order to estimate future population and economic growth and assess the implications of this growth on the supply of energy and water to these areas as well as to the broader region demanding it. This is particularly important since Imperial County and Mexicali have experienced rapid population growth in recent years. The even more rapidly growing coastal regions adjoining Imperial County and Mexicali, namely San Diego and Tijuana, are increasingly demanding part of their eastern neighbors' water and energy resources. There is a particular focus on the Imperial County economic sectors and how they are affected by the rapid growth of the city of Mexicali.

The research methods include demographic techniques and economic trend analysis, spatial techniques using geographic information systems (GIS), and environmental trend analysis. Recent events have been influential in answering this research problem, including the proposal by the Imperial Irrigation District in 2002 to divert water from agricultural to extra-county urban uses, the demands of other states that California adhere to its Colorado River water allotment, the California energy "crisis" and its aftermath, and entrepreneurial energy developers in Mexicali. A number of these events had not yet occurred, or were in early stages, when the proposal was submitted in the fall of 2000, so the research plan has had to be somewhat modified from its original form.

This research builds on a number of research projects conducted by the principal investigator and members of the research group at University of Redlands and University of Ca.ifornia Riverside over the past ten years. Major projects by the group during this period were study of the demographic and economic information for Mexico (Pick and Butler, 1982), analysis of the socio-demographic growth and spatial patterns for Mexico City (Pick and Butler, 1997), study of the Mexico and the world economy (Butler, Pick, and Hettrick, 2001), and research on commonality in the U.S.-Mexico border sister cities (Pick et al., 2000c). All this research utilized extensive Mexican and United States governmental data. The group has especially collaborated with the Mexican national statistical agency, INEGI (Instituto Nacional de Estadísticas, Geografía, y Informática) and is indebted to the support and cooperation of that agency. The current research team listed on the cover page includes past and present faculty and graduate students of the School of Business of University of Redlands.

Other research groups have also investigated the border population and environment, and our research work builds on theirs. Among the major research efforts that have contributed a base to the present research are studies at El Colegio de la Frontera Norte (COLEF), the Instituto de Investigaciones Sociales of the Universidad Autónoma de Baja California (UABC), and Southwest Center for Environmental Research and Policy (SCERP), Institute for Regional Studies of the Californias, and the conferences and journal of the Association for Borderlands Studies (ABS). There are other sources of research as well that are too numerous to mention. These groups have identified the U.S.-Mexico border as a region of rapid growth and change, for which more knowledge and planning is necessary.

The research original research questions of this project were the following (Cuerec Proposal, October 13, 2000), with additions stated in parentheses:

1. *What is the extent of population growth in Imperial County and its cities (and of Mexicali Municipio), and what will be the projected population growth and its spatial array in the county?*

2. *Why hasn't the Imperial County system of cities, adjacent to the border, developed in base size to the extent of other U.S. border cities, such as San Diego and El Paso?*

3. *Do indicators and trends present in the late 1990s and 2000 point to a substantially larger urban complex in Imperial County (and Mexicali Municipio)?*

4. *What county industry sectors have benefited by the influence of Mexicali and the border, and how have they benefited?*

5. *How are those border-influenced sectors arranged spatially in the county, and what factors are influencing their future spatial pattern?*

6. *What are the effects on the urban structure of Imperial County (and Mexicali Municipio) from the NAFTA-driven growth in cross-border trucking and transport?*

7. *What are the potential environmental impacts of the border-influenced economic sectors on the environment of Imperial County (and Mexicali Municipio)? In particular, of*

major analytical interest here are the effects of population and economic growth in Imperial County and Mexicali on availability of water supply to Imperial County (and Mexicali Municipio)? What are the spatial proximities of future population and economic growth and water supply locations?

8. *What are the effects of population and economic growth on the availability of energy supply to Imperial County (Mexicali Municipio, Tijuana Municipio, and San Diego)? What is the spatial distribution of energy supply for Imperial County and its population centers (Mexicali Municipio, Tijuana Municipio, and San Diego), based on the southern California-Mexico energy grid?*

All of the original questions concerning Imperial County have been addressed in the research. Because of intervening events in the past year and a half and our recognition of long-term trends that have impacted this project, we have expanded the research questions 1, 3, 6, and 7 to also pertain to the Mexicali Municipio. In many cases, the two sides of the border are influencing or complementing each other, so it makes sense conceptually to include Mexicali as well as Imperial County. We acknowledged in the original proposal that we would need to include Mexicali. "[Mexicali] is influential to Imperial County's population i.e. through immigration; to its economy; and to its environment, since many systems including water and energy are interconnected" (Cuerec Proposal, October 13, 2000).

Also, we have broadened research questions 7 and 8 to include the demand in the energy-hungry and water-hungry urban regions of Tijuana and coastal southern California, especially San Diego. In fact, one conclusion of this project will be that the rapid growth and concomitant demands of these large coastal urban regions is the driver that puts especially large pressure on the water and energy supply systems of Imperial County and Mexicali.

The data from this project were drawn mostly from the U.S. and Mexican censuses, especially those of 2000. Those data are made available every ten years from the U.S. Census and from INEGI. Both the U.S. and Mexican censuses of 2000, are still, two years later, in the process of publishing the 2000 data. For instance, most of the U.S. Census small area (block group) data will not be available until fall of 2002, and cannot be utilized as was planned. The reason for this delay had to do with court challenges to the U.S. Census, which has mandated review of alternative procedures causing delays of up to a year. INEGI already has published nearly all of the data at the state, county and locality levels, which this project made extensive use of (INEGI, 2001). However, INEGI's small area (AGEB) data were only made available in April of 2002, which was 14 months later than expected. With two months remaining for the grant, we were not able to utilize those small area data. INEGI was delayed by about 8 months in its production of the AGEB data.

There were a variety of other sources of data, including those from:

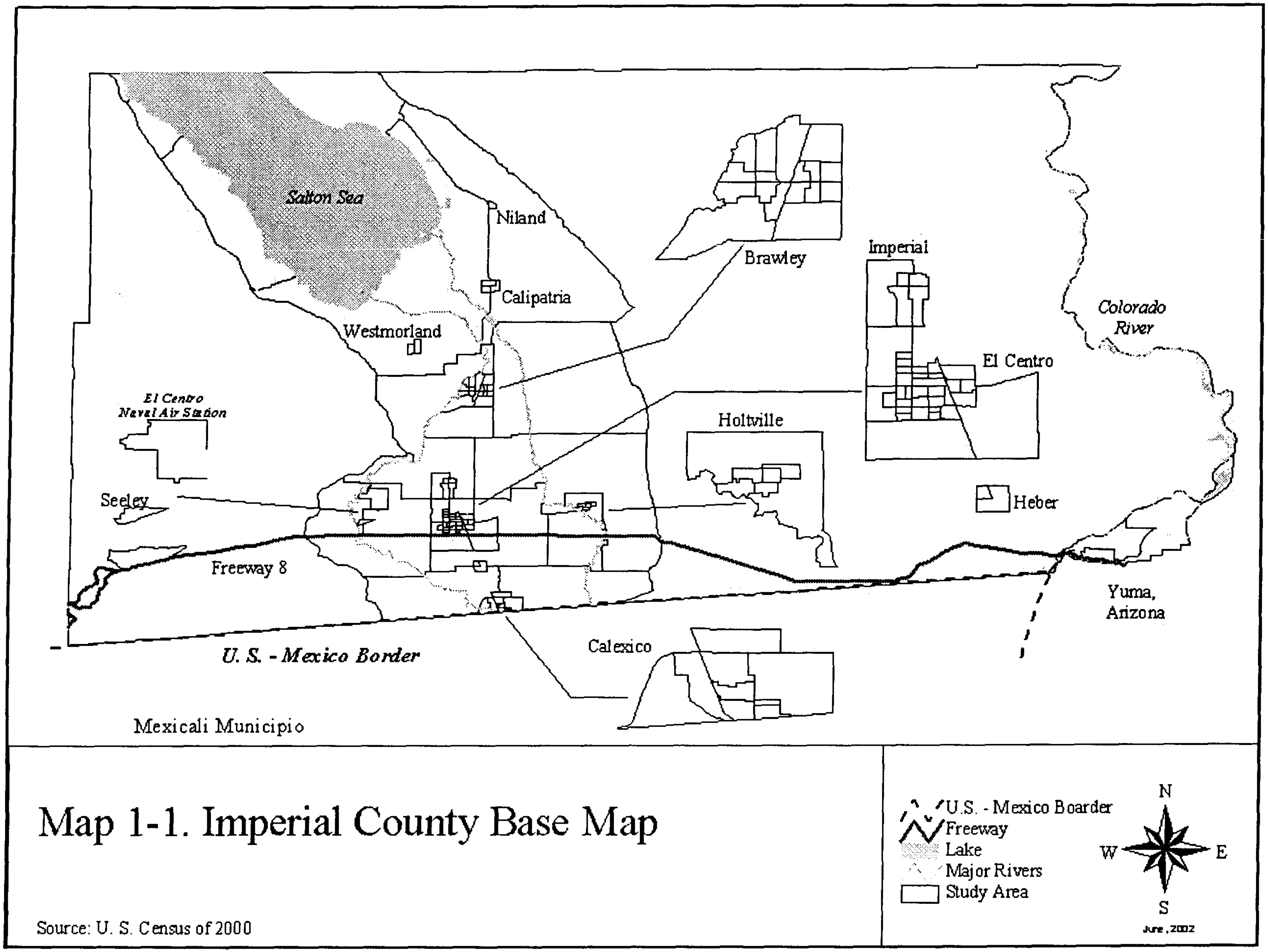
- *Comisión Federal de Electricidad (CFE)*
- *Comisión Reguladora de Energía (CRE)*
- *United Status Energy Information Administration*
- *San Diego Dialogue, a nonprofit in San Diego*
- *State of California Department of Finance*
- *Southern California Association of Governments (SCAG)*
- *San Diego Association of Governments (SANDAG)*
- *Imperial Irrigation District (IID)*
- *Bureau of Land Management*
- *Interviews with government and private sector energy experts*
- *CACI Inc. (now the business GIS division of ESRI Inc.)*
- *County of Imperial and Imperial County's planning departments*

All these are considered sufficiently accurate for this project. We have cross-checked and error-checked the data as much as possible. In a project as broad as this one, there were some data gaps. Although we met with staff specialists, we were not able to obtain data from the local water and energy agency offices in Mexicali. We were not able to obtain data directly from energy development companies operating in the study region, although we do cite secondary sources for some of that information. Although some data were available for crossings, transport, and trade from Mexicali into Imperial County, very little such data are available in the opposite direction. Overall, we were able to obtain a large proportion of the data that we needed to answer the research questions.

The research methods in this project were statistical and trend analysis, adjustment to population projections, and geographical information systems (GIS). The statistical analysis mainly consisted of descriptive statistics. The project used trend analysis to project energy, water, and other trends. The trend analysis was conducted by combining linear formulas on spreadsheets. It also applied some interpolation where intermediate years were missing. The project utilized a mixture of government and academic population projections, but adjusted those projections to the actual data from the 2000 Mexican and U.S. censuses, unless their starting data were already for 2000. The adjustments were done by determining the adjustment factor for year 2000, and then applying that adjustment factor for the remainder of the projection years.

Spatial analysis was conducted through use of GIS. GIS was utilized to study the spatial patterns for population, housing, and business sectors in Imperial County. The business data came from the Business Analyst product of ESRI Inc. (ESRI, 2001). The data at the time the Business Analyst was provided were packaged by CACI Inc. and consisted originally of U.S. Census and Dun and Bradstreet data. During the course of this research project, CACI Inc. was acquired by ESRI Inc. GIS is a software tool that allows computerized mapping and analysis of spatial distributions and trends. It consists of a spatially-registered data-base connected to layers of boundary files (Clarke, 2001). GIS includes tools that allow analysis and comparisons of spatial patterns. This research made use of the Business Analyst and ArcView 3.2 software (ESRI Inc., 2001).

The present GIS is based on two base maps, which cover the region and its key features. One base map is for Imperial County and its cities (**Map 1-1. Imperial County Base Map**) and gives the block groups of Imperial County. A block group is a population unit of the U.S. Census of about 1,500 population. It varies in physical size, being much smaller within cities and much larger in the rural countryside. **Map 1-1** shows the county, which is bounded by San Diego County on the east, Riverside County on the North, the state of Arizona on the east, and Mexicali Municipio on the south. The agriculturally fertile Imperial Valley is shown in the left-center of the county. The Valley contains the county's system of cities. There are six zoomed out enlargements of these cities, in particular for Brawley, Imperial-El Centro, Heber, Holtville, and Seeley. The enlargements enable the reader to better see the block groups features within the cities. This base map is useful at understanding the spatial distribution of features throughout the



Map 1-1. Imperial County Base Map

Source: U. S. Census of 2000

county and its cities. The second GIS base map of the water and energy systems in the study region will appear and be discussed in Chapter 8.

The second GIS base map is for the two-county/two-municipio study region of San Diego County, Imperial County, Tijuana Municipio, and Mexicali Municipio (see **Map 8-1. Regional Base Map**). This base map also includes Tecate Municipio, which is not very populated and parts of less populous Rosarito Municipio to the south of Tijuana. This base map includes geographic features such as the Salton Sea, Laguna Salada, and the mountains separating the coast from the interior valleys. It has the county, municipio, and international boundaries. In addition, this base map shows the water canal systems, energy plants, and water and energy transmission systems for the entire region, as well as the region's two international energy inter-connects between the energy grids of the U.S. and Mexico. This base map is utilized in the research to model eleven energy and water alternative scenarios for the year 2010.

The core project team consisted of two faculty members (James Pick from University of Redlands (UR) and Nanda Viswanathan from U.C. Riverside) and two graduate students (Kohei Tomita and Swarna Keshavan). In addition, project management and research analysis were provided by former UR graduate student Katsumi Funakoshi. Doug Mende of ISMS Inc. provided GIS consulting throughout the project. The project involved considerable fieldwork in Imperial County and Mexicali. Field visits were made to the partner organization, Imperial County Community and Economic Development (ICCED), to other county officials including County Executive Officer, Ann Capela, to city planning agencies, the Imperial Irrigation District, and various city and non-profit agencies. The team also visited Mexicali several times. Those trips were hosted by Guillermo Alvarez and Djamel Toudert of the Instituto de Investigaciones Sociales of UABC and included visits to INEGI, utility offices, and other research centers of UABC. We especially thank Dr. Toudert for his exceptional interest and assistance. A further field aspect was the sabbatical leave of Dr. James Pick in Mexico City from August through December of 2001, that allowed access to Mexican federal government agencies including CFE, CRE, Comisión Nacional parar el Ahorro de Energía (CONAE,) the Comisión Nacional del Agua (CNA). It also enabled meetings with energy experts, including David Shields, Manuel Frias, Eduardo Flores-Magón, Odón de Buen, and Gastón Luken.

The partner organization, ICCED, provided excellent support for contacts and information related to Imperial County. ICCED (formerly known as VIDA) is an office of the Imperial County government that supports grants and projects for community development. The Redlands research team was in continual communication and interchange with this partner, including exchange of data and reports, discussions about economic development in the county, and gaining understanding of the counties current problems and history. Through the generosity of ESRI Inc., one copy of ArcView 3.2 was provided to the ICCED office, and our research team provided installation support and some beginning training. It is important to mention and express appreciation that ESRI Inc. also provided the research team with one copy of the Business Analyst software, a significant supplementary grant support for the research.

The culmination of the county partnership was the Workshop on May 15, 2002, "GIS Initiatives for Imperial County and the Bi-National Region," co-sponsored by Imperial County and The University of Redlands School of Business. This workshop included the presentation and preliminary report of the present grant results by the research project team. The workshop also had presentations by CCBRES, ICCED, ISMS Inc., TESCO Engineering, and ESRI Inc., that concerned other aspects of GIS in Imperial County. About 40 persons attended from city, county, and state agencies, as well as from the private sector and community.

This report is organized into chapters that cover the project's background and research. Chapters 2 and 3 concern population growth, the first focusing on all the border cities and Chapter 3 on the study region. Chapter 4 examines the economic growth of Imperial County and Chapter 5 the cross-border transport. Chapters 6 and 7 analyze the energy and water resource supply of Imperial County and Mexicali and also of the broader regions of demand. Chapters 9 and 10 concern respectively the economic and environmental impacts from the energy and water scenarios. Chapter 11 returns to the project's goals, summarizes the project's findings for each research question and gives the overall conclusions.

Chapter 2

Population Growth of the Border Twin Cities

2. Population Growth of the Border Twin Cities

The border twin cities have grown rapidly in the twentieth century and are projected to grow rapidly in the future. **Table 2-1** shows the population of the major twin cities of the U.S-Mexico border in 1990 and population estimates for 2000. This table gives city population i.e. the population within the city limits, in contrast to metropolitan population. There is one exception, which is Imperial County. Rather than identifying a dominant border-adjacent city, in Imperial County we utilize the concept of a system of seven adjacent small cities, namely Calexico, El Centro, Imperial, Holtville, Brawley, Seeley, and Heber, the latter two being unincorporated. Since no city dominates within the system, it is appropriate to include all of them. These seven cities are separated by 5 to 10 miles, with rural land in between. We did not think it was appropriate to restrict the "city" concept in Imperial County only to Calexico, which directly touches the border with Mexicali. The reason is that all seven cities are within 10-20 minutes commute time of each other and of the border with Mexicali, and have interactions at many levels with Mexicali. Calexico had a year 2000 population of only 27,109. By contrast, the system of seven adjacent cities had a 2000 population of 104,780. Thus we substituted the Imperial County system of border-neighboring cities in place of one border-contiguous city.

The largest border twin cities are San Diego-Tijuana and El Paso-Ciudad Juarez. In year 2000, according to estimates, these twin cities accounted for 62.0 percent, or nearly two thirds, of the aggregate border twin city population. It is particularly noteworthy that Ciudad Juarez and Tijuana reached populations of 1,187275 and 1,148,681 in 2000, which constitutes one third of the aggregated border twin-city population. These cities have had huge maquiladora industry growth over the past thirty years (Butler, Pick, and Hettrick, 2001), and that growth has been a major engine for population growth.

The maquiladora industry is based on co-production plants on both sides of the border that cooperate with each other. Low cost assembly takes place on the Mexican side, while on the U.S. side the partner company performs some or all of the following: component manufacture, design, warehousing, distribution, and/or transportation. The maquiladora sector has grown rapidly since 1965. For instance, there were only 3,000 maquiladora workers in 1965, 67,241 in 1975,

Table 2-1. U.S.-Mexico Border Twin City Populations, 1900–2000

Twin Cities, State	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000	Rate of Increase, 1920-2000	Rate of Increase, 1920-1950	Rate of Increase, 1950-2000	Rate of Increase, 1990-2000
Matamoros, Tamaulipas	8,347	7,390	9,215	9,733	15,699	45,737	143,043	186,146	188,745	266,055	376,279	4.64	5.34	4.21	3.47
Brownsville, Texas	6,305	10,517	11,791	22,021	22,083	36,066	48,040	52,522	84,997	98,962	139,722	3.09	3.73	2.71	3.45
Reynosa, Tamaulipas	1,915	1,475	2,107	4,840	9,412	34,076	134,869	150,786	194,693	265,663	403,718	6.57	9.28	4.94	4.18
McAllen, Texas			5,331	9,074	11,877	20,067	32,728	37,636	66,281	84,021	106,414	3.74	4.42	3.34	2.36
Nuevo Laredo, Tamaulipas	6,548	8,143	14,998	21,636	28,872	57,669	96,043	151,253	201,731	218,413	308,828	3.78	4.49	3.36	3.46
Laredo, Texas	13,429	14,855	22,710	32,618	39,274	51,510	60,678	69,024	91,449	122,899	176,576	2.56	2.73	2.46	3.62
Piedras Negras, Coahuila	7,888	8,518	6,941	15,878	15,663	27,578	48,408	46,698	67,455	96,198	125,538	3.62	4.60	3.03	2.66
Eagle Pass, Texas		3,536	5,765	5,059	6,459	7,267	12,094	15,364	21,407	20,651	22,413	1.70	0.77	2.25	0.82
Ciuadad Juarez, Chihuahua	8,218	10,621	19,457	19,669	48,881	122,566	276,995	424,135	385,603	789,522	1,187,275	5.14	6.13	4.54	4.08
El Paso, Texas	15,906	39,279	77,560	102,421	96,810	130,485	276,687	322,261	425,259	515,187	563,662	2.48	1.73	2.93	0.90
Nogales, Sonora	2,738	3,117	13,445	14,061	13,866	24,480	39,812	53,494	65,603	107,937	156,854	3.07	2.00	3.71	3.74
Nogales, Arizona		3,514	5,199	6,006	5,135	6,153	6,286	8,946	15,683	19,489	20,878	1.74	0.56	2.44	0.69
Mexicali, Baja California		462	6,782	14,842	18,775	64,658	281,333	396,324	341,559	438,337	549,873	5.49	7.52	4.28	2.27
Imperial County, California		13,591	43,453	60,903	59,740	62,975	72,105	74,492	83,269	109,303	142,361	1.48	1.24	1.63	2.64
Tijuana, Baja California	242	733	1,028	8,384	16,486	59,950	165,690	340,583	429,500	698,752	1,148,681	8.77	13.55	5.91	4.97
San Diego, California	17,700	39,978	74,683	147,897	203,341	334,387	573,224	697,027	875,538	1,109,962	1,223,400	3.50	5.00	2.59	0.97
Mex. Twin Cities, excluding Tijuana	35,654	39,726	72,945	100,659	151,168	376,764	1,020,503	1,408,836	1,445,389	2,182,125	3,108,365	4.69	5.47	4.22	3.54
U.S. Twin Cities, excluding San Diego	35,640	85,292	171,809	238,102	241,378	314,523	508,618	580,245	788,345	970,512	1,172,026	2.40	2.02	2.63	1.89
Total U.S.-Mexico Twin Cities, excluding Tijuana-San Diego	*71,294*	*125,018*	*244,754*	*338,761*	*392,546*	*691,287*	*1,529,121*	*1,989,081*	*2,233,734*	*3,152,637*	*4,280,391*	3.58	*3.46*	3.65	*3.06*
Mexican Twin Cities	35,896	40,459	73,973	109,043	167,654	436,714	1,186,193	1,749,419	1,874,889	2,880,877	4,257,046	5.07	5.92	4.55	3.90
United States Twin Cities	53,340	125,270	246,492	385,999	444,719	648,910	1,081,842	1,277,272	1,663,883	2,080,474	2,395,426	2.84	3.23	2.61	1.41
Total U.S.-Mexico Twin Cities	*89,236*	*165,729*	*320,465*	*495,042*	*612,373*	*1,085,624*	*2,268,035*	*3,026,691*	*3,538,772*	*4,961,351*	*6,652,472*	3.79	*4.07*	3.63	*2.93*
Mexico	13,607,272	15,160,369	14,334,780	16,552,722	19,653,552	25,779,254	34,923,129	48,225,238	66,846,833	81,249,645	97,483,412	2.40	1.96	2.66	1.82
United States	75,994,575	91,972,266	105,710,620	122,775,046	131,669,275	150,697,361	178,464,236	203,302,031	226,542,199	248,718,301	281,421,906	1.22	1.18	1.25	1.24

* Year 2000 city populations were extrapolated from late 1990s data from Banamex, California Department of Finance, State of Arizona Department of Economic Security, and Texas Data Center.

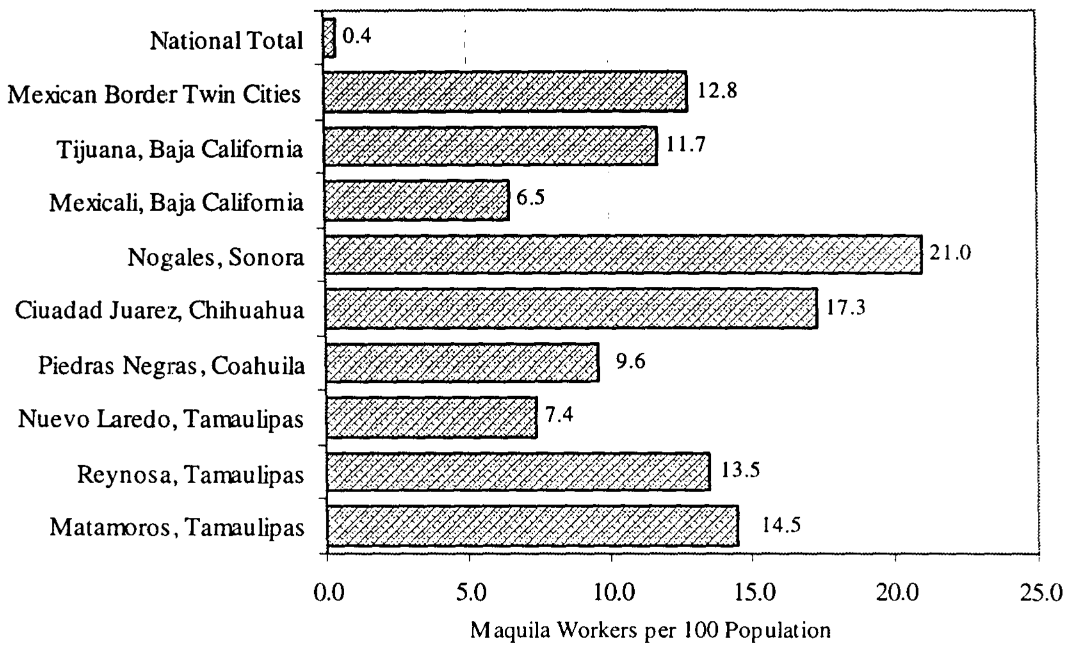
Sources for data 1900-1990: U.S and Mexican Censuses of Population, various years.

211,969 in 1985 (INEGI, 1997). By 1996, there were 754,858 maquila workers and 2,411 maquiladora enterprises (INEGI, 1997). Currently there are over one million workers. The preponderance of these firms and workers are in the border states and mostly in the major border cities. In 1991 for instance, out of 2,000 maquiladora plants, 630 were located in Tijuana and 315 in Ciudad Juárez (INEGI, 1994).

There is huge presence of the maquiladora industry in all the Mexican border cities today. As seen in **Figures 2-1 and 2-2**, for 1996, by far the largest border, and Mexican, centers for maquiladora workers and plants were Ciudad Juarez and Tijuana. Ciudad Juarez was first in plants and second in workers, while the opposite is true for Tijuana. Together these two cites in 1996 had about 280,000 maquila workers and over 700 plants! It is not surprising that the cities have grown rapidly. The intensity of maquila industry may be compared across the twin cities utilizing the ratio of the number of maquiladora workers per 100 population. Overall, the border cities had a ratio of 12.8, which is vastly more than Mexico's rate of 0.4. Ciudad Juarez had a very high ratio of 17.5, while Tijuana is average for the border. This may reflect that the more advanced industry in Tijuana has greater automation and hence needs fewer workers. The lowest ratios are for Nuevo Laredo (7.4) and Mexicali (6.5). Thus, these two cities have potential to expand their maquiladora industry over the next 25 years.

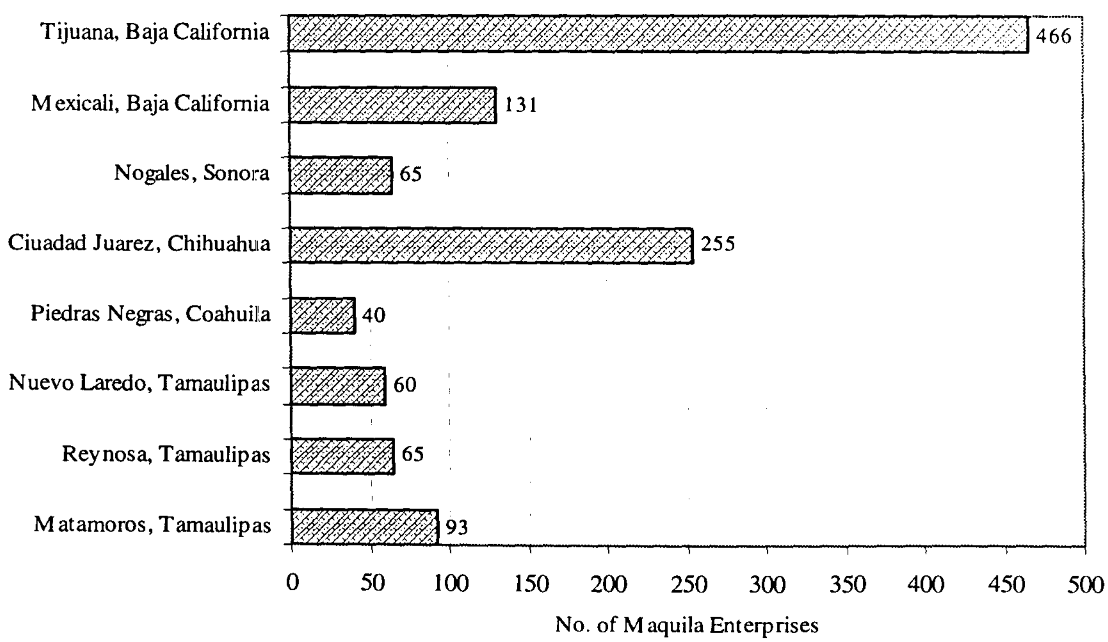
The greatest benefits to maquiladora enterprises of locating in the Mexican border region is low cost of labor, proximity to the U.S. for importing of components, and close shipping distances to the U.S. market. Some NAFTA-related changes took place in year 2001 in the maquiladora taxation and duties, but those changes do not appear to have slowed the growth (Butler, Pick, and Hettrick, 2001). The U.S. and Mexican recessions of 2000-2002 have slowed down the maquiladora industry, although their long-term impacts are unknown (INEGI, 2002). Besides Ciudad Juarez and Tijuana, maquiladoras are prevalent in the other Mexican border cities, including the current study city of Mexicali, Matamoros, Nuevo Laredo, and Reynosa. Nogales, although small in size, has some maquiladoras. Overall, the maquiladora industry has been a primary driver over the past thirty five years in the Mexican border cities' rapid population growth.

Figure 2-1. Maquila Workers per 100 Population for Mexico and Mexican Border Cities, 1996



Source: INEGI, 1997

Figure 2-2. Number of Maquila Enterprises, Mexican Border Cities, 1996



Source: INEGI, 1997

Another demographic growth factor is that Tijuana and to a lesser extent other border cities serve as staging areas for migration into the United States. Migrants have tended for generations to move up the western half of Mexico from western states like Jalisco and Sinaloa ending up mostly in Tijuana (Butler et al., 1987; Butler and Pick, 1991). From Tijuana, Jorge Bustamante and others have documented the continued further movement of those migrants into the U.S.

The second population tier of border twin cities consists of Brownsville-Matamoros, McAllen-Reynosa, Laredo-Nuevo Laredo, and Mexicali-Imperial County. In year 2000, these twin cities are estimated to account for 33 percent of the aggregated twin city population. They grew rapidly during the twentieth century and have become major metropolitan areas. Mexicali in 2000 is among Mexico's top 10 largest cities.

The small U.S.-Mexico border cities in population are Eagle Pass-Piedras Negras and Nogales-Nogales, each accounting for 2 percent of border twin city population. Those cities developed much less than the others because of transport, locational, and economic reasons. The reduced growth also stems from their remote inland locations, diminished regional economies, and lack of transport arteries serving these cities. Their growth rates have tended to trail the average twin-city growth.

The concept of metropolitan area is that of concentrated central place(s) and surrounding urban areas. A metropolitan area may contain one or several cities. For the present study, a rough proxy for metropolitan area is to use the counties and municipios that contain border twin cities. This approach to metropolitan area avoids major binational problems of trying to reconcile the different metropolitan concepts of the two nations. In fact, the U.S. Census concept of metropolitan is much more developed than INEGI's. **Table 2-1** gives the twin-city county and municipio populations for 1930 through 2000, and year 2020 projections (Peach and Williams, 2000). The total population of twin-city counties and municipios in 2000 was 9.45 million, which is 42 percent higher than for the border twin cities.

Table 2-2. Populations of Twin Cities Counties and Municipios, 1930-2020

	1930	1950	1970	1990	2000	2020	Percent in Mexico and U.S. in 2000
Matamoros, Tamaulipas	9,733	45,846	140,660	303,295	418,141	736,891	55.5
Cameron (incl. Brownsville, Texas)	77,540	125,170	140,368	260,120	335,227	554,307	44.5
Cameron-Matamoros	*87,273*	*171,016*	*281,028*	*563,415*	*753,368*	*1,291,198*	
Reynosa, Tamaulipas	4,840	34,087	140,480	282,666	420,463	658,403	42.5
Hidalgo (incl. McAllen), Texas	77,004	106,446	181,535	383,545	569,463	1,050,166	57.5
Hidalgo-Reynosa	*81,844*	*140,533*	*322,015*	*666,211*	*989,926*	*1,708,569*	
Nuevo Laredo, Tamaulipas	21,636	57,668	152,325	219,465	310,915	633,770	61.7
Webb (incl. Laredo), Texas	42,128	56,141	72,859	133,239	193,117	407,110	38.3
Webb-Nuevo Laredo	*63,764*	*113,809*	*225,184*	*352,704*	*504,032*	*1,040,880*	
Piedras Negras, Coahuila	15,878	27,581	40,885	98,184	128,130	231,580	73.0
Maverick (Eagle Pass), Texas	6,120	12,292	18,093	36,378	47,297	94,495	27.0
Maverick-Piedras Negras	*21,998*	*39,873*	*58,978*	*134,562*	*175,427*	*326,075*	
Ciuadad Juarez, Chihuahua	39,669	122,566	414,908	798,500	1,218,817	2,395,024	64.2
El Paso, Texas	131,597	194,968	359,291	591,610	679,622	1,103,065	35.8
El Paso-Ciudad Juarez	*171,266*	*317,534*	*774,199*	*1,390,110*	*1,898,439*	*3,498,089*	
Nogales, Sonora	14,061	24,478	53,119	107,937	159,787	299,598	80.6
Santa Cruz (Nogales), Ariz.		6,153	8,946	29,676	38,381	71,796	19.4
Santa Cruz-Nogales	*14,061*	*30,631*	*62,065*	*137,613*	*198,168*	*371,394*	
Mexicali, Baja California	14,842	65,749	276,167	601,938	764,602	1,232,953	84.3
Imperial County, California	60,903	62,975	74,492	109,303	142,361	327,790	15.7
Imperial-Mexicali	*75,745*	*128,724*	*350,659*	*711,241*	*906,963*	*1,560,743*	
Tijuana, Baja Calif.	8,384	59,952	341,067	747,379	1,210,820	2,676,672	30.1
San Diego, California	209,659	334,387	696,769	2,498,106	2,813,833	3,294,769	69.9
San Diego-Tijuana	*218,043*	*394,339*	*1,037,836*	*3,245,485*	*4,024,653*	*5,971,441*	
Mexican Twin City Municipios	129,043	437,927	1,559,611	3,159,364	4,631,675	8,864,891	49.0
U.S. Twin City Counties	604,951	898,532	1,552,353	4,041,977	4,819,301	6,903,498	51.0
Twin City Totals - Counties and Municipios	*733,994*	*1,336,459*	*3,111,964*	*7,201,341*	*9,450,976*	*15,768,389*	

Sources: 1930-1990, INEGI; 2020 estimates, Peach and Williams, 2000.
Note: the Peach and Williams projections are not adjusted for the 2000 censuses.
Note: the year 2000 and 2020 figures for Tijuana Municipio also include the new Rosaito Municipio.

The total of city-county differences for 2000 was 2,798,504, and is accounted for as follows. For San Diego, the county is much larger than our metropolitan area definition, and includes other adjacent cities especially to the north. The metropolitan areas of Brownsville and even more so of McAllen have become quite dispersed and far exceed the city populations. In fact, the cities of Brownsville and McAllen are in process of melding together on the U.S. side of the border. This is happening within the two counties of Cameron and Hidalgo. In Hidalgo County, the major city McAllen is located considerably to the northeast of the border crossing. This dispersed aspect means that there are today significant population centers in the counties containing Brownsville and McAllen beyond their city limits. For Mexicali, the municipio contains dozens of cities besides Mexicali, but many are a considerable distance away. In particular, Mexicali municipio contains three adjoining small cities 5-7 miles to the southwest of Mexicali and a larger system of about 40 small cities 5 to 45 miles to the east and southeast in the agricultural Mexicali Valley that together constitute substantial population. However, only about five of these cities are within 10 miles of Mexicali and could be considered metropolitan, so perhaps a third of this 163,000 population is part of the Mexicali metropolitan area.

The aggregated total population of the counties and municipios containing twin cities grew rapidly in the 20th Century and is projected to continue to expand. In 1930 the aggregated population of the counties and municipios containing twin cities was three quarter of a million. It rose to 3.1 million in 1970 and 7.2 million in 2000 (see **Table 2-2**). Peach and Williams (2000) project as a medium estimate that the counties and municipios containing twin cities will reach 15.8 million in population by year 2020. This 90 year growth path is very high and resembles the growth of rapidly growing third world nations. This growth was more rapid for Mexico than for the U.S.

The twin city county and municipio populations show large differences in the relative weightings on one side of the border or the other. The populations in year 2000 for the large "metropolitan" areas were 1.9 million for the county and municipio of El Paso and Ciudad Juarez and 4.0 million for the county and municipio of San Diego and Tijuana (see **Table 2-2**). In a second tier are the counties containing Brownsville-Matamoros, McAllen-Reynosa, and Mexicali-Imperial County, ranging in population from 753,000 to 990,000. The combined metropolitan areas for Nogales-

Nogales and Piedras Negras-Eagle Pass are under 374,000 in size. The proportion of county and municipio population on the U.S. side can be calculated for twin cities in 2000. This proportion was 51 percent overall, but varied widely, between the extremes of 16 and 70 percent. The differences are due to a combination of historical, topographical, political, and demographic-economic reasons (Stoddard et al., 1983; Arreola and Curtis, 1993.) For example, we can contrast San Diego-Tijuana, mostly in the U.S., with Imperial County-Mexicali, mostly in Mexico. San Diego started growing earlier by several decades than Tijuana and has retained its lead in size, although Tijuana has been catching up the past two decades (Herzog, 1990). By contrast, Imperial County's population did not grow for most of the 20^{th} century and has only grown in the past twenty years, whereas Mexicali has rapidly increased in population since 1940, due largely to border migration and maquiladora expansion. The relative North-South sister-city population proportions in Mexicali-Imperial County cities, versus Tijuana-San Diego influence urban and economic structure, and are discussed more in the next chapter.

The urban concepts emphasized in this study are city, as well as counties and municipios i.e. metropolitan areas. Both the Mexican and U.S. censuses have clear city definitions and tabulate information on cities. The reason that we sometimes focus on city, rather than metropolitan area, is because we can utilize small area data, which are available in the 1990 and 2000 Mexican Censuses only within cities. Likewise, in the U.S. there are much better small area data for cities. The aggregated twin cities population in 2000 was 6.65 million persons (see **Table 2-3**). This aggregate grew at an average annual rate of 3.91 percent during the twentieth century. This is a very high rate of growth and implies a doubling every 18 years. In the twentieth century, the U.S. had an annual growth rate of 1.22 percent and Mexico a rate of 2.40 percent. By comparison, on the worldwide level today, only a handful of nations approximate the twin cities century-long growth rate, countries such as Libya, Togo and Chad in Africa, Oman and Yemen in the Middle East, and Maldives and Bhutan in Asia. Although the border region's economic development status is much higher than for those nations, the U.S.-Mexico border region has parallel problems associated with rapid population growth including deficits in infrastructure, public health, and education.

Table 2-3. Population of U.S.-Mexico Border Twin Cities in 1990 and 2000

	1990	Percent of Total Twin City Pop. 1990	2000	Percent of Total Twin City Pop. 2000
Matamoros, Tamaulipas	266,055	5.4	376,279	5.7
Brownsville, Texas	98,962	2.0	139,722	2.1
Brownsville-Matamoros Twin City	*365,017*	*7.4*	*516,001*	*7.8*
Reynosa, Tamaulipas	265,663	5.4	403,718	6.1
McAllen, Texas	84,021	1.7	106,414	1.6
McAllen-Reynosa Twin City	*349,684*	*7.0*	*510,132*	*7.7*
Nuevo Laredo, Tamaulipas	218,413	4.4	308,828	4.6
Laredo, Texas	122,899	2.5	176,576	2.7
Laredo-Nuevo Laredo Twin City	*341,312*	*6.9*	*485,404*	*7.3*
Piedras Negras, Coahuila	96,198	1.9	125,538	1.9
Eagle Pass, Texas	20,651	0.4	22,413	0.3
Eagle Pass-Piedras Negras Twin City	*116,849*	2.4	*147,951*	2.2
Ciuadad Juarez, Chihuahua	789,522	15.9	1,187,275	17.8
El Paso, Texas	515,187	10.4	563,662	8.5
El Paso-Ciuadad Juarez Twin City	*1,304,709*	*26.3*	*1,750,937*	*26.3*
Nogales, Sonora	107,937	2.2	156,854	2.4
Nogales, Arizona	19,489	0.4	20,878	0.3
Nogales-Nogales Twin City	*127,426*	*2.6*	*177,732*	*2.7*
Mexicali, Baja California	438,337	8.8	549,873	8.3
Imperial County, California	109,303	2.2	142,361	2.1
Imperial County-Mexicali Twin City	*547,640*	*11.0*	*692,234*	*10.4*
Tijuana, Baja California	698,752	14.1	1,148,681	17.3
San Diego, California	1,109,962	22.4	1,223,400	18.4
San Diego-Tijuana Twin City	*1,808,714*	*36.5*	*2,372,081*	*35.7*
Mexican Twin Cities	2,880,877	58.1	4,257,046	64.0
United States Twin Cities	2,080,474	41.9	2,395,426	36.0
U.S. - Mexico Twin Cities	*4,961,351*	*100.0*	*6,652,472*	*100.0*
Mexico	81,249,645		97,483,412	
United States	248,718,301		281,421,906	
Mexican Twin City Proprotion of Nation	3.55		4.37	
U.S. Twin City Proportion of Nation	0.84		0.85	

Sources: U.S. Census and INEGI, various years

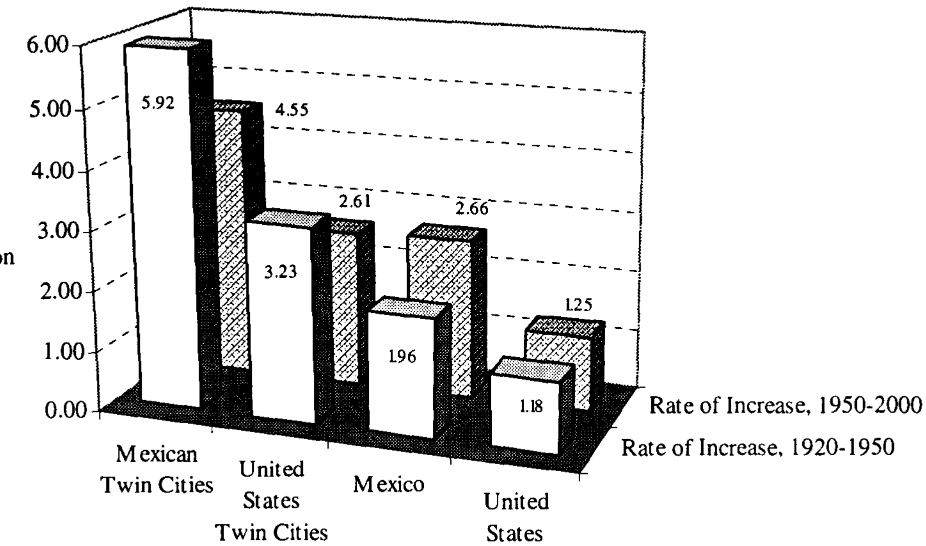
The Mexican twin cities expanded during the twentieth century at about twice the rate as the U.S. twin cities. Among the reasons for this differential are the higher fertility rate of Mexico, the economic strength of the northern region of Mexico, migratory-pull attraction of the U.S., special worker programs at certain times periods such as the Bracero Program and Border Industrialization Program, and since 1960 the growth in the maquiladora industry (Stoddard et al., 1983; Herzog, 1990).

For the period 1920 to 2000, the Mexican twin cities grew at an average annual rate of 5.07 percent, while the U.S. twin cities grew at 2.84 percent. Nevertheless, the U.S. twin-city growth rate is rapid -- it was double that of the U.S. as a whole for the period. This differential continues for the decade of the 1990s. The 1990s annual growth rates for the Mexican and U.S. twin cities are 3.90 and 1.41 percent respectively.

The extent of increase varied quite significantly at different periods during the 20th century. As is seen in **Table 2-1** and **Figure 2-1**, the average annual rate of population increase was a somewhat higher for both the Mexican and U.S. twin cities in the period 1920 to 1950, compared to 1950 to 2000. The difference may reflect the very small starting base of border twin-city populations in 1900, which offered more potential for increase in the first half century. However, Mexican national population increased more rapidly in the late century compared to the early century, while the U.S. population grew equivalently for the two periods. The late century boost for Mexico may stem from the pull factor of the maquiladora industry (Pick et al., 2000).

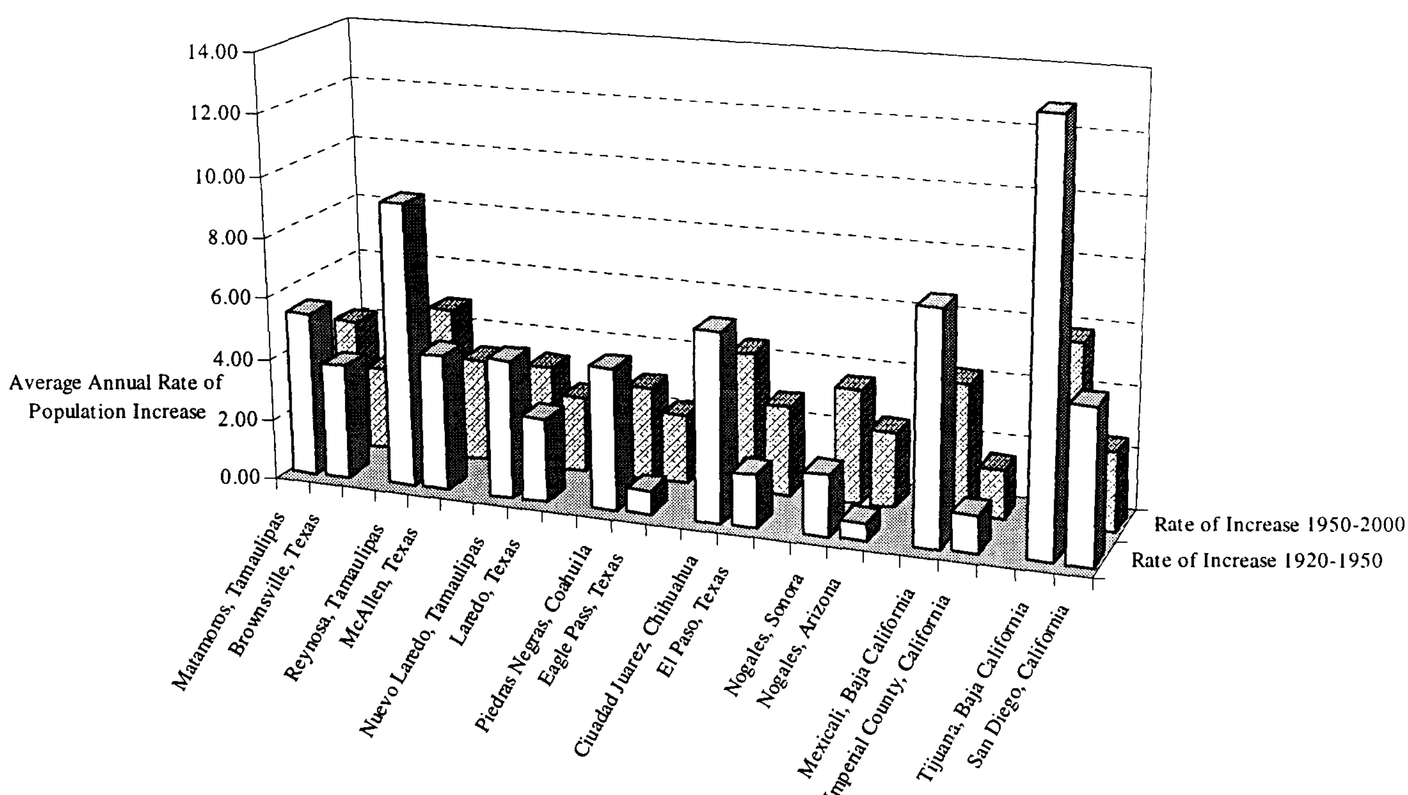
Since San Diego-Tijuana is a focus of this study and accounts for a third of the aggregate twin city population, it is important to ask how this twin city grew relative to the rest of the twin cities. As seen in **Figure 2-2** and **Table 2-1**, the Tijuana-San Diego twin city growth rates were exceptionally high for the period 1920-1950. In fact, Tijuana had an incredible growth rate of 14 percent annually and San Diego grew at over nine percent yearly. It was during the 1920s through 1940s that major migration flows came from western Mexico to Tijuana (Butler and Pick, 1987); San Diego experienced major build-up in military and defense industries; and southern California grew substantially (Herzog, 1990). In contrast to San Diego's greater growth in the early versus late century, the other U.S. twin cities increased at a much higher rate

Figure 2-1. Rates of Increase 1920-2000, in Border Twin City and National Populations, Mexico and United States



Sources: U.S. Census and INEGI, various years

Figure 2-2. Rates of Increase 1920-2000 in Border Twin City Populations

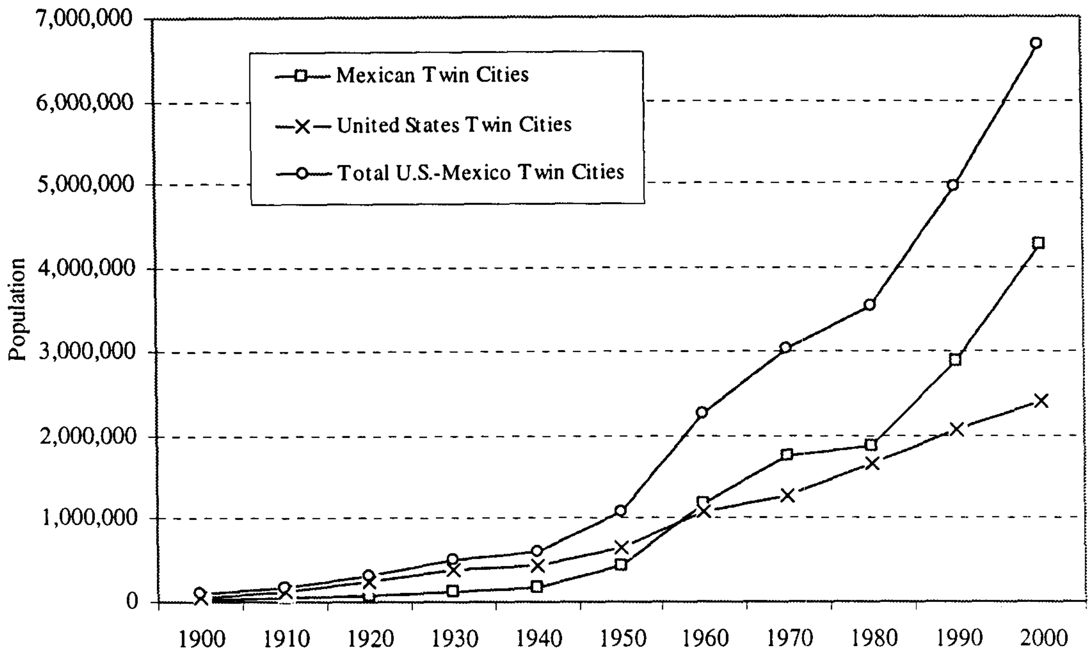


Sources: U.S. Census and INEGI, various years post-1950 than before. As a benchmark, the U.S. twin cities post-1950 growth rates approximated those of the nation of Mexico, which may not be surprising since there was substantial migration flow from Mexico to the U.S. twin cities during the whole century and after 1950. The immigrants may have retained somewhat higher fertility rates that approximated those of Mexico.

It is clear that the twentieth century population growth for the border cities has been exponential. By the 1950s, the Mexican side displaced the U.S. side as the growth leader. Although Mexico trailed considerably in total population until the late 1950s, there was a spurt in the growth rate of the Mexican twin cities population from 1940 to 1960. During that time, the Mexican border city population grew by seven fold! At the same time, during that time, the U.S. border population grew from 445,000 to 1.28 million, an increment of nearly three fold. The U.S. population growth was due in large part to World War II and continuing development of the military/government sector in the 1950s. Major twin cities such as El Paso and San Diego today still have substantial military population and bases. Much of this military complex and associated population first appeared during World War II (Herzog, 1990). Since 1960, Mexican and U.S. border city growth rates have been high, but not at Mexico's extraordinary mid century rate. Mexico growth rates led the U.S. by about almost two percent.

How do the patterns in the twin cities compare to national patterns? Is the rapid population growth of the border cities reflected in the nations? The nations also grew substantially in the 20th century, with the Mexico growing more rapidly. Comparing the raw plots of growth for the border twin cities and the nations (**Figure 2-3),** the border twin cities have consistently had two to three times the growth rates of the nations. However, the rate differential between twin cities and nation was greater in the early century than late century. This may be due to the slowing of twin city growth in second half of the century, combined with a significant increase in Mexico's growth rate in the second half. In the 1990s, the Mexican differential decreased further, while the U.S. differential remained high. In this decade, the Mexican twin cities grew at 1.6 times than of Mexico, while the U.S. twin cities grew at 3 times that of the U.S. Part of the U.S. growth may be derivative, that is Mexican immigrants to the U.S. border cities may bring along fertility norms and behavior that contribute to growth.

Figure 2-3. Growth of U.S.-Mexico Border Twin Cities in the 20th Century

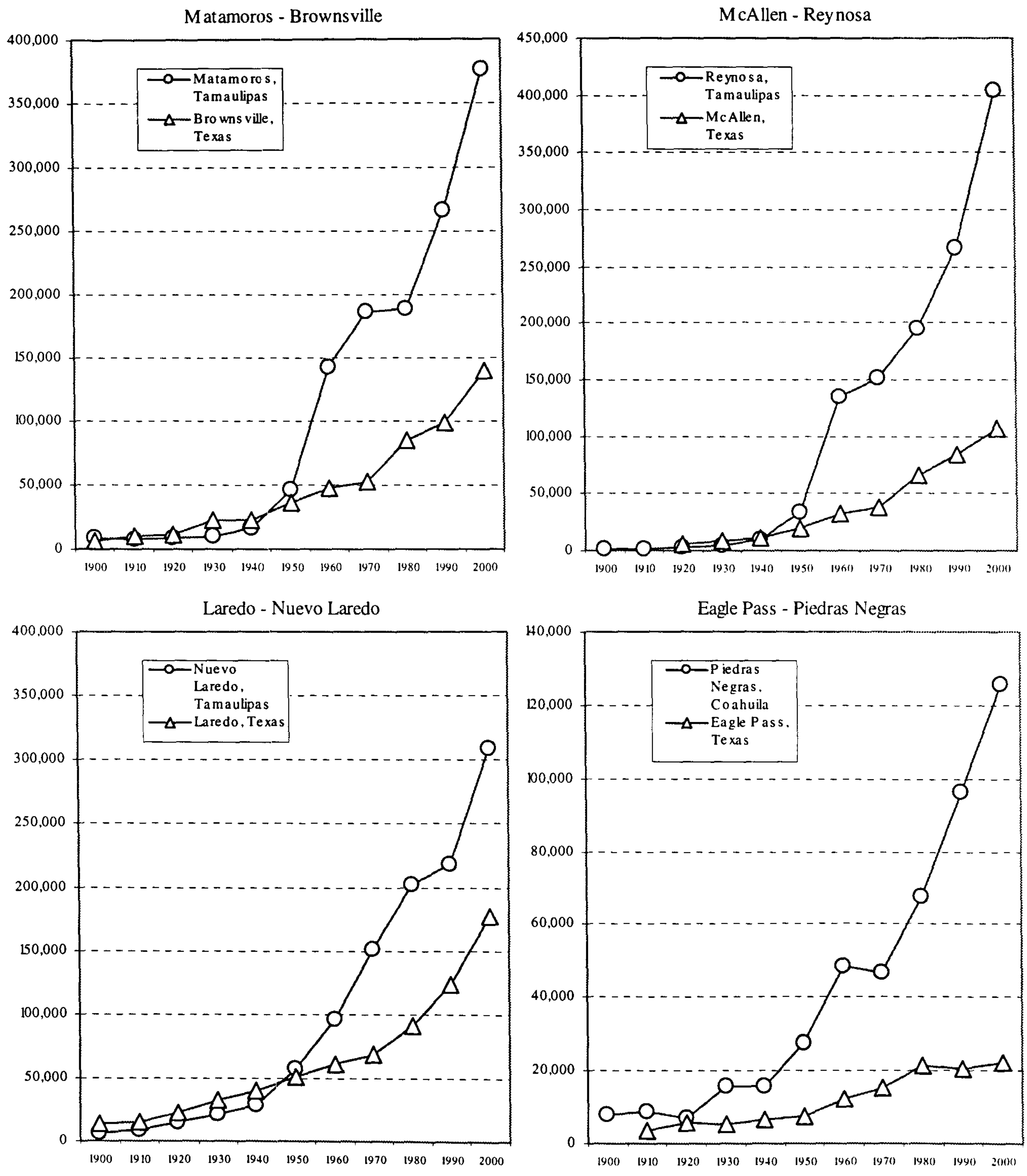


Sources: U.S. Census and INEGI, various years

The bottom line is that, during the twentieth century, Mexico grew at double the U.S. rate. Mexico was a nation about a sixth the size of the U.S. in 1990 but is one third the size today. This pattern is replicated in the border shifts. In 1900, the twin-city population was 60 percent U.S. but is 64 percent Mexican today. The border changes replicate a general shift in the population size of the U.S., relative to Mexico. Another aspect is that, throughout the century, compared to the U.S., Mexico has had a much greater proportion of its population in the border region. The figure also reveals a slight decline in population growth rates on the Mexican side in 1980. However, this is partly due to a problem of the 1980 Mexican population census of high undercount that was especially acute in the border region (Lopez Chavez, 1982).

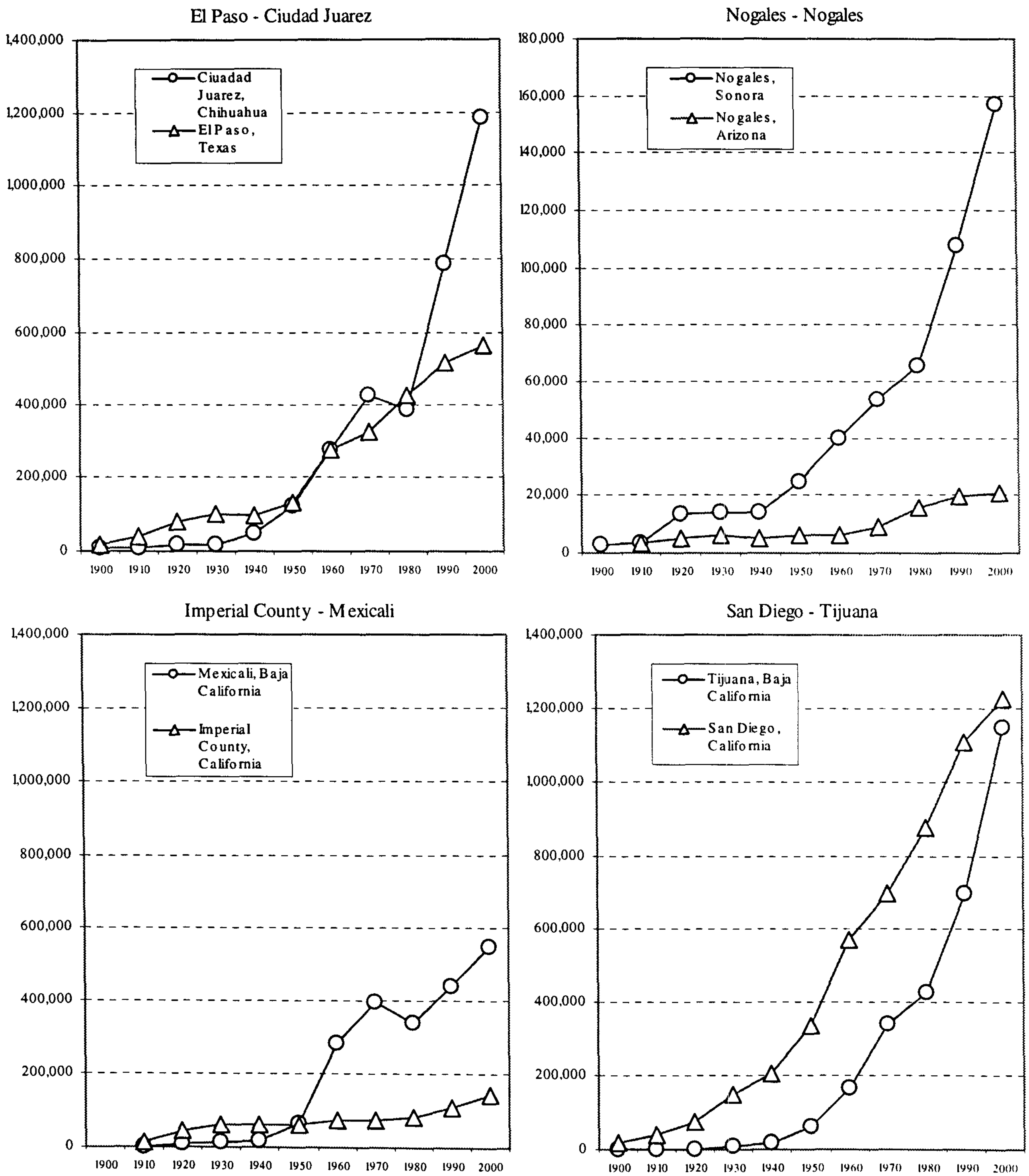
The growth patterns for the eight individual border sister cities vary considerably. The differences are due to historical and demographic reasons. Starting in the eastern border, Matamoros-Brownsville and McAllen-Reynosa are remarkably similar (see **Figure 2-4** for the eastern and twin cities and **Figure 2-5** for the western twin cities). This is not surprising since these

Figure 2-4. Population of Four Eastern U.S.-Mexico Border Twin Cities in the 20th Century



Sources: U.S. Census and INEGI, various years; Banamex, 1998

Figure 2-5. Population of Four Western U.S.-Mexico Border Twin Cities in the 20th Century



Sources: U.S. Census and INEGI, various years; Banamex, 1998 twin city neighbors, only fifty five miles apart, are economically and demographically linked in many respects. Comparing these two cities on annual growth in the 20th century (see **Figure 2-1),** it is evident that McAllen-Reynosa has been somewhat higher. This may reflect a somewhat more accessible geographical location, better connection to major Mexican highways, and a more vigorous maquiladora industry. Also, historically, Reynosa and McAllen started out in the early 20th century as smaller towns than Matamoros and Brownsville.

Both easternmost twin cities had large growth spurts on the Mexican side in the 1950s followed by slowing in the 1960s. This is tied to the Bracero Program, which lasted from 1950 to 1964 (Rochín and Ballenger, 1983) and had impacts on all the Mexican border cities. The specific patterns of slowing of growth in the 1960s, also apparent for Piedras Negras, may be tied to local economies.

The twin city of Laredo-Laredo increased in size steadily throughout the 20th century but at rates lower that its two eastern neighbors.

Eagle Pass-Piedras Negras started later and grew more slowly than most of the other twin cities. Eagle Pass grew at under one percent rate in the early century and had a population of only 7,267 in 1950. Piedras Negras trailed the growth of other Mexican twin cities also. Eagle Pass averaged only 1.8 percent growth during the century (see **Table 2-1** and **Figure 2-1**). The reason this twin city has lagged is due to its interior remoteness, lack of a major international transportation artery, and a largely stagnant economy until late century. It is important to emphasize that Eagle Pass at century's end is particularly impoverished and has very high unemployment rates. On the other hand, over the past two decades, Piedras Negras has been stimulated increasingly by a small but thriving maquiladora industry.

The major twin city of El Paso-Ciudad Juarez expanded, with several pauses, during the century. Ciudad Juarez far exceeded El Paso in the first half of the century. However, both sides grew rapidly in the 50s, and Ciudad Juarez moved ahead in the 60s. Ciudad Juarez's sharp drop in the 70s is puzzling and may be due to an local undercount problem in the 1980 Mexican Census (Lopez-Chavez, 1982) or unexplained reasons. Ciudad Juarez's 1950-2000 annual growth rate was quite high 4.5 percent, a rate that continued in the 1990s (see **Table 2-1** and **Figure 2-1**). Overall, the El Paso-Ciudad Juárez twin city increased at average border city rates, taking into account El Paso's lagging performance pre-1950. In concert with the entire border, the national composition of this twin city changed during the 20th century, tilting dramatically towards the Mexican side. From even binational composition in 1960, the dual city shifted so that for year 2000, the population is twice as large on the Mexico side, with an absolute a difference estimated at 600,000 for the year 2000.

The demographic pattern for the small twin city Nogales-Nogales resembles closely that of the other small case, Eagle Pass-Piedras Negras. The major difference is the slower growth 1920-1950 of both of the Nogales, as compared to Eagle Pass-Piedras Negras. There was nevertheless an unusual, early-century growth spurt in Nogales, Sonora, in the decade of the teens. That spurt apparently led to residual slowing for twenty years afterwards.

The dual sister city complex of Mexicali-Imperial County, the main focus of the present research, has the largest differential in growth rates on the two sides during the 20th century, with Imperial County lagging. Mexicali's annual growth 1920-2000 averaged 5.5 percent, versus only 1.5 percent for Imperial County, a nearly four-fold difference! A consequence has been a rise in the importance of the Mexican side, from one quarter of persons in the twin city in 1930 to nearly five sixths in 2000 (see **Table 2-1** and **Figure 2-5**). However, at the end of the century, the century long swing again reversed. Annual growth rates in the 1990s are 0.4 percent higher on the Imperial County side. A key question here is: what factors, during most of the century, prevented Imperial County from experiencing the high growth of the other U.S. twin cities? One explanation is that Imperial County historically was very agricultural, although today its economy is only about half farm-related (VIDA, 1998). The rich agricultural productivity including lands adjacent to the border and the political conservatism of Imperial County, may have reduced urban development. Secondly, the maquiladora industry in Mexicali developed later than for the other twin cities and it still lags its potential, delaying and reducing economic growth. When substantial maquila growth finally arrived, it led to the population reversal that occurred in the 1990s. The long-time lagging growth of Imperial County stems from its strong agricultural nature and its remoteness from the urban parts of southern California. Some of the lagging growth may relate to Imperial County's agricultural-rural culture, which is not encouraging to businesses and investments to move in. It weak economy and lack of skilled labor force compound the problems.

The western-most twin city of San Diego-Tijuana has been remarkably expansive. Its yearly growth rate averaged 4.3 percent for the century. San Diego grew during the 20th century at a rate roughly equivalent to El Paso, McAllen, and Brownsville; San Diego started out as the largest U.S. twin-city from the beginning of the century with 18,000 people and has remained so throughout. Today, the city of San Diego is a part of a U.S. metro area of over 2.81 million. One of the study problems presented by its huge size is the question of how closely the different parts of this large metropolis interact with Tijuana and Mexico. The San Diego metropolitan region extends from north to south approximately 55 miles. Do the northern parts of the region interact substantively with Tijuana?

In contrast to San Diego's average border expansion rate, Tijuana's growth has been explosive. Tijuana expanded during the century at a 8.8 percent yearly rate. That rate implies a doubling time of every eight years! Tijuana's growth rate slowed in the late century compared to the early century, but still was the highest of any U.S.-Mexico border sister city (see **Table 2-1** and **Figure 2-1**). In the 1990s, Tijuana increased at an estimated 5.0 percent, which implies a doubling every 14 years.

There are a number of relevant aspects of this very rapid growth. First, the growth has been driven by in-migration throughout the century into Tijuana of large numbers of Mexican internal migrants (Butler et al., 1987). Tijuana is largely a city formed of migrants and has considerable turnover and instability in its population. The culture, values, and identity of many residents are drawn from prior, rather than current, place of residence. A city of migrants may reduce the extent of cross-border families and relationships. On the other hand, Tijuana constitutes a staging area for migration from Mexico into the United States. As a result, after migrants move to the U.S., they may retain ties to Tijuana.

A second driver of this growth has been a large presence of the maquiladora industry. Its over 600 maquiladora plants include giants such as Sony TV and monitor plant employing over 8,000 workers and SI Electrónica de Baja California, with 4,500 workers (Expansión, 1997). Tijuana's maquiladora industry has been the highest skilled and most technology-driven, compared to other maquiladora cities (Expansión, 1997).

Another consequence of Tijuana's rapid growth has been inadequate urban infrastructure and environmental deterioration. The land area of Tijuana had doubled every eight years, so that it is not possible for the federal, state, and local governments to provide adequate infrastructure. The city falls behind even more during periods of national economic adversity. Deleterious environmental aspects stemming from this growth will be discussed later.

In even the nine years since the 1990 Census, Tijuana's urban patterns have shifted. The extent of change in the city depends partly on city land annexation. Preliminary examination of the recently released INEGI coverages for the 2000 Census points to continuing rapid expansion of the urban land area (INEGI, 2002).

San Diego-Tijuana stands out as an exceptional example of growth in the border. The twin city had large volumes of resident and transient migrants; has had high demographic turnover; and has a rapidly changing urban structure (Herzog, 1993). This mixing can be expected to influence the extent of commonality of characteristics, based on the census-based measures (Pick and Viswanathan, 2002).

Given the rapid and sometimes erratic growth patterns of the twin cities during the 20th century, it is risky to forecast their populations into the future. This is especially difficult for cities such as Reynosa, Ciudad Juarez, Mexicali, and Tijuana that have grown so rapidly. For instance, the population native to state in Baja California in 1995 was only 50 percent, compared to a national figure of 76 percent. Since Baja consists mostly of Tijuana and Mexicali, this highlights the transience and high proportion of new arrivals in these cities.

The year 2000 population figures in Tables 2-1 and 2-3 imply some slowing in growth rates, in particular that 1990-2000 growth rates for the aggregated twin cities are about one third percent lower than for the prior four decades. Tijuana, Ciudad Juárez, and three medium sized U.S. cities were expanding, while the large U.S. cities are slowing. In particular, the most rapidly growing border twin cities in the 1990s were Tijuana (4.8 percent), Ciudad Juarez (4.2 percent), Laredo, Texas (3.5 percent), Imperial County (2.6 percent), and Brownsville (2.5 percent), while slow growth cities were San Diego (1.2 percent) and El Paso (1.7 percent). This can be viewed as a continuation of long-term trends of maquiladora driven growth, combined with slowing of larger U.S. cities.

One attempt to project the border twin-city county and municipio populations was based on the age-sex component model (Peach and Williams, 1999). The projections made various assumptions about fertility, mortality, and migration. Their "Medium projection series" assumes (1) constant 1995 fertility rates from the 1995 national survey (INEGI, 1995) apply for the duration of the projection period, (2) Mexican national mortality rates are lowered to year 2000 and are held constant for the remaining projection period, and (3) based on "residual estimation, migration rates are assumed to fall to 75 percent of 1990-1995 levels for 1995-2000 and to 50 percent of 1990-1995 levels throughout the remainder of the projection period. These projections have some serious drawbacks, including use of averaged national mortality data, dependence on the 1995 Conteo sample for age-specific projection purposes, and lack of explanation for the age-specificity of migration. The projections are for counties and municipios, not for cities. The reason is that the data are less complete for cities and the city definitions less consistent. Nevertheless, the projection results summarized in **Table 2-2** indicate a total twin-cities county and municipio population of 15.8 million in 2020, which compares to 7.2 million counted in 1990. The annual growth rate implied for the 1990-2020 projection period is 2.6 percent, which compares to an actual 3.8 percent growth rate 1930-1990. These assumptions imply that the Mexican side will continue in the 1990s and beyond to grow twice as fast as on the U.S. side. The projection point to continued rapid increase, with an even greater proportion of population moving to the Mexican side. In fact, the projections imply that in 2020 only 44 percent of the border twin-city county and municipio population will be U.S.-based, versus 56 percent in 1990.

The numbers must be taken very cautiously, especially for Ciudad Juárez and Tijuana, because the assumed early 1990s immigration rates may overestimate future migration.

Rather than reflecting on these specific results, we regard these projections as useful in recognizing several likely trends. It must be noted that the projections are for border sister-city counties and municipios, but they can be regarded as pointing the way for border cities as well. The following trends are implied by the projections:

- *There is a long-term trend towards higher populations in the border metropolitan areas and sister cities, which adds to their importance for research study*
- *There is a shift in the preponderance of population from the U.S. toward the Mexican side. This implies that the urban infrastructure will need to develop and change in the future more on the Mexican side.*
- *There is a trend for all of all the sister cities to become larger. The large twin cities today may become very large, with the two largest combined sister cities approached 3.5 to 6 million population and the next two nearly 2 million. These cities will have greater reason to cooperate with each other and to improve data collection and joint planning tools.*

An overall conclusion on the history and future trends in population in the U.S.-Mexico border sister cities is the presence of rapid population growth, accentuated even more so on the Mexican side. One of the major reasons for the rapid expansion was the high level of fertility in Mexico, especially in the mid century (Pick and Butler, 1994). The high fertility of Mexico also influenced the U.S. side through the heightened fertility of the many international inmigrants from Mexico to the U.S. border cities.

Another set of growth drivers were the special worker programs in Mexico that attracted workers to the border cities. One program was the Bracero Program that occurred officially from 1950 to 1964, but which actually started in the 1940s (Rochín and Ballenger, 1983). That program attracted Mexican migrants to work in agriculture on the U.S. side of the border, but not necessarily to reside in the border twin cities. A more recent influence has been the maquiladora industry. The underlying cause for the exponential growth of this industry has been the low cost of Mexican labor (Butler, Pick, and Hettrick, 2001).

Chapter 3

Population Growth in the Region of Imperial County, Mexicali Municipio, San Diego County and Tijuana Municipio

3. Population Growth in the Region of Imperial County, Mexicali Municipio, San Diego County and Tijuana Municipio

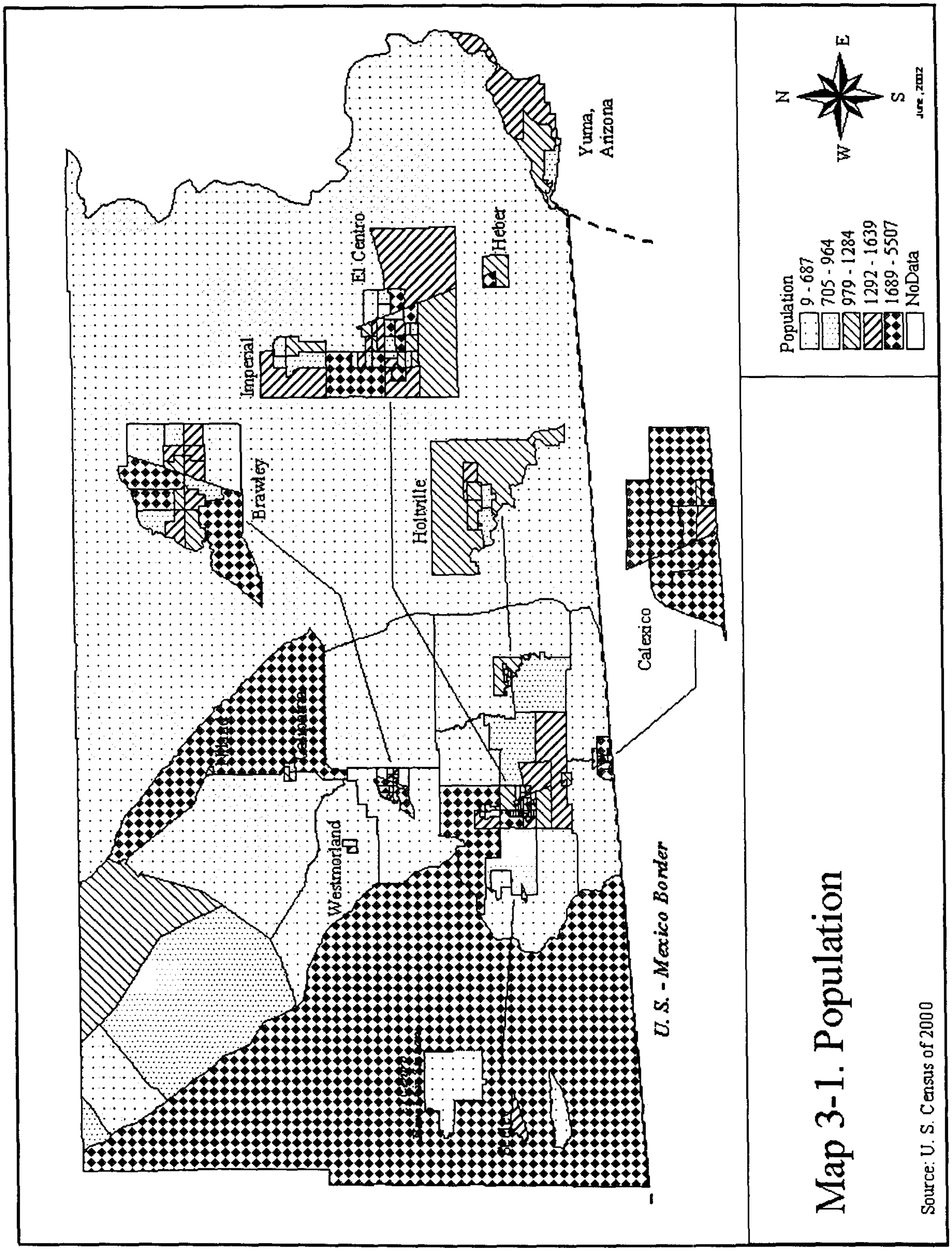
This chapter examines the population growth and related socioeconomic characteristics for Imperial County and the Mexicali Municipio, as well as adjoining coastal municipios. Since the areas to the west of Tijuana Municipio and San Diego County are important to the current research study with respect to energy and water demand, they are also discussed and compared to the primary areas. This chapter concerns the size of the study region's populations, their growth and change, and their current socioeconomic characteristics and profile in terms of migration, ethnicity, education, housing, income, and poverty. The data are updated to the year 2000 censuses for the United States and Mexico. The data from these censuses started to appear in early to mid 2001 and are still being published in the U.S. Final small area data for U.S. socioeconomic characteristics are not expected until fall of 2002, and hence cannot be included in this report. The chapter presents population and socioeconomic trends and population projections that are linked to the energy and water development discussed in subsequent chapters. There is some preliminary discussion in this chapter of the implications of social attributes and forces for water and energy supply, in the 2- county/2-municipio region. This chapter discusses this material by topical area, starting with population growth. Imperial County trends and characteristics are compared to San Diego and California. Mexicali is compared to Tijuana, as well as to Baja California and Mexico.

The prior chapter already pointed to the rapid growth of the entire border region, including the four focus municipios and counties. For instance, the chapter underscored that San Diego and Tijuana were very rapidly growing in the twentieth century. Mexicali also grew rapidly since 1940. On the other hand, Imperial County grew rapidly from its population inception in 1904 to reach 60,000 by 1930, but then stagnated until 1970, after which it grew rapidly until today. The reasons for the forty years of stagnation are discussed later in the chapter.

Overall, this is a century long process of population growth. As seen in the last chapter, in 1930 the two counties and two municipios had a total population of 293,788 (U.S. Census of 1930; Lorey, 1993). By 2000, the population of the four units was 4,931,616 (INEGI, 2001, U.S. Census, 2002). This growth was among the most rapid urban growth in North America in the 20th century. The expansion is the result of a combination of forces. For Mexicali and Tijuana, the border was attractive as a staging location for labor migration to the United States. This started with the Border Industrialization Program and Bracero Program in the mid twentieth century (Dillman, 1983). The maquiladora industry was another major cause of growth (Stoddard, 1987; Butler, Pick, and Hettrick, 2001). It commenced in the mid 1960s because U.S. companies sought to achieve lower production costs, by collaborating with Mexican "partner" firms. Maquiladora plants produce electronics, auto parts, textiles, furniture, and other products, predominantly for sale into U.S. markets. From an early size of 3,000 maquiladora workers in 1965, there are today over one million maquiladora workers throughout the border region and some in the central parts of Mexico. About a fifth of employment in this industry is located in the cities of Tijuana and Mexicali (INEGI, 1999).

Another attraction for internal migration to Mexicali and Tijuana has been these cities as staging areas for later movement to the U.S. The scale of this, in recent years, is seen by the growth of Mexican-origin population in the U.S. Between 1990 and 2000, it grew by 7.1 million, predominantly by migration from Mexico to the U.S. (U.S. Bureau of the Census, 2002). A significant portion of the Mexican migrants came via Baja California. Most came in stages, staying for a while in the border cities before migrating across the border. The bottom line motivator has been the push-pull factor of the sharp economic difference between the U.S. and Mexico. In the U.S., wages were 7-10 times greater, with much higher standard of living and wealth.

The chapter turns next to analyze and consider growth patterns in the binational region. **Map 3-1** gives the distribution of population within Imperial County. It is evident that growth patterns have been spatially uneven. As seen in **Table 3-1 and Map 3-1,** Imperial County consists of ten small cities, plus other scattered population. The three largest cities are El Centro, Calexico, and Brawley, with year 2000 populations of 37,835, 27,109, and 22,052 persons respectively (U.S. Census, 2002). Among all the county's cities from 1950 to 2000, Calipatria was the most rapidly growing. However, the big jump for this city was from 1990 to 2000, when it increased by 4,599 persons. This jump was due to the arrival of a new prison. The next fastest growing cities were Imperial and Calexico, which increased by 2.9 percent yearly from 1950 to 2000. This was



Map 3-1. Population

Source: U. S. Census of 2000

Table 3-1. Historical Population Growth of Imperial County and Its Cities, 1910-2000

Incorporated	City or Town	2000	1990	1980	1970	1960	1950	1940	1930	1920	1910	Annual Grwoth Rate 1950-2000	Annual Growth Rate 1990-2000
1908	Brawley	22,052	18,923	14,946	13,746	12,703	11,922	11,718	10,439	5,389	881	1.2	1.5
1908	Calexico	27,109	18,633	14,412	10,625	7,992	6,433	5,415	6,299	6,223	797	2.9	3.7
1919	Calipatria	7,289	2,690	2,636	1,824	2,548	1,428	1,799	1,554	785		3.3	10.0
1918	El Centro	37,835	31,384	23,996	19,272	16,811	12,590	10,017	8,434	5,464	1,610	2.2	1.9
	Heber	2,988	2,566	2,221									1.5
1908	Holtville	5,612	4,820	4,399	3,496	3,080	2,472	1,772	1,758	1,347	729	1.6	1.5
1904	Imperial	7,560	4,113	3,451	3,094	2,658	1,759	1,493	1,943	1,885	1,257	2.9	6.1
	Niland	1,143	1,183	1,042									-0.3
	Seeley	1,624	1,228	1,058									2.8
1934	Westmorland	2,131	1,380	1,590	1,175	1,404	1,213	1,010				1.1	4.3
	Other	27,018	22,383	22,359	21,260	24,909	25,158	26,516	30,476	22,360	8,317	0.1	1.9
	Imperial County	142,361	109,303	92,110	74,492	72,105	62,975	59,740	60,903	43,453	13,591	1.6	2.6

Source: U.S. Census, various years

driven by expansion in their job base, especially in the 1990s. El Centro grew faster than the County at a 2.2 annual rate 1950-2000. Brawley grew more slowly, at a 1.2 percent rate over the fifty years. Brawley lacks the job growth, including in the commercial/retail, government, and transportation sectors that have been characteristic of growth close to the border. Except for Calipatria and Seeley, both having prisons, the small cites and unincorporated areas also grew slowly, in the range of 1.5-1.9 percent annually. The more rapid growth of the larger cities has contributed to higher urbanization in the county. In 1950, 49 percent of population lived in places of 5,000+ population, compared to 61 percent in 2000. This trend can be expected to continue, implying a gradually more urban and less rural/agricultural environment. It is important to mention that historically, new cities have appeared, such as Westmoreland in 1940, and Heber, Niland, and Seeley in the 1970s. Complementing the growth of old cities, more new cities may be expected in the 21st century.

The spatial distribution of population (see **Map 3-1**) shows the concentration of population in the major cities of Calexico, El Centro, and Brawley, with mostly sparse population in the agricultural areas of the Imperial Valley. The higher population in the agricultural areas east of Calipatria and north and east of Imperial are due mostly to prisons located in agricultural areas. The population concentrations within the cities vary, with El Centro having the heaviest concentration in its center, Brawley in the north and southwest, and Calexico evenly and heavily concentrated throughout.

As seen in **Table 3-2**, the municipios of Mexicali and Tijuana grew yearly by 3.63 and 5.84 percent from 1950 to 2000. The city of Mexicali grew from a 1950 level of 64,658 to 549,873 in year 2000 at a yearly rate of 4.28 percent. The city of Tijuana grew from 1950 population of 59,950 in 1950 to 1,148,681 in year 2000 at an annual rate of 5.91 percent. Mexicali Municipio grew 150 percent more rapidly than Imperial County during this period, and Tijuana Municipio even faster. For Baja California and its municipios in the 1990s, the absolute population addition equaled about 60 percent of 1990 population (see **Table 3-3**). Imperial County pales compared to Mexicali. In particular, the absolute increment of 245,954 new Mexicali residents in the 1990s was double the total Imperial County population mid-decade. This disproportionate change on both sides is likely to continue, as discussed under population projections.

Table 3-2. Population of Tijuana and Mexicali, 1950-2000

Year	Total Population Tijuana	Total Population Mexicali
1950	65,364	124,362
1960	165,690	281,333
1970	340,583	396,324
1980	461,257	510,664
1990	747,381	601,938
1995	991,592	696,034
2000	1,210,820	764,602

Sources: INEGI, Baja California, Resultados Definitivos VII, VIII, IX, X y XI Censos, *Generales de Poblacion y Vivienda 1950, 1960, 1970, 1980 y; 1990*
For 1995: INEGI, Baja California, Resultados Definitivos:Tabulados Basicos. Conteo de Poblacion Vivienda, 1995
For 2000: INEGI. Estados Unidos Mexicanos, XII Censo General de Poblacion y Vivienda, 2000.

Table 3-3. Population of Baja California State and Municipios, 1990-2000

	Mexicali	Tecate	Tijuana	Playas de Rosarito	Ensenada	Baja California
1990	518,648	44,449	639,451	26,696	259,379	1,202,548
1995	696,034	62,629	991,592	46,596	315,289	2,112,140
2000	764,602	77,795	1,210,820	63,420	370,730	2,487,367
Population Growth 1990-2000	245,954	33,346	571,369	36,724	111,351	1,284,819
Annual Growth Rate 1990-2000	3.9	5.6	6.4	8.7	3.6	7.3

Source: INEGI, 1992, 1996, 2002

Since Mexicali's energy and water also supply the municipios of Tecate, Playas de Rosarito, and Ensenada, their demographic growth needs to be considered as well. Their urban population located in the north part of the state, well within reach of the water and energy distribution networks that stem from Mexicali. In the 1990s, these three municipios grew and the rapid rates of Tijuana and Mexicali. Combined, they grew by 181,421 persons, at an yearly rate of 4.4 percent.

The enormous 1990s growth caused Tijuana and Mexicali to leapfrog upwards in the Mexican national rankings of cities. In 1990, Tijuana and Mexicali ranked 7th and 19th respectively. In 2000, they moved up to 6th and 8th. They now are among the biggest cities in the nation, only exceeded substantially by Mexico City, Guadalajara, Monterrey, and Puebla, and in a group along with Ciudad Juarez, Leon, and Culiacan (Pick and Butler, 1994; INEGI, 2001). Likewise, in parallel with its major cities, the state of Baja grew rapidly during the 1990s – the second most rapidly growing among Mexico's 32 states at a rate of 4.04 percent. During the decade, it moved up in state size rankings from 19th to 15th (INEGI, 2002).

Population Projections

An objective of this study to project the regional population from 2000 to 2020. As discussed in Chapter 1, although present water and energy supplies may be adequate, the rapid population growth of the region may overwhelm them. This section does not consider water and energy linked to population, but focuses mainly on demographic projections and what they signify. In Chapters 9 and 10, the economic and environmental implications of the population increase will be evaluated and discussed.

Extensive population projections are available from county planning agencies and academic sources. Thus, we did not perform our own projections. Instead, we utilized three fairly recent projection series by other groups, adjusting two of them for the results of the 2000 censuses (Peach and Williams, 1999; SANDAG, 1998; SCAG, 2002). This section explains briefly the assumptions of those projections and indicates how we performed the year 2000 census adjustment. Later, the chapter covers the implications of the combined projections for the region.

Peach and Williams (1999) utilized a cohort-component methodology. This means that births, deaths and migration rates are estimated by 5 year age groups and by gender. The 1990 and 1995 Mexican census data were utilized. Age-specific migration rates were determined by residual estimation, which subtracts the 1990 age-specific projections to 1995 in absence of migration from the 1995 actual age-specific population. We refer to their medium project series, which assumes that migration rates fall to 75 percent of 1990-1995 during 1995-2000 and fall to 50 percent for 2000-2020. Mexican age-specific death rates are assumed to trend downwards slightly from 1995 to 2000 and then held constant 2000-2020. The standardized, but not age-specific, fertility rates for 1995 are held constant for 1995-2020 projection period. This method has the following weaknesses: (1) the fertility does not take account the age structure, which has some substantial irregularities in the present and future fertile age ranges of ages 10 through 35 (INEGI, *Anuario of Baja California*, 2001). Second, the age-specific migration rates are calculated based on a five year period that may not be representative economically of what will occur 2000-2020. However, this is understandable since age-specific fertility rates for the state are not reliable and an economic model of migration is difficult to build due to lack of consistent and accurate data. This type of projection may be an appropriate one, given the Mexican data.

Both the San Diego Association of Governments (SANDAG) and Southern California Association of Governments (SCAG) projections are based on models, which combine cohort-component demographic methods with an econometric model for the county or multi-counties (SANDAG, 1999; SCAG, 2002). SCAG is responsible for overall planning in six southern California counties, including Imperial County but not San Diego. SANDAG provides the planning for San Diego County. For SCAG and SANDAG, an econometric model determines the migration rates depending on the economic conditions for jobs in the labor force. Over the projection period, the SCAG model assumes gradually reducing fertility, based on the U.S. Census middle series of projections. Starting mortality rates are based on the California life expectancies from the State of California, which are projected by the rates of change in the U.S. Census middle series of projections. The SANDAG model assumes the fertility rates for non-Hispanics from the U.S. Census middle series of projections and that the Hispanic standardized fertility declines by 15 percent from 1995 to 2020. For death rates, it uses the trends in California life expectancy from the State of California Department of Finance, to compute mortality rates. The SANDAG and SCAG econometric models to project migration are somewhat different and are adaptive to regional features. SCAG has a separate Imperial County model based on a set of economic assumptions that differ from its other five counties. There is not time in this report to discuss in detail the differences between these two models (see SANDAG, 1999; SCAG, 2002). However, they are considered similar enough to utilize the two models in parallel.

The projections from SCAG were based on starting population data from the 2000 U.S. Census of Population. By contrast, the SANDAG and Peach-Williams Mexico projections were based on 1990 U.S. Census and 1995 Mexican Census population data respectively. Hence, we adjusted the SANDAG and Peach/Williams projections as follows for San Diego, Mexicali, and Tijuana. We utilized the projection series, but adjusted the year 2000-projected value by a constant multiplier that adjusted it to the actual census figure. Then we applied that constant multiplier to the subsequent projected values. This adjustment was downwards by 3.8, 4.0, and 4.5 percent for San Diego, Mexicali, and Tijuana respectively (see **Table 3-4**). Since the SCAG projection did not provide a 2005 projected figure, we used exponential interpolation to estimate that value.

The projection results (see **Table 3-4**) point to sustained growth for the whole region that corresponds to long-term historical trend lines. San Diego County demonstrates continuing rapid increase but with some deceleration. The other three county/municipios have unabated rapid increase. The average forecast yearly growth rates for Mexicali and Tijuana are 2.20 and 3.77 percent respectively, which are lower than their rates for the 1990s. Imperial County's average forecast growth rate of 2.27 percent is also somewhat lower that its 2.6 percent growth in the 1990s. The continued rapid growth over the 20 years comes from both immigration, fertility, and population momentum, i.e. growth that has been "built-in" to the age structure, ready to be released. The forecast absolute increment in Imperial County's population over the two decades is 81,639, and for Mexicali is 422,037. The effect will be to create a border city complex that is even more skewed towards the Mexican side – it is estimated to reach a ratio of over 5:1. This will tend to place Imperial County in a more subsidiary economic position relative to its much larger Mexican sister city.

The forecast 20-year absolute population increments for San Diego and Tijuana are 865,971 and 1,416,551 respectively. This prospective absolute growth of 2.3 million will exert much greater water and energy strain on Imperial County and Mexicali Municipio, which will be looked to as the primary water sources for both San Diego and Tijuana and the primary energy source for Tijuana. This point is considered further in Chapters 8 and 9. The year San Diego-Tijuana sister city complex has a 2020 forecast total population of 6.25 million. This will place it slightly larger in size than today's Philadelphia metropolitan area and somewhat smaller than present-day San Francisco-Oakland-San Jose.

Table 3-4. Population Projections for Imperial and San Diego Counties and Mexicali and Tijuana Municipios, 2000-2020

	Actual Populations		Projected Populations						
	1990	2000	2000	2005	2010	2015	2020	Percent Growth 2000-2020	Annual Growth Rate 2000-2020
Imperial County	109,303	142,361	142,361	160,965	182,000	203,000	224,000	57.3	2.27
San Diego County	*2,511,400*	*2,813,833*	*2,946,500*	*3,223,500*	*3,437,700*	*3,634,000*	*3,853,300*	30.8	1.34
San Diego County (Adjusted)	*2,511,400*	*2,813,833*	*2,813,833*	*3,078,361*	*3,282,917*	*3,470,378*	*3,679,804*	30.8	1.34
Mexicali Municipio	*601,938*	*764,602*	*794,444*	*893,876*	*1,000,684*	*1,113,609*	*1,232,953*	55.2	2.20
Tijuana Municipio	*747,381*	*1,210,280*	*1,260,121*	*1,532,687*	*1,855,867*	*2,235,062*	*2,676,672*	112.4	3.77
Mexicali Municipio (Adjusted)	*601,938*	*764,602*	*764,602*	*860,299*	*963,095*	*1,071,778*	*1,186,639*	55.2	2.20
Tijuana Municipio (Adjusted)	*747,381*	*1,210,280*	*1,210,280*	*1,472,065*	*1,782,463*	*2,146,660*	*2,570,803*	112.4	3.77
Total - 2 U.S. counties (Adjusted)	*2,620,703*	*2,956,194*	*2,956,194*	*3,239,326*	*3,464,917*	*3,673,378*	*3,903,804*	32.1	1.39
Total - 2 Mexico municipios (Adjusted)	1,349,319	1,974,882	1,974,882	2,332,364	2,745,558	3,218,438	3,757,442	90.3	3.22
Total - All 4 counties and municipios (Adjusted)	3,970,022	4,931,076	4,931,076	5,571,690	6,210,474	6,891,816	7,661,246	55.4	2.20

Note: The adjustments are to adjust the year 2000 starting population by the actual U.S. and Mexican census counts.

Note: Year 2005 forecast population for Imperial County was exponentially interpolated.

Sources: Mexicali and Tijuana, Peach and Williams, 1999; Imperial County, SCAG, 2002; San Diego, SANDAG, 1998

The urban issues faced by this much larger urban complex will far exceed those of water and energy that are included in this project. They will also include housing, transportation, infrastructure, crime and public safely, and governance. Although beyond the scope of this project, they need to be addressed in further research and long-range planning.

It is also important to foresee Imperial County in 2020 having a forecast population of only 224,000 and located within a 4 county/municipio region of 7.66 million. Yet, it will likely continue to control most of the region's available water supply and will provide a significant energy capacity. This will be returned to in Chapter 8.

Other Demographic and Socioeconomic Characteristics

This section examines other population and socioeconomic characteristics of Imperial County and Mexicali including demographic components of change, migration, age structure, ethnicity and language, education, and housing. They are sometimes compared to San Diego, California and the U.S., as well as to Tijuana, Baja California, and Mexico.

The basic demographic indicators for Imperial County are significantly different from San Diego and California. As seen in **Table 3-5,** Imperial County historically had higher fertility than California (Butler and Pick, 1982). This continues today, e.g. year 2000 gross fertility rates are 14 percent higher than for California. This is explained by the county's elevated Hispanic proportion, much higher than California's. The Hispanic population is known to have higher fertility than non-Hispanic. The County's younger average age by 2.3 years than the state is linked to higher fertility rate. The spatial distribution of standardized fertility appears in **Map 3-2**, which shows the child/woman ratio, or the ratio of population under 5 years to women age 15 to 49. Standardized fertility is seen to be highest near the centers of the cities and low in most of the agricultural valley areas. This County fertility located more in the interior of the cities is contrasted with Mexicali and Tijuana, which tend to have fertility concentrated in the city peripheries (Pick at al., 1999b, 2000c, 2001).

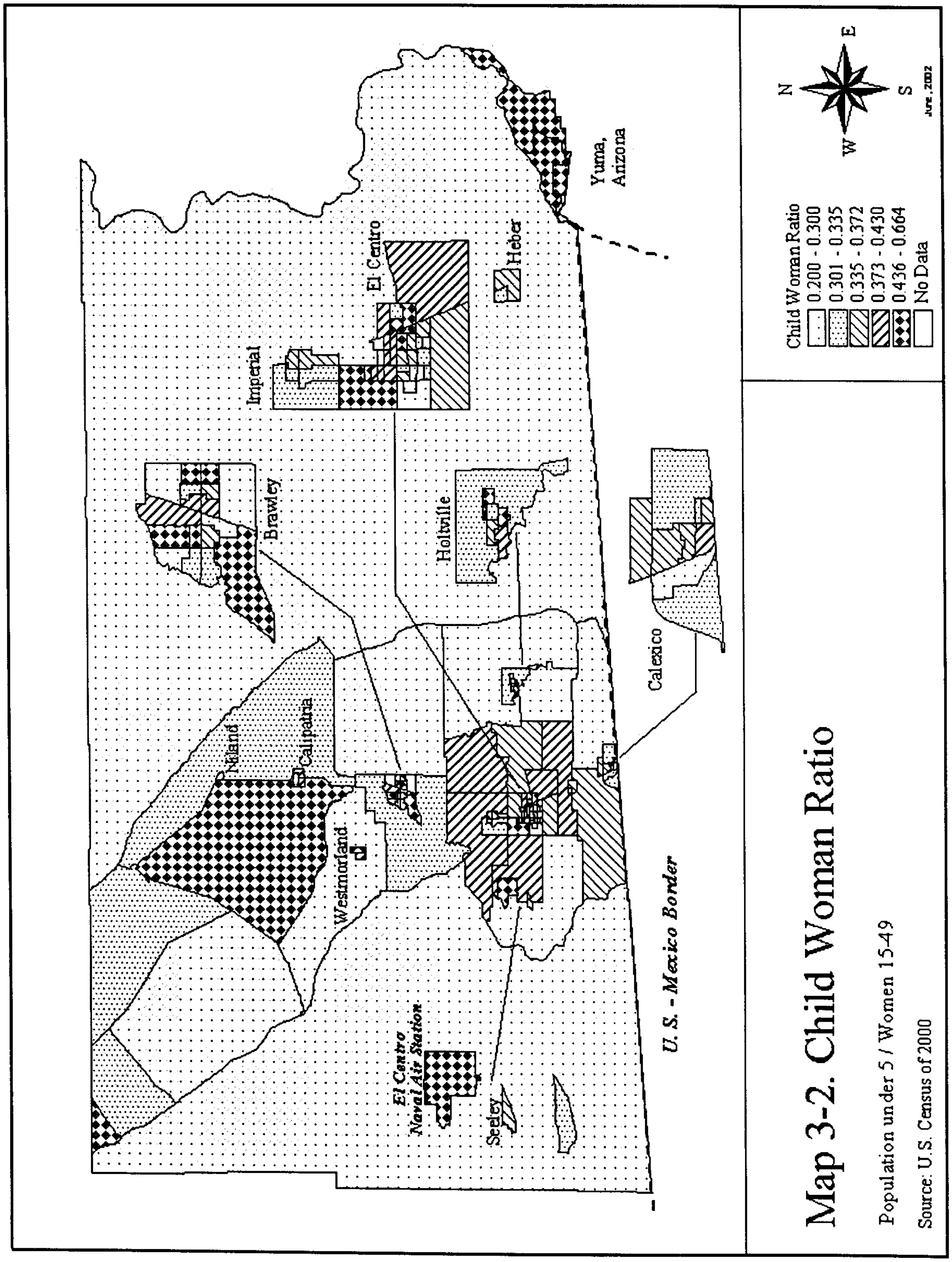
Table 3-5. Demographic Indicators for the U.S., California, and Imperial County, 2000

Variable	U.S.	California	Imperial County
Median Age	35.3	33.3	31.0
Gender Ratio	0.962	0.992	1.093
Dependency Ratio	0.598	0.593	0.675
Gross Birth Rate (Births /1000 Persons)	14.80	15.80	18.07
International Migration Rate (International Migrations /1000 Persons)	2.9	4.5	5.1
Gross Mortality Rate (Deaths / 1000 Persons)	8.50	6.77	NA
Rate of Infant Mortality	7.1	5.7	NA

Sources: NCHS, 2002; California Department of Finance, 2002

A related but somewhat different indicator is the proportion of households that consist of married couples with children less than 18. This represents childbearing units that have had fertility over the past 18 years. As seen in **Map 3-3,** married couples with children are most heavily concentrated in the peripheries of the three major cities and in agricultural areas in the center of the Imperial Valley surrounding El Centro and Imperial. This can be regarded as an early sign of "suburbanization" of older and somewhat more affluent married households. These families with children do not elect to live in the city centers but prefer to commute for some distance, which however, is a much shorter commute distance than in large urban areas. This tendency has some long-range import for this study, since those larger and more affluent households would consume more residential energy and water.

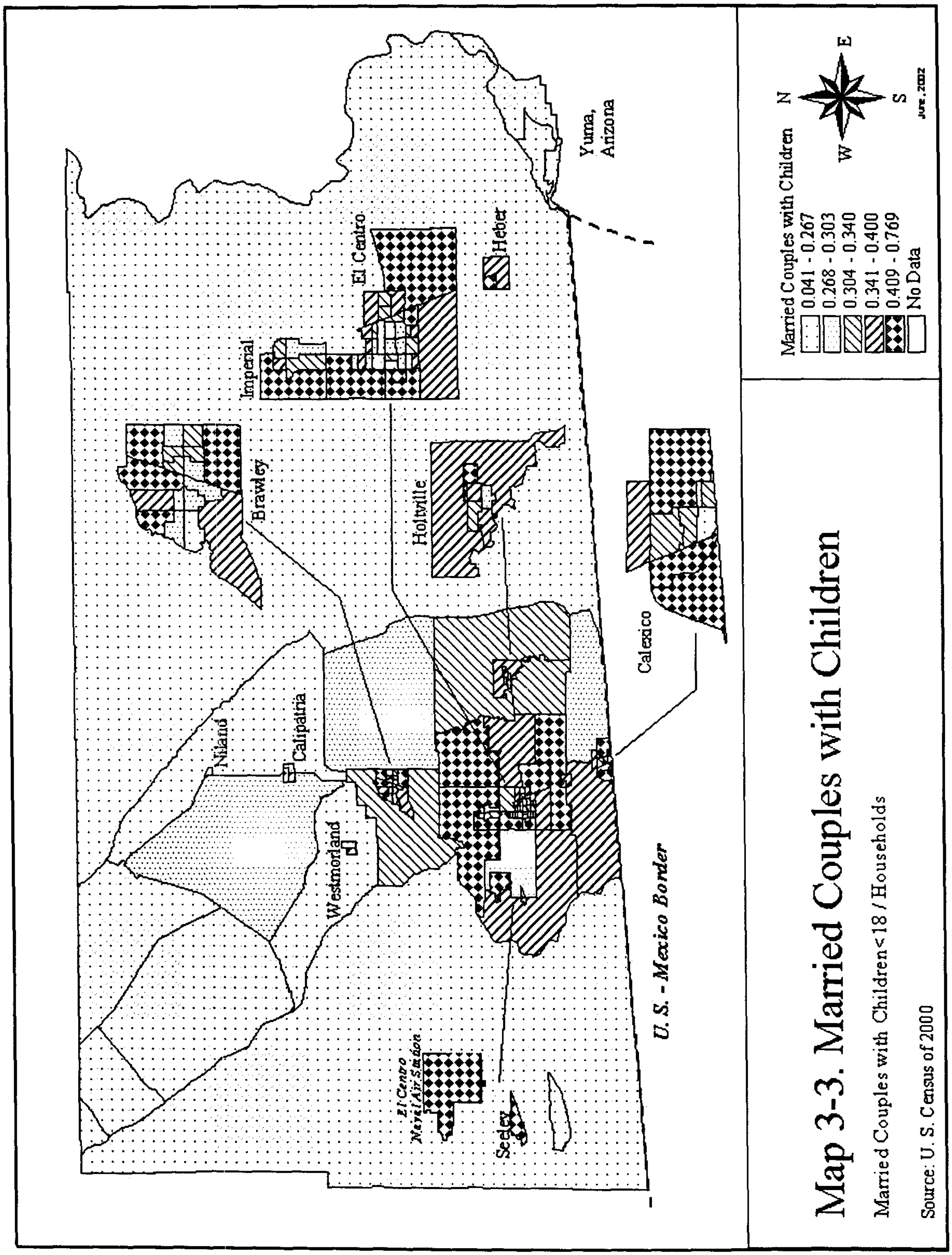
Imperial County is younger than California and the U.S. and it has a higher dependency ratio. As seen in **Table 3-5**, it is 2.3 years younger than California, the result of higher fertility and the migration of younger age persons. Dependency ratio is ratio of children (less than 17 years) and elderly (over 65 years) to the working age population (18-64 years). It indicates relative dependency versus work-readiness of a population unit. Imperial County's dependency ratio of 0.675 is 14 percent higher than the state's. **Map 3-4** indicates that, like standardized fertility, dependency ratio is high in the interior parts of cities. Similar to fertility, this contrasts with Mexicali and Tijuana, which have high dependency ratios in their peripheries (Pick at al., 1999b, 2000c, 2001). In parts of the agricultural Imperial Valley, dependency ratio is low mostly but high in its southeast and northeast valley sections. It is also high in the northern and eastern flanks surrounding the Imperial Valley, which may relate to concentrations of elderly persons.

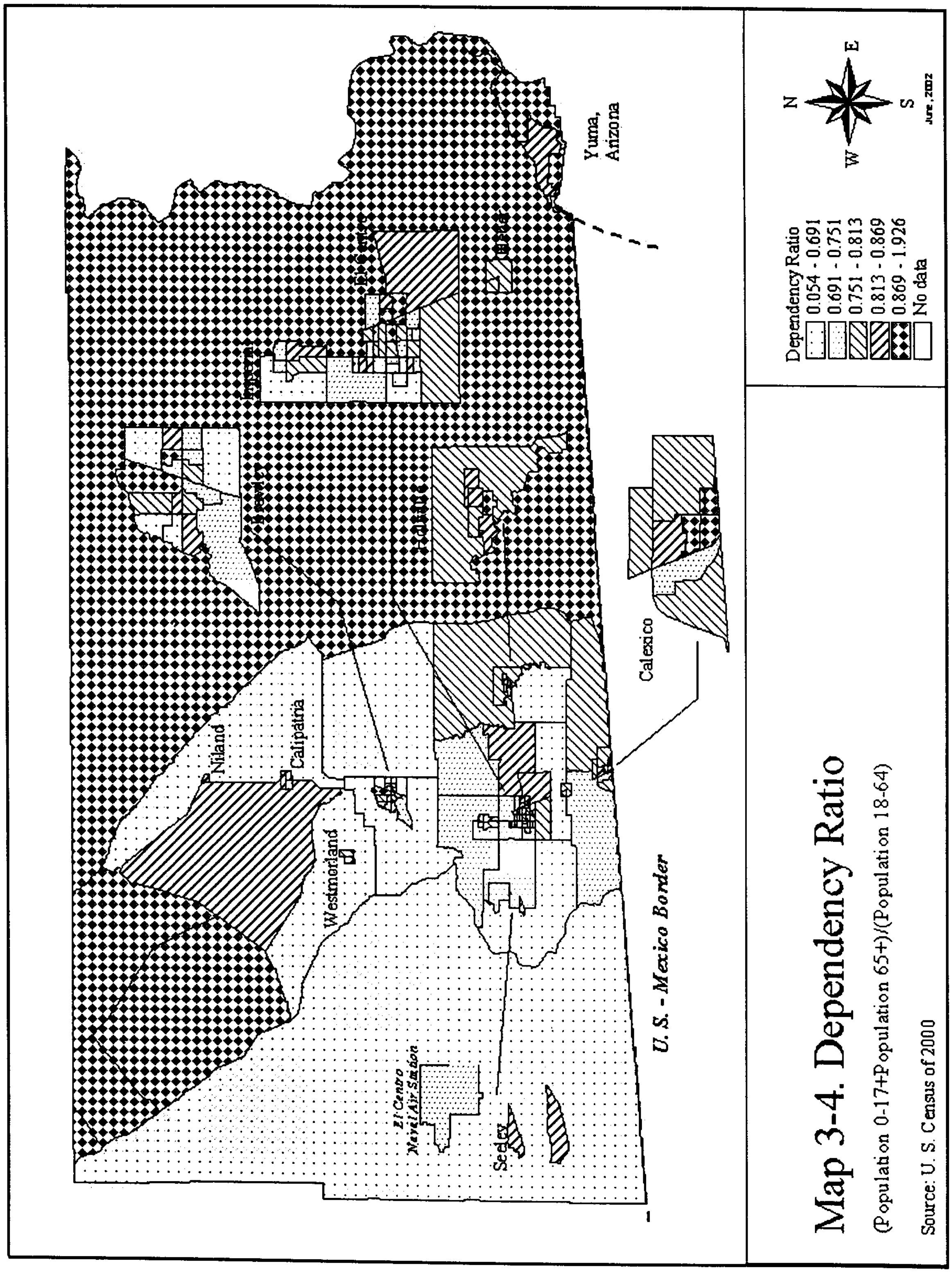


Map 3-2. Child Woman Ratio

Population under 5 / Women 15-49

Source: U.S. Census of 2000


Map 3-3. Married Couples with Children
Married Couples with Children<18 / Households
Source: U. S. Census of 2000
Married Couples with Children
0.041 - 0.267
0.268 - 0.303
0.304 - 0.340
0.341 - 0.400
0.409 - 0.769
No Data
N
E
S
W
Yuma, Arizona
Heber
El Centro
Imperial
Brawley
Holtville
Calexico
Niland
Calipatria
Westmorland
El Centro Naval Air Station
Seeley
U. S. - Mexico Border



Map 3-4. Dependency Ratio

(Population 0-17+Population 65+)/(Population 18-64)

Source: U. S. Census of 2000

Another remarkable demographic feature of Imperial County is its high gender ratio of 109, implying that there are nine percent more males than females. Historically, the county's gender ratio was 1.90 in 1910, dropping to 1.19 in 1950, and 1.24 in 1970 (Butler and Pick, 1982). Thus, the present ratio is low historically. The year 2000 elevated ratio may be ascribed to the dominance of agriculture in the county economy, which draws in many temporary male workers. As agricultural workforce dropped over the past 100 years, the sex ratio converged towards the state norm.

Recent mortality and infant mortality rates are not available for Imperial County. These rates were lower for California than for the U.S., which reflects its younger age structure than the nation. With respect to components of population change, fertility remains more important than migration. In the year from July 1 of 2000 to July 1 of 2001, Imperial County grew by 1.97 percent, of which 1.81 percent was due to fertility and 0.83 percent to migration, with the remainder being mortality loss (California State Department of Finance, 2002).

In Mexico, demographic indicators are available at the state and national levels, but less so at the municipio level (see **Table 3-6**). However, since Mexicali and Tijuana comprise 83 percent of Baja's population, the state figures are informative about the two municipios. Several indicators stand out as particularly important. First, the state's fertility rate is low – eleven percent beneath the national rate. This is a significant demographic facet of Baja California, that although its cities have grown rapidly, it has been more through migration than fertility. Baja's life expectancy is high nationally, reflecting better access to health services, which was ranked 7th among states, and an overall improved standard of living. The state's crude mortality rates are high, which reflects a younger age structure than for the nation. Its lower nuptiality rate and higher divorce rate than for the nation are characteristics of states that are more advanced economically (Pick and Butler, 1994). International rates of inmigration are lower by 40 percent than for the nation. Although Baja California has been a staging area for Mexicans to emigrate to the U.S., the percent of residents who inmigrated from overseas is low nationally. We presume that the return migrants from the U.S. mostly do not stay in Baja after their return, so they would not be contributing to Baja's rate.

Table 3-6. Demographic Indicators, 1997

Variable	Nation	State	Rank Nationally
Median Age	22.0	22.0	6
Gender Ratio	95.1	98.1	9
Gross Fertility Rate	3.0	2.7	27
Gross Birth Rate (Births/1000 Persons)	23.9	21.2	29
Life Expectancy	73.6	74.5	4
International Migration Rate (International Migrants/1000 Persons)	2.3	1.4	20
Doubling Time	36.9	17.4	31
Gross Nuptiality Rate	7.6	7.2	25
Ratio of Divorce to Marriages	5.8	8.5	8
Median Age of First Union	19.0	19.0	5
Percent Woman Headed Households	16.9	19.4	5
Population with Health Services	40.0	54.2	7
Dependency Ratio	0.7	0.6	20
Gross Mortality Rate (Deaths / 1000 Persons	4.6	4.7	12
Rate of Fetal Mortality	10.1	12.2	6
Rate of Infant Mortality	16.4	21.2	6
Rate of Maternal Mortality	4.7	1.9	32
Gender Ratio of Mortality	128.2	164.7	2

In general, Baja's demographic indicators reflect an economically advanced part of Mexico that has a young age structure stemming more from domestic immigration than fertility. Comparing the two sides of the border, the Mexican side is considerably younger, has higher gross fertility, lower gross mortality, and a lower gender ratio. Not surprisingly, the international migration net flow is substantial and directed from Baja into the U.S.

Migration and nativity underscore major differences on the two sides in mobility and "rootedness." In 2000, Imperial County had 32.2 percent foreign born in 2000, above the state level of 26.2 percent. This contrasts with the slight levels of foreign born of 2 to 3 percent in Mexicali and Tijuana. Since the vast majority of Imperial County's foreign born are from Mexico, this reflects Mexican migration to, and settlement in the county. The same trends to a lesser extent are present for San Diego. Not surprisingly, domestic inter-state migration rates are elevated for San Diego County and Tijuana Municipio. In 2000, nine percent of San Diegoans and 15 percent of Tijuanans came from a different state in the same nation during the past five years. Imperial County's lower interstate immigration is evident at 3 percent. On the other hand, the above mentioned much higher international immigration rates are evident for the U.S.

counties versus Mexican municipios. What stands out in all of this is the Mexican internal migration flow to the border and the cumulative inflow of Mexicans to the U.S. border counties. Both of these tendencies have contributed to the region's rapid regional population increase already nated.

In age structure, Baja California and its municipios are younger than Imperial County and California. This is due to long-term outcomes of its higher fertility, which is known to result eventually in a younger age structure. As seen in **Table 3-7**, Baja California versus California had 13 percent more children and adolescents and seven percent fewer elderly. However, there is some convergence of these differences in comparing Imperial County and Mexicali, Mexicali had only 9 percent more younger age people and five percent fewer elderly. The convergence makes sense due to the County's high Mexican nativity and migration from Mexico. The age structure differences need to be considered in assessing water and energy needs to satisfy Mexican and U.S. demand. The water and energy utilization and consumption patterns by different age group need to be identified and applied in planning

Table 3-7. Age Structure of California and Baja California, 2000

Age Category	California		Baja California	
	Population	Percent	Population	Percent
0-19	10,234,571	30	976,478	43
20-64	20,041,419	59	1,216,792	53
65+	3,595,658	11	86,281	4
Not Specified			207,816	
Total	33,871,648		2,487,367	

Source: U.S. and Mexican Census of 2000

In ethnic distribution, Imperial County had a very high Hispanic proportion long before it became widespread in the state. In 1950 California had 4.1 percent of population of Mexican origin, compared to Imperial County's 37.1 percent (U.S. Census of 1950, cited in Butler and Pick, 1982). By contrast, in the 2000 U.S. Census, Imperial County had 72.2 percent Hispanic, as compared to 32.4 percent Hispanic for the state (see **Figure 3-1**). Imperial County is among the highest of California counties in percent Hispanic. Within Imperial County, Calexico, with close proximity to the border, is 95 percent Hispanic. Nearly all the county's cities are over 70 percent Hispanic (see **Figure 3-1 and Table 3-8**). Calipatria's 57 percent rate is due to its large state prison population, which is drawn statewide and thus is not representative of the county. The spatial distribution of Hispanic population shows it more heavily concentrated in the south central part of the county that includes the cities of Imperial, El Centro, Heber, and Calexico (see **Map 3-5**). Especially high at over 90 percent are the northeastern parts of Brawley and El Centro, Heber, and Calexico. Areas of "low" Hispanic ethnicity, i.e. under half, are concentrated in the southwest of El Centro, northwest and southeast of Brawley and agricultural areas in the north of the county. Generally, the Hispanic ethnicity is proportional to closeness to the border and to Mexicali.

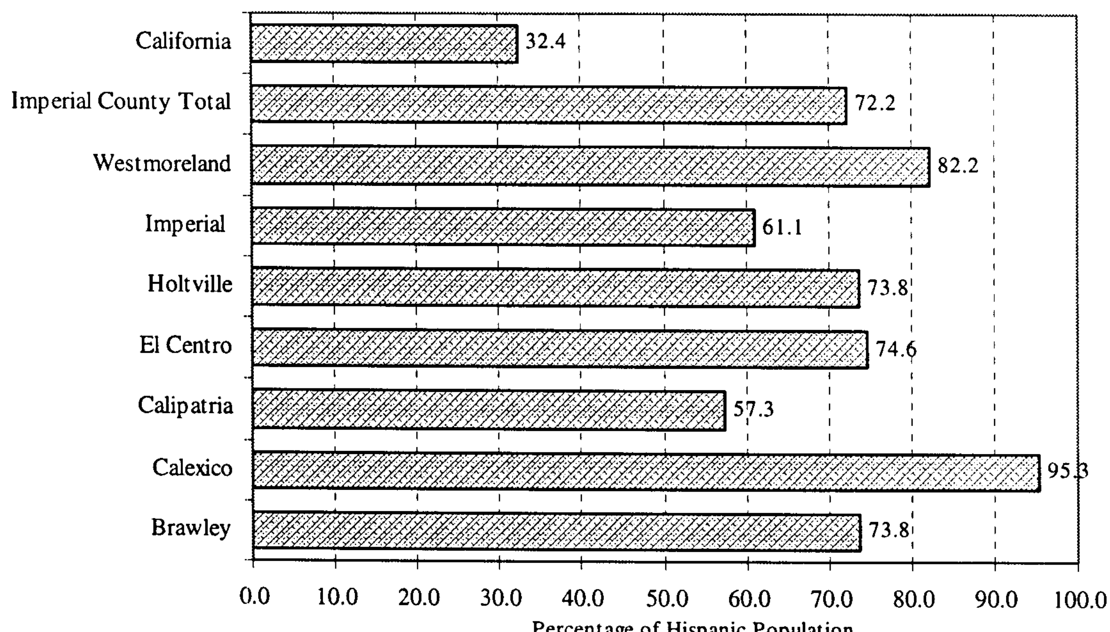
It is interesting to consider by contrast the spatial location of Imperial County's second largest ethnic group, African Americans. In 2000, the county population included 5,624 African Americans, or 4.0 percent. As seen in **Map 3-6**, the black population is mostly located in the cities of El Centro Imperial, and Brawley. There are also high percentages of African American population in certain agricultural and flanking areas. This may be partly due to the presence of the El Centro Naval Air Station and institutional population particularly state prisons in those areas.

Table 3-8. Race and Ethnicity, Calexico, Brawley, El Centro and California, 2000

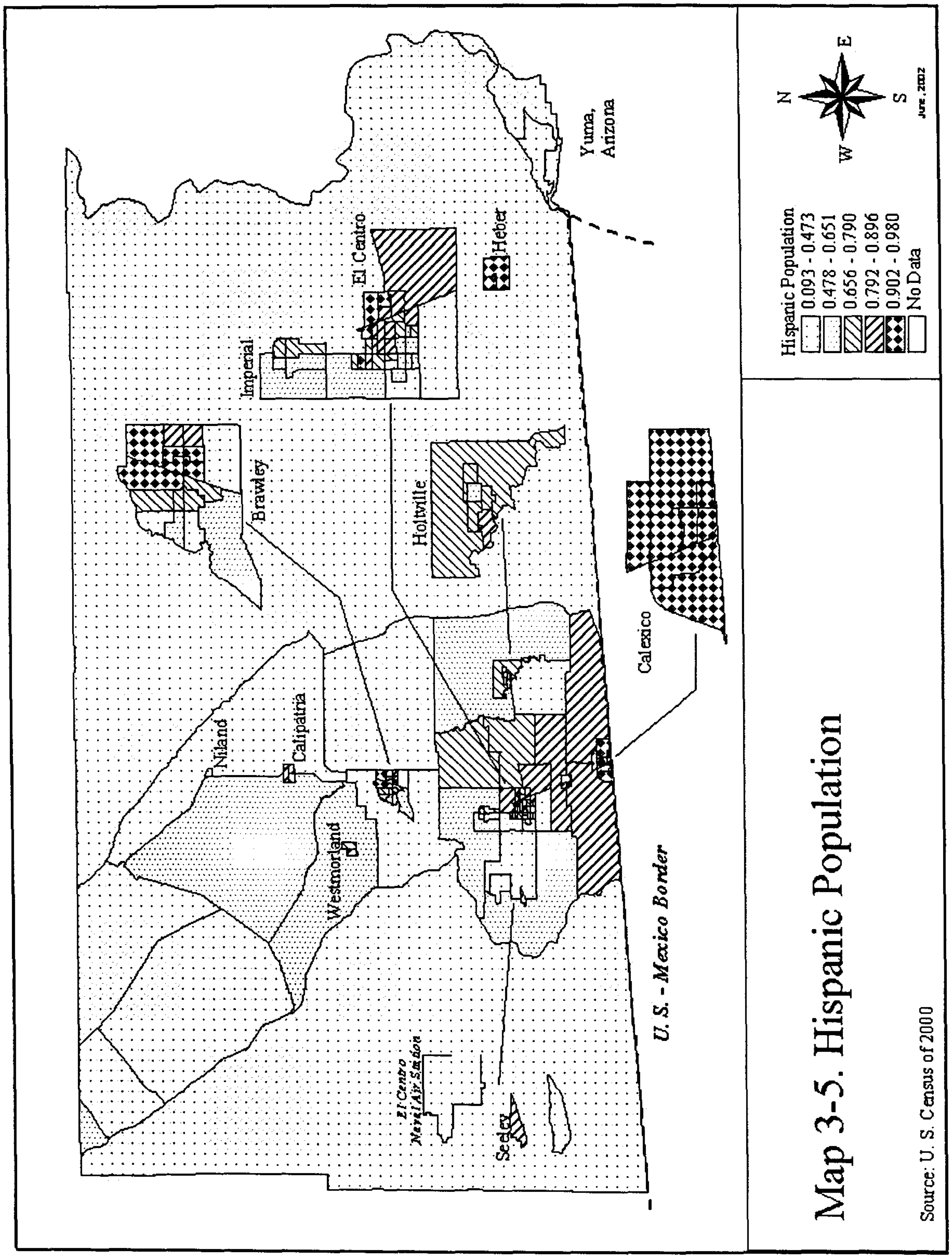
	Calexico	Brawley	El Centro	California
Race				
White	46.6	56.4	74.6	63.4
Black	0.5	2.8	3.5	7.4
Asian	1.8	2.1	4.1	12.3
Some Other Race	47	41.3	17.8	19.4
Hispanic or Latino Race	95.3	73.8	74.6	32.4
Total Population	27,109	22,052	37,835	33,871,648

Source: U.S. Census, 2002

Figure 3-1. Percentage of Hispanic Population in Imperial County and Its Cities, 2000

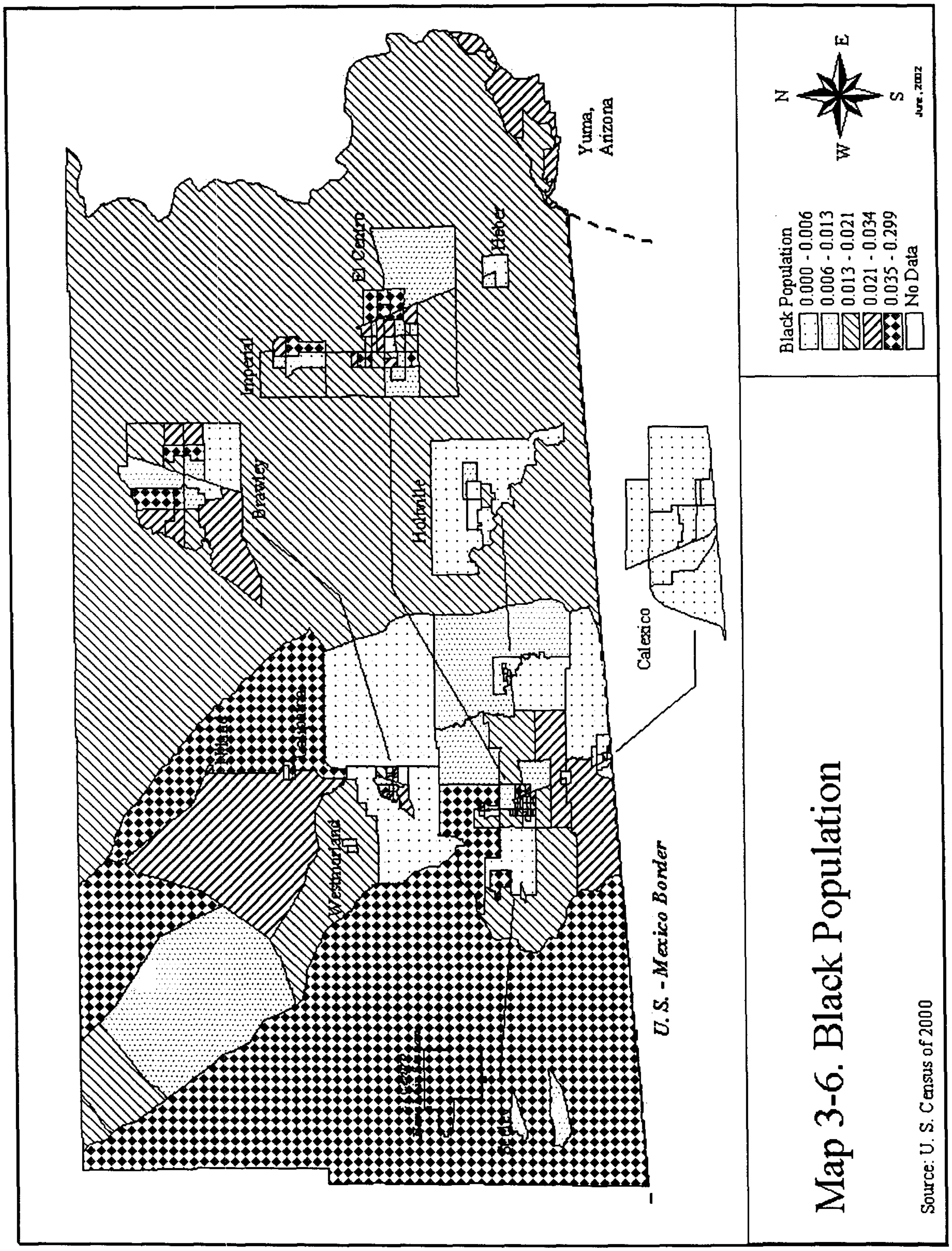


Source: U.S. Census, 2002



Map 3-5. Hispanic Population

Source: U. S. Census of 2000



Map 3-6. Black Population

Source: U. S. Census of 2000

Language patterns in the region point to English with substantial Spanish on the U.S. side of the border and Spanish backed up by English on the Mexican side. In 2000, in additional to almost 100 percent English speaking, Imperial County was two thirds Spanish speaking, versus 26 percent for California (see **Table 3-9**). This bilingual capability is very encouraging to cross-border collaboration including on water and energy, so it is surprising that more inter-governmental planning and cooperation has not occurred. The potential for cooperate is discussed later.

Table 3-9. Languages Spoken. Imperial County, California, Mexicali Municipio, Baja California

Census Attributes	Imperial County	Calexico City	California	Mexicali Municipio	Tijuana Municipio	Mexico
U.S. Census Attribute				NA	NA	NA
English Only	32.2	5.9	60.5	NA	NA	NA
Spanish	65.3	94.1	25.8	NA	NA	NA
Other Non-English Languages	2.5	-	13.7			
Mexican Census Attribute						
Spanish Only	NA	NA	NA	98.3	97.5	92.4
Indigenous Language	NA	NA	NA	0.9	1.4	7.1
Not Specified	NA	NA	NA	0.8	1.1	0.4

NA = does not apply.

Note: the percentages are for population 5+

Source: U.S. Census, 2002; INEGI, 2001.

While the Mexican side has nearly complete Spanish fluency, only one percent of Baja's population speaks an indigenous language. Not available in the Mexican census or any of INEGI's publications is the percent of border population who speak English. It is likely to be much higher in the border region than nationally, perhaps over 25 percent, and constitutes an important cultural linkage between the two sides.

Imperial County historically trailed the state in educational level (Butler and Pick, 1982). This was evident again for the 2000 U.S. Census. As seen in **Table 3-10**, the county's percent of college graduates is 6.6 percent versus 18.7 percent in San Diego. Likewise, the county's college enrollment trails San Diego 18.3 percent to 29.2 percent. In graduate and professional degree holders, Imperial County has only 4 percent versus 10 percent in San Diego. These disparities are sharp, and reflect the county's poor economy and low standard of living. It is not surprising that some of the county decision-makers' hopes and dreams for technology and service enterprises have not been realized with such a low educated population. Another historical facotr has added to this differential has been the outmigration of many more educated residents. They have sought greater opportunities appropriate to their educational credentials.

Table 3-10. Educational Levels, Imperial County, San Diego County, Mexicali, Tijuana

Percent	Imperial County	San Diego County	Mexicali Municipio	Tijuana Municipio
High School Enrollment, pop 3+	26.4	19.3	NA	NA
College Enrollment, pop. 3+	18.3	29.2	NA	NA
High School Graduate	22.0	19.9	14.0	10.7
College Graduate	6.6	18.7		
Graduate or Professional Degree	3.70	10.90	14.42	10.65

Note: high school and college graduates for pop 25+ in U.S. and pop. 15+ in Mexico
graduate or professional graduates for pop 25+ in U.S. and pop. 18+ in Mexico
Sources: U.S. Census, 2002; INEGI, 2001

South of the border, Mexicali and Tijuana have high levels of education for Mexico, with about 12 percent high school graduates and 12 percent holding a graduate or professional degree (INEGI, 2001). The definition of "graduate or professional degree" is different in Mexico. It does not connote as high an educational level as the equivalent U.S. Census designation, Nevertheless, Baja is one of Mexico's most educated states. Its advanced position in Mexico leads to more educational comparability on the two sides of the border that can foster academic, business, and industry interchanges. The region has not realized this potential up to this point, but it may be possible in the next twenty years. It is pertinent to this study, i.e. that cooperation could build in planning, researching, and developing energy resources.

This section describes the overall housing stock in Imperial County and Mexicali and then focuses on housing construction on the Mexican side. The Mexican Census is particularly rich in information on housing construction. Housing is influential with energy, because its prevalence and construction can influence greatly energy efficiency and losses (de Buen, 1993).

In 2000, Imperial County had 43,891 housing units. These were 52 percent owner-occupied, and were somewhat smaller in room size than for California, although room sizes have become steadily larger since 1950 (see **Table 3-11**). Spatially, the owner-occupied housing units are concentrated in more affluent, peripheral parts of the major cities and in the center of the Imperial Valley surrounding Imperial and El Centro (see **Map 3-7**). In some of these small areas, the proportion of owner-occupied units exceeded 75 percent. Renting was more prevalent in poorer, mostly interior parts of the major cities.

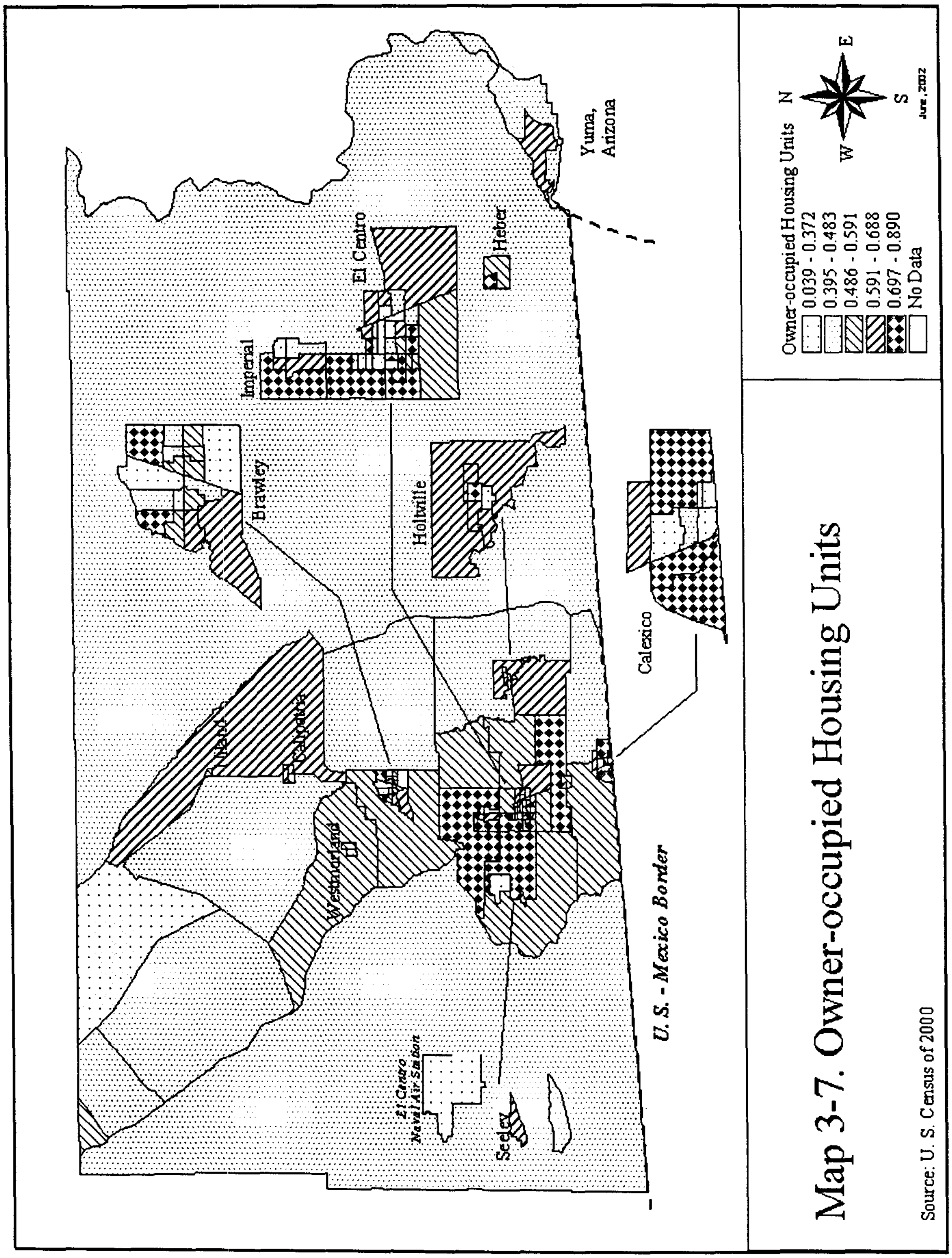
Table 3-11. Characteristics of Housing Units in Imperial County, 1950-2000

	Imperial County 1950	Imperial County 1970	Imperial County 2000	California 2000
Housing Units	17,904	23,401	43,891	12,214,549
Percent Owner Occupied	43.8	51.9	52.3	53.6
Percent Renter Occupied	48.4	37.8	37.4	40.6
Percent Vacant Year Round	5.9	9.2	10.3	5.8
Number of Rooms				
1-2 Rooms (Percent)	24.6	10.4	15.7	14.4
3-4	40.5	39.2	34.0	29.5
5-6	24.8	40.1	36.4	35.4
7+	5.1	9.2	13.9	20.7
Median Household Size per Unit	3.2	3.2	3.3	2.9

Source: U.S. Census of 2000

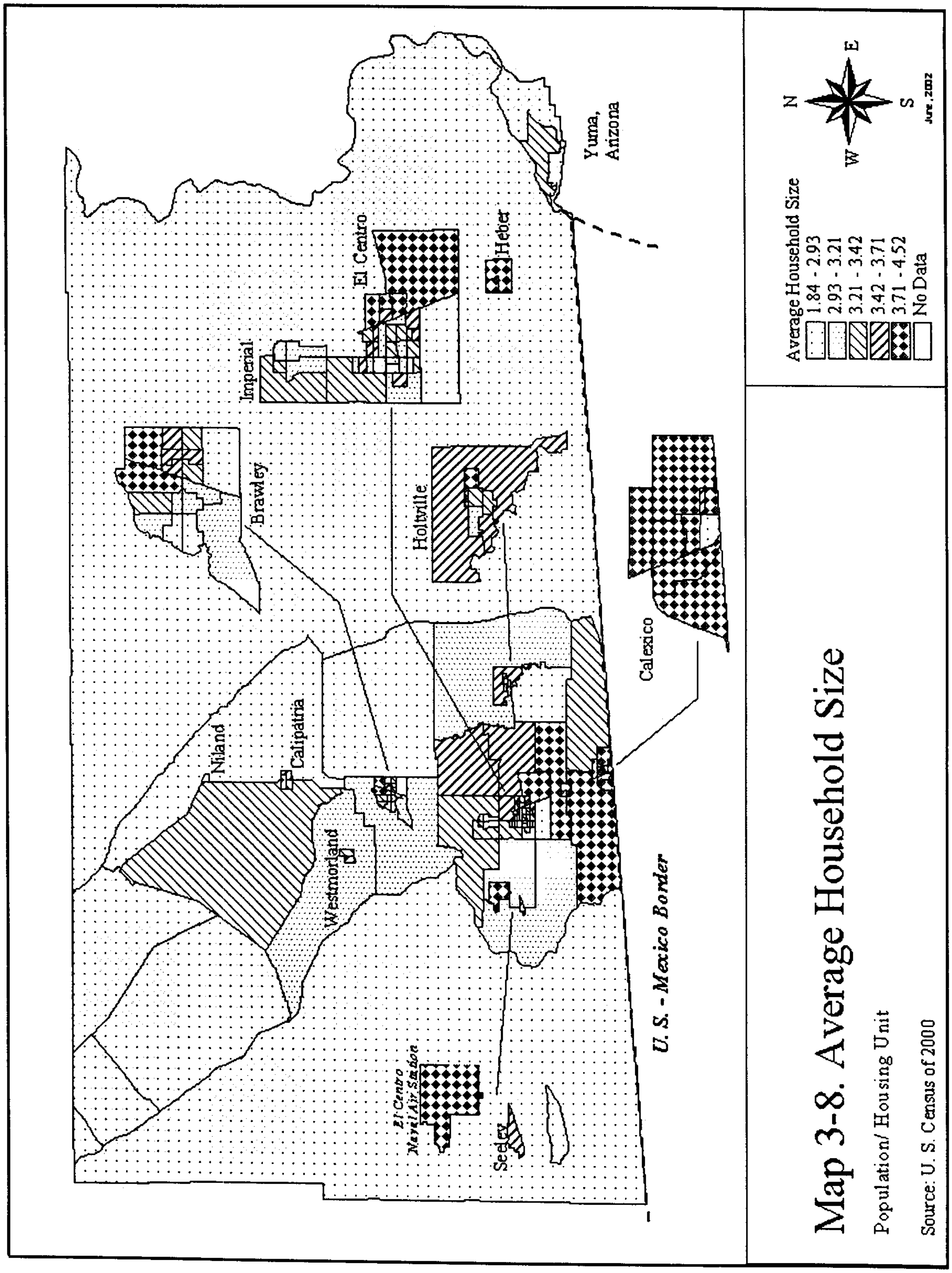
Average household is linked to prior fertility rates and migration, as well as to income. It serves as an indicator of crowding. As seen in **Map 3-8,** crowded households tend to be located nearer to the border, in Calexico, Heber, southeast El Centro and the agricultural areas between El Centro and Calexico. This is associated with the higher fertility present in the center and south of the Imperial Valley and its cities (see **Map 3-2**), as well as with the migratory influence of Mexicali i.e. there may be temporary or longer-term migrants including some Mexican citizens living in households in these areas. Broadly speaking, this indicator reflects the growing social influence of Mexicali in Imperial County.

The County's 7,300 new housing units in the 1990s were mostly added in the cities of Calexico, El Centro, and Imperial. These are the two major county population centers and comprise the centers of government and retail commerce. It is curious that, although Calipatria grew the most in population, it was largely due to a new prison, so few housing units were added (see **Table 3-12**).



Map 3-7. Owner-occupied Housing Units

Source: U. S. Census of 2000



Map 3-8. Average Household Size

Population/ Housing Unit

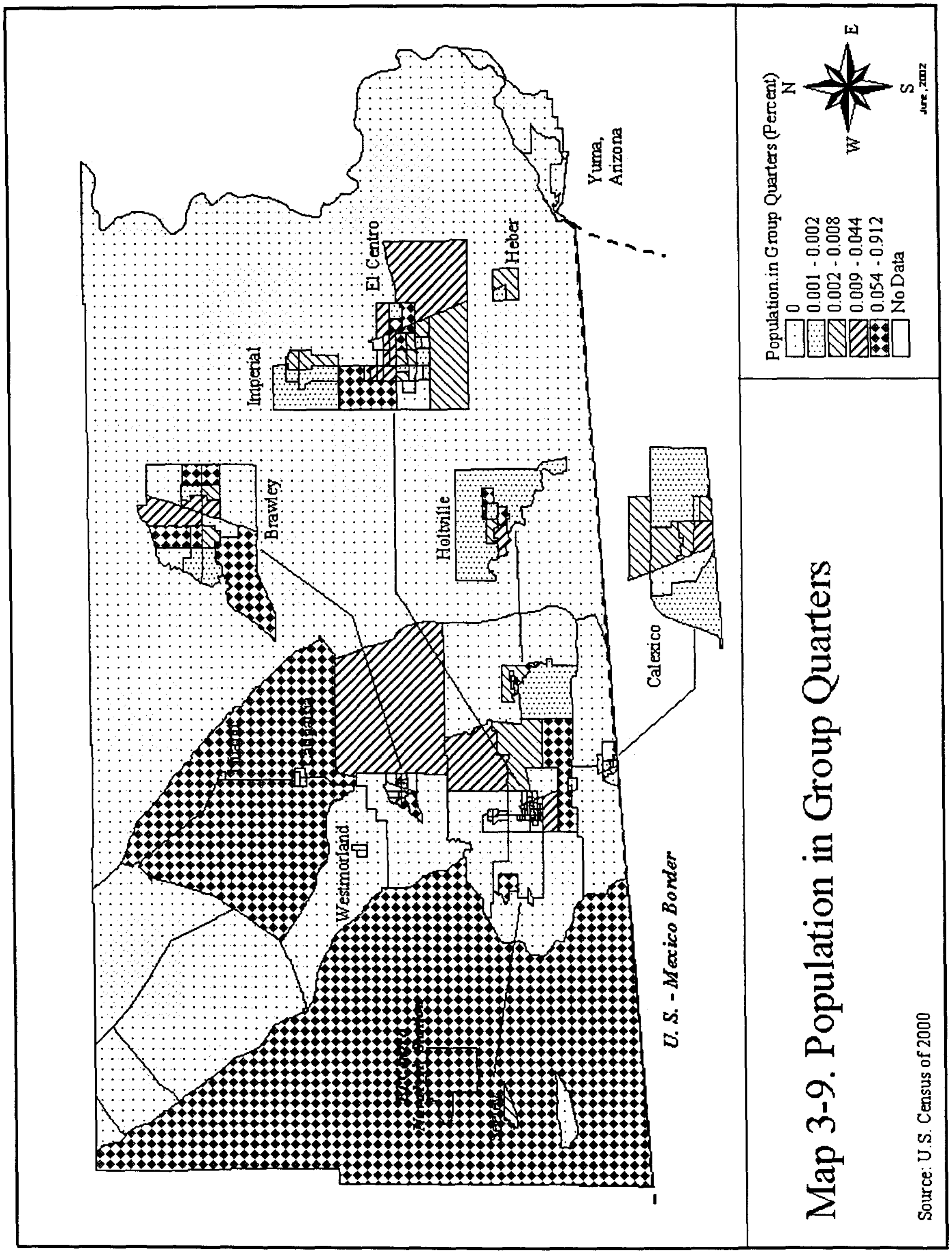
Source: U. S. Census of 2000

Table 3-12. Population and Housing Units of Imperial County and Its Cities, 1990-2000

	Population 1990	Population 2000	Percent Population Change 1990 2000	Housing Units 1990	Housing Units 2000	Percent Change in Housing Units 1990-2000
Calipatria	2,690	7,289	171.0	767	962	25.4
Imperial	4,113	6,560	59.5	1,372	2,339	70.5
Calexico	18,633	27,109	45.5	4,832	6,984	44.5
El Centro	31,405	37,835	20.5	10,200	12,287	20.5
Westmoreland	1,380	1,624	17.7	432	458	6.0
Brawley	18,923	22,052	16.5	6,124	7,034	14.9
Holtville	4,820	5,612	16.4	1,477	1,600	8.3
Unincorporated	27,339	34,280	25.4	11,355	12,227	7.7
Imperial County Total	109,303	142,361	30.2	36,559	43,891	20.1
California	29,758,213	33,871,648	13.8	11,182,513	12,214,549	9.2

Source: U.S. Census of 2000

An unusual facet of Imperial County's housing situation is the presence of large institutionalized population, predominantly resident in prisons. As seen in **Table 3-13**, 7.3 percent of the county's population in 2000 was institutionalized, compared to only 1.2 percent for California. Most of the prisons are located away from the major cities, in Calipatria and unincorporated areas, although some institutionalized population, mainly prisoners, is located in El Centro. The spatial distribution of this prison population is seen in **Map 3-9**. This map shows that the large prison concentrations are east of Calipatria, in the western unincorporated flank, near Heber, and in the north center of El Centro. Of the 9,859 prison population, all except El Centro's 557 are situated in agricultural and peripheral unincorporated areas. There have been advantages to Imperial County's receptivity to host state prisons, in particular state flow of funds to the County and some additional jobs to operate the institutions. On the other hand, prisons, even ones located away from the county's large cities, contribute to a reduced quality of life, or at least the lowered "image" of life quality, which is important in attracting additional business and industry. This aspect will be discussed more in the economic growth chapter.



Map 3-9. Population in Group Quarters

Table 3-13. Population in Group Quarters and Institutionalized, Imperial County, 2000

	Population	In Group Quarters	Institutionalized	Non-Institutionalized	Percent Institutionalized
Brawley	22,052	312	144	168	0.7
Calexico	27,109	103	0	103	0.0
Calipatria	7,289	4,095	4,095	0	56.2
El Centro	37,835	887	749	138	2.0
Holtville	5,612	130	128	2	2.3
Imperial	6,560	32	29	3	0.4
Westmoreland	1,624	0	0	0	0.0
Unincorporated	34,280	5,485	5,278	207	15.4
Imperial County Total	142,361	11,044	10,423	621	7.3
California	33,871,648	819,754	413,656	406,098	1.2

Source: U.S. Census, 2002

Table 3-14. Housing Types in Mexicali, Tijuana, and Mexico, 2000

	Mexicali		Tijuana		Mexico	
Type of Housing	Number	Percentage	Number	Percentage	Number	Percentage
Free-Standing House	163,197	85.7	201,576	68.8	18,708,569	85.2
Attic	51	0.0	243	0.1	29,495	0.1
Attached Housing	5,232	2.7	19,487	6.7	839,675	3.8
Apartment in a Building	2,550	1.3	29,575	10.1	1,270,606	5.8
Local Structure Not Built for Housing	154	0.1	251	0.1	25,637	0.1
Mobile Home	608	0.3	673	0.2	6,667	0.0
Shelter	38	0.0	74	0.0	3,576	0.0
Not Specified	18,513	9.7	40,700	13.9	1,058,310	4.8
Collective Housing	83	0.0	203	0.1	12,198	0.1
Total	190,426	100.0	292,782	100.0	21,954,733	100.0

Source: INEGI, 2001

Regarding the housing situation on the Mexican side, Mexicali and Tijuana had 190,426 and 292,782 housing units respectively in 2000. As seen in **Table 3-14**, Mexicali has nearly all free-standing houses, while Tijuana has 10 percent apartment buildings. In Mexico, apartment buildings often connote ownership and greater prosperity, so this difference reflects greater prosperity in Tijuana (Pick and Butler, 1997). Based on recent INEGI data (2002), comparisons can be made in housing construction. As seen in **Table 3-15,** housing units in Mexicali and Tijuana are built similarly, except Mexicali has reduced extent of wooden walls versus Tijuana and much higher proportion of adobe and brick/cement/concrete walls. This underscores a key problem for Mexicali, which is .

Table 3-15. Types of Housing Material in Mexicali, Tijuana, and Mexico, 2000

Mexicali	*Type of Material in Roof*					
Type of Material in Walls	Wood, Palm	Concrete Slab, Partition, Brick, Steel Frame	Other Types of Material	Not Specified	Total	Percentage
Wood	21,551	241	53	48	21,893	12.2
Adobe	18,953	216	1,139	33	20,341	11.3
Partition, Brick, Block, Rock, Stone, Cement, Concrete	70,919	55,411	1,149	211	127,690	71.2
Other Types of Material	2,152	134	4,539	18	6,843	3.8
Not Specified	161	52	1,386	1,039	2,638	1.5
Total	113,736	56,054	8,266	1,349	179,405	100.0
Percentage	63.4	31.2	4.6	0.8	100.0	

Tijuana	*Type of Material in Roof*					
Type of Material in Walls	Wood, Palm	Concrete Slab, Partition, Brick, Steel Frame	Other Types of Material	Not Specified	Total	Percentage
Wood	399,469	6,281	20,582	1,788	428,120	38.7
Adobe	2,781	891	334	32	4,038	0.4
Partition, Brick, Block, Rock, Stone, Cement, Concrete	228,730	405,960	12,172	1,549	648,411	58.6
Other Types of Material	7,977	1,551	7,896	77	17,501	1.6
Not Specified	391	413	71	7,786	8,661	0.8
Total	639,348	415,096	41,055	11,232	1,106,731	
Percentage	57.8	37.5	3.7	1.0	100.0	

Mexico	*Type of Material in Roof*					
Type of Material in Walls	Wood, Palm	Concrete Slab, Partition, Brick, Steel Frame	Other Types of Material	Not Specified	Total	Percentage
Wood	1,498,435	46,319	5,225,324	12,115	6,782,193	7.1
Adobe	895,472	2,264,331	6,758,813	14,011	9,932,627	10.4
Partition, Brick, Block, Rock, Stone, Cement, Concrete	1,730,130	57,023,372	15,337,072	69,962	74,160,536	77.8
Other Types of Material	779,699	71,219	3,093,246	7,961	3,952,125	4.1
Not Specified	5,492	30,537	26,531	483,488	546,048	0.6
Total	4,909,228	59,435,778	30,440,986	587,537	95,373,529	100.0
Percentage	5.1	62.3	31.9	0.6	100.0	

Source: INEGI, 2002

housing construction with poor thermal materials (de Buen, 1993). In particular the most commonly utilized materials, cement blocks, have mediocre thermal performance (de Buen, 1993). The new construction materials coming into the market do not seem to have been implemented sufficiently. Although Mexico has put forward an energy conservation construction standards through the federal government's Comisión Nacional para el Ahorro de Energía or CONAE (National Commission for Energy Savings), much of the housing stock is built without construction permits, by a process known as self construction or accretion (de Buen, 1993; Pick and Butler, 1997). In this process, a family makes self improvements to its housing over a long period of time, often a generation or more, steadily expanding and improving it. In 1993, De Buen estimated that 2/3 of Mexicali's housing stock had been self-constructed. An implication of this is that regulation was missing for most of it. CONAE has a special program for energy savings in homes in the border region (de Buen, 2001), but the key problem is to provide real savings to households making improvements and to market and attract people to the program (de Buen, 2001). These energy consumption issues are highlighted in Mexicali, since the summer months are extremely hot, as seen by the average monthly temperatures (**Table 3-16**). In fact, they are among the hottest summer temperatures among all Mexican cities. In the months of June through September, the daily temperature is customarily over 100 degrees Fahrenheit. The policy side of the energy conservation issues are discussed more in the final chapter.

Table 3-16. Average Monthly Temperature in Mexicali

Station	Period	Months											
		Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Tijuana	1999	14.9	15.9	18.0	20.1	26.3	30.2	34.3	34.0	31.4	26.7	19.4	13.4
Average	1986-1999	13.6	16.0	18.8	22.3	26.4	30.7	34.3	34.6	30.6	25.4	18.2	13.1
Coldest Year	1986	14.1	15.3	18.6	20.5	24.7	30.6	32.2	34.2	26.5	21.1	17.2	12.6
Hottest Year	1996	14.8	18.0	20.2	24.0	28.4	32.3	36.0	35.1	31.0	24.5	18.1	14.0

Note: the temperatures are average monthly temperature in degree centigrade.
Source: CNA. Comisión Nacional del Agua

The housing situation in Baja California is not static, but is gradually being improved over time. One relevant aspect to this research is the increase in utility hook-ups to the state's housing. As seen in **Table 3-17**, for the 1990s, a very high proportion of Baja's housing units had piped water, electrical energy, and toilets, with the ratio of plumbing increasing at national rates. Baja substantially exceeded the nation in these hook-ups and is beginning to approach U.S. standards for utility connectivity. Higher utility connectivity is usually associated with greater water and energy consumption. Over the next 20 years, as utility connectivity continues to improve, it should marginally add to the total demand for energy and water.

Table 3-17. Principal Characteristics of Housing Units, Mexico and Baja California, 1990 and 1997

	Nation	Baja California
1990		
Total Number of Housing Units:	**16,035,233**	**362,727**
With Non Earth Floor	79.9	91.5
With Piped Water	79.4	80.5
With Plumbing	63.6	66.8
With Electrical Energy	87.5	89.5
With toilet	74.8	91.9
1997		
Total Number of Housing Units:	**20,768,861**	**540,759**
With Non Earth Floor	85	94.8
With Piped Water	88.1	92.6
With Plumbing	78.2	79.7
With Electrical Energy	94.5	96.9
With toilet	83.1	96

Source: INEGI, 2000

Table 3-18. Income and Poverty in Imperial County, San Diego County, and California, 1999

	Imperial County	San Diego County	California
Income			
Median Household Income	$31,870	$47,067	$47,493
Percent of Households with Income $14,999 or Less	23	12.5	14
Percent of Households with Income $100,000 or More	7.1	15.7	17.3
Poverty Status			
Families in Poverty Status	6,171	59,221	845,991
Total Families	31,731	669,102	7,985,489
Percent of Families in Poverty Status	19.4	8.9	10.6
Individuals in Poverty Status	29,681	338,399	4,706,130
Total Individuals	142,361	2,813,833	33,871,648
Percent of Individuals in Poverty Status	20.8	12.0	13.9

Source: U.S. Census, 2002

In income and poverty, Imperial County stacks up poorly on a national basis, whereas Mexicali and Tijuana, as well as Baja California, are well off on a Mexican national basis. Imperial County is one of the poorest counties in California by almost any per capita measure. Its median household income in 1999 was $31,870, which was one third below the state average and San Diego County (see **Table 3-18**). On the other hand, it had under half as many households with high incomes of more that $100,000, versus the state and San Diego.

Twenty percent of Imperial County individuals were in poverty status in 1999, seven percent more than for California and nine percent more than for San Diego County. The economic hardship status for Imperial County has been present since the mid 20^{th} century (Butler and Pick, 1982). Among the reasons for this are lack of education, low-level occupations, high proportion of first generation migrants, and steady loss of higher skilled and educated workers through out-migration. The economy is largely agriculturally based, and the agricultural owners often reside outside the county (Butler and Pick, 1982).

By contrast, Mexicali and Tijuana are prosperous versus Mexico. As seen in **Table 3-19**, their level of high income was twice that of the nation. Poverty, defined here as the proportion of population at less than one minimum wage, is greatly reduced, at levels of 3-4 percent, compared to 21 percent of employed population for the nation (INEGI, 2001). A recent study (Butler, Pick, and Hettrick, 2001) examined the development levels of all the Mexican states, and indicated that the two most advanced states in development level were the Federal District, i.e. the central part of Mexico City, and Baja California. The reasons for Baja's advanced economic level are presence of a prosperous maquiladora industry, proximity to San Diego and California, cross-border economic linkages and exchange, illegal flows of money and profits, and a high level of educational attainment, fostered by a moderately good education systems.

Table 3-19. Income and Poverty in Mexicali, Tijuana, and Mexico, 2000

	Mexicali Municipio	Tijuana Municipio	Mexico
Employed population	284,884	446,339	33,730,210
High Income			
Employed population with more than 5 times minimum wage	63,641	104,748	3,998,828
Percent of population with more than 5 times minimum wage	22	23	12
Poverty			
Employed population with less than minimum wage	11,742	14,915	6,972,344
Percent of population with less than the minimum wage	4.1	3.3	20.7

Source: INEGI, 2001

Overall, for the region, three of the four county/municipio economies are prosperous by their nation's standards. One is backward. Imperial County's low income stands in contrast to its high endowments of water resources and native energy sources. Its economic mix is also significant from a demand standpoint. The economic prosperity associated with most of the demand region tends to raise the per capita urban consumption levels for water and energy. At the same time, there is a trend of urban water demands to displace agricultural water consumption in Imperial County. One study implication is that the relative prosperity of most of this demand base can lead to the future charging of higher consumer prices for water and energy and to more potential to invest in developing the resources.

Chapter 4

Economic Growth of Imperial County

4. Economic Growth of Imperial County

Background

Even though the Imperial County receives less than 3 inches of rainfall a year, it receives a large supply of water from the Colorado River through the All American Canal. Most of this water is used to support a large agricultural sector that is also the largest employer in the community accounting for 30 percent of total employment (VIDA 2000).

Even though the agricultural sector in Imperial County has been relatively stagnant in terms of employment generation, the county continues to experience rapid growth in population due to employment growth in other sectors such as retail trade, services, and government. Such a view is also supported by the fact that recently about a third of the population increase in the county can be attributed to net migration, rather than to natural increase. Overall from the period 1990-1999 the county experienced a population growth rate of 31 percent and from a population of 142,361 in 2000, the county is projected to reach a population of 182,000 by the year 2010 and a population of 224,000 by 2020. The projected population for Imperial County were summarized in **Table 3-4** (see **Chapter 3**).

The population centers of Imperial County are essentially located in a number of small cities such as Calexico, El Centro, Brawley, Calipatra, Holtville, with the larger cities mostly in the southern part of the county closer to the Mexican border, in the agricultural area that is called the Imperial Valley. Details of the cities and their historical population growth were presented in **Table 3-1** (see **Chapter 3**). While the cities of Holtville, Brawley, Imperial, Westmoreland, and Calipatra, are primarily agricultural with some mining activities, the cities of El Centro and Calexico are dominated by other economic sectors including government, retail trade, and services.

As pointed out in the previous chapter, the population Imperial County has been among the poorest counties in California. Its median Household Income was $22,442 in 1990 as compared to a median household income of $35,798 for the whole of California (California State Department of Finance, 2002). The primary reason for the relative lower incomes in Imperial

County can be attributed to the dominance of agriculture and retail trade in the employment make up of the county and the low levels of literacy. Since most of these agricultural or retail service jobs are at or near minimum wage, the median household income tends to be depressed when compared to other counties in California.

Table 4-1. Personal Per-Capita Income

	Imperial County		California	
	Total	**% Change**	**Total**	**% Change**
1990	$15,161	---	$21,289	---
1991	$14,571	-4.05%	$21,425	0.63%
1992	$14,077	-3.51%	$22,128	3.18%
1993	$15,149	7.08%	$22,389	1.17%
1994	$14,121	-7.28%	$22,828	1.92%
1995	$14,790	4.52%	$24,090	5.24%
1998	$17,353	7.5%	$28,163	6.7%

Source: California Department of Finance, California Statistical Abstract

Table 4-2. Poverty 1990

	Imperial County	**California**
Median Household Income	$22,442	$35,798
Median Family Income	$25,147	$40,559
Persons Living in Area	107,402	29,003,219
Persons below Poverty Level	25,517	3,627,585
Percent of Persons below Poverty Level	23.8%	12.5%

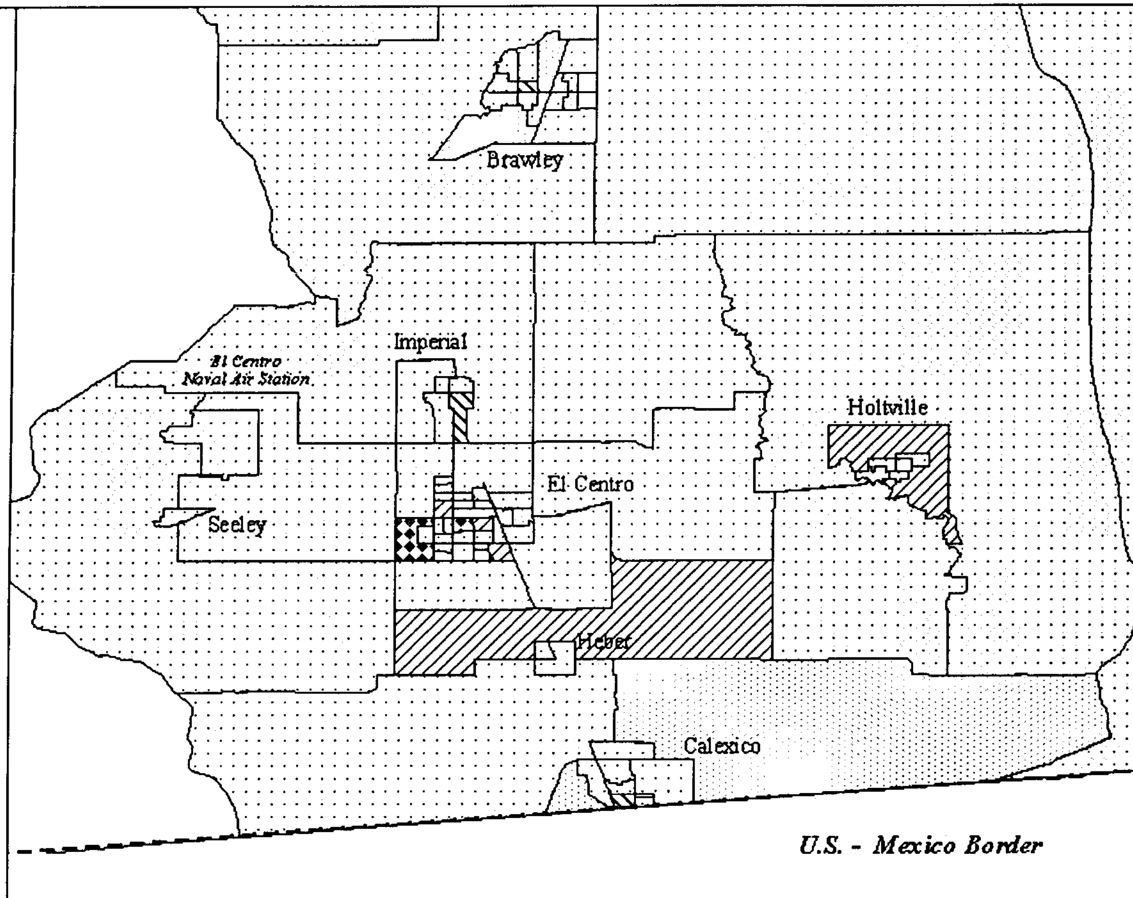
Source: California Department of Finance, California Statistical Abstract, 2002

Employment in Imperial County

The three largest sectors in the Imperial County economy with regard to employment are agriculture, retail, and government. According to the 2000 U.S. Census, the government sector is the largest employer in the county accounting for 16,100 jobs or 31 percent of the total employment of 50,400. Among the various categories of government employees, the largest is that of local government which accounts for 11,700 employees. As a share of the total number of jobs in Imperial County government jobs have increased substantially from 8,000 jobs out of a total of 35,700 jobs in 1984, or a share of 24 percent, to almost a one third increase in share to 31 percent in 2000. In addition, most of this job increase has occurred at the local government level.

The spatial distribution of government organizations shows that small and middle-sized ones are spread out in the county's system of cities, but large ones are located in the El Centro-Calexico corridor. Government organizations with 10 to 49 employees are located in the cities of Brawley, Imperial, El Centro, Holtville, the area north of Heber, Calexico, and the area to its west (see **Map 4-1**). On the other hand, large government organizations with more than 100 employees are located mostly in the center of El Centro, but also north of Heber and in Calexico(see **Map 4-2**). These offices are county, state, and federal ones and include the County of Imperial and the U.S. Border Patrol. The larger federal government organizations tend to be located nearer the border, because it is where border trade, transit, entry, and other activity occurs.

Relative to the other economic sectors, the importance of the agricultural sector to the Imperial County economy has declined over time. In 1984, agriculture accounted for 12,700 or close to a third of the county's 35,700 jobs. In 2000, while overall employment had increased from 35,700 to 50,400, agricultural jobs remained relatively stable and accounted for 12,300 jobs (U.S. Census, 2002). Overall, agriculture as a provider of employment is decreasing in importance and this trend will probably continue, since it is unlikely that the county will have increased land for agriculture, and labor-intensive agricultural practices will probably continue to shift to the Mexicali Valley.



Map 4-1. No. of Government Organizations with 10-49 Employees, 1999

Source: ESRI Inc.

10-49 Employees
- 0
- 1
- 2
- 3
- 4 - 15
- No Data

N
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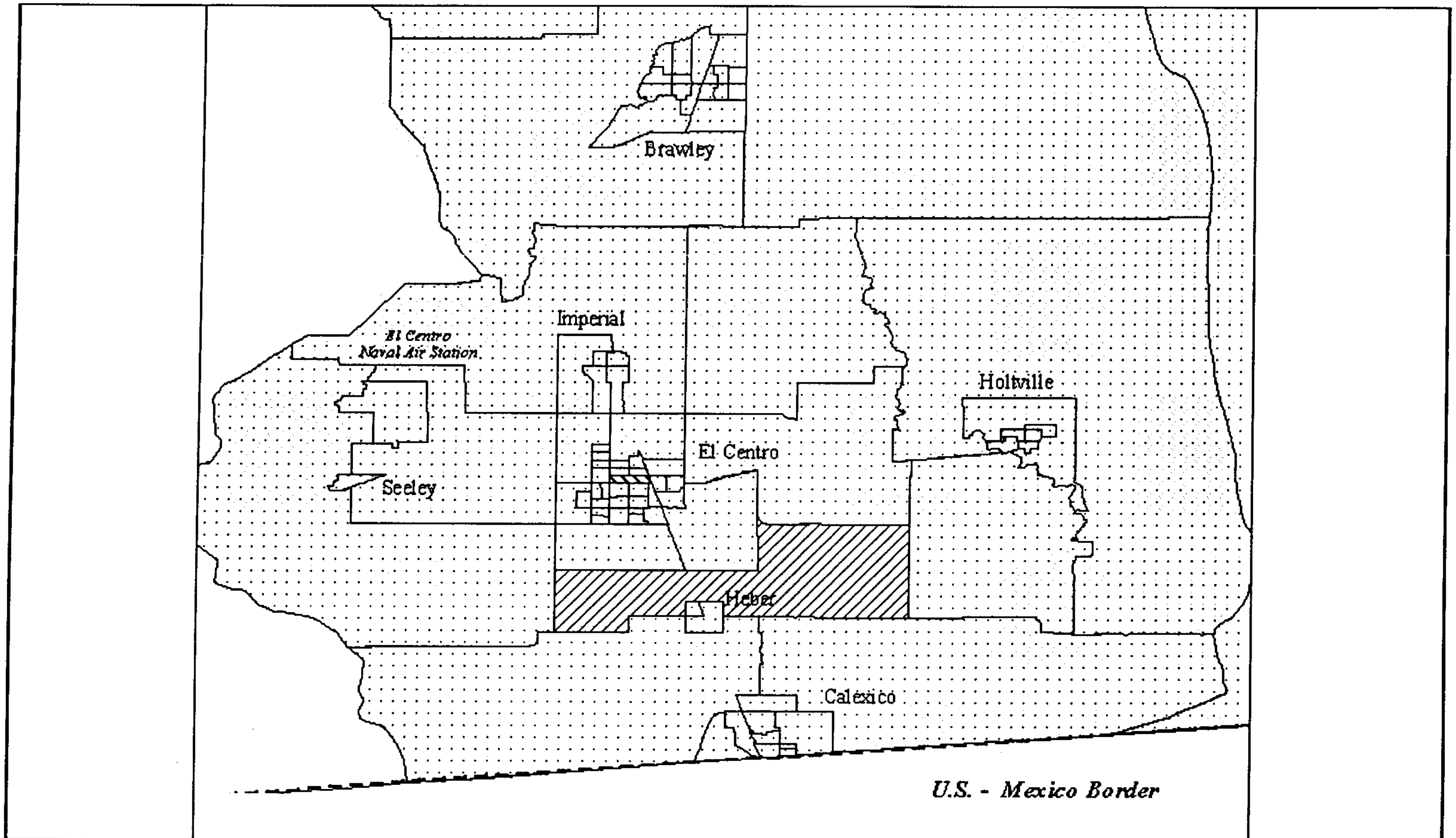
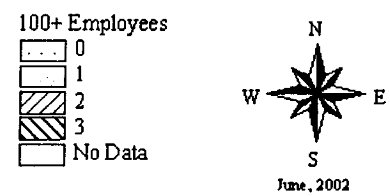
June, 2002



Map 4-2. No. of Government Organizations with 100+ Employees, 1999

Source: ESRI Inc.

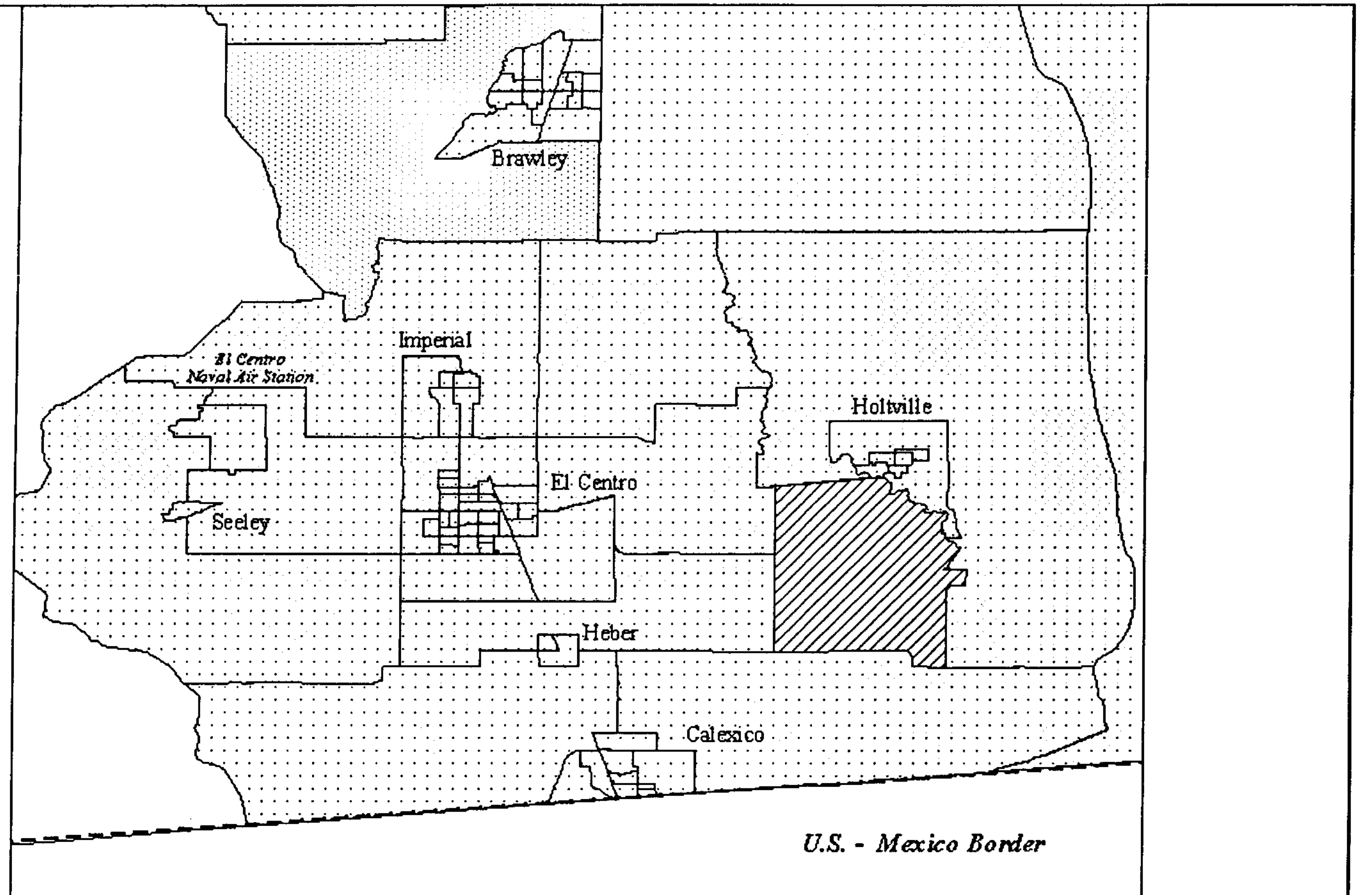


The spatial pattern of agricultural organizations is that their offices are predominantly located away from the cities in the agricultural "Valley" area. This can be seen for larger agricultural organizations in **Maps 4-3 and 4-4.** These large farms and other agricultural entities are located in the rich farmlands of the "Valley." Agricultural organizations are important in this study, because together they are the largest water and energy consumers in the county. They are considered later in the report in terms of future change including in water and energy consumption.

The retail sector of the Imperial County shows a steady growth in employment over time. In 1984 the sector accounted for 5,300 jobs, which grew to 8,200 in 2000. Overall, the pattern of growth has been steady and this may be attributed to growth in employment in Imperial County and more importantly to derivative effects of the rapid growth of the city of Mexicali, which was discussed in Chapter 3.

The connection with Mexicali can be seen by examining the spatial distribution of retail trade enterprises. **Map 4-4 through 4-6** show differences in patterns between small and larger retail. The small retail enterprises are distributed evenly in the county's system of cities and surrounding agricultural areas (**Map 4-5**). On the other hand, retail businesses with more than 50 workers are located in El Centro, Calexico, and the area to the east of Calexico that includes the new East Calexico Port of Entry (see **Maps 4-6 and 4-7**). The explanation is that the customers for the county's larger retail businesses come predominantly from Mexicali. Those shoppers are known to concentrate shopping in Calexico and El Centro (San Diego Dialogue, 1998). The new border gate area is an emerging location for retail trade. It can be expected to increase in the volume of trade in the future, as the port of entry area gets built out more, a topic discussed in the case study of the Port in the next chapter.

Spending patterns in the county for personal consumption items follow the distribution of population that appeared in **Map 3-1.** A wide variety of personal consumption items follow this pattern. For example, the total spent in 1999 on household furnishings is concentrated, like population, in the major three cities (**Map 4-8**). Likewise, spending on medical care (**Map 4-9**) follows closely the population distribution. The availability of such personal goods and services, mostly in El Centro and Calexico, to spending also by Mexican visitors. The future possibilities of expanding these retail goods and services for Mexicali purchasers is large, and will be discussed more later.



Map 4-3. No. of Agricultural Mining Businesses with 50-99 Employees, 1999

Source: ESRI Inc.

50-99 Employees
- 0
- 1
- 2
- No Data

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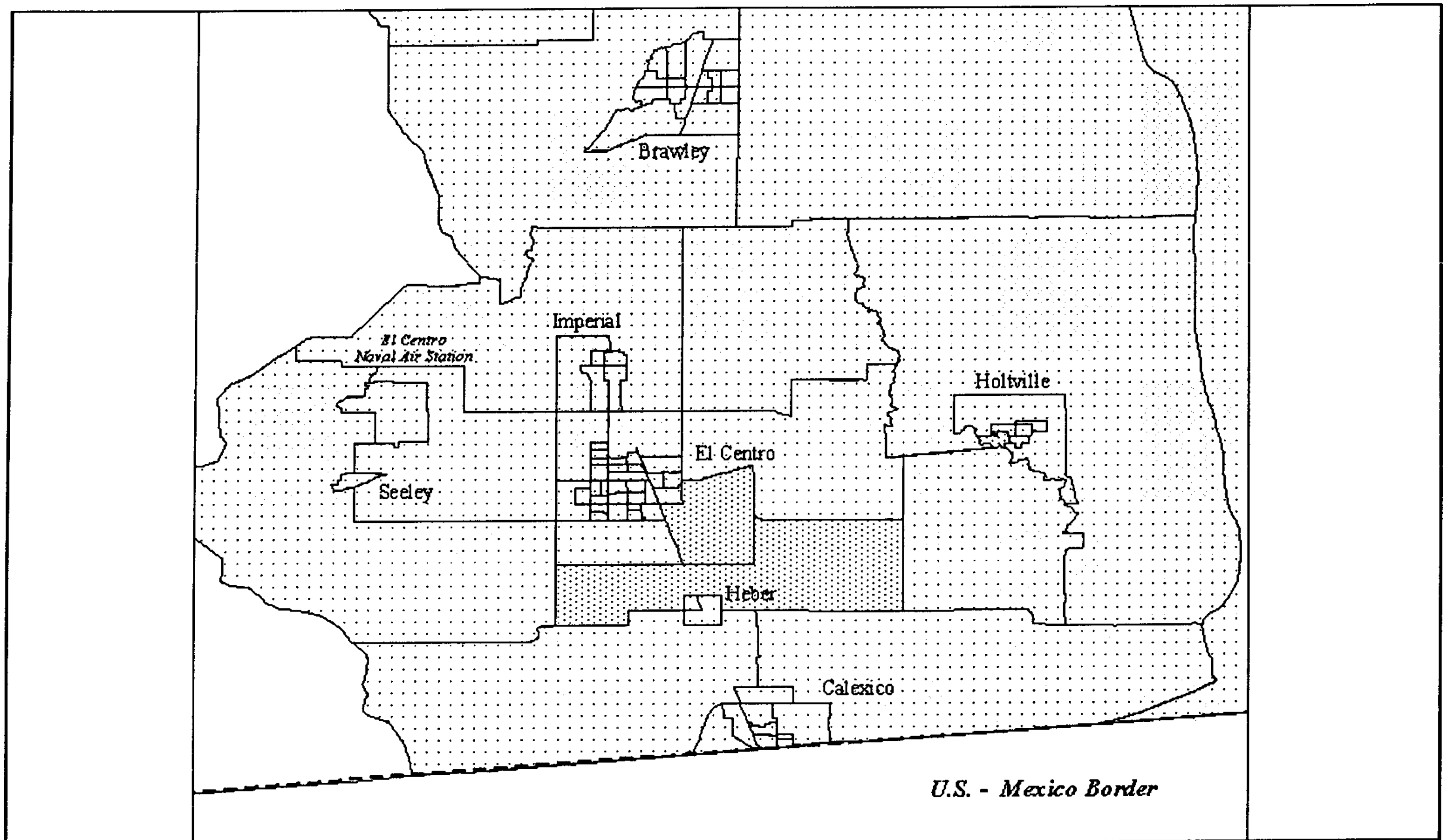
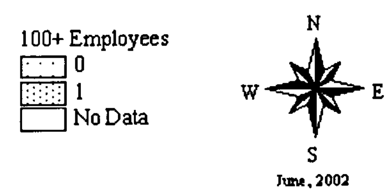
S

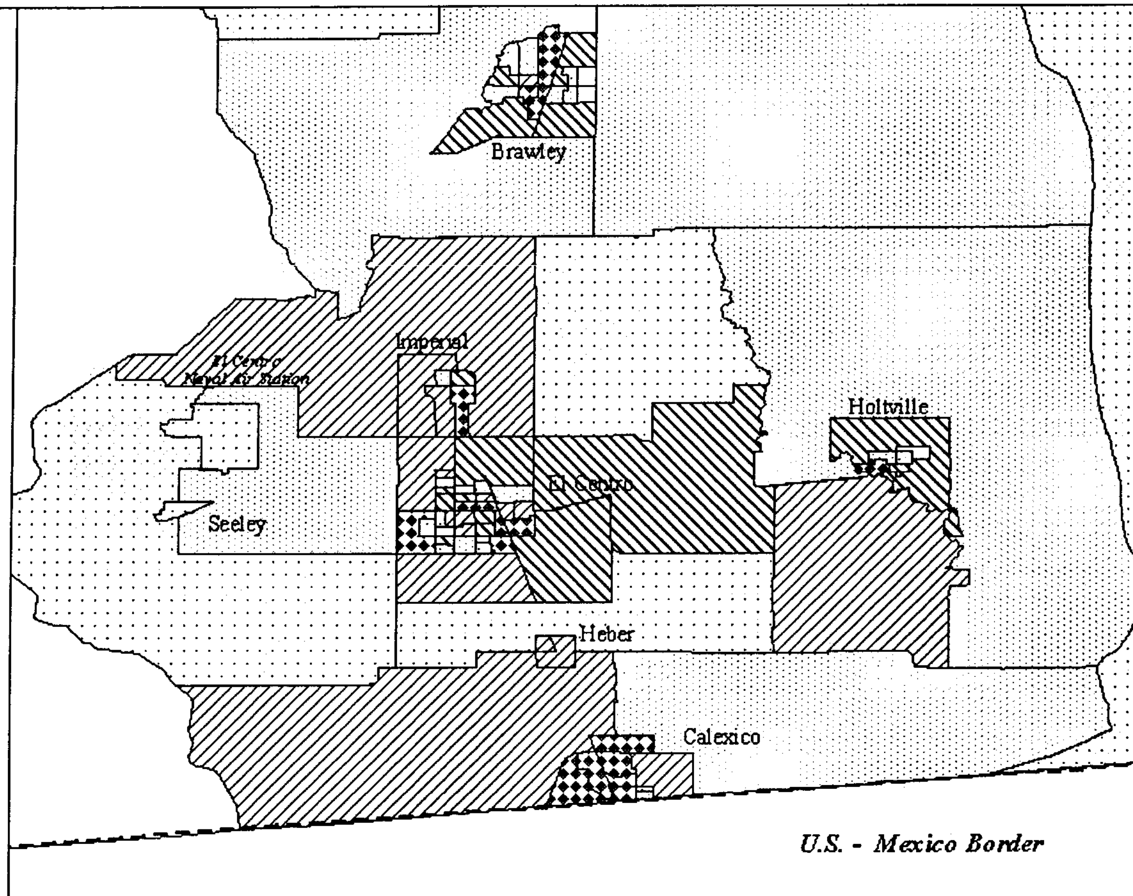
June, 2002



Map 4-4. No. of Agricultural Mining Businesses with 100+ Employees, 1999

Source: ESRI Inc.





Map 4-5. No. of Retail Trade Businesses with 1-4 Employees, 1999

Source: ESRI Inc.

1-4 Employees
- 0
- 1
- 2 - 3
- 4 - 6
- 7 - 56
- No Data

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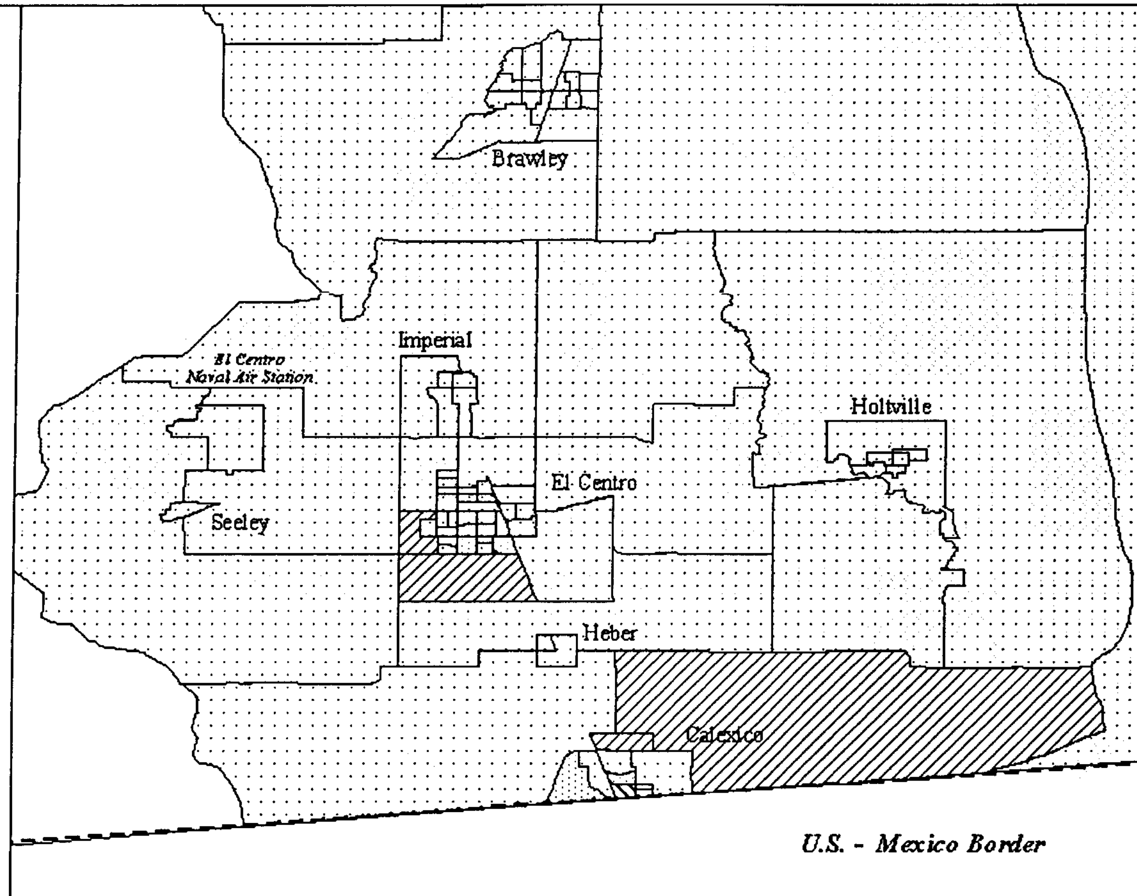
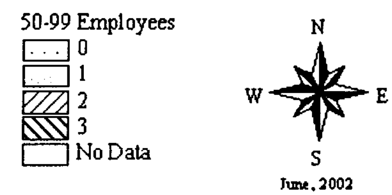
W E
S

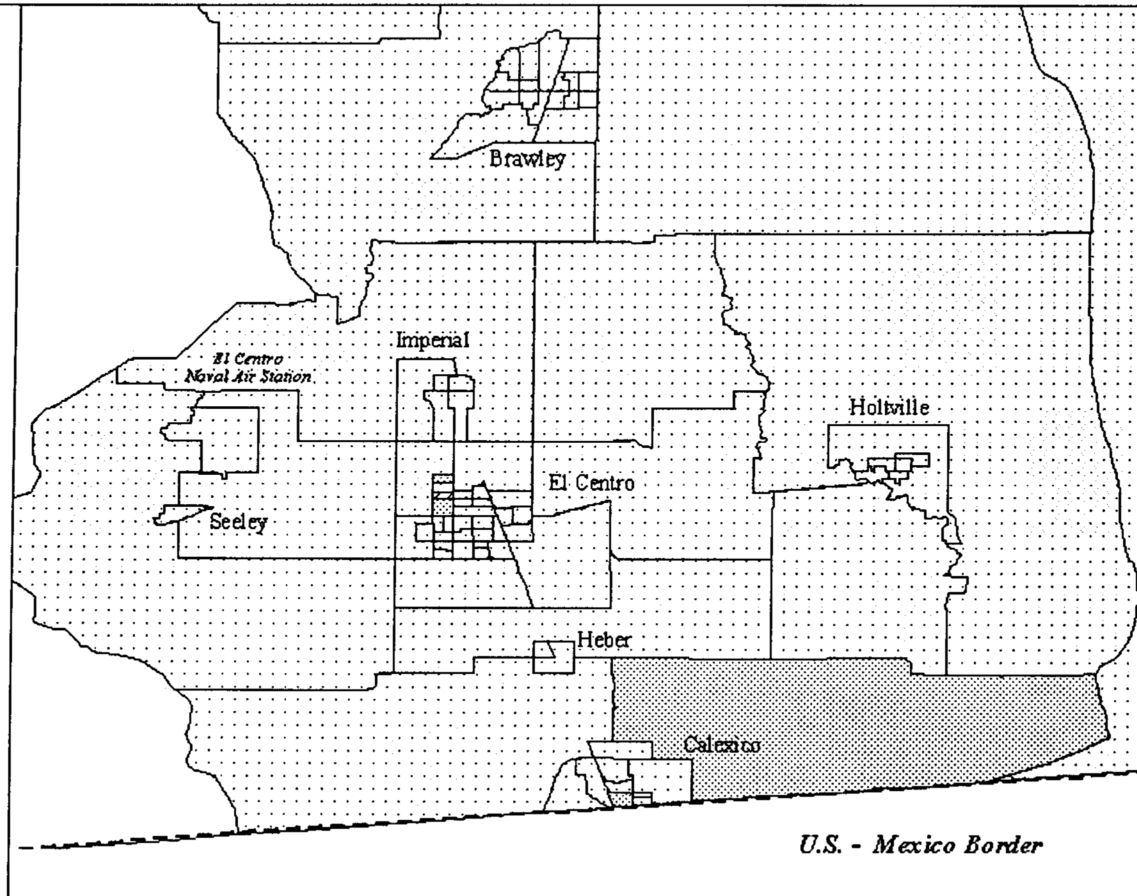
June, 2002



Map 4-6. No. of Retail Trade Businesses with 50-99 Employees, 1999

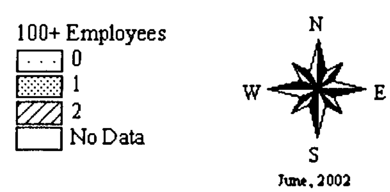
Source: ESRI Inc.

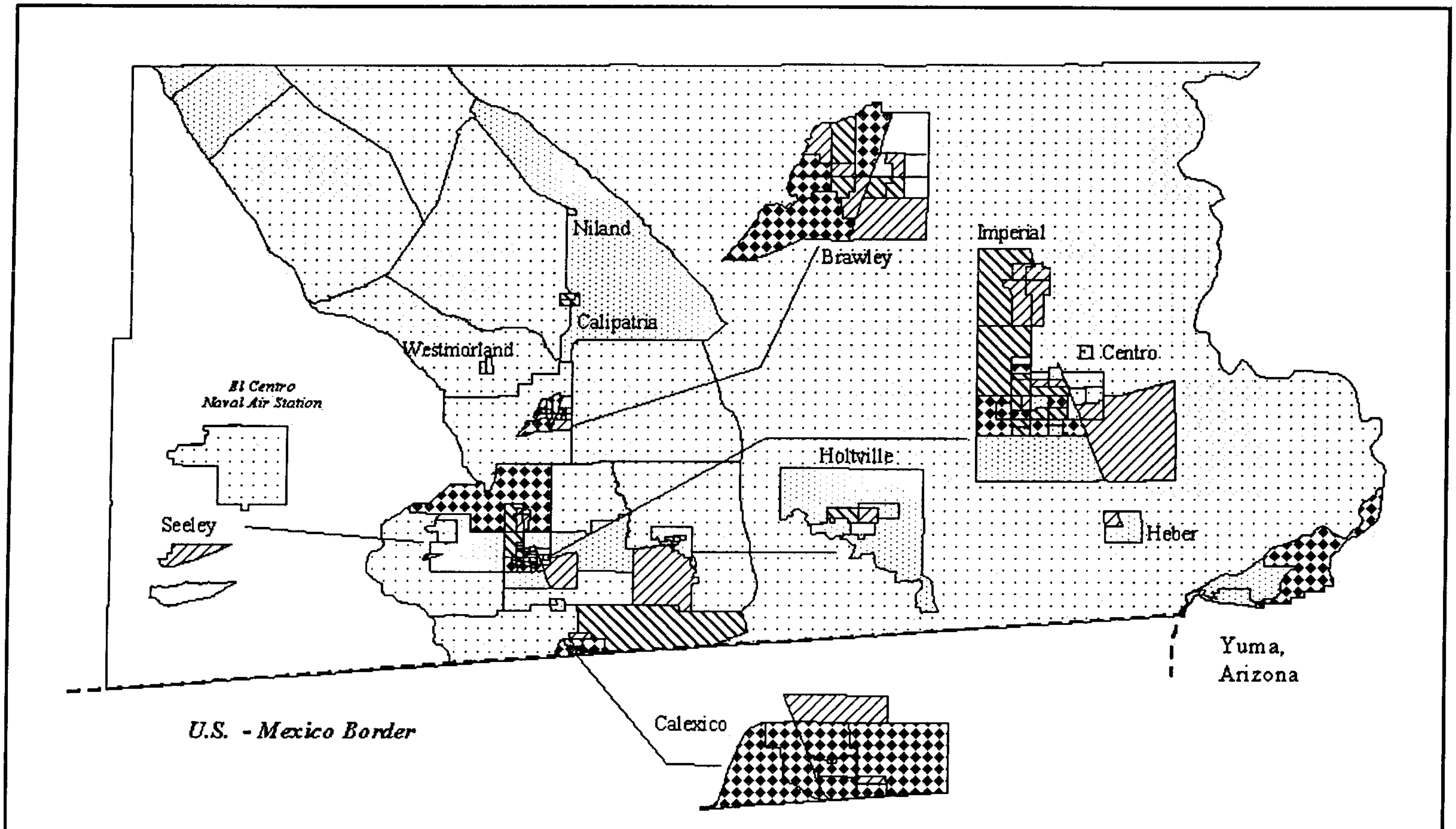




Map 4-7. No. of Retail Trade Businesses with 100+ Employees, 1999

Source: ESRI Inc.





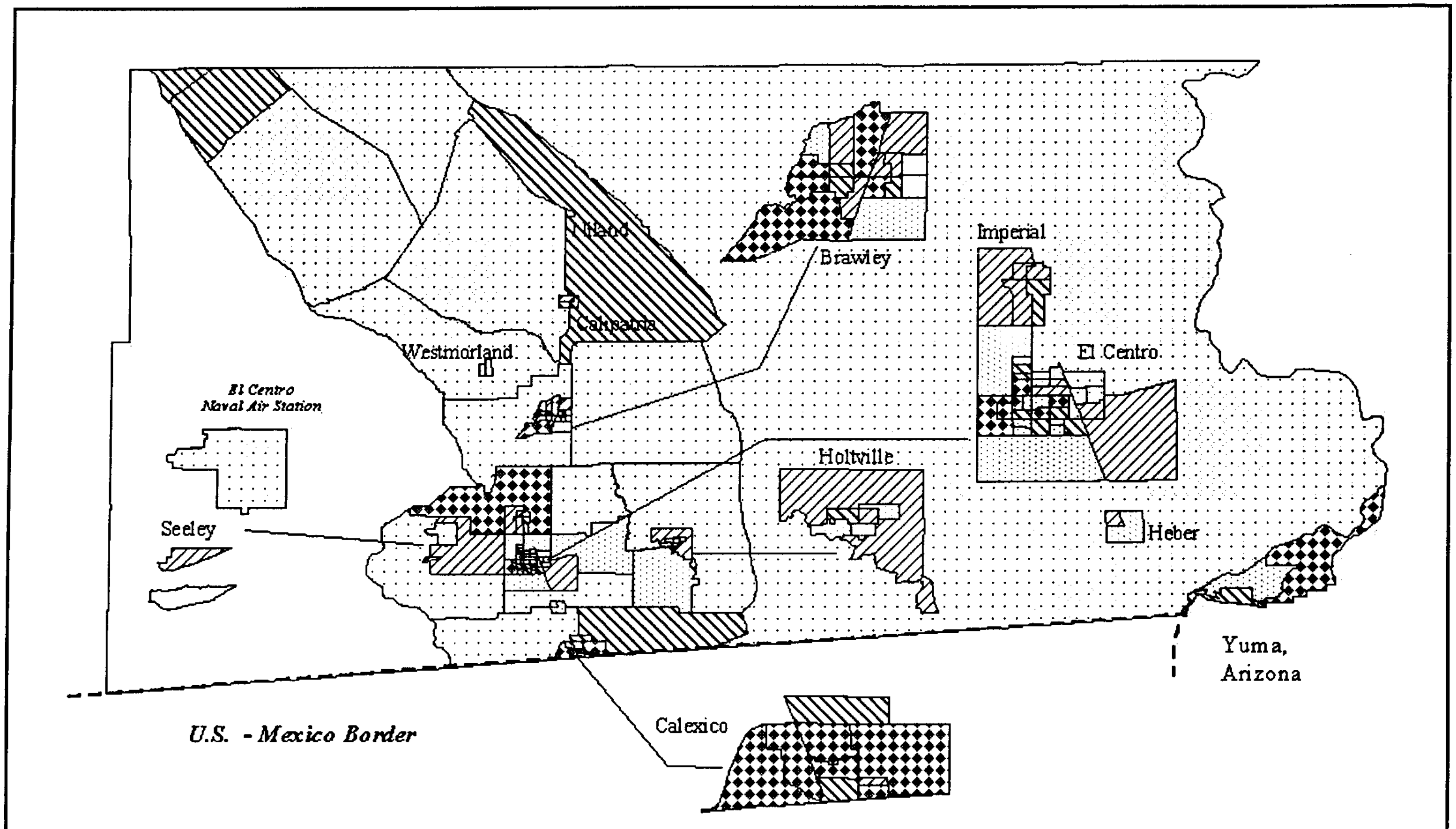
Map 4-8. Household Furnishings Total Spending (in $1,000), 1999

Source: ESRI Inc.

Household Furnishings
- 1 - 124
- 126 - 172
- 179 - 209
- 211 - 295
- 304 - 616
- No Data

N W E S

June, 2002



Map 4-9. Medical Care Total Spending (in $1,000), 1999

Source: ESRI Inc.

Nature of Jobs in Imperial County

According to data available from the California's Employment Development Department (California State EDD), the county's major occupations are concentrated in the sectors of retail, agriculture, and government. Short-term forecasts of growth related to different occupations for 2001-2006 indicate that the occupations of retail salespersons, cashiers, janitors, teachers and teacher aides, truck drivers, correctional officers, and patrol officers are likely to experience the greatest growth (EDD, 2002). Overall the growth rates of sectoral employment are expected to be 12 percent for retail, 9.3 percent for services and 7.9 percent for government, with either a stable or decreasing employment for the agricultural sector.

The majority of jobs in the retail and services sectors are likely to be at close to minimum wage while the jobs related to the government sector are likely to be relatively higher paying. In general, even if the county achieves higher levels of education, it is not clear whether unemployment can be substantially reduced from its current levels of over 25 percent. Industries and occupations with the largest likely employment gains.

Housing

The age profile of housing stock in Imperial County in comparison to that of California indicates that Imperial County has enjoyed a relative housing boom in the last decade 1990-2000. For the state of California, 12.9 percent of the total housing stock represents structures that are less than ten years old, while for Imperial County close to 21.1 percent of the housing stock was built in the 1990s. In addition there are regional variations within Imperial County. Among the three larger cities of El Centro, Brawley, and Calexico the percentage of housing stock built in the last ten years ranges from 17.2 percent for El Centro to 19.9 percent for Brawley to 31 percent for Calexico, next to the Mexican border.

However, it is also important to note that relative to population the per capita number of housing units in Calexico is still less than that of Brawley and El Centro. In 2000 Brawley had 7,034 housing units for a population of 22,052, El Centro had 12,287 housing units for a population of 37,835, while Calexico had a 6,984 housing units for a population of 27,109. The relatively lower housing density in Calexico suggests a deficit that will be made up by continued growth of housing in Calexico. In addition, the impact of Mexicali's growth will also add to the impetus for housing growth in Calexico, especially with an increase in management employees in the maquiladora industry who prefer to live on the U.S. side of the border.

Interestingly, while Calexico has the lowest per capita income among the three cities at $9,981 compared to $12,881 for Brawley and $13,874 for El Centro, the median housing value is the highest for Calexico at $108,200 compared to $97,800 for Brawley and $104,300 for El Centro. The primary cause for this differential is the higher percentage of mid range housing in Calexico in comparison to the other two cities. The percentage of housing with values between $150,000 - $200,000 is 13.1 for Calexico in comparison to 6.6 for Brawley and 9.1 for El Centro. One reason may be the higher level housing demanded by maquiladora managers, who live in Calexico.

The growth of the maquiladora industry in Mexicali, the growth in retail trade in Calexico and El Centro, and the likely growth of government especially as it relates to border issues is likely to result in continued housing growth in Calexico and to some extent in Brawley as well.

Income Generation in Imperial County

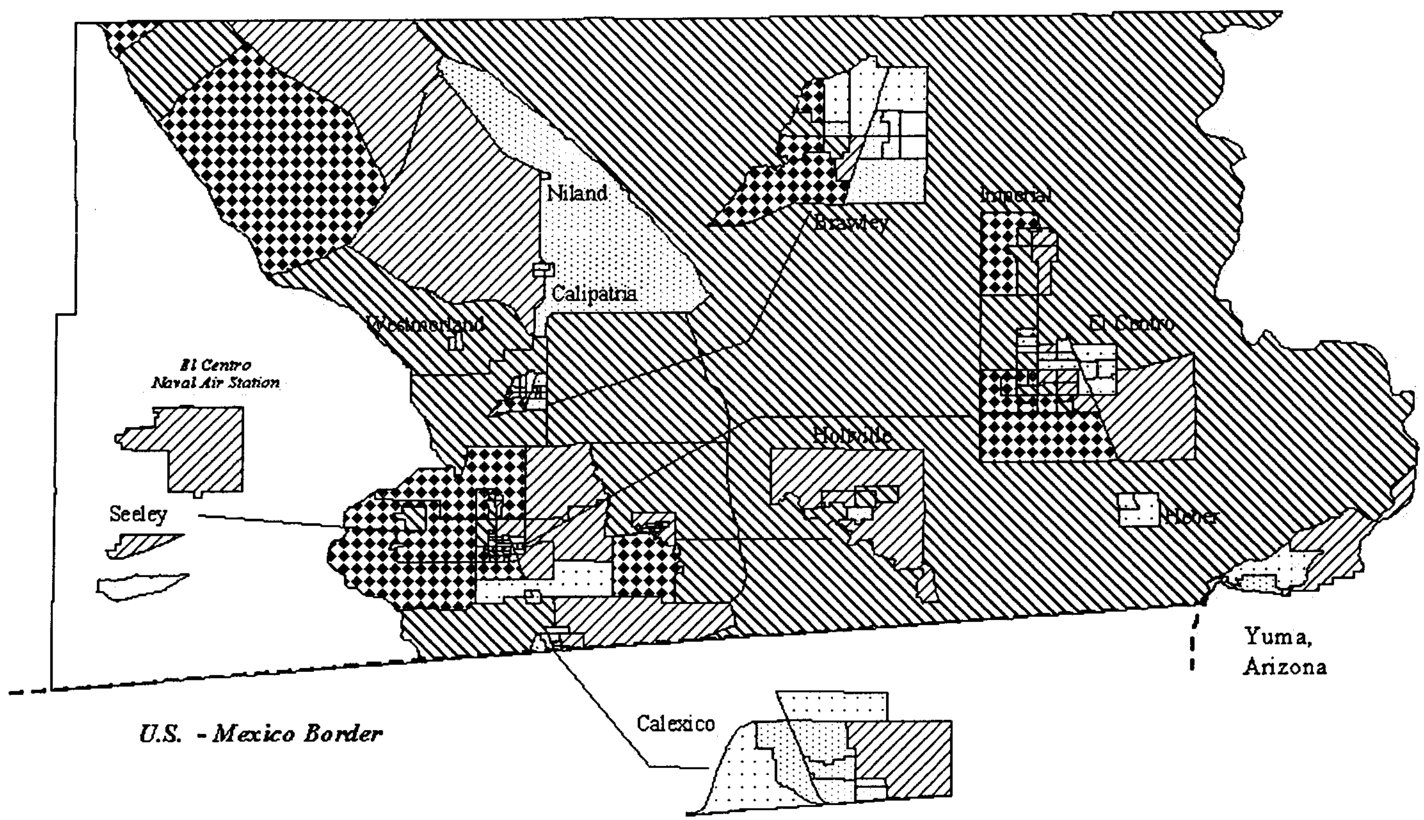
Historically agriculture has been the dominant sector of the Imperial County economy, and the personal income generated from agriculture has been an important element in this economy. However, in recent years the ability of agriculture to generate personal income that is spent in Imperial County has been declining as a percentage of the total personal income generated by all sectors. In 1970 farm income accounted for $103 million of a total of $286 million for Imperial County. By 1980 farm income had grown to $271 million of a total of $881 million dollars. By 1990 the dominance of agriculture began to decline and accounted for only $386 million dollars out of the total personal income of $1.78 billion for Imperial County. The relative decline in the importance of agriculture continues, and the latest available figures for 1999 indicate that agriculture only accounted for $343 million out of the total personal income of $2.55 billion for the county. Thus, the 1999 figures compared to 1970 indicate that the personal income generated by agriculture grew by a factor of 3.5, while the overall personal income for Imperial County grew by a factor of over 9. Although agriculture is still a major employer in the county, the relative decline in the income generated by agriculture may be attributed to the relatively low agricultural wages, as well as by the lack of growth in agricultural employment. If agriculture is losing its dominance in generating income, the question arises as to what other sectors have moved up in importance, to fill in the gap.

Data on personal income indicates that the sectors of government, retail and services have been the predominant gainers over the last three decades. Retail trade, accounting for $29 million in personal income in 1970, has grown to $178 million in 1999; services accounted for $21 million in 1970 and grew to $237 million in 1999, while government rose from $54 million in 1970 to $580 million in 1999. It is also noteworthy that most government related personal income is generated by local government, rather than by the state or the federal government. In the retail sector, the primary categories that contribute to personal income include food stores, automotive dealers and service stations, and eating and drinking places. The contribution of trucking and warehousing to county personal income increased from $6 million in 1970 to $58 million in 1999, much having to do with NAFTA, a topic discussed further in Chapter 5. With the continued increase in NAFTA related trade traffic, as well as expansion in cross border tourists, the contribution of the food and the automobile sectors to the generation of personal income in Imperial County will continue to grow in the future. In the services sector, the primary categories contributing to the generation of personal income are Business Services and Health Services. Anecdotal evidence and the demographic profile of the population suggest continued growth in these categories, especially in the area of health services.

Although Imperial County still retains its perception as an agricultural region, other sectors of the economy especially government, retail and services, have overtaken agriculture and are likely to continue to grow in importance and displace it, including in the generation of personal income that is likely to be spent in Imperial County.

The spatial distribution of personal income indicates wide variations throughout the county and its cities. As seen in **Map 4-10**, per capita income is highest and also lowest in particular sections of Brawley and El Centro. In fact the per capita income varies in these cities between zones with \$22,000-\$35,000 incomes down to areas of under \$8,315. Calexico has low per capita income, which reflects a less productive workforce and lower educational levels. The high-income area south of Holtville may relate to income generated by the new border gate corridor. In the agricultural "Valley" area, there is also a wide range of per capita income.

Spatial patterns for average personal net worth (**Map 4-11**) are associated to per capita income. The variations in net worth are remarkable. The largest concentration of wealth in the county is in El Centro and particularly in the southwest part of the city. Brawley also has considerable wealth, especially in its west. This contrasts with Calexico having a much lower average net worth on the average.



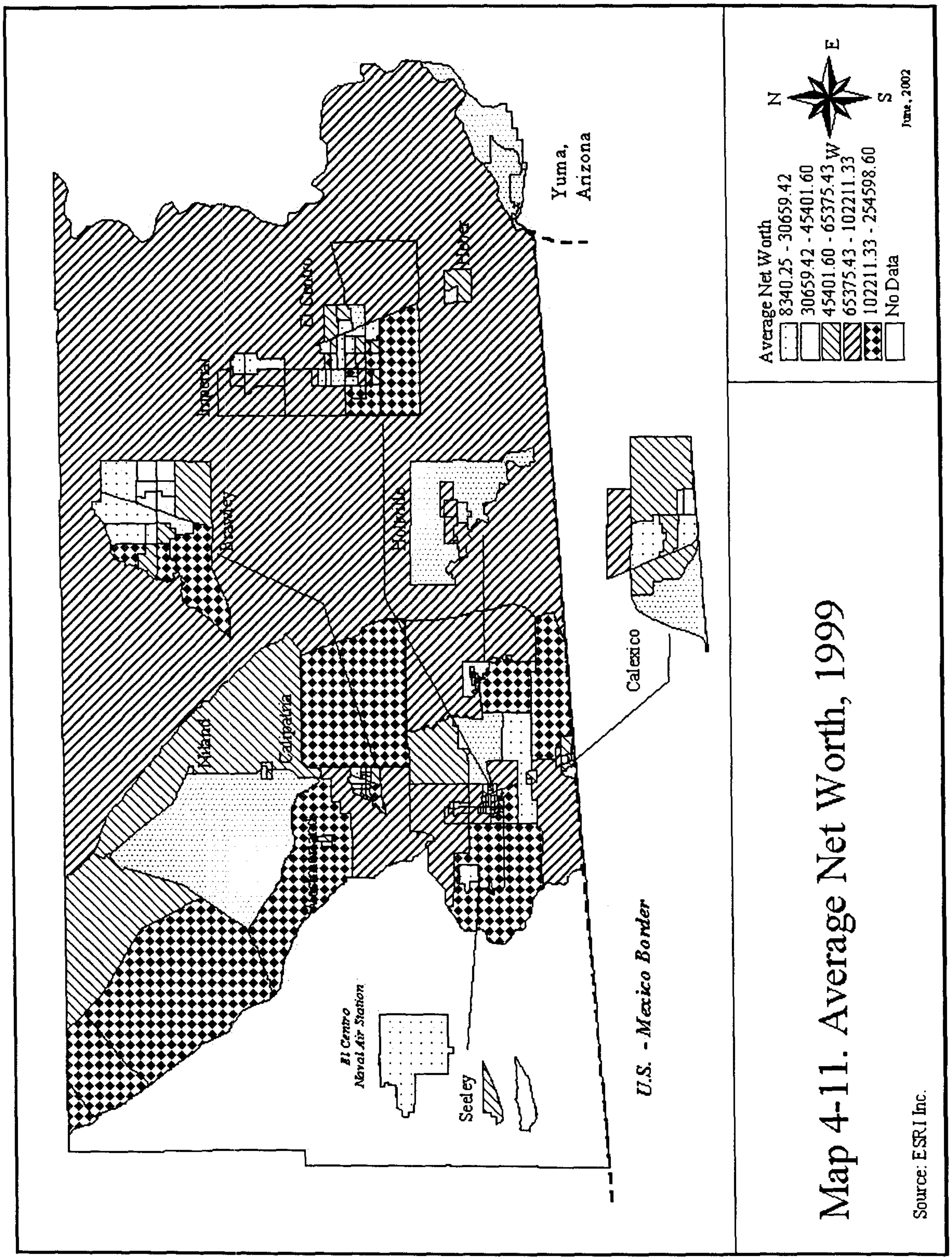
Map 4-10. Per Capita Income, 1999

Source: ESRI Inc.

Per Capita Income
- 2138.14 - 7315.07
- 7315.07 - 9571.80
- 9571.80- 12302.63
- 12302.63 - 16321.27
- 16321.27 - 34931.08
- No Data

N W E S

June, 2002



Map 4-11. Average Net Worth, 1999

Source: ESRI Inc.

Nature and Growth of Retail Sales

As identified earlier, the contribution of the retail sector to personal income generated in Imperial County has grown substantially over the past three decades. The rise in retail sales itself over the last these decades points to the potential for future growth. The 1972 retail sales of $193 million has now grown to $1.4 billion in 2000. Although the general trend is upwards, the year-to-year pattern of growth has not been uniform, with retail sales actually decreasing in some years: 1982, 1983, 1986, 1994, and 1995. Interestingly, the pattern of growth in retail sales in Imperial is different from that of other counties in the Southern California region suggesting unique factors that impact retail sales in Imperial County. In 1983, 1986, 1994, and 1995 when there was a decrease in retail sales in Imperial County the retail sales in all other southern California counties experienced an increase. Such differences in patterns of retail sales in Imperial County with that of most other counties in the Southern California region can be attributed to the dependence of Imperial County on cross border shoppers and the effect of exchange rates between the Mexican peso and the U.S. dollar on retail sales.

Over the last two decades, there has been substantial consolidation of the retail sector in Imperial County. According to the U.S. Economic Census, there were 757 retail establishments in Imperial County in 1977, 565 retail establishments in 1987, 688 retail establishments in 1992, and 521 retail establishments in 1997. The corresponding figures for retail sales in millions of dollars are 299 million dollars for 1977, 477 million dollars for 1987, 846 million dollars for 1992, and 989 million dollars for 1997. Even as we see continued increase in retail sales, in fact a tripling from 1977 to 1997, the number of retail establishments has decreased pointing to a rising proportion of larger retail establishments and consolidation in the retail sector. As the volume of retail sales continue to increase this pattern should continue in the near term, since larger sales volumes make larger retail establishments economically viable.

The growth in retail sales by category indicates tremendous expansion especially in the sale of building materials and garden supplies which grew from $18.3 million in 1977 to $174.1 million in 1997 with most of the growth occurring from 1992 to 1997. Other categories which also increased rapidly included general merchandise which grew from $40 million in 1977 to $203 million in 1997, auto dealers with sales expanding from $50 million in 1977 to $171.4 million in 1997, and gasoline service stations which grew from sales of $23.8 million in 1977 to $98.7 million in 1997. These sectors underscore the importance of retail and transportation. Relatively slow growth retail categories include food stores (sales of $81.3 million in 1977 to $190.1 million in 1997), apparel ($21.5 million in 1977 to $55.5. million in 1997), and furniture ($8.7 million in 1977 to $12.9 million in 1997).

Binational Economic Linkages between Imperial County and Mexicali

In order to facilitate binational planning, it is essential to identify and examine in further detail the sectoral linkages between the two border entities of Imperial County and Mexicali Municipio. While the examination of such linkages is currently limited by the lack of access to detailed economic data on Mexicali, the access to data on Imperial County enables us to initiate such an examination. The binational linkages between Imperial County and Mexicali exist in a number of sectors of the economy including agriculture, education, financial services, retail trade, transportation, energy, and water.

Agriculture plays a major role in the economy of Imperial County. One of the factors contributing to the enduring success of this sector is the role played by immigrant labor from Mexico. Immigrant labor willing to work at low wages helps to keep the agricultural sector of Imperial County competitive. In comparing the agricultural sectors of Imperial County and Mexicali, it is worth noting that the sizes of the farms in Imperial are on average much larger than the farms in Mexicali. In addition, the composition of the output on both sides of the border is different, with Mexicali farms focused on agriculture produce such as vegetables and Imperial County farms focused on raising livestock and livestock feed such as alfalfa. The large farms in Imperial use a higher level of mechanization than the smaller ones in Mexicali. Thus the agricultural sectors in Imperial County and Mexicali are complementary with regard to their output and their relative uses of labor.

In the education sector the nature of binational linkages are complex. Since the need for skilled labor in Imperial County is low, the level of education in Imperial County is also low in comparison to the rest of California. As discussed in the last chapter, the county trails San Diego County and California on every educational indicator. The growth of the educational sector in Imperial County would be rather limited if it were entirely dependent on the Imperial County economy. However, anecdotal evidence suggests two possible sources for increases in the educational sector of Imperial County at the school and the college level. The first source is wealthier students from Mexicali who study in Imperial County schools, while the second is upper level U.S. managers working in the maquiladoras in Mexicali and living in Imperial County, who are likely to send their children to school in Imperial County. The primary reason for preferring to study in Imperial County would be to benefit from "perceived long term advantages" of studying where the medium of instruction is English and to benefit from the resources that may be available to a school system in California.

As will be discussed in more detail in the next chapter, the transportation sector in Imperial County is closely linked to activities across the border in Mexicali. While truck traffic related to the maquiladora sector has expanded on a regular basis, automobile and pedestrian traffic derived from Mexicali shoppers in Imperial County also forms a major and growing part of the transportation sector. There are two major ports of entry in Imperial County with the second port of entry opened in 1996.

The retail systems of Imperial County and Mexicali are linked by the thousands of shoppers from Mexicali who shop on a daily basis in Imperial County. The large number of automobiles with Mexican license plates in the parking lots of shopping malls in Imperial County cities such as Calexico and El Centro is a testament to the contribution of cross border retail commerce to the retail economy of Imperial County. It is estimated that shopping trips from across the border generated approximately $70 million in monthly (March 1998) sales in Imperial County.

Retail Commerce

GIS (Geographic Information Systems) has useful potential in retail location, planning, and in understanding consumer expenditure patterns. The implication of cross border shopping on the different aspects of retail commerce in Imperial County is examined through spatial analysis in this section. A few key variables are mapped to illustrate the usefulness of GIS in enhancing our understanding of the retail economy. The variables that are discussed here include per capita income for 2000, and expenditures on food, furnishings, and apparel.

Per capita incomes are higher in two cities located away from the border namely El Centro and Brawley with per capita incomes between $15,933 and $34,931. The city of Calexico located at the border with Mexicali has relatively lower per capita incomes of less than $15,900 per annum. The lowest per capita incomes of less than $12,000 per annum are found in block groups located in rural areas. The map of expenditures on household furnishings demonstrates that the block groups with the highest level of expenditures are located in the cities of El Centro and Brawley primarily in the strip north of El Centro and south of Brawley. Expenditures on furnishings are also high in block groups located close to the border in Calexico, although the per capita incomes are low. This could potentially be due to the effects of cross border shopping and needs to be explored further. Rural areas to the east and west of El Centro and Brawley have very low levels of expenditure on furnishings. However block groups to the east of Calexico show relatively higher expenditures.

Mapping of food expenditures for block groups in Imperial County high values in the cities of El Centro and Brawley, and the highest expenditures close to the Mexicali border in Calexico. This may be due to the high automobile and truck traffic at the border crossing, and the consequent expenditures on food that this transit population incurs. Food expenditures to the east of Calexico are also elevated, and this would be due to the location of the second border crossing to the east of Calexico. Expenditures on infant apparel and children's apparel follow the same pattern as for food with the highest expenditures close to the border in Calexico.

Thus a preliminary mapping of per capita incomes, and expenditures on furnishings, food, and apparel point to interesting areas for further research. While the cities of El Centro and Brawley located further from the border than Calexico, have higher incomes and expenditures on furnishings, expenditures on food and apparel are greater nearer the border in Calexico. One possible explanation may be that Mexicans traveling by car may be in a better position to travel away from the border to the cities of Brawley and El Centro in Imperial County to buy furnishings, while the city of Calexico is in a better position to serve cross border truck drivers as well as relatively lower income pedestrian traffic who are more interested in the purchase of apparel. If food and apparel retailers are more likely to locate closer to the border, the implication for planning in terms of tax revenue as well as environmental issues related to the operation of food service businesses needs to be considered. Total retail sales in Imperial County and its major cities are given in **Table 4-3**. The highest growth in retails sales have taken place in the major cities close to the border namely El Centro and Calexico, while sales in the other cities have remained relatively stable.

Table 4-3. Retail sales in Imperial County and major cities 1997-2000
(Figures are in thousands of dollars)

	1997	1998	1999	2000
Brawley	103,469	106,430	107,812	110,169
Calexico	231,195	256,835	300,112	333,136
Calipatria	5,426	7,237	8,456	9,914
El Centro	304,903	407,781	471,979	507,562
Holtville	8,570	11,557	11,975	11,472
Imperial (city)	35,184	68,323	67,012	80,543
Westmorland	6,045	7,627	9,757	11,635
Imperial County	**1,051,327**	**1,105,405**	**1,293,324**	**1,403,530**

Source: California State Board of Equalization

Implications of National Boundaries for Retail Commerce

The northern and Southern borders of the U.S. attract cross border shoppers from Canada and Mexico respectively. Estimates of money spent by same day Canadian shopping in the US ranged from Canadian 5 to 10 billion dollars in 1992 (Econoscope, 1992; Cleroux, 1992) and today one would expect the figure to be even higher. For Imperial County the estimate of $70 million in March 1998 would amount to an annual total of $840 million assuming that the monthly sales is reasonably representative of sales throughout the year. Annual sales of $840 million from cross border shoppers would represent more than half of the total retail sales in Imperial County (based on sales in the first quarter of 268 million in 1998 estimated by the California State Board of Equalization). Even allowing for errors in estimates, cross border shopping contributes significantly to the economy of Imperial County. Similarly elderly shoppers form the US purchasing medicines contribute significantly to retail sectors in Mexico in cities such as Algodanes on the Arizona border. Thus an analysis of the factors that impact cross border shopping would help binational planning of the retail sector for US and Mexico.

In the context of the US – Mexico border, exchange rates may be a particularly important variable given the relative strength of the dollar and the peso. Anecdotal evidence suggests that when the peso loses value relative to the dollar, retail sales on the U.S. side of the border are adversely affected in the short term. However decreases in the value of the peso have also made Mexican labor rates more competitive and served to enhance the growth of the maquiladora industry thus increasing the aggregate income on the Mexican side of the border. Increases in aggregate income on the Mexican side of the border should result in increased retail sales on the Mexican side of the border eventually spilling over to the U.S. Thus one may hypothesize that in the short term, decreases in the value of the peso relative to the dollar should result in a decrease in sales on the U.S. side of the border, with no significant change in retail sales on the Mexican side. In the long term, decreases in the value of the peso should result in enhanced retail sales on the U.S. and Mexican sides of the border.

The impact of differential prices on retail sales in Imperial County would be difficult to ascertain without data on consumer motivations and shopping behavior. Anecdotal evidence suggests that middle and upper income Americans primarily shop for goods that are not easily available in Mexico. For goods that are purchased by middle and upper income Mexicans, marginal variations in price are unlikely to have a strong impact on retail sales. However, for lower income Mexicans who shop very close to the border as exemplified by the retail sector in Calexico in Imperial County and El Paso that are accessible to pedestrian cross border traffic, changes in price differentials between Mexicali and Imperial County will have a strong impact on retail sales. Variations in price differentials between Imperial County and Mexicali will have a stronger impact on the sales of goods to lower income Mexicans in comparison to the sales of goods to middle and upper income Mexicans.

Retail sales in Imperial County will also be impacted by the waiting times and the costs involved in crossing the border as reflected by customs and immigration policies. Increase in waiting times and tolls would mean greater cost of shopping for the Mexican shopper and would adversely impact retail sales in Imperial County. The larger costs of crossing the border would be particularly strong for Mexican shoppers from Mexicali who do not work in Imperial County. In the case of Mexican shoppers from Mexicali who commute to Imperial County on a daily basis for work, the costs of crossing the border will not have a substantial impact on their shopping behavior, since they have to cross the border for work. Increases in the costs of crossing the border will adversely impact retail sales to Mexican shoppers from Mexicali who do not commute to Imperial County on a regular basis for work.

Research on boundary effects suggests that retail sales will be impacted by consumer attitudes and cultural distance between both sides of the border. In general, it is assumed that more cultural distance will mean less cross border shopping. Data on cross border shopping by Mexicali shoppers in Imperial County and Tijuana shoppers in San Diego suggest that the retail sales to these shoppers is proportional to the populations in Mexicali and Tijuana respectively (Gerber, 1999). This would imply that cultural distance does not have a strong impact on retail sales since the cultural distance between San Diego and Tijuana is larger than the cultural distance between Mexicali and Imperial County, if we were to use the percentage of Hispanic population in Imperial County and San Diego as an indicator of cultural distance. As pointed out in the last chapter, the percentage of Imperial County's Hispanic population is much larger than for San Diego.

Per capita income and population density are both likely to impact cross border retail sales. Increases in the per capita income and population density in Mexicali will result in increased sales in Imperial County. The level of cross border retail sales to shoppers from Mexicali and Tijuana is illustrative. Estimates of the values of retail sales in 1998 suggest that retail sales in Imperial County to shoppers from Mexicali amounted to an annual total of $840 million and retail sales in San Diego to shoppers from Tijuana amounted to an annual total of $1.5 billion. The ratio of retail sales to cross border shoppers in San Diego and Imperial County is proportional to the population of Tijuana and Meicali respectively, suggesting that cross border retail sales is substantially influenced by the population density across the border. Per capita incomes of cross border shoppers are likely to have a similar relationship with retail sales. Retail sales to cross border shoppers will increase with increases in their per capita income. Retail sales to cross border shoppers will increase with increases in the population density of the population from which the cross border shoppers originate. Thus Imperial County has a stake in the economic development of Mexicali and binational planning needs to take such effects into consideration.

Chapter 5

Transportation

5. Transportation

Transportation is a crucial aspect of the border sister urban complex of Imperial County and Mexicali. It constitutes a form of economic exchange between the two countries, two states, and the adjoining urban areas on both sides of the border. This chapter analyzes the background and trends of U.S.-Mexico border trade in the light of the implementation of the NAFTA agreement of 1994. Following this discussion, the chapter examines border transport implications, such as expanded traffic volume and value of goods. It finishes by looking at Imperial County's and Mexicali Municipio's transportation and border trade.

The North American Free Trade Agreement (NAFTA) between the U.S., Mexico, and Canada went into effect in January of 1994. It was timed to be phased in gradually over a 15 year period. Many of its expectations have been realized. Among them is a major expansion in U.S.-Mexico Trade (U.S. DOT, 2001). The total of U.S.-Mexico trade in both directions rose from $100 billion in 1994 to $248 billion in 2000 (see **Table 5-1**). This amount of trade is important for the U.S. economy and huge with respect to Mexico's $450 billion GDP (Butler, Pick and Hettrick, 2001). Although the total trade is smaller than for Canada, it increased in NAFTA's first six years of data at double the rate for Canada and may eventually exceed Canada. This U.S. Mexico trade has been in a negative trade balance for the U.S. that reached -224 billion dollars in 2000. The low value of the peso and the strong economy in the U.S. have been key factors leading to this deficit (see **Table 5-2**). Other factors are increased U.S. foreign direct investment (FDI) in Mexico, better distribution mechanisms for goods, and the growing GDPs of the two nations (U.S. DOT, 2001). FDI is particularly beneficial to expanded intra-firm trade, since overseas facilities are improved. U.S. FDI in Mexico grew from 1994 to 2000 at a 13 percent rate (U.S. DOT, 2001; Butler, Pick, and Hettrick, 2001).

The U.S. Department of Transportation does not make publicly available what is being shipped through specific U.S.-Mexico land ports, but its general list emphasizes electrical machinery, equipment, and parts; motor vehicle parts and accessories, mineral fuels, oils, and related products; and plastic products (U.S. DOT, 2001).

Table 5-1. Value of U.S. Merchandise Trade with Mexico and Canada, 1994-2000 (Billions of Current Dollars)

	Imports from Mexico	Exports to Mexico	Total Trade with Mexico	Imports from Canada	Exports to Canada	Total Trade with Canada
1994	49	51	100	128	114	243
1995	62	46	108	144	127	272
1996	74	57	131	156	134	290
1997	86	71	157	168	150	318
1998	95	79	174	175	154	329
1999	110	87	197	198	164	362
2000	136	112	248	229	176	406
Percent Change 1994-2000	175	121	147	79	54	67

Sources: U.S. Department of Transportation, Bureau of Transportation Statistics, special tabulation, April 2001; based on: **total trade, air and water**—U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Division, *FT920 U.S. Merchandise Trade* (Washington, DC: Various years); **all land modes**—U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight Data.

Table 5-2. Balance of U.S. Merchandise Trade with Canada and Mexico, 1994-2000 (Billions of Current Dollars)

Year	Balance of exports and imports with NAFTA	Balance of exports and imports with Canada	Balance of exports and imports with Mexico
1994	-13	-14	1
1995	-33	-17	-16
1996	-39	-22	-18
1997	-32	-18	-14
1998	-36	-21	-16
1999	-57	-34	-23
2000	-77	-53	-24

SOURCES: U.S. Department of Transportation, Bureau of Transportation Statistics, special tabulation, April 2001; based on: **total trade, air and water**—U.S. Department of Commerce, U.S. Census Bureau, Foreign Trade Division, *FT920 U.S. Merchandise Trade* (Washington, DC: Various years); **all land modes**—U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight Data.

The NAFTA-related trade does not occur evenly in the U.S., but is focused particularly in Texas and California (U.S. DOT, 2001). Out of the $200 billion in U.S.-Mexico trade in 2000, Texas accounted for $69 billion, followed by California at $32 billion. These states are adjacent to the largest concentration of maquiladora plants. They have relevant large manufacturing and population centers to support maquila exchanges.

Mexicali and Imperial County are a part of this enhanced trade and have benefited in significant ways. In the case of Mexicali, NAFTA trade further stimulated Mexicali's maquiladora industry. Another benefit has been the development of the much larger Port of East Calexico to become one of the largest ports of entry for the U.S. This has had the advantage for Mexicali and Imperial County of greater services and business supporting this growing volume of truck traffic. Among the disadvantages are environmental impacts, costs of infrastructure improvements, and lifestyle changes.

In the NAFTA era of 1995 to 2000, Calexico moved up as a Port of Trade. As one of the Top 20 Land Ports between the U.S. and its two trading partners of Mexico and Canada, it rose from 19th in 1995, with 0.91 percent of Top 20 value of traded merchandise, to 13th in 2000, with 1.45 percent of traded merchandise (see **Table 5-3**). This represents 3.8 percent of U.S.-Mexico trade among the Top 20 Ports. Calexico became more important due to the advent in the late 1990s of the new East Calexico "Gateway" border crossing, a huge facility that will have an eventual truck capacity of 19,000 trucks daily. In 2000, the Top 20 NAFTA Land Ports accounted for 27,802 truck crossings into the U.S., which was 88 percent of all such crossings. The Calexico/East Calexico Combined Port had 764 northward crossings, which represented 2.6 percent of all inward crossings. By comparison, the biggest U.S.-Mexico land port, Laredo, Texas, accounted for 12.9 percent of inward crossings, while California's largest port of Otay Mesa/San Ysidro for 6.16 percent. Although East Calexico was built for up to a 15,000 truck capacity in 2 directions, its eventual growth will depend on the efficiencies and geography of binational trucking transport routes. One important question is how much of the Otay Mesa trucking traffic, near San Diego, will be diverted to the east to cross at East Calexico. Laredo is likely to remain in first place because it serves a North American backbone route going from Windsor-Detroit-Chicago complex down the center of the U.S. through Laredo to Monterrey and directly to Mexico City.

Table 5-3. Top 20 NAFTA Land Ports: 1995 and 2000 (Percentage of value)

2000 Rank	Port	Port Share (Percent)	
		2000	1995
1	Detroit, MI	16.40	21.84
2	Laredo, TX	14.53	8.04
3	Buffalo-Niagara Falls, NY	12.18	15.44
4	Port Huron, MI	10.37	8.09
5	El Paso, TX	6.84	5.51
6	Otay Mesa, CA**	3.26	2.36
7	Champlain-Rouses Pt., NY	3.00	3.59
8	Nogales, AZ	2.37	1.97
9	Hidalgo, TX	2.19	1.50
10	Blaine, WA	2.14	2.68
11	Brownsville-Cameron, TX	2.10	1.90
12	Alexandria Bay, NY	2.08	1.86
13	Pembina, ND	1.84	1.64
14	Calexico, CA	1.45	0.91
15	Sweet Grass, MT	1.35	1.14
16	Highgate Springs, VT	1.32	2.37
17	Eagle Pass, TX	1.27	1.30
18	Portal, ND	1.15	1.18
19	International Falls, MN	0.75	1.06
20	Eastport, ID	0.47	0.50
	All U.S. Ports and Customs Districts	**100.00**	**100.00**

**1995 data for Otay Mesa, CA, include traffic crossing the border at San Ysidro, CA, which has since been closed to truck traffic.

Note: Land trade includes truck, rail, pipeline, and miscellaneous and unknown modes.

Sources: U.S. Department of Transportation, Bureau of Transportation Statistics, Transborder Surface Freight Data, 1995 and 2000.

The implication to the present research project is that the expanding truck transport through Mexicali and Imperial County will impact their economies, energy consumption, and pollution. The economic and employment impact is highlighted later through a case study of the new East Calexico border gate. Regarding energy consumption and pollution, the energy consumed by the much larger trucking transport is quite large. Studies have shown that, in the U.S. and Mexico, transportation energy consumption represents about one quarter of total energy consumption (U.S. DOT, 1999). In the present border city complex, this large transportation-related consumption does not compete with electrical energy sources, since electrical production utilizes oil and diesel fuels that do not compete with the natural gas, geothermal, and hydro energy sources in the border city complex. However, nearly all forms of energy produce pollution. The air, noise, and odor expansion from the increased trucking volume will reinforce and augment pollution from the anticipated expansion in electrical energy production in Mexicali. Geothermal plants produce noise, smell, and air pollution (Butler and Pick, 1982). Natural gas plants produce varying amounts of air pollution depending on their design (Hinrichs and Kleinbach, 2002). Hence, the expansion in trucking needs to be considered in environmental planning in Imperial County and San Diego and underscores the need to incorporate as much pollution control mitigation as possible for trucks as well as for energy plants.

The Imperial County economy's transport sector in its economy that is geared to a variety of needs, not only border trucking. Although border-related transport stands out, other needs include public transport of residents, agricultural-related transport, and servicing of the east-west U.S. trucking that traverses the county, especially on U.S. Highway 8. Smaller transport businesses are spread out in the county's cities and surrounding rural areas (see **Map 5-1**). Nevertheless, they are more concentrated in Calexico, demonstrating that the border-related portion of transport is especially important. Larger transport businesses (see **Map 5-2**) are mostly located in Calexico and the area to its west, again emphasizing border-related transport.

The next chapter section considers the transport profiles for individuals in Mexicali and Tijuana. It is not a complete analysis, since the data are incomplete and there are few prior studies. Imperial County's transport profile resembles California's, except there is more carpooling and less public transport. This makes sense, since a small, more rural county has reduced public transport, and carpooling is a cost savings measure in a poorer area. It is also not surprising that Imperial County's average commute time is only twenty minutes, eight minutes shorter and California, reflecting its uncongested traffic setting.

On the Mexican side, Mexicali has relatively high automotive density, in third place along the border (see **Table 5-4**, which shows 1990 data). This relates to its high proportion of single family residences, as well as to a street layout much broader and more rectangular than a typical Mexican city. This is emphasized in **Table 5-5,** which shows that nearly three fourths of housing units in Mexicali have autos available. This extent of automotive dependence resembles that of

Imperial County (see **Table 5-6**). From the standpoint of trips, 52 percent occur in personal vehicles, versus 48 percent use of public transport.

Table 5-4. Vehicular Density in the Border Cities, 1990

City	Private Automobiles	Total Population	Automobiles per Person
Tijuana	153,601	698,752	0.220
Ensendada	71,999	169,426	0.425
Tecate	13,595	40,240	0.338
Mexicali	141,722	438,377	0.323
Nogales	19,758	105,873	0.187
Ciudad Juarez	206,254	789,522	0.261
Mier	1,850	6,190	0.299
Nuevo Laredo	28,635	218,413	0.131
Matamoros	32,122	266,055	0.121

Source: Aguilar, G., 1999. Cited in Toudert, *Atlas of Mexicali*

Table 5-5. Availability of Automobiles per Housing Units, Mexico, Baja, and Its Cities, 2000

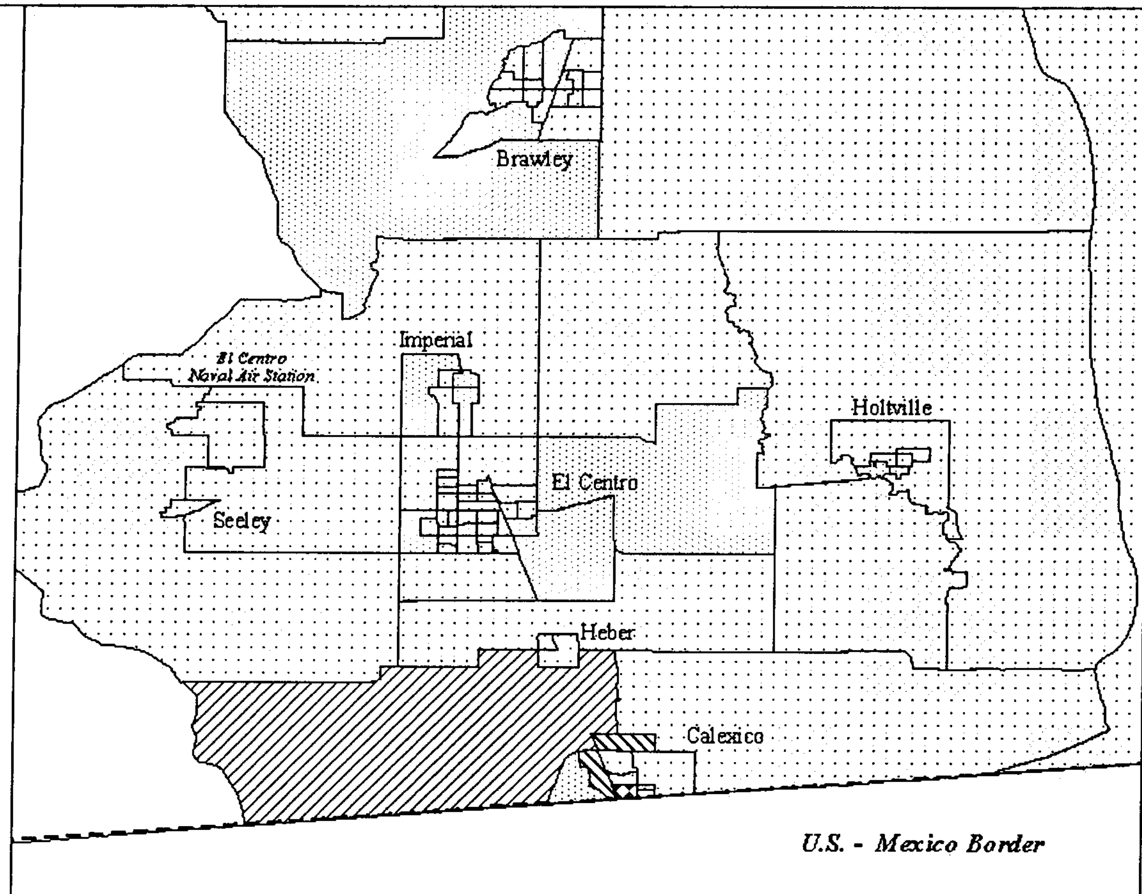
	No. of Housing Units	No. of Housing Units with a Private Auto or Truck Available	Percent
Mexicali	179,368	132,708	74.0
Tecate	17,080	11,788	69.0
Tijuana	265,683	162,817	61.3
Ensenada	84,137	54,249	64.5
Baja California	559,402	370,276	66.2
Mexico	21,513,235	6,992,055	32.5

Source: INEGI, 2001

Table 5-6. Transport in Imperial County, San Diego County, and California, 2000

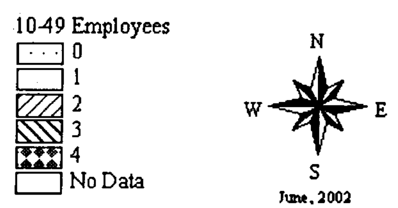
Form of Transport	Imperial County		San Diego County		California	
	Persons	Percent	Persons	Percent	Persons	Percent
Car, Truck, or Van, Driving Alone	31,406	72.7	960,065	73.9	10,432,462	71.8
Car, Truck, or Van, Carpooled	7,358	17.0	169,340	13.0	2,113,313	14.5
Public Transport	747	1.7	43,757	3.4	736,037	5.1
Walked	1,597	3.7	44,107	3.4	414,581	2.9
Other Transport Means	810	1.9	25,052	1.9	271,893	1.9
Worked at Home	1,286	3.0	57,182	4.4	557,036	3.8
Total	43,204		1,299,503		14,525,322	
Mean Travel Time to Work (Minutes)	**20**		**25**		**28**	

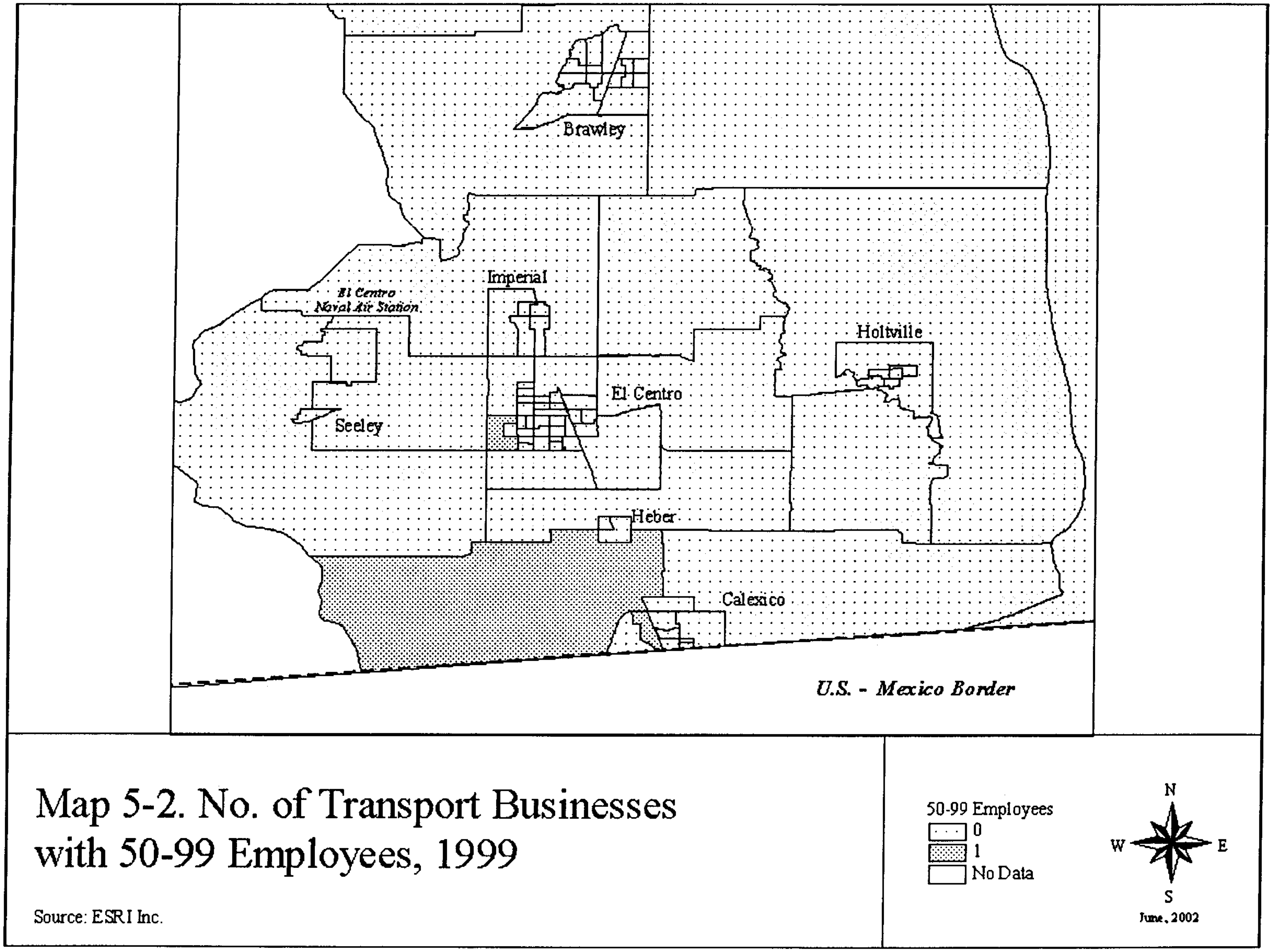
Source: U.S. Census, 2002



Map 5-1. No. of Transport Businesses with 10-49 Employees, 1999

Source: ESRI Inc.





Map 5-2. No. of Transport Businesses with 50-99 Employees, 1999

Source: ESRI Inc.

The reason for this high number and density of automobiles is also the result of the isolation of Mexicali from other parts of Mexico (Toudert, 2001). It is cut off from the center of the nation, 1,800 miles from Mexico City, and from Tijuana by a mountain barrier. Historically, the automobile has offered more ties with the nearby U.S. side. The practice also developed of purchasing used vehicles on the U.S. side, a custom that also prevails in south Texas border cities, such as Brownsville.

Mexicali's transportation growth started with narrower roads in the traditional city center and later extended to major arteries connecting the traditional city center to developing outlying nucleuses, such as maquiladora parks (Toudert, 2001). However, this growth pattern also created a critical problem in the public transport system. Cross city trips still required entry, transfer, or exit through the old narrower central area. This has created poor circulation, long travel times, and increasing congestion in the city center, as well as augmented air pollution from idling.

Surprisingly, fuel costs are somewhat higher in Mexico than the U.S. (see **Table 5-7**). This difference is even more pronounced, because per capita income in Mexico is ten percent that of the U.S. It is unexpected, since Mexico is one of the world's leading petroleum producers (Butler, Pick, and Hettrick, 2001). The reason for this asymmetry is the lack of refining capability in Mexico, so retail petroleum costs are elevated by the costs of refining in the U.S. The effect of high prices is to reduce the potential for vehicular travel throughout Mexico. This may be one reason that Mexicali half depends on public transport, in spite of its otherwise "southern California-like" transport profile.

Table 5-7. Average Fuel Price for End User, U.S. and Mexico, 1996

	Mexico	U.S.	Ratio U.S. to Mexico
Motor Vehicle Fuel			
Unleaded Premium Gasoline	158.2	141.3	0.89
Unleaded Regular Gasoline	143.5	123.1	0.86
Diesel Fuel	106.7	123.5	1.16
Aviation Fuel			
Gasoline	143.5	111.6	0.78
Jet Fuel	88.6	64.8	0.73
Rail Fuel			
Diesel Fuel	106.7	67.7	0.63

Note: all prices are in U.S. cents per gallon
Source: U.S. Dept. of Transportation, 1999

This chapter section looks at the impacts of increasing border trade and transport on the economy of Imperial County. It first presents more background on the magnitude of these exchanges and then examines two case studies, one of economic impact of individual border crossings and the second of the East Calexico "Gateway" project. This section intends to make real the largely statistical perspective covered up to now. The 1997 data for Calexico in **Table 5-8** show that not only were there incoming 213,662 truck crossings, but also 8.2 million pedestrian crossings, 19.2 million incoming vehicle passengers, and 246 incoming train crossings. Because of the transport growth already alluded to, today the trucking and other figures would be about 30 percent higher. As the U.S. DOT (2001) has pointed out, "As U.S. trade with Mexico and Canada grows, pressure on border and gateway infrastructure can be expected to rise, with the potential to increase congestion levels, alter current traffic flow patterns, and create demand for congestion mitigation strategies, particularly at intermodal connectors, where multiple modes meet."

With respect to pedestrians and passengers, the most informative source of information was a survey of border crossers conducted under the leadership of San Diego Dialogue and Centro de Estudios Economicos del Empressarial de Mexicali in March 1998 (San Diego Dialogue, 1998). 3,188 survey questionnaires were filled out at pedestrian and vehicle areas of the 3 ports of entry between Mexicali and Imperial County of Calexico, East Calexico, and Andrade. The small Andrade port is located in the eastern part of Imperial County away from its urban areas.

The key findings from this survey, summarized in **Table 5-9**, distinguish several important groups of crossers. The most prevalent were Mexican residents shopping in the U.S. This is also reinforced by the finding that 84 percent of crossers were non U.S. citizens. According to the survey, in March of 1998 there were 2.8 million legal crossings in the two ports of entry of which 75 percent were related to passengers in vehicles and 25 percent were pedestrian. Most of these crossings were related to shopping. This underscores the importance of the retail sector in Imperial County, stressed earlier in the report.

Table 5-8. U.S. Border Crossings of Pedestrians, Passengers, Trucks, and Trains, 1997

	Incoming Pedestrian Crossings	Incoming Passengers**	Incoming Truck Crossings	Incoming Train Crossings
California				
Calexico actual data	8,167,540	19,241,319	33,611	43
Calexico extrapolated*			213,662	246
Andrade	1,360,393	1,650,543	2,647	NA
Otay Mesa	621,517	8,362,058	567,715	NA
San Diego			NA	NA
San Ysidro	8,476,225	30,720,332		
Tecate	272484	2,820,394	61,804	20
Arizona				
Douglas	599,082	4,803,469	35,718	NA
Lukeville	76274	1,046,450	3,671	NA
Naco	71839	765,688	6,575	NA
Nogales	4,643,538	9,647,457	242,830	560
Sasabe	3097	67,501	1,546	NA
San Luis	2,220,799	6,852,002	42,351	NA
New Mexico				
Columbus	119418	490,706	2,305	NA
Texas				
Brownsville, TX	3,726,740	15,404,435	247,578	613
Del Rio, TX	262,717	5,373,966	45,059	NA
Eagle Pass, TX	529,897	6,594,028	71,656	1,254
El Paso, TX	4,542,646	43,155,367	582,707	889
Fabens, TX	14737	1,966,078	168	NA
Hildago, TX	2,429,241	23,318,753	234,800	1,399
Laredo, TX	5,427,815	17,638,438	1,251,365	2,400
Presidio, TX	11890	1,687,001	4,752	55
Progreso, TX	1,164,483	2,327,914	16,680	NA
Rio Grande City, TX	85,919	1,572,304	14,494	NA
Roma, TX	443949	3,426,737	10,671	NA
	45,272,240	**208,932,940**	**3,694,365**	**6,590**
Calexico as Percent of Entire Border	18	9	6	4

*data reported for Jan. and April was extrapolated based on California averages. Other months data largely missing.

** incoming passengers in personal crossings

Source: U.S. Customs Service, Mission Support Services, Office of Field Operations.

Table 5-9. Key Findings from San Diego Dialogue 1998 Survey of Border Crossers between Imperial County and Mexicali

- 70 percent of crossers crossed less than once a week. However, 75 percent of crossings were at least once a week.
- Of 2.9 million legal admissions n March 1998 from Mexicali to Imperial County to the U.S. 75 percent were vehicle passengers and 25 percent were pedestrians.
- Three quarters of border crossings are generated as a visit to the U.S. side. Only ¼ are to visit the Mexican side.
- The most important 3 reasons for border crossings were to shop in the U.S. (34 percent), to work in the U.S. (22 percent) and social visits to Mexico (15 percent
- Of work-related border crossers, 60 percent had agricultural occupations. One quarter are in production-related occupations.
- Work-related border crossings are almost 70 percent for agricultural jobs, follow by 12 percent in retail/wholesale trade, and 6 percent each in manufacturing and services.
- Of 51,500 workers employed in Imperial County in March 1998, 40 percent were border crossers. Agriculture had a workforce of 16,200, of which 14,300 or 88 percent were Mexicali residents. Other sectors with high work-related border crossing were construction/mining and manufacturing.
- U.S. citizens accounted for only 16 percent of border crossings, non-U.S. citizens, nearly all Mexicans, accounted for 84 percent of crossings. However, this group includes "green card" holders.

Source: San Diego Dialogue, 1998

Work-related visits were dominated by agricultural workers. The estimated agricultural workforce in Imperial County of 16,200 consisted of 88 percent Mexicali residents (San Diego Dialogue, 1998). Other secondary occupations having work-related crossings were retail/wholesale trade, production/manufacturing and construction/mining. The prevalence of border commuters in Imperial County agriculture has been present for several generations (Butler and Pick, 1982), but is hard to quantify, since the U.S. Census counts workers who are present at the census time, regardless of residence. The other types of border crossers are not surprising, given the large amount of border shopping in the U.S., the large maquila manufacturing base in Mexicali, and the housing and construction build-up on both sides of the border.

A case study of the new East Calexico Port of Entry (POE) between Mexicali and Imperial County highlights some of the key transport issues. The East Calexico POE, or "Gateway of the Americas," was developed shortly after the passage of NAFTA in 1994, in order to accommodate greater anticipated volumes of truck traffic crossing the border in both directions. That traffic could no longer be handled by the traditional border gate located between downtown Calexico and Mexicali. The new POE opened in December of 1996 with an emphasis on commercial vehicles, but not excluding passenger vehicles and pedestrians. It was designed on a large scale, so that it could be built up to handle 12 primary and 36 secondary inspection lanes. There were five import and export inspection booths, with 85 import and export docks, potentially expandable to 250. In 1997, the vehicle traffic in two directions was 8,400 vehicles, of which about 1,550 were trucks (Imperial County Transportation Plan, 1999). The projected maximum vehicle traffic was 19,000 per day (Imperial County General Plan, Land Use Element, 1997). By 1997, the East Calexico POE truck volume had already exceeded somewhat that at the traditional Calexico gate. Pedestrian traffic at the East Calexico POE was very slight.

The hopes and potential, as well as problems, in the new border gate are highlighted in the plan "Gateway to the Americas," which proposed the development of an area in Imperial County surrounding and to the north of the East Calexico POE (Gateway of the Americas Specific Plan, 1997). Although now five years old, this plan still conveys many key issues of realizing economic benefits from the new POE. The Gateway is an area of 1,775 gross acres next to the 87 acres of the POE itself. The dream in the plan was that the East Calexico POE "ultimately will be the largest land crossing located along the 2,000 mile Republic of Mexico/United States border" (Gateway of the Americas Specific Plan, 1997).

The underlying premise of the "Gateway" was that it could sprout up and become a major commercial and industrial center relative to the entire southwestern U.S. A plan was written by Imperial County and 16 private property owners to try to foster this. The anticipated land use of the acreage was as follows:

Table 5-10. Anticipated Land Use of "Gateway of the Americas"

Type of Land Use	*Acreage*	*Percent of Total*
Port of entry	87	5
State inspection facility	25	1
Rights-of-way and easements	242	14
Industrial	1,144	64
Retail/commercial	277	16

Source: Gateway of Americas Specific Plan, 1997

One of plan's major objectives was to create employment opportunities through the Gateway (Gateway of the Americas Specific Plan, 1997). The plan forecast that the expansion in cross-border traffic from the East Calexico POE would create 6,350 permanent primary jobs in transportation, warehousing, and activities related to trade -- jobs at a higher than average pay. The secondary (multiplier) effect would be to create another 6,330 jobs, at lower pay. The total of 12,680 permanent new jobs would stimulate housing demand and retail and commercial sectors. To construct the Gateway's industrial/commercial facilities, 3,160 job years would be needed. In retrospect, this amount of job creation has shown little evidence of taking place. For instance, from 1996 to 2000, transportation and public utilities jobs in the county dropped by 200 workers to 1,900. Trade workers increased by 1,400, while services increased by 300. If one quarter of countywide changes were attributed to Gateway, only 375 new permanent primary jobs would be created, only 6 percent of the amount of new primary jobs projected (California Department of Finance, 2001).

The plan calls for land use changes for diverse industrial and commercial uses. This array includes:

- *Warehousing for international commerce based on trucking.*
- *Distribution centers for storing and routing goods that are changing carriers or transport mode.*
- *Import and export custom broker premises.*
- *Industrial sites on large parcels, especially related to international commerce*
- *Office parks for professional services, public and private agencies and services, and maquila administration.*
- *Shopping for Mexico-bound travelers.*
- *Shopping for pedestrians.*
- *Hotel accommodations for people conducting business related to the international border.*

There is also no evidence that such a wide spectrum of development occurred. For instance, the U.S. Census of 2000 indicated that Calexico had only 511 wholesale trade workers and 296 construction workers (U.S. Census, 2002), which is far less than the requirements for such broad-scale Gateway development.

The Gateway Plan also called for flexibility in land use regulation, legal mechanisms that are clear with respect to the project, development guidelines, and policies on environmental mitigation. It would seem that, because Gateway is slowed down, most of these are not necessary at this point, but may be needed if the Gateway were to develop significantly in the future. The environmental impacts so far of the new POE are from increased trucking traffic. These impacts are a longer-term trend than the Gateway Project and regulated more at the state and federal, rather than county level.

In summary, Gateway to the Americas was an ambitious development project created shortly after NAFTA's start and with the expectation of major build-up in industry and commerce surrounding the new East Calexico Port of Entry. Although trucking traffic has increased through the POE, it is at half of the level expected. This new POE has not so far sparked major real estate, commercial, and industrial development to create thousands of jobs and major tax benefits for the county.

Chapter 6

Energy Resources and Supply in Imperial County and Mexicali

6. Energy Resources and Supply in Imperial County and Mexicali

Introduction

The twin urban region of Mexicali and Imperial County has substantial existing energy capacity. Imperial County has developed fossil, hydro, and geothermal energy capacity. Mexicali has installed a large geothermal field in Cerro Prieto. This chapter analyzes the size, type, and geographic distribution of the energy production and supply in this twin urban area. Cross border transfer of energy as well as seasonal fluctuations in energy production are examined, as well as the implications of energy from this twin-urban region provided to coastal metropolitan areas, such as Tijuana and San Diego. Four scenarios of future energy capacity build-up of the region are given -- natural gas driven combined cycle Mexicali power plants, liquid natural gas plants in Tijuana, geothermal buildup in Mexicali, and other renewables such as solar. The advantages as well as constraints of each of the four energy types are examined.

Energy is a vital resource in the study region, as well as in California and Baja California. The energy crisis in California in 2000 highlighted that the energy systems, and possibly energy markets, were not working well. These energy systems are aggravated in the region's border cities by its rapid demographic growth.

As pointed out in Chapter 5, populations are forecast to continue to grow significantly over the next twenty years. Energy demand will grow at a rate greater than population growth, which adds to the present challenge. The fact that the 2000 California energy crisis resolved itself economically within a year does not lessen the likelihood of long term of challenges and crises. There are several other detriments to energy growth in the region. One is that environmental impacts are associated with all forms of energy. Many times, a convenient energy plan to solve a short-term problem of demand may lead to environmental worsening and problems in the long term (Hinrichs and Kleinbach, 2002).

This chapter considers the current energy supply situation in Imperial County and Mexicali Municipio in terms of the types of power plants, type of energy system, sources of energy supply, environmental impacts, locations of demand, need for transport, gridding, and inter-connections.

The demand side is considered less, since there are few data sources about it. One aspect of demand in Mexicali that is discussed is the need for, and progress towards energy conservation.

As background, Imperial County and Mexicali constitute a rather small portion of Mexico's or California's energy capacity. Mexicali in 2000 had 720 MW of electrical generation capacity, while Imperial County had 857 MW. Mexicali's was 2.4 percent of Mexico's 35,330 MW in electrical generation capacity, while Imperial County constituted 1.4 percent of California's 51,888 MW capacity. Mexico's power plant locations are shown in **Table 6-1**. It is clear that fossil fuel sources dominate nationally.

Table 6-1. Change in Electrical Production Capacity, Mexico, 1995-2000

	1995	1997	2000	Change 1997-2000
Fossil Fuels				
Combustion - Oil and/or Gas	13,371	14,058	14,058	0.0
Combined Cycle	1,890	1,942	2,914	50.1
Dual	2,100	2,100	2,100	0.0
Turbo Gas	1,308	1,301	1,986	52.7
Internal Combustion	129	121	116	-4.1
Subtotal	18,798	19,522	21,174	8.5
Coal	2,250	2,600	2,600	0.0
Nuclear	1,309	1,309	1,309	0.0
Renewable Energy				
Hydro	9,056	9,761	9,390	-3.8
Geothermal	753	750	855	14.0
"Eoloelectrica"	2	2	2	0.0
Subtotal	9,811	10,513	10,247	-2.5
Total	32,168	33,944	35,330	4.1

Up to now, the Imperial County and Mexicali energy production mix has been largely renewable energy. 100 percent of Mexicali's 2000 production is renewable, versus 62.5 percent for Imperial County. Both are considerably higher than for their respective nations. This renewable energy is in the form of geothermal deposits, which extend across both sides of the border, as well as hydro energy in Imperial County, which consists mostly of small plants associated with the All American Canal and other irrigation channels. Although this largely renewable mix has been fairly robust in the past decade, it will change substantially in the next five years with the addition of two or three combined cycle natural gas-fired power plants in Mexicali.

This chapter examines the region's future buildup of energy capacity, the alternative approaches that can be taken to develop the region's energy supply further, and what their advantages and disadvantages are.

The specific research questions addressed in the chapter are the following:

- *What are the major energy additions planned over the next ten years in Imperial County and Mexicali? What is the likely amount of energy to be developed by type, and how does it affect the regional deployment of energy?*
- *Besides the planned additions in 1., what other types of energy might be developed? For each type, what are the constraints to development?*
- *What factors influence the demand for the energy in Imperial County and Mexicali? For each energy type, where will the energy be consumed and how important will be price, transmission lines, and international inter-connections?*

Prior Studies

The energy situation on both sides of the border has been studied by various researchers and government bodies. This literature review covers a few of the studies that have been done up to now. The impacts of residential construction and air conditioning on energy demand in Mexicali are quite significant. This is because of the very hot temperatures in Mexicali during the summer months, which often exceed 100 degrees F for extended periods. A study (de Buen, 1993) examined the background of the power industry in northern Mexico, focusing on the Comisión Federal de Electricidad (CFE). It analyzed electricity consumption by types of customers and the spatial pattern of consumption. It pointed to the rapid population growth of Mexicali, which is coupled with a residential population with increasingly high proportion of air conditioning use in the summer. The upsurge in air conditioning use, driving up energy consumption, can be offset somewhat by conservation programs in Mexicali. Examples of CFE's conservation programs are insulation for roofs and walls, and an interruptible rate option allowing CFE to turn off air conditioning units at quarter hour intervals (de Buen, 1993). The policy options in Mexicali to mitigate this crisis are: changes in energy supply, including CFE added capacity, capacity imported from the U.S., building self generation facilities, and building privately owned co-generation plants in Mexicali (co-generation produces both electricity and process heat), and establishing leasing alternatives for projects identified as important by CFE. That research also points to the potential detriments of environmental impacts from substantially more power production. One solution emphasized by de Buen is to reduce energy losses through better construction and improved housing and appliance standards, especially for air conditioning.

In a series of papers, Sweedler et al. (1995, 2001) examined the energy situation facing Baja California and California, with particular focus on Mexicali, Tijuana, and San Diego. Topics covered in these papers include energy capacity, energy types, private energy development in Mexico, projected growth rates for energy and population, energy regulation on both sides of the border, residential consumption levels, and energy inter-connection between Mexico and the U.S. (Sweedler et al., 1995, 2001). The authors identify possible energy scenarios for San Diego-Baja Region as follows: (1) new plants developed by independent power producers in Baja California that sell energy to CFE, (2) new power plants built on U.S. side with the energy being transported to Tijuana, (3) building renewable energy facilities, such as solar and wind energy. This study somewhat resembles the present one in its methodology, but differs in its greater interest in Tijuana-San Diego and lesser interest in Imperial County (Sweedler et al., 2001).

Helpful reports are available at the U.S. federal, state, and county levels (EIA, 2002a,b; CEC, 2002; IID, 2001). A report of the Energy Information Administration (EIA, 2002a) examines the overall energy situation of Mexico. Mexico is a huge player in global oil. For instance, it is the world's fifth largest oil producer and the fourth largest Western Hemisphere producer of natural gas. The EIA points out that Mexico is beginning to emphasize natural gas more. The reason is that NG is much less polluting when used to fuel combined cycle plants. Mexico's major natural gas production is underutilized. For instance, much of its natural gas associated with petroleum is flamed and not consumed. The giant Burgos field in Tamaulipas contains the preferred, non-associated type of natural gas (i.e. it's not associated with an oil deposit). It is likely that some of the "downstream" parts of the Burgos field project will be let as bids to private firms for development.

Another deficit in Mexico is a small and rather old natural gas distribution network. It is only 8,700 Km in length, compared to 463,000 Km for the U.S. Generally, Mexico's relatively weak energy transmission infrastructure needs investment and improvement. In summary, this report points to Mexico as a nation with huge energy capacity, but limited realization of its potential. The U.S., by contrast, is an energy giant in its technology and consumption levels (EIA, 2002b). For instance, in contrast to Mexico's production capacity of 38,500 MW, the U.S. has 687,000 MW of annual production!

This report emphasizes the importance of natural gas (NG) for the U.S. NG accounts for 24 percent of U.S. primary energy, a fraction that is increasing every year. The reason is that the combined cycle plants, with efficient natural gas turbines, produce lower cost electricity that is also less polluting. The U.S. has already commenced projects using liquid natural gas (LNG). LNG refers to the super-cooling and liquefaction of NG to 1/600 the ordinary volume of NG. The LNG plant then can be transported in specially designed ocean tankers to destination ports. At the port, the LNG enters a regasification facility, which decompresses the LNG to normal form for use as fuel for electricity or heating. A single LNG plant costs billions of dollars to develop, but can transform the NG potential of a region by an order of magnitude or more. In the U.S., successful LNG facilities are operated by Distrigas in Everett, Massachusetts, and at Lake Charles, Louisiana, and Elba Island, Georgia. A Maryland facility will open soon (EIA, 2002b). The U.S. interest in LNG is important here, since Mexico is considering locating its first LNG plant nearby the U.S. in Baja California.

After the California energy crisis of 2000, the state has been cautious in its assessment and predictions of energy growth. A recent report from the California Energy Commission (CEC, 2002) delineates the current approvals for additional energy capacity. For instance, an additional 25,570 MW, beyond California's 51,888 MW capacity is in various stages of construction, approval, permitting, and announcement (CEC, 2002). This report points to many constraints on new plants, which include air pollution, supply of cooling water, environmental impacts such as endangered species, land use, transmission line congestion, and natural gas supply. For instance, power plants in California consume 235,000 acre feet of water annually. This water is small compared to the state's annual consumption of 78 million acre feet, but it may have impacts in particular local communities, where cooling water will take away from other uses or cause shortages. As California becomes more populous and congested, the land use and transmission corridor congestions become more serious and limiting (CEC, 2002). It is remarkable that given all these constraints, there are underway requests to increase the energy supply by 50 percent. However, it is equally sobering to realize that state population projections show the population growing by 50 percent over the next 40 years, with per capita demand expanding simultaneously.

At the local level of county government, Imperial County is not highly sophisticated and the county is fairly impoverished relative to California. Its energy is partly generated, and entirely distributed by the Imperial Irrigation District (IID). This is a community-based utility, with elected commissioners. Information on the IID energy system is summarized in the annual IID Power Report (IID, 2001). Although full of financial, infrastructure, and power data, this volume contains minimal analysis and evaluation of county energy resources (IID, 2001). For many decades prior to some move towards deregulation in the 1990s, the IID was secretive. Hence, it is not surprising that this volume is mainly a series of data tables. It is the sole and rich data source for an overall picture of energy production in the county.

In summary, there is a limited amount of literature on energy development in Imperial County and Mexicali. This paucity stems from the binational region being relatively remote, that is away from the seats of government and corporate power. In addition, some government planning agencies appear bound by secrecy, so relatively little information is available. However, the lack of literature attention should not detract from the importance of the region. It is growing rapidly in population, and connects California and Mexico. It has high potential to be a leading region in renewable energy, which is the preferred form of energy for the future.

Methodology

This chapter applies simple estimation and GIS procedures to data gathered from government sources and as well as from case study interviews with several leading experts. The simple estimation consists of spreadsheet-like calculations and graphing. GIS is used to show the distribution of power plants and transmission lines in relation to energy alternatives.

The government sources consulted to gather data and information include in Mexico the Comisión Nacional de Electricidad (CFE), Comisión Nacional de Ahorro de Energía (CONAE), Petroleos Nacional de México (PEMEX), and Baja California state government reports. In the U.S., the government agency reports and data-bases consulted were the Energy Information Agency (EIA), California Energy Commission (CEC), County of Imperial, and Imperial Irrigation District (IID). Additional information was available from other agencies such as the Secretaria de Energía and from academic articles.

Case study interviews were conducted during 2001 in Imperial County, Mexicali, and Mexico City. Among the people interviewed were the general manager of the IID, leaders of the CFE regional office in Mexicali, the Economic Development office of Imperial County, CFE, CONAE, and CRE headquarters offices in Mexico City, the *Los Angeles Times*, and the president of GE Capital in Mexico, which funds private energy projects in Baja California. Standard case study methods were utilized. This included a standard set of questions, and detailed written recording of the full interviews (Yin, 1994).

Results

The findings are presented in terms of the research questions.

1. ***What are the major energy additions planned over the next ten years in Imperial County and Mexicali? What is the likely amount of energy to be developed by type and how does it affect the regional deployment of energy?***

In Imperial County, the starting energy situation in 2000 is shown in **Table 6-2**. It is evident that the county's energy production is dominated by geothermal. These plants tend to be smaller ones. There is a modern combined cycle plant that accounts for 28 percent of capacity. However, that plant tends to be utilized in the summer months for peaking purposes. The other forms of energy are small hydro plants, which are connected to the irrigation canals, two small fossil plants, and a biomass plant that processes plant and animal wastes. It is generally a stable energy arrangement, since geothermal and hydro do not vary much seasonally, nor in market price. It is more than sufficient to satisfy the needs of a population base of 142,000 people.

Table 6-2. Imperial County Energy Generating Plants, 2000

County	Site	Fuel	Capacity MW	Percent
Imperial	2 Plants with Sizes of 20 and 46 MW	Oil and Gas-Combustion	66	7.7
Imperial	Combined Cycle Plant	Oil and Gas-Combined Cycle	240	28.0
Imperial	16 Plants with Average Size of 29.7 MW	Geothermal	475	55.4
Imperial	10 Hydro Plants with Average Size of 6.1 MW	Hydro	61	7.1
Imperial	1 Biomass Plant Based on Agricultural and Animal Wastes	Biomass	15	1.8
Total			**857**	**100.0**

Source: California Energy Commission, 2002

In Mexicali (see **Table 6-3**), the year 2000 energy production is 720 MW of geothermal, which is located in large geothermal plants that are part of the Cerro Prieto energy site about 20 km south of Mexicali. **Map 8-2** (see Chapter 8) shows the locations of power plants and transmission corridors in the region. The Cerro Prieto energy source is likewise quite stable throughout the year, which helps offset the high demands placed on the Mexicali energy system in the summer. The reason for lack of fossil plants is that, up to recently, transport and delivery of fossil fuels to Mexicali has not been easy. Another problem is the potential air pollution created by a traditional fuel oil plant. This energy capacity in Mexicali is supplemented by production elsewhere mostly in Tijuana – namely, a 620 MW combustion oil-gas plant located in Rosarito Beach, a 60 MW diesel plant in Tijuana, and a 55 MW diesel plant in Ensenada. These three plants total 735 MW in capacity.

Table 6-3. Mexicali Energy Generating Plants, 2000

Municipio	Site	Fuel	Capacity MW
Mexicali	Cerro Prieto I	Geothermal	180
Mexicali	Cerro Prieto II	Geothermal	220
Mexicali	Cerro Prieto III	Geothermal	220
Mexicali	Cerro Prieto IV	Geothermal	100
TOTAL			**720**

Source: Secretaria de Desarrollo Economico de Baja California, 2000

About 15 percent of the energy production from Mexicali is used to pump water supply over the mountains from Mexicali to Tijuana, so the actual year 2000 capacity left to satisfy the Mexicali demand is 612 MW. That may appear to be ample for a metropolitan area in 2000 of 765,000 persons. However, because of the great demands for air conditioning in the summer, it is merely sufficient at that time. Another demand on the energy is the heavy industrial use of it in the maquiladora industry. In Mexicali, about 50 percent of the energy use is for commercial and industrial purposes (Sweedler, 1995).

The California Energy Commission projects growth in the next decade of 180 MW. **Table 6-4** indicates that the growth is proposed for 2000-2005, but it can be assumed it will not be on line until later in the decade. Since the Imperial County population is projected by SCAG to increase from 140,000 to 182,000 in 2010, an increase of 30 percent, the energy increase of 21 percent should be more than sufficient, given that the county is under-utilizing its present energy supply most of the year. It is important to note that the geothermal and hydro proportion of the total will rise to 70 percent, which is remarkably high for California for these seasonally stable forms of energy.

Table 6-4. New Power Plants Proposed in Imperial County, 2000-2010

Facility	Location	Capacity	Total Installed-Imperial County	On-Line Date	Technology	Company
Salton Sea I	Imperial County	60	917	2005	Geothermal	NA
Salton Sea II	Imperial County	60	977	2005-2010	Geothermal	NA
Salton Sea III	Imperial County	60	1,037	2005-2010	Geothermal	NA
Total		**180**				

Source: California Energy Commission, 2002

The power additions in Mexicali are more considerable, as seen in **Table 6-5**. A number of combined cycle natural gas plants will be added over the next ten years. These plants are developed by independent private energy companies, and do not conform to the usual development of energy in Mexico, which is semi-monopolized by CFE. These plants will be supplied by gas lines that enters Mexico near Yuma, Arizona. The origin of the gas is most likely from Texas by way of Arizona, although Canadian gas sources might be utilized in the future. It is important to reiterate that Baja California is cut off from the electrical and natural gas distribution networks for Mexico. Thus it makes more sense that the gas will be supplied from an extension of the U.S. grid.

Table 6-5. New Power Plants Proposed in Mexicali, 2000-2010

Facility	Location	Capacity	Total Installed-Mexicali	Total Installed - Baja	On-Line Date	Technology	First Type	Company
Rosarita 10 and 11	Mexicali	506	1226	2756	2003	Combined Cycle	Natural Gas	InterGen
Baja California I	Mexicali	269	1495	3025	2005	Combined Cycle	Natural Gas	Sempra
Baja California II	Mexicali	269	1764	3284	2007	Combined Cycle	Natural Gas	Sempra
Baja California III	Mexicali	269	2033	3563	2008	Combined Cycle	Natural Gas	Am. Electric Power
Total		**1,313**						

Source: CFE, 2001

It is important to point out that the production capacity for Mexicali is proposed by CFE to double during the ten year period. The reasons for this planned doubling must be examined. The Mexicali population increase during this 10 year period will be much less, about 26 percent or 206,000 persons (see Table 135). The reason for the energy increase is that a good proportion of the consumption of the new plants is intended for the U.S. markets. The energy will mostly be transported across the Mexico-U.S. inter-connection to supplement the southern California grid. The need for this imported energy is evident by the net growth of 3 million people in the southern California population anticipated during the decade. The energy may also be needed by the much larger municipio of Tijuana, which is predicted to grow by 572,000 persons during the decade (see Table 135 in Chapter 3).

2. ***Besides the types included in the planned additions in 1., what other types of energy might be developed? For each type, what are the constraints to development?***

The major types of energy that might be developed in the region are geothermal, natural gas, liquid natural gas, and other renewable energy sources, particularly solar, wind, and tidal.

Geothermal. The Cerro Prieto geothermal field was first started commercially in 1972 (Holguín and Terrazas, 1995). About 75 percent of the brine is reinjected and 25 percent flows into ponds. Over 200 wells have been drilled into the geothermal deposit (Holguín and Terrazas, 1995). The four existing geothermal plants vary in their potential. For instance the Cerro Prieto III plant is located in an area of high steam production, so its geothermal potential is larger than the others. Cerro Prieto I plant has the lowest production potential, since it brings up lower proportions of steam (Holguín and Terrazas, 1995). There are a variety of estimates of how much additional capacity can be added to Cerro Prieto, without exhausting the field. In the interviews with experts, figures for this additional capacity were cited in the range of 200 to 800 MW. The fact is that the subsurface geology, geothermal well systems, and production systems are very complex (Holguín and Terrazas, 1995; Butler and Pick, 1982). Hence this wide range given for possible additions is appropriate. If the field begins to deplete, then the amount of addition may need to be scaled down. On the other hand, if the steam resources lead to greater replenishment of the field, then the higher figure of 800 MW is appropriate. Another constraint is that the relative pricing of geothermal to other forms of energy is unknown and depends on highly uncertain fluctuations in the international energy marketplaces.

Natural gas has distinctive advantages in both nations. It is a cleaner form of energy than other fossil fuels. Second, its price has been favorable in recent years. However, supply and transmission present potential problems. The tendency in both the U.S. (EIA, 2002b) and Mexico (EIA, 2002a) is for increasing utilization of natural gas for power plants. Natural gas currently accounts for 18 percent of U.S. energy capacity. From 1990 to 2000, it increased by 22 percent and more growth in likely during this decade (EIA, 2000b). In Mexico, natural gas is also expected to increase substantially. "Pemex plans to increase Mexican-U.S. border infrastructure and capacity, and to focus more on gas exploration and production activities." (EIA, 2002a). Part of the challenge in Mexico will be to upgrade its gas distribution network, which is old in many places and is only 8,700 km in length. The natural gas network of Mexico has eight interconnections with the U.S. network. It is likely, however, that demand will outstrip supply of natural gas in Mexico, leading to increasing imports. Consider the following analysis done by the Comisión Reguladora de Energía (CRE).

Table 6-6. Mexico's Demand and Supply of Natural Gas, 2000-2010

	2000	2006 (Estimated)	2010 (Estimated)
Demand	4,326	7,983	9,499
Supply	4,026	5,167	6,681
Imports to Mexico	300	1,916	2,618

Source: CRE, 2001

Another constraint to natural gas involves regulation. The regulatory bodies in Mexico that have a say-so in natural gas facilities are first CFE, which has a semi-monopoly on electrical distribution. The CRE makes the decision on initial approvals for projects by independent producers. Other regulatory bodies may be involved, including Secretaria de Energía. A U.S.-based independent producer seeking to build a plant in Mexico will need to contend with regulation and approvals, which are not static but vary from year to year. In summary, natural gas has many advantages that make it perhaps the most promising larger-sized energy type to be added to the Imperial County-Mexicali region. If supply, infrastructure, and regulatory problems can be overcome, providers can develop this energy type, which will also be of benefit environmentally.

Liquid natural gas is a newer energy type that is just beginning to be utilized in the U.S. and has not yet been used in Mexico. The potential of LNG came from the Mexican regulatory reforms of 1995. It is a way to satisfy a huge increase in natural gas demand. For instance from 1995 to 2000, natural gas demand in Mexico increased by 7 percent annually (Estrada, 2001). The LNG is liquefied at -256 F and the volume is reduced by 600 times. There are major U.S. companies with experience in it, including Phillips, Distrigas, El Paso Corp, and Williams Pipeline.

In Mexico, the growing markets in Tijuana and Mexicali, combined with the export market to California, make LNG attractive. Either natural gas or electricity can be exported. A degasification facility could be established along the coast of Baja California, somewhat south of the urban area of Tijuana.

The constraints are many. First of all, LGN would need to clear the regulatory framework, which consists of the CRE. There is not a precedent for how to do this, since it hasn't yet been accomplished. There are other regulatory entities, including the National Water Commission (CNA), which approves concessions for water use and for ocean discharges. The National Institute of Ecology is responsible to authorize accepting environmental impact studies and risk analysis reports. Port and local authorities give concessions to construct a degasification terminal, regulate land use, permit for contraction, and giving government protection. Another constraint is the lack of reliability of some producers. Right now the largest producers are Indonesia, Malaysia, Algeria, Qatar, and Australia. However, several of them have problems in today's world that may make their supply risky. There are constraints from the economic feasibility of LNG. The bottom line is that the future prices of NG are not known, yet are key to the success or failure. If electrical production is keyed with LNG, then it needs also to be thought out in advance. Another factor is that long term contracts must be sought. The investment in one LNG operation in Mexico is estimated at $2.650 billion dollars. Potentially thousands of megawatts can be brought on line. Because of the huge size of the projects, long-term contracts are the preferred way to go.

Another factor is the need for a better transmission network. This network might involve both transport of gas, as well as electricity.

The last type of energy option is renewable. The chapter already discussed ***geothermal*** as an energy type. It was seen that geothermal is quite viable in this region. It has proven steady and reliable. Geothermal is also somewhat less polluting than some other forms of energy. Also, the region has developed expertise in this type that can be helpful in succeeding with it. ***Hydro*** energy is heavily utilized in Mexico as a nation. In fact, Mexico's hydro proportion is 18 percent (EIS, 2002a). In Imperial County, hydro is a minor form with only 7 percent use. One of the points here is that the county doesn't have the large water courses that can be altered, except for the irrigation canals of IC. Hence hydro is naturally limited. ***Solar*** is a possibility that needs to be considered. The region has a lot of sunlight and open spaces, so solar is probably a good choice. Among the constraints with solar are lack of available land and location – it may need to be away from urban areas. Relative costing versus other forms of energy also is unknown. However, it is worthwhile for some businesses or business consortia to try out solar on a test basis, to get feel for it. Full implementation would require solid homework and some tenacity.

3. ***What are the current factors influencing demand for the energy in Imperial County and Mexicali? For each energy type, where will the energy be consumed and at what approximate price level?***

This part of the study shows that the factors that influence demand are, first, the pricing of the energy, which depends on fixed pricing schemes for some energy types or on international markets. The amount of air conditioning can increase demand for energy. We have already discussed that this is at a high level and increasing in Mexicali, which gets extremely hot in the summer. Another demand factor is the amount of conservation that is put into effect. If there is a lot of conservation, it may reduce demand. The maquiladora industry in Mexico has a large impact on demand. If the maquiladora slows down, the demand will be reduced. The reason is that many maquiladora industries especially electronics are energy intensive.

Another influence on demand is the amount of binational energy inter-connection that is allowed and the capacity of the interconnection. Because the southern California and Baja markets are growing so rapidly, an open market of exchange may be possible, if the regulatory environment relaxes. In that case, the inter-connections between the two nations may be increased. This will shift demand patterns, since pricing can be quite different between the two nations. Mexican natural gas-fired energy, for instance, can be sold in quantity to well-off southern California customers, who can pay a lot more. Conversely, U.S. energy could be sold at lower prices to Mexican customers. Another factor is the need for a better transmission network. This network might involve both transport of gas, as well as electricity.

Conclusion

This chapter examined the energy production situation in Imperial County and Mexicali. It has shown that substantial energy production of a stable, renewable form, exists in this region. Because of the historical and projected rapid population growth of the region, there will be pressure in the region on the energy supply and transmission.

This chapter has examined a variety of alternatives for energy production growth. It includes combined cycle natural gas plants, liquid natural gas, geothermal energy, and other renewable forms of energy. Each energy type has problems and constraints associated with its increasing production. Problems also exist in regulation, especially in Mexico, in the transmission infrastructure, and in conservation of energy in the hot summer environment of Mexicali.

Energy can be developed in this region to satisfy the much larger populations of the future. To do this, planning needs to be done at the national, state, and local levels, and also binationally, in order to coordinate and optimize these resources.

Chapter 7

Water Resources and Supply in Imperial County and Mexicali

7. Water Resources and Supply in Imperial County and Mexicali

Water resources have been one of the most critical elements in the growth and development of Imperial County and Mexicali Municipio. The Colorado River is nearly the unique source of water for this region. The region was largely a desert prior to the diversion of the Colorado River in 1904. That diversion created the agricultural potential of the Imperial Valley. It led to 221,000 hectares currently farmed in Imperial County, which is expressed in terms of a one billion dollar agricultural sector in the county economy.

The total water supply picture is seen in **Table 7-1**, which shows the water supply to the Lower Basin States and Mexico. It is clear that other states have a lot of use of the Colorado River water and the states of Arizona and Nevada are also growing rapidly in population and urbanization. The contesting demands from other states puts national pressure on the limited Colorado River supply to southern California. It is also evident that the Colorado River forms about three fifths of southern California's water supply. Since southern California is growing rapidly in population, increasing pressure from the region is being put on the Colorado River water. The sources of demand for water in the lower Basin States and Mexico is shown in **Table 7-2**. What is remarkably clear is that the southern California part of the basin states has the largest urban water demand, accounting for 44 percent overall in the mid 1990s (Morrison et al., 1996). Together, these pressures have led to a recent proposal by the Imperial Irrigation District to reduce its water consumption along with instituting increasing conservation measures, in order to transfer water to urban areas in coastal California (IID, 2002).

The water systems of Imperial County and Mexicali are strongly linked. The water system of Imperial County stems from the Colorado River. Water is diverted through the All American Canal and flows then through a large system of canals to irrigate the large agricultural areas of Imperial County. Wastewater flows eventually through the New and Alamo rivers draining ultimately into the Salton Sea. The water system of the Mexicali Valley is also served by the Colorado River through a system of irrigation canals. The wastewater from the Mexicali Valley also drains into the New and Alamo Rivers draining ultimately into the Salton Sea. The Salton Sea thus consists of wastewater flows from both Imperial County and Mexicali.

Table 7-1. 1990 Water Supply by Source for Lower Basin States and Mexico (Thousand Acre-Feet)

Source	Arizona	Southern California	Southern Nevada	Mexico	Regional Total
Local Surface	1,367	260	15	-	1,642
Colorado River	1,954	5,164	347a	1,640c	8,965
Other Imported	-	1,730	-	-	1,730
Reuse	119	89	22	-	230
Total Groundwater Use	3,334	1,260	147b	823	5,704
Sustainable Pumping	2,334	1,163	96	727	4,320
Groundwater Overdraft	1,000	97	51	96	1,384
Region Total	6,774	8,503	531	2,463	18,271
Colorado as Percent of Region's Supply	29%	61%	65%	61%	49%

a: Southern Nevada's Colorado River number is 1993-1995 average and are the total diversion for the region. Although there is a return flow credit system with wastewater returning to Lake Mead, diversions more accurately represent water supply for urban use.

b: Based on perennial yields, sustainable pumping in the region is estimated at 80,570 af/yr with overdraft 65,962 af/yr. Due to groundwater artificial recharge programs in Las Vegas Valley Water District (average 13,360 af/yr) and North Las Vegas (1,640 aflyr)(15000 af/yr total), sustainable pumping increases to 95,570 af/yr, while overdraft is reduced to 50,962 af/yr.

c: 1952-1992 average annual diversion at Alamo Intake, Morelos Dam.

Sources: Munson et al, 1996

Table 7-2. Water Demand by Sector for Lower Basin States and Mexico, 1990 (Thousand Acre-Feet)

Source	Arizona	Southern California	Southern Nevada	Mexico	Regional Total
Urban	1,594	3,715	453	184	5,946
Residential	1,105	2,192	275	NA	3,572
Commercial	NA[a]	669	83	NA	752
Industrial	409	297	29	NA	735
Government	NA[a]	223	28	NA	251
Unaccounted/other	80	334	38	NA	451
Agriculture/Livestock	5,180	4,083	77	·2,279	11,619
Other/Environmental	NA	705	1	NA	706
Total	6,774	8,503	531	2,463	18,270[b]

a: Commercial and Government included in Arizona's industrial.

b: Total supply and total demand difference due to rounding error.

Sources: Munson et al, 1996

The Mexicali Valley received legal rights to 1.5 million acre feet annually of Colorado River Water through the 1944 Water Agreement between the U.S. and Mexico. At the same time, California was granted 4.4 million acre feet annually. The state agreed to give Imperial County 75 percent of this water allocation.

The water that is currently supplied to Imperial Valley and Mexicali Valley is managed by the Imperial Irrigation District on the U.S. side and by the Irrigation District of the Valley of Mexicali on the Mexican side (Román Calleros, 1990). The IID was formed in 1911 as a community managed and operated utility, with responsibilities for water and energy production. Its irrigation network is 2,600 km long and well lined with also a well-developed network for wastewater drainage. As seen in **Table 7-3,** the extent of these irrigated agricultural areas are roughly similar. However, the average water cost is much higher on the U.S. side (Román Calleros, 1990). The water pricing has to do with the relative standards of living and currency valuation of the two nations.

Table 7-3. Basic Information on the Irrigation Districts of Imperial and Mexicali

	Imperial Irrigation District	Irrigation District of Valley of Mexicali
Date Formed	July 25, 1911	June 1938
Type	Private	Public from Government
Authority	Board of Directors	District
Services Provided	Urban, Agricultural, Industrial, Recreational and for electrical energy	Urban, Industrial and Recreational
Water Source	Colorado River	Colorado River and Wells
Annual Volume	2.5 m/af	2.4 m/af
Irrigation Surface Area	221,204 hectares	203,700 hectares
Principle and lateral Canals	2,573 km (1,602 miles)	2,507 km (1,558 miles)
Open Drains	2,336 km (1,454 miles)	1,492 km (927 miles)
Re-lined Canals	1,280 km (797 miles)	2,268 km (1,409 miles)
Irrigation Structure	5,846 sections	6,443 sections
Efficiency of Conduction		
Major Network	79%	75%
Water Cost *	7,792 (7.30 dollars/af)	234 (.22 dollars/af)
Number of Users	6,856	14,065
Type of Land Tenancy	Private	Ejidos, Colonias and small land ownership
Average Parcel Size	28.74 hectares	14.61 hectares
Minimum Land Plot	800 hectares	14.61 hectares

* In the Imperial Valley 1 acre foot costs 9 dollars and in Mexicali 1 acre foot costs 0.27 dollars
Source: Román Calleros, 1990

The water system in Imperial County was analyzed by Ch2MHill (IID, 2002). It is important to discuss the water system. The water balance, as analyzed by Ch2MHill, depends at its origin on imported water from the Colorado River. Its level at the inflow at Pilot Knob is 2.910 million acre-feet (maf)/yr. After being conveyed along the All American Canal, to the west, 2.855 maf/yr enter the IID's irrigation delivery system. 2.458 maf/yr are delivered to the on-farm irrigation systems throughout the Imperial Valley. Although most of the water is absorbed by drops, about 0.99 maf/yr are drained and eventually transpired.

The irrigation delivery system delivers about 0.120 maf/year for municipal and industrial uses (IID, 2002). This constitutes 12 percent of the inflow to the delivery system. Hence nearly 90 percent of water use in Imperial County is agricultural. The drainage system includes 0.99 maf/yr from Imperial County agriculture. This is supplemented by large amounts of surface drainage into the major water canals, the Alamo River and the New River. An important and fairly unique factor to this system is that 0.165 maf/yr of wastewater comes along the New River from Mexico (IID, 2002). The reason for this is that 1.5 maf/yr of Colorado River water is provided to Mexico. It flows northward through the Mexicali Valley collecting agricultural wastewater and accounts for the wastewater inflow of the New River coming from Mexico. This applies to a small extent for the Alamo River, which receives only 0.002 maf/yr from Mexico. The pooled drainage flows into the Salton Sea at the annual rate of 1.089 maf/yr (IID, 2002).

The loss between Pilot Knob and the delivery system is 0.099 maf/yr (IID, 2002). This water is lost to groundwater, which is utilized by Mexico. It is a source of dispute because the IID is currently in process of lining the All American Canal as a conservation measure. Mexico has protested this.

Another key point of this system is that significant diversion of water to urban users outside of California would disrupt the rather delicate balance. Diversion with increased on-farm conservation to compensate would reduce the "tailwater" outflows from farms and lessen wastewater flow into the Salton Sea, hence lowering the level of the Sea. This would have adverse environmental impacts that are discussed in Chapter 10. On the other hand, if cropping is reduced through the fallowing of land, the crop evapotranspiration is reduced and more water flows through as "tailwater," so that the Salton Sea would not be disrupted.

The Mexicali water system is similar to this Imperial County's in that 1.6 maf/yr of Colorado River Water enters an irrigation delivery system. The ultimate drainage, as mentioned, is through the New River into the Salton Sea. One difference is that considerable groundwater pumping, an average of 0.727 maf/yr is also used as a source of supply (see **Table 7-4**). Another difference is that currently 0.080 maf/yr is diverted by pumping over the mountains to supply Tijuana's urban needs. Again, disruption of the Mexicali water system will affect the volume of New River outflows coming across the border and draining into the Salton Sea. Hence, such shifts as greater water conservation in the Mexicali Valley or increased amount of water diversion to Tijuana will potentially reduce wastewater flows and the Salton Sea level, causing potential environmental harm in the U.S.

Table 7-4. Mexicali Valley Water Balance, 1998-1989

Water Supply	Acre-Feet
Local Surface	0
Colorado River[a]	1,640,000
Other Imported	0
Sustainable Groundwater Extractions[b]	727,400
Direct Reuse	0
Total	**2,367,400**
Water Demand (1998-1989)	
Urban	184,500
Agriculture (Irrigation District No.14)	2,278,600
Total	**2,463,100**
S & D Balance (Groundwater Overdraft)	-95,700

a: Alamo intake 1952-1992 annual average (IBWC, 1992)
b: Mexicali and Mesa Arenosa aquifers.

Source: Munson et al, 1996

The problem of wastewater also relates to intake in the Mexicali water system. In particular the Colorado River water flowing into the Mexicali Valley is much more polluted than the upstream water entering the Imperial County system. Another inflow into Mexicali having pollution problems is the groundwater inflow, which is becoming increasingly polluted and saline through wastewater incursion. This presents a problem in water quality. Water in this "vicious cycle" can be treated, but that is expensive (Román Calleros, 2002).

Since 1992, the Mexicali water system has been managed by 23 civic associations of water producers, instead of by the National Water Commission (Román Calleros, 2002). The urban water in Mexicali is managed by a city utility known as CESPM. The civic associations and CESPM are roughly equivalent to the IID with respect to its water purview.

Although the water rights were given to private landholders as result of the 1992 Law of Natural Waters, other Mexican laws give priorities to urban over agricultural water uses (Román Calleros, 2002). Mexicali through CESPM consumes currently about 82,000 af/yr. At the same time, about an equivalent amount is being pumped over the mountains to Tijuana. Part of the pressure on the Mexicali system comes from the likely enlarged increments of urban and industrial water use, as the two cities grow rapidly.

The only source of additional water for Mexicali in the mid-term future is by increased conservation and/or diverting more water away from Mexicali Valley agriculture. One of the measures that can be taken if water supply to Mexicali Valley agriculture is lowered is to change cropping patterns. Different cropping patterns with more vegetables emphasized has already occurred in response to more saline water. The consumptive use of water in the Mexicali Valley varies considerably. For instance, alfalfa, asparagus, and fruits all consumed more that 5 acre-feet/acre per year, whereas barley, canola, corn, rye grass, and wheat consumed less than 2.5 acre-feet/acre per year (CNDA, 1991, from Munson et al., 1996). Therefore, conservation measures could be achieved through changed cropping patterns, although the market would have to support such changes. In summary, Mexicali's urban/industrial versus agricultural demand problems are quite similar in broad form to those in Imperial County. They differ greatly, however, on the political processes to decide on and resolve the problems.

Recently, the pressure being put on the water supply to the IID has led to its decision to line 23 miles of the All American Canal (Kraul and Perry, 2002). It is likely this canal lining with concrete will proceed. The California legislature has provided sufficient funding to accomplish the project. This may effect up to 75,000 acre feet per year of seepage from the canal into Mexicali as clean groundwater. This development is controversial and has led to government confrontation between Mexico and the U.S. The International Boundary and Water Commission (IBWC) has indicated its support for the Imperial County position (Kraul and Perry, 2002). The IBWC reasons that the IID can appropriately claim that the canal lining encourages greater efficiency of use of water. The outcome of this canal lining project is uncertain at this point, but lining is likely to occur. It has heightened political, agricultural, and economic tensions already present in the region.

A relatively small proportion of the water supply to Mexicali is utilized for Mexicali's city use. However, the sharp population increase of the city of Tijuana and concomitant pressure to pump water into that city is putting more pressure on the water supply from Mexicali. In 1997, there were about 520,000 persons provided with potable water in the city of Mexicali (see **Table 7-5**). According to CESPM, the average daily demand to serve expanded population will grow from its current water pumping capacity of 4,560 lps in 1998 to a level of 6,960 lps in 2020 (see **Table 7-6**). However, this may well not be enough capacity given that Mexicali Municipio's population is forecast to be 1,186,639 in 2020. Rising urban water consumption also implies the need to expand water treatment. A capacity of 2,335 lps should hold the situation through the year 2007; however, much higher population will force the building of more water treatment plants.

Table 7-5. Coverage of Utility and Infrastructure Services in Mexicali, 1997

Service	Population with Service	Coverage of Urban Area
Potable Water	519,970	98
Sanitary Plumbing	472,218	89
Water Plumbing	222,844	42
Pavement	238,762	45
Electricity	519,970	98
Public Lighting	371,407	70
Telephone	355,490	67
Piped Gas	37,141	7

Note: In 1997, 530,582 persons are estimated to correspond to the urban area of Mexicali, in accord with INEGI figures of 1995
Source: INEGI, 1999

Table 7-6. Demand for Potable Water, City of Mexicali, 1995-2010

Year	Population	Average Daily Demand for Potable Water (lps)	Maximum Daily Demand for Potable Water (lps)	Peak Hourly Demand for Potable Water (lps)	Total Water Treatment Capacity (lps)	Water Pumping Capacity (lps)
1995	485,472	2,405	3,319	4,329	3,450	4,560
1998	553,574	2,742	3,784	4,936	3,450	4,560
2001	613,745	3,040	4,195	5,472	5,050	6,960
2003	643,795	3,189	4,401	5,740	5,050	6,960
2007	699,842	3,466	4,783	6,239	5,050	6,960
2010	739,874	3,665	5,058	6,595	5,050	6,960

Source: CESPM, 1997

Mexicali city has a large water distribution system that has an average of 5 persons per each water tap. Its industrial water taps are 0.32 percent of all taps, but presumably of higher capacity (see **Table 7-7**). Its drinking water supply, however, is quite adequate by Mexican standards, with 0.444 cubic meters of drinking water per person per day (see **Table 7-8**). Mexicali's relatively good situation in urban and industrial water supply reflects its ample water supply, compared to other Mexican border cities.

Table 7-7. Size of Water Distribution Network, Mexicali Municipio, Tijuana Municipio, and Baja California, 2000

	Mexicali Municipio	Tijuana Municipio	Baja California
No. of Water Taps			
Domestic	160,746	313,558	543,858
Commercial	11,672	17,963	35,187
Industrial	519	2,367	3,574
Percent of Industrial Water Taps	0.32	0.75	0.66
No of Drinking Water Systems	132.00	18.00	243.00
Population 2000	764,602	1,210,820	2,487,367
Water Taps per Capita	0.21	0.26	0.22

Source: Comision Federal de Energía, Baja California Region, 2001

Table 7-8. Sources and Volume of Drinking Water, Mexicali, Tijuana, and Baja California

	Mexicali Municipio	Tijuana Municipio	Baja California
Number of Deep Wells	81	15	192
Number of Other Drinking Water Sources	61	2	83
Volume of Drinking Water from Deep Wells*	48,978	23,155	192,938
Volume of Drinking Water from Other Sources	290,323	204,250	494,573
Total Volume of Drinking Water	339,301	227,405	687,511
Population 2000	764,602	1,210,820	2,487,367
Per Capita Supply of Drinking Water	0.444	0.188	0.276
Percent of State's Drinking Water Supply	0.494	0.331	1.000

* Thousands of cubic meters per day

Source: INEGI, 2001

Tijuana had a year 2000 population of around 1.4 million people, and it continues to grow rapidly (INEGI, 2002). However, as seen in **Table 7-9**, Tijuana has limited water production – only 73,847 million acre feet per year. Hence, Tijuana is under great pressure to import water. Currently it is importing around 64,000 acre-feet per year by pumping over the aqueduct from Mexicali (Michel, 2000). However, pressure is growing on the Baja California state government to construct a larger aqueduct from Mexicali to Tijuana. A new aqueduct would be expensive and is not a high priority of the current Fox Administration in Mexico. Tijuana also has the problems on increasing its city pumping capacity and increasing the water treatment capacity (see **Table 7-10**).

Table 7-9. Water Production in Tijuana, July 1999

Source of Water Supply	Liters per Second	Acre-Feet per Year
Surface Water: Presa Rodriguez (Rodriguez Dam)	2,250	56,612
Surface Water: Presa Carrizo Dam	789	19,852
Tijuana-Alamar River Aquifer	40 (Capacity:200)	1.006 (Capacity 5,032)
Colorado River-Tijuana Aqueduct*	0 (Capacity:4,000)	0 (Capacity:100,645)
Water Supplies Sent to Rosarito Beach	-144	-3,623
Total	**2,935**	**73,847**

Source: Michel, 2000

Table 7-10. Water Treatment Plants in Mexicali Municipio, Tijuana Municipio, and Baja California, 2000

	Mexicali Municipio	Tijuana Municipio	Baja California
Number of Water Treatment Plans	14	2	19
Installed Capacity of Water Treatment Plants*	3,694	4,600	8,744
Volume of Water Supplied from Plants**	86.3	106.1	224.1
Population 2000	764,602	1,210,820	2,487,367
Volume of Treated Water per Capita***	112.87	87.63	90.10

* liters per second

** millions of cubic meters per year

*** cubic meters per year

Source: Comision National del Aqua, Baja California Region, 2001

The city of Tijuana has a large water distribution system, similar to Mexicali, that has an average of 4 persons per each water tap. Its industrial water taps are double the prevalence of Mexicali at 0.75 percent (see **Table 7-7**). This reflects a larger maquiladora-driven industrial base in Tijuana, versus Mexicali. However, its drinking water provision per capita is only 0.188 cubic meters of drinking water per person per day, a level that is two fifths that of Mexicali (see **Table 7-8**). This points to the need to conserve water that is already in place in a city strapped for water supply.

Another aspect of border metropolitan water use is the comparative level of per capita consumption of water on both sides of the border. As seen in **Table 7-11**, this metropolitan consumption varies quite a lot across the border and is not necessarily higher on the U.S. side. In the current analysis of water use in Imperial County and Mexicali, these differences are not too important in the large picture, because the proportions of urban water use in Imperial County and Mexicali are quite small. However, the reduced level per capita consumption for Tijuana is an important factor that influences the urgency of constructing an additional aqueduct from Mexicali to Tijuana.

Table 7-11. Per Capita Water Use For Selected Counties and Municipios on the U.S. - Mexico Border (in litters per Capita per Day)

County	Water Usage
San Diego, CA	630
El Paso, TX	700
Maverick, TX	380
Webb, TX	750
Cameron, TX	620
Nogales, Son.	350
Cd. Juarez, Chihuahua	400
Piedras Negras, Tamaulipas	600
N.Laredo, Tamaulipas	650
Reynosa, Tamaulipas	250
Matamoros, Tamaulipas	220
Hidalgo, Tamaulipas	580

Source: Infomexus, 1996

The water situation in Imperial County is likely to be influenced considerably by the planned water transfer and conservation project that is proposed by the IID (IID, 2002). This proposal includes a scale-up to over 300,000 acre-feet per year of water transferred to other water districts in southern California. In particular, the water would be transferred to the San Diego County Water Authority (SDCWA), Coachella Valley Water District (CVWD), and/or Metropolitan Water District (MWD). The terms of the water transfers and conservation are embodied in the "IID/SDCWA Transfer Agreement" that was approved by IID an SDCWA in 1998 and further amended. In addition, further agreement would be achieved through the "Quantification Settlement Agreement" between the IID, DVWD, and MWD.

The water diversion would help in reducing California's supply of Colorado River Water. As pointed out earlier in the chapter, California's overage above treaty levels is a source of tension between the Lower Basin States that consume Colorado River water. As a consequence, the diversion of IID water would enable California to lower its allocation of Colorado River Water below its current average level of 4.4 million acre-feet.

The water diversion by the IID has habitat and environmental implications. Perhaps the most serious is the potential lowering of the level of the Salton Sea, if conservation measures are put into place. The conservation measures include on-farm improvements and canal linings, among others. The EIR for this water transfer project includes a "Habitat Conservation Plan" which considers species' impacts within the IID service area of various scenarios. It also considers the effects on the Salton Sea and the area of the All American Canal (IID, 2002).

The Seven-Party agreement establishes the prioritization of water uses amoung southern California water agencies (**see Table 7-12**). It is clear that a lot of water is already diverted to the MWD, City and County of San Diego, and Palo Verde Irrigation District. The new proposed plan includes scenarios that would divert an additional 130,000 acre-feet/yr, 230,000 acre-feet/yr, or 300,000 acre-feet per year to other southern California water districts, especially MWD and SDWD. These levels would be phased in over some years. The IID proposes to have an amount of conservation equal to the water allocations. This would minimally impact the economy and agriculture of Imperial County.

Table 7-12. The Priority System Established by the Seven-Party Agreement

Priority	Description	Annual AF
1	Palo Verde Irrigation District-gross area of 104,500 acres	
2	Yuma Project (Reservation District) - not exceeding a gross area of 25,000 acres	
3a	Imperial Irrigation District and lands in Imperial and Coachella Valleys to be served by ACC	3850000
3b	Palo Verde Irrigation District - 16,000 acres of mesa lands	
4	Metropolitan Water District and/or City of Los Angeles	550,000
	SUBTOTAL	4,400,000
5a	Metropolitan Water District and/or City of Los Angeles and/or others on coastal plain	550,000
5b	City and/or County of San Diego	112,000
6a	Imperial Irrigation District and lands in Imperial and Coachelle Valleys	300000
6b	Palo Verde Irrigation District - 16,000 acres of mesa lands	
7	Agricultural Use	all remaining water
	TOTAL	5,362,000

Notes :

1 Total amount of water available to satisfy Priorities 1, 2, 3a and 3b is 3.85 MAFY.

2 CVWD' s Priority 3 rights are secondary to IID's rights as a result of the 1934 Compromise Agreement between IID and CVWD.

3 In 1946, the City of San Diego agreed to merge its rights with, and into, the rights of MWD.

4 The total amount of water available to satisfy Priorities 6a and 6b is 300 KAFY.

5 The california Plan describes the strategy to assist California to reduce its annual use to its legal apportionment of 4.4 MAF in normal years, or to meet its needs from sources that do not jeopardize the apportionment of others.

Sources : Draft EIR, Imperial Irrigation District, 2002

Table 7-13. Water Transfers under Proposed Project's Second Scenario: QSA Implementation

Year	Minimum Primary Transfer to SDCWA (130 KAFY)	Maximum Primary Transfer to SDCWA (200 KAFY)	Transfer to CVWD or MWD (100 KAFY)	Total IID Transfer (SDCWA at 130 KAFY)	Total IID Transfer (SDCWA at 200 KAFY)	Notes
2002	20.0	20.0		20.0	20.0	Primary transfer to SDCWA commences
2003	40.0	40.0		40.0	40.0	
2004	60.0	60.0		60.0	60.0	
2005	82.5	82.5	2.5	85.0	85.0	Early water transfer commences
2006	105.0	105.0	5.0	110.0	110.0	
2007	122.5	122.5	7.5	130.0	130.0	1st 50 KAFY transfer commences to CVWD and/or MWD
2008	130.0	140.0	10.0	140.0	150.0	
2009	130.0	160.0	15.0	145.0	175.0	
2010	130.0	180.0	20.0	150.0	200.0	
2011	130.0	200.0	25.0	155.0	225.0	Maximum, annual primary transfer to SDCWA
2012	130.0	200.0	30.0	160.0	230.0	
2013	130.0	200.0	35.0	165.0	235.0	
2014	130.0	200.0	40.0	170.0	240.0	
2015	130.0	200.0	45.0	175.0	245.0	
2016	130.0	200.0	50.0	180.0	250.0	
2017	130.0	200.0	55.0	185.0	255.0	2nd 50 KAFY tranfer commences from IID to CVWD and /or MWD. Tranfer of this increment is the responsibility of MWD, and not IID, after year 2047.
2018	130.0	200.0	60.0	190.0	260.0	
2019	130.0	200.0	65.0	195.0	265.0	
2020	130.0	200.0	70.0	200.0	270.0	
2021	130.0	200.0	75.0	205.0	275.0	
2022	130.0	200.0	80.0	210.0	280.0	
2023	130.0	200.0	85.0	215.0	285.0	
2024	130.0	200.0	90.0	220.0	290.0	
2025	130.0	200.0	95.0	225.0	295.0	
2026	130.0	200.0	100.0	230.0	300.0	Maximum Transfers
2047	200.0	200.0	100.0	230.0	300.0	IID and SDCWA each have option to extend the terms of the IID/SDCWA Transfer Agreement for 30 additional years.
2077	200.0	200.0	100.0	230.0	300.0	Project term ends

Source: Draft EIR, Imperial Irrigation District, 2002

Table 7-13 shows the possible scenarios of scale-up of water diversions according to different scenarios. It is evident that most of the scale-up would be complete by the year 2010, although not all of it until the year 2026.

The IID has projected various results from scenarios on employment in Imperial County. The scenarios with conservation have minimal employment impact, but as seen in **Table 3.10**, water diversion along with fallowing would result in employment impacts from of 1,400 jobs compared to year 2000 employment level of 49,800. The impact on agricultural sector would be more extreme, with 1,300 jobs lost out of a sector employment of 11,300, or 11.5 percent of the sectoral workforce.

Table 7-14. (Table 3.10)

Another perspective on the water resource situation is that of the county of San Diego and municipio of Tijuana, working together in a combined manner. This has not happened on water issues up to now, but there is a lot of potential, because many of the problems are shared. The differences are also large between the two sides – for instance, Tijuana's consumption per capita has been reduced over time, so today it is 320 liters/day versus 830 liters per day for San Diego (Turner et al., 2002). The key problem is that Tijuana's water supply comes mainly by pumping from Mexicali.

In recent years, the city of Tijuana has received 95,874 af/year from Mexicali, but can only make available through the city water agency 115,048 af/year, or 83 percent. With the population increases discussed for Tijuana, this dependency on Mexicali for 5/6 of Tijuana's water is problematical. There have been a variety of solutions proposed for this problem. They include the following:

- *Water sharing, which might include transboundary water transfers, bi-national aqueduct expansion, bi-national desalinization plant, and recycled water*
- *A jointly owned and operated new water aqueduct or canal might run from the Colorado River and serve San Diego and Tijuana.*

- *Groundwater can be managed binationally with more information. This could emphasize re-charge and re-injection of the groundwater basin.*
- *Desalinization can potentially support huge water supplies, but so far this technology for large-scale use is unproven.*
- *Recycled water could potentially be a reliable water source, but its use is controversial among the general public.*
- *Agricultural water can be traded for urban water to bring more water to the areas and cities of growing population (Bradley, 2002).*

Overall, the fundamental ways to address the shortage problem are: (1) to make more efficient use of the scarce Colorado River water, (2) to trade water with agricultural areas, and/or (3) to create new source of water through desalinization, which however is expensive. Any of these alternatives will take political will, tenacity in seeing projects through, and sources of capital to accomplish them.

Chapter 8

Water and Energy Scenarios for Year 2010

8. Water and Energy Scenarios for Year 2010

This short chapter summarized the water and energy scenarios for year 2010. The scenarios are based on the analysis of the prior two chapters. **Tables 8-1 and 8-2** show the potential water and energy scenarios for 2010. The starting situation of water and energy infrastructure in the region is given in **Map. 8-2**. Each scenario is shown in mapped form in **Maps 3-12**. **Map 8-13** shows all scenarios combined. The energy scenarios in **Table 8-1** have already been discussed in Chapter 6.

The water scenarios in **Table 8-2** have been discussed in Chapter 7, but are presented formally here. They consist of the IID's three scenarios of Small Water Diversion, Moderate Water Diversion, and High Water Diversion, along with an equivalent amount of conservation. The diversions refer to diversion of agricultural water to other water districts in southern California, particularly San Diego (IID, 2002). The Small Water Diversion has conservation of on-farm improvements only (IID, 2002). The Moderate Water Diversion has on-farm as well as canal conservation. The Large Water Diversion has fallowing of land occurring along with on-farm and canal conversation, so that, on net balance, there is not much effect on the sea level of the Salton Sea (IID, 2002)

The next water scenario emphasizes Moderate Water Pumping from Mexicali to Tijuana i.e. additional water pumping to Tijuana beyond the water already being pumped through the existing Mexicali to Tijuana aqueduct. This implies construction of an additional aqueduct that would pump 120,000 acre-feet per year from Mexicali to Tijuana. This is about double the current aqueduct capacity of around 64,000 acre-feet per year. A fifth scenario refers to High Water Pumping from Mexicali to Tijuana, which consists of pumping of 180,000 acre-feet per year, or about three times the current aqueduct capacity.

Finally, the last scenario of High Conservation reflects substantial conversation on both sides of the border, but without water diversions for urban uses e.g. in southern California urban districts or water transfers to Tijuana. It reflects a general movement on both sides of the border towards increased conservation.

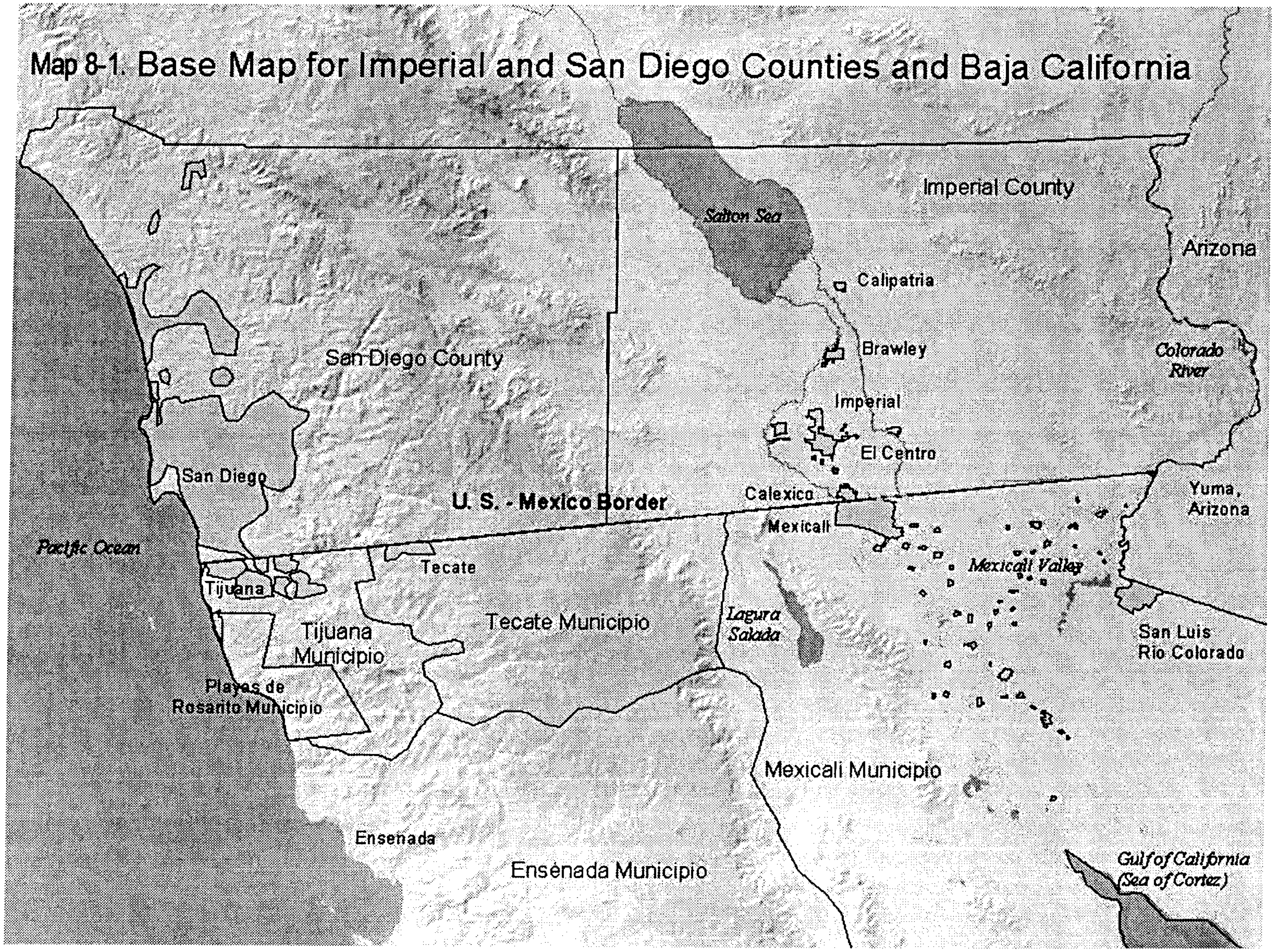
Table 8-1 Five Energy Scenarios in Year 2010 for Baja California and Imperial County

Scenario	Capacity Detail Imperial County	Imperial County Location	Total Capacity	Capacity Detail Mexicali or Tijuana	Mexicali Location	Tijuana or Ensenada Location
Geothermal Low Scenario 2010	180 MW new (three 60 MW plants)	nearby and south of Salton Sea	200 MW	one 200 MW plant	Cerro Prieto	
Geothermal High Scenario 2010	240 MW new (five 60 MW plants)	nearby and south of Salton Sea	400 MW	400 MW new (two 200 MW plants)	Cerro Prieto	
Liquid Natural Gas			1000 MW 1000 MW	1000 MW 1000 MW		Rosarito Ensenada
Natural Gas			506 MW 269 MW 269 MW 269 MW			
Alternative (Solar, Wind, and Tidal)		solar and wind in south of Imperial County	total of 100 MW on both sides of border.			Solar and wind south of the city of Mexicali. Tidal further south.

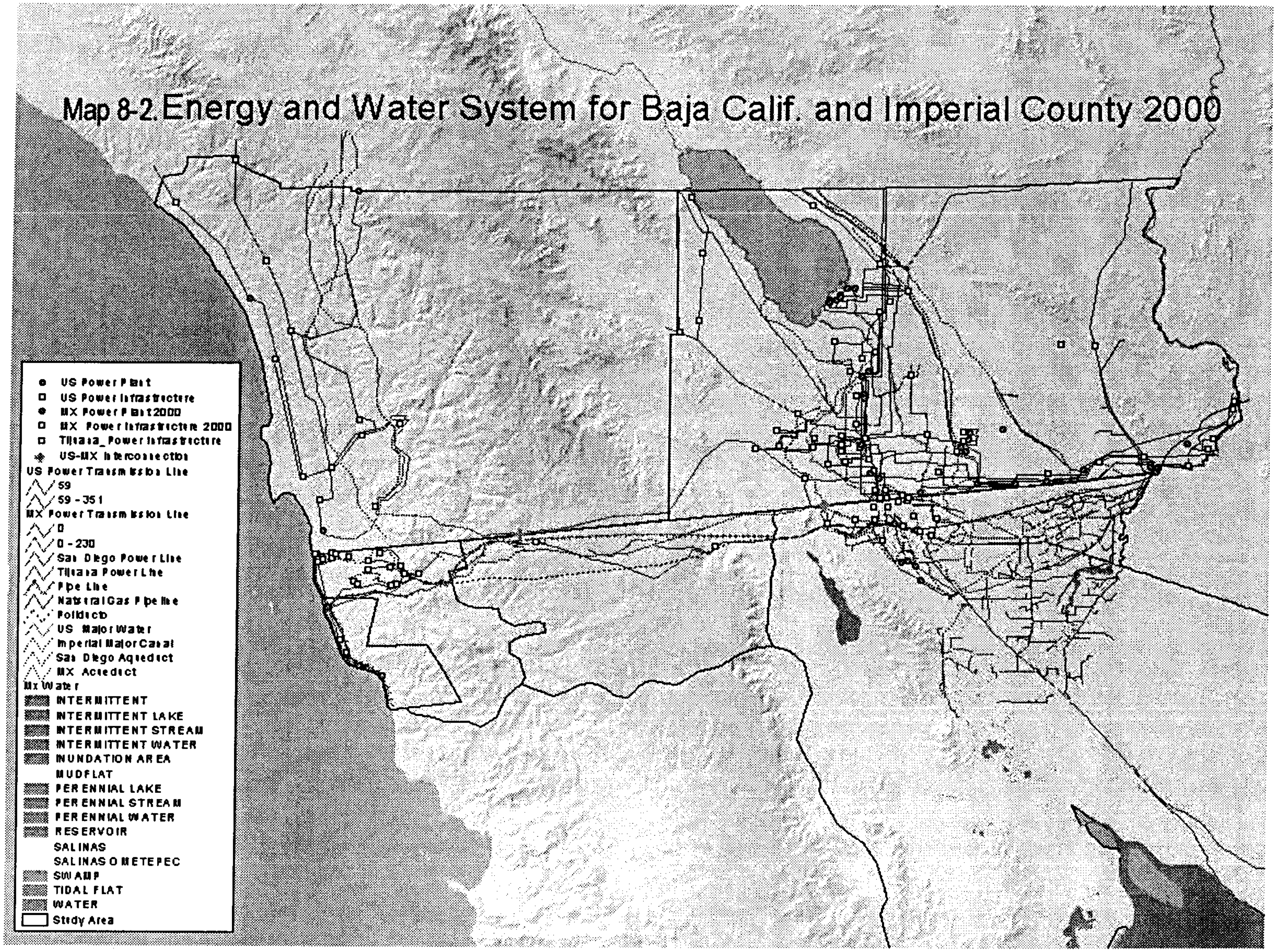
Table 8-2. Six Water Scenarios in Year 2010 for Baja California and Imperial County

Scenario	Water Diversion from Imperial County to Outside Urban Areas	Location	Water Diversion from Mexicali to Tijuana	Location
Small Water Diversion to other S. Calif. Water districts (on-farm conservation improvements only)	-130,000 af/yr to other S. Calif. Water districts, especially Los Angeles (MWD) and San Diego (SDMWD)	130,000 af/yr of conservation		
Moderate Water Diversion to other S. Calif. Water districts	-230,000 af/yr to other S. Calif. Water districts, especially Los Angeles (MWD) and San Diego (SDMWD)	230,000 af/yr of conservation		
High Water Diversion to other S. Calif. Water districts (fallowing)	-300,000 af/yr to other S. Calif. Water districts, especially Los Angeles (MWD) and San Diego (SDMWD)	300,000 af/yr of conservation		
Moderate Water Pumping to Tijuana			-120,,000 af/yr to Tijuana	no conservation
High Water Pumping to Tijuana			-180,000 af/yr to Tijuana	no conservation
High Conservation (with no water diversion to other S. Calif. Water districts and not added water diversion to Tijuana)	75,000 af/yr in conservation		75,000 af/yr in conservation	
	note: total water usage cap for Imperial County is 3,100,000 af/yr		note: total water inflow for Mexicali is 1,500,000 af/yr, including ground water	

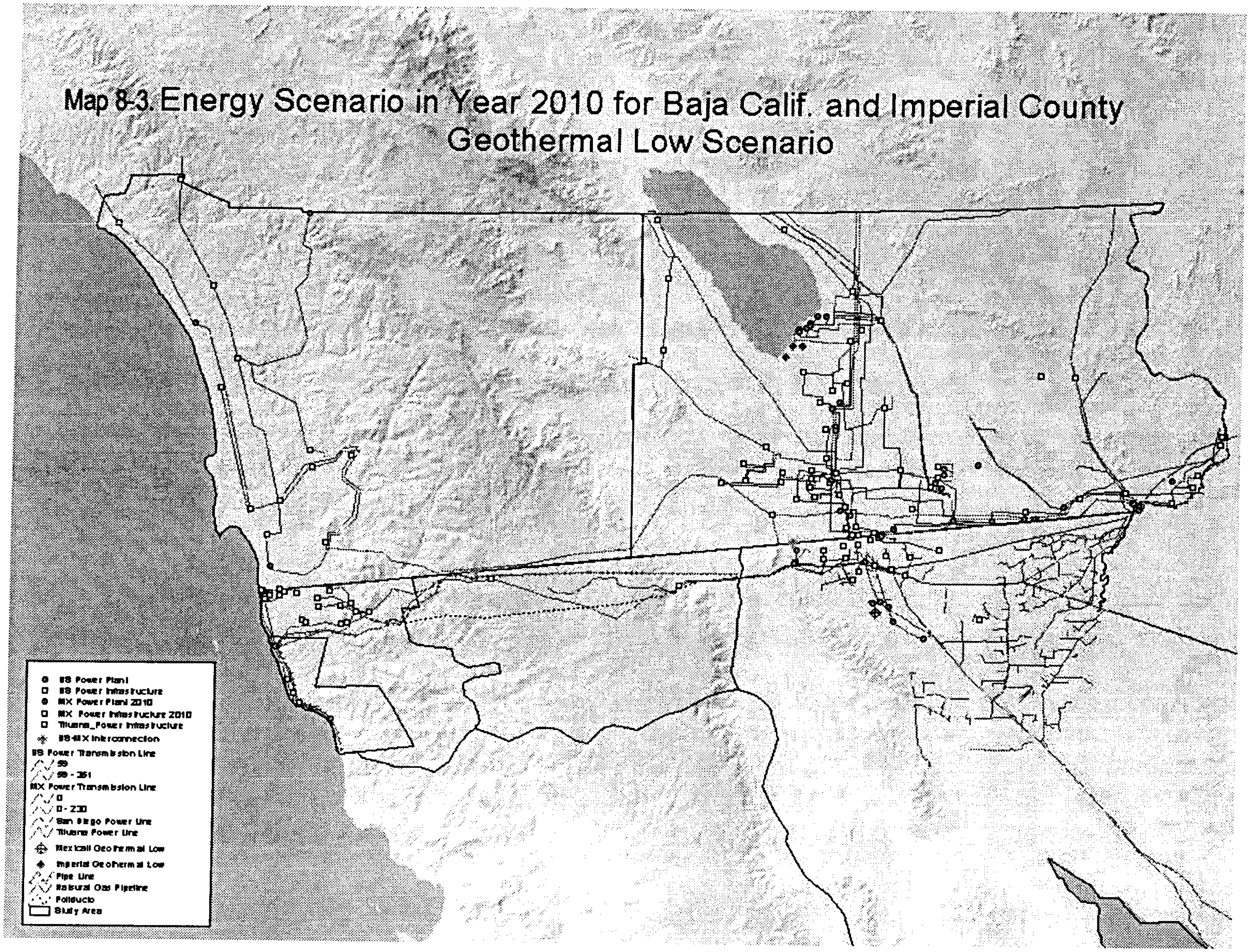
NOTE: Conservation needs to be symbolized in the agricultural areas of Imperial County and Mexicali
af/yr = acre feet per year.



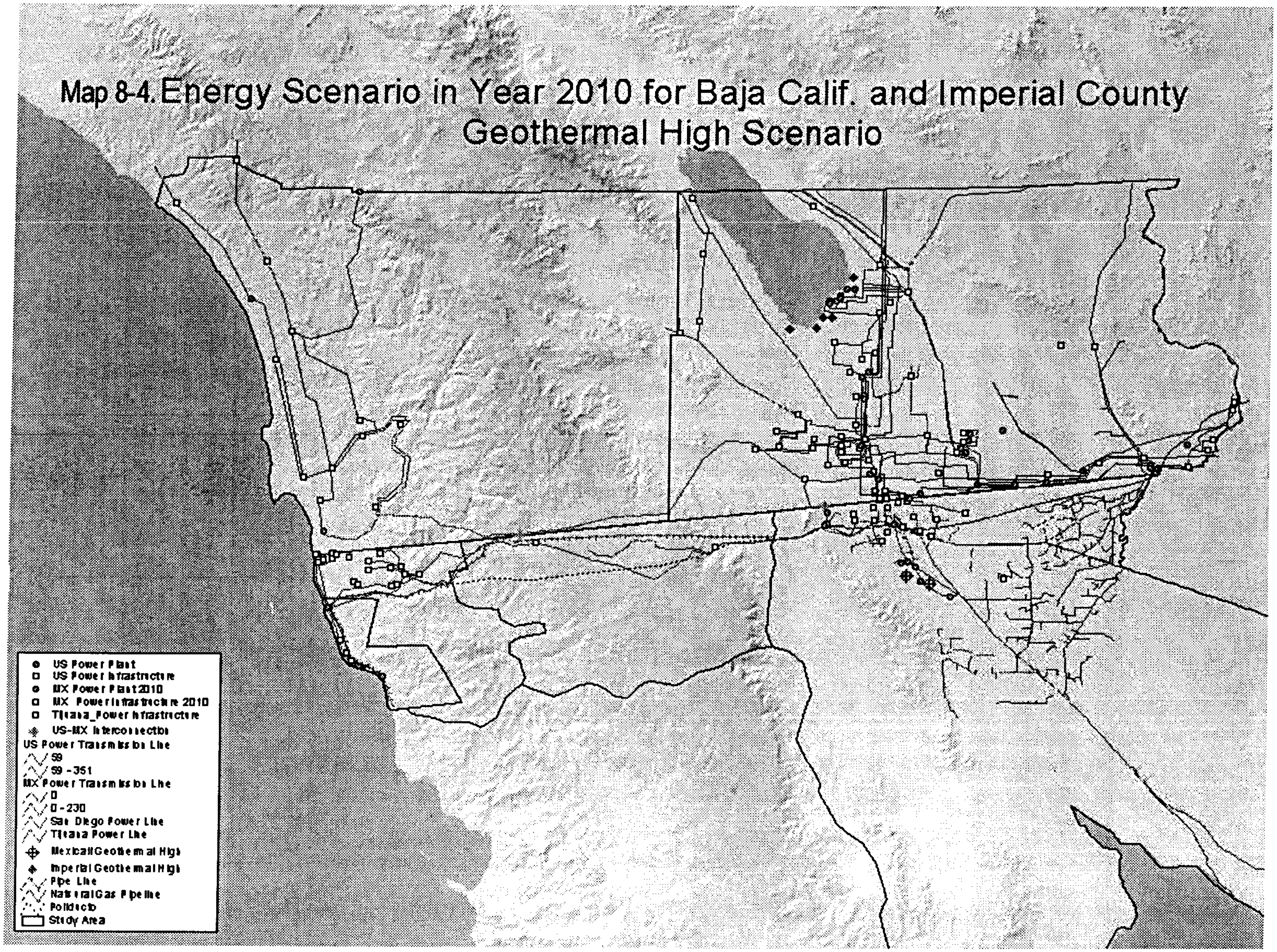
Map 8-1. Base Map for Imperial and San Diego Counties and Baja California



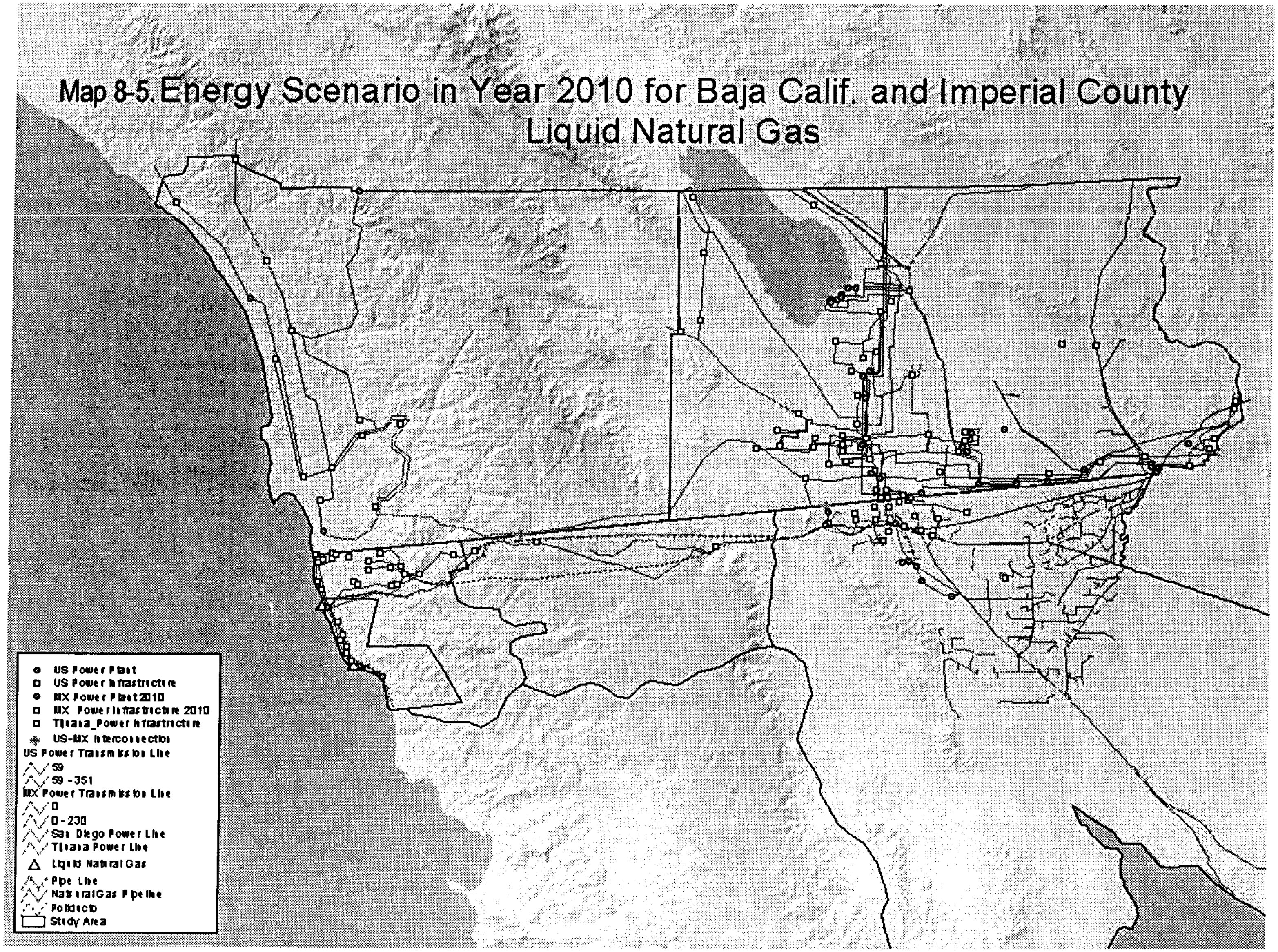
Map 8-2. Energy and Water System for Baja Calif. and Imperial County 2000

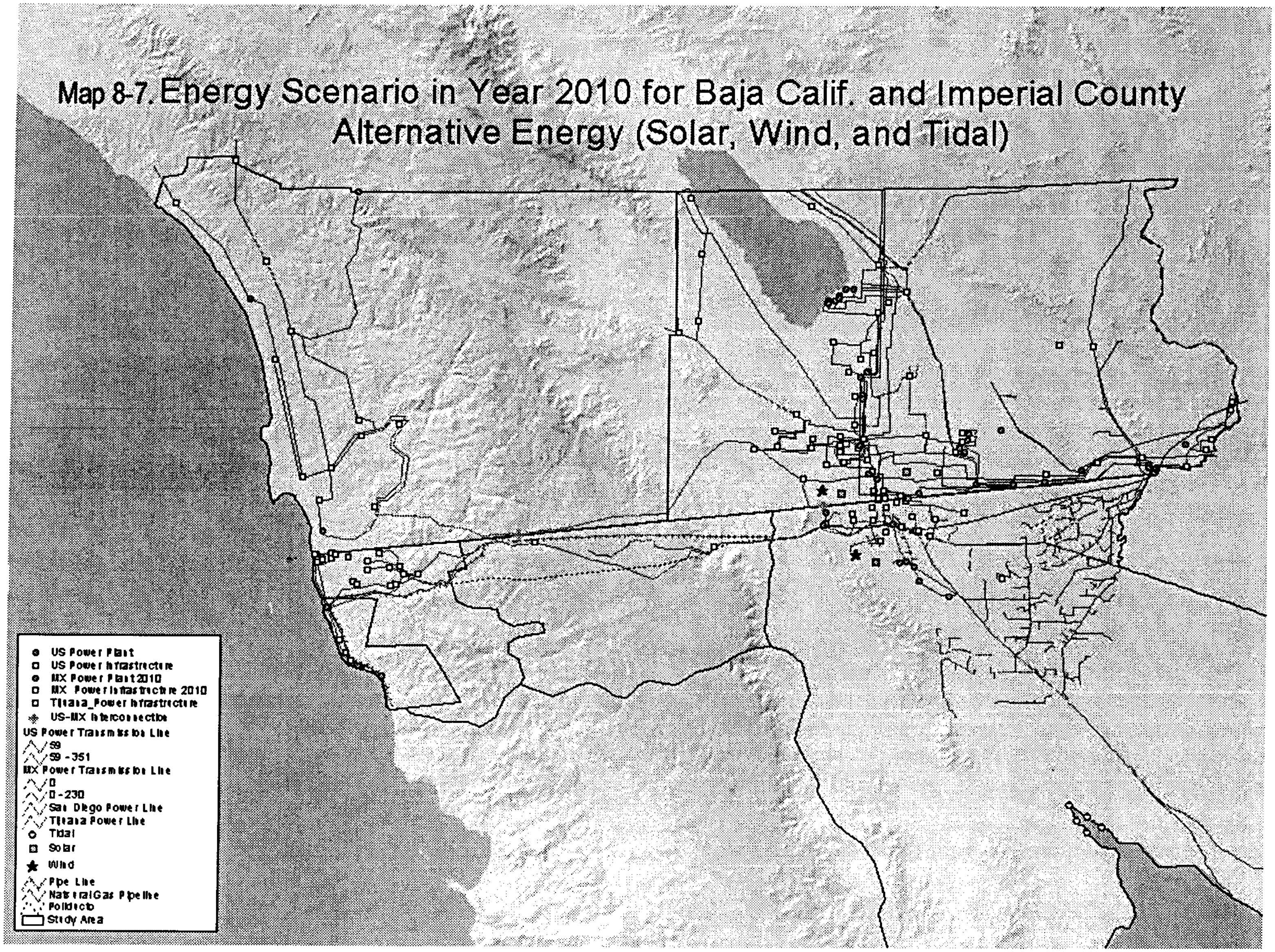


Map 8-3. Energy Scenario in Year 2010 for Baja Calif. and Imperial County
Geothermal Low Scenario

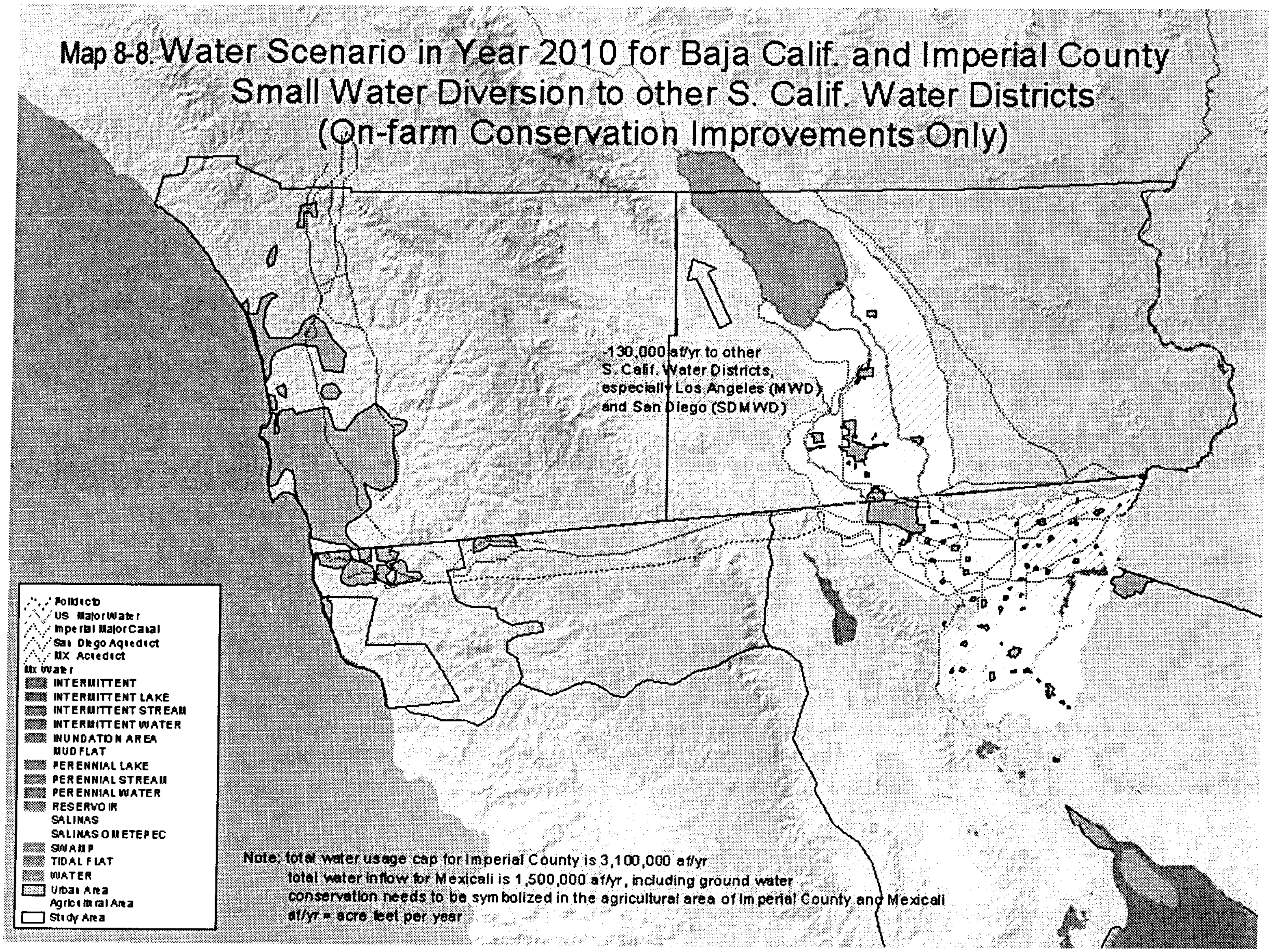


Map 8-4. Energy Scenario in Year 2010 for Baja Calif. and Imperial County
Geothermal High Scenario


Map 8-5. Energy Scenario in Year 2010 for Baja Calif. and Imperial County
Liquid Natural Gas
US Power Plant
US Power Infrastructure
MX Power Plant 2010
MX Power Infrastructure 2010
Tijuana_Power Infrastructure
US-MX Interconnection
US Power Transmission Line
59
59 - 351
MX Power Transmission Line
0
0 - 230
San Diego Power Line
Tijuana Power Line
Liquid Natural Gas
Pipe Line
Natural Gas Pipeline
Poliducto
Study Area

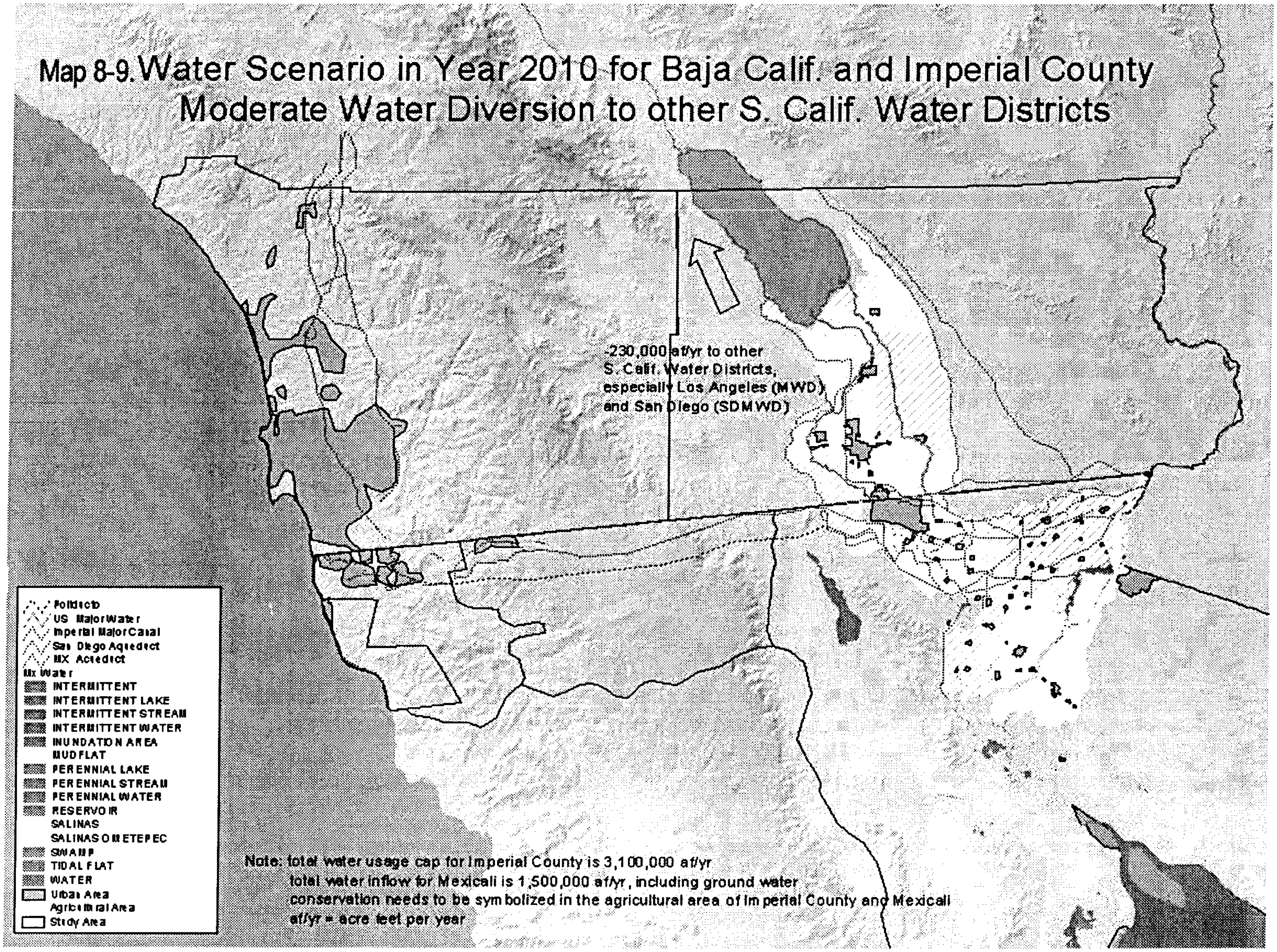


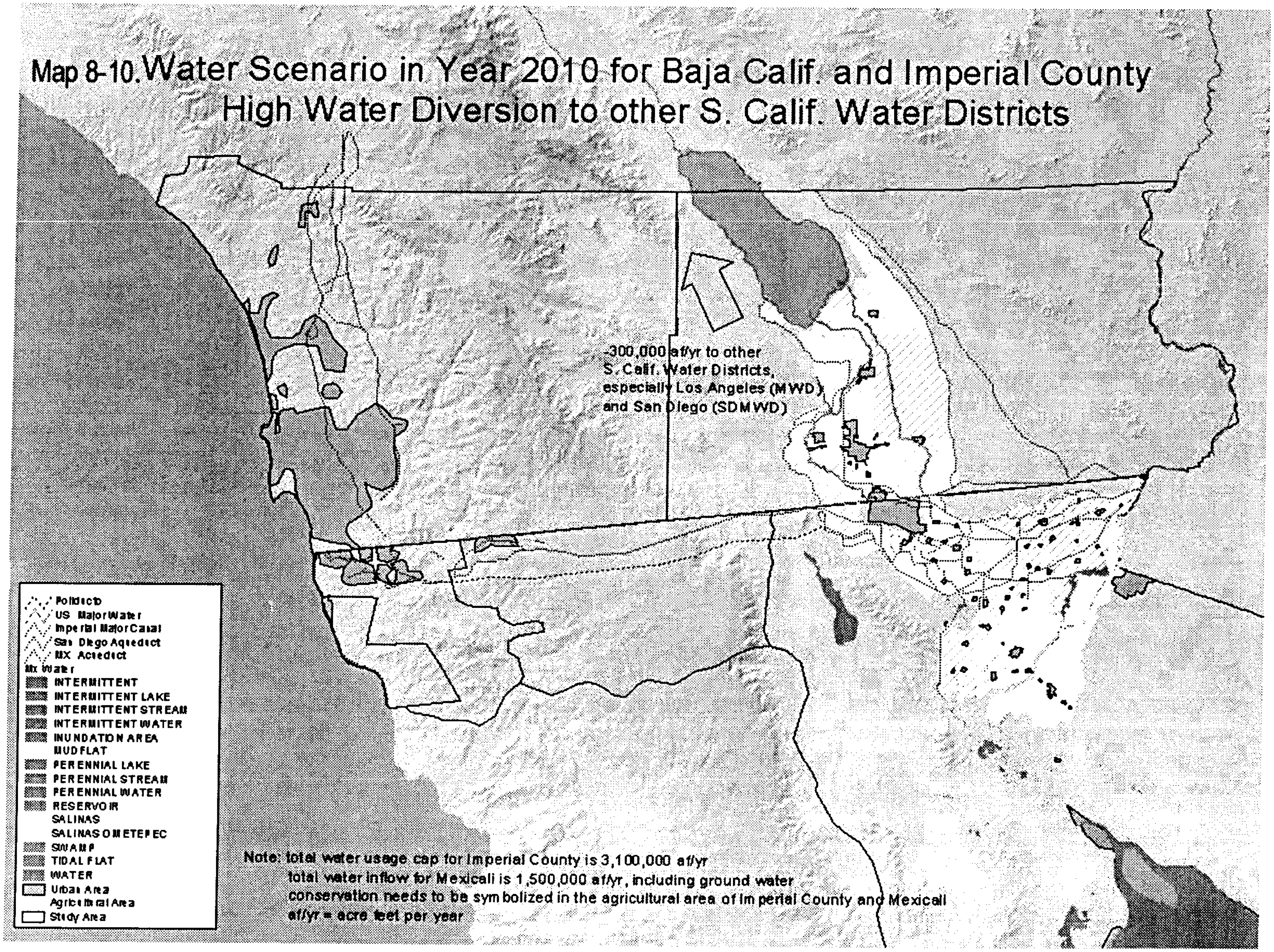
Map 8-7. Energy Scenario in Year 2010 for Baja Calif. and Imperial County
Alternative Energy (Solar, Wind, and Tidal)

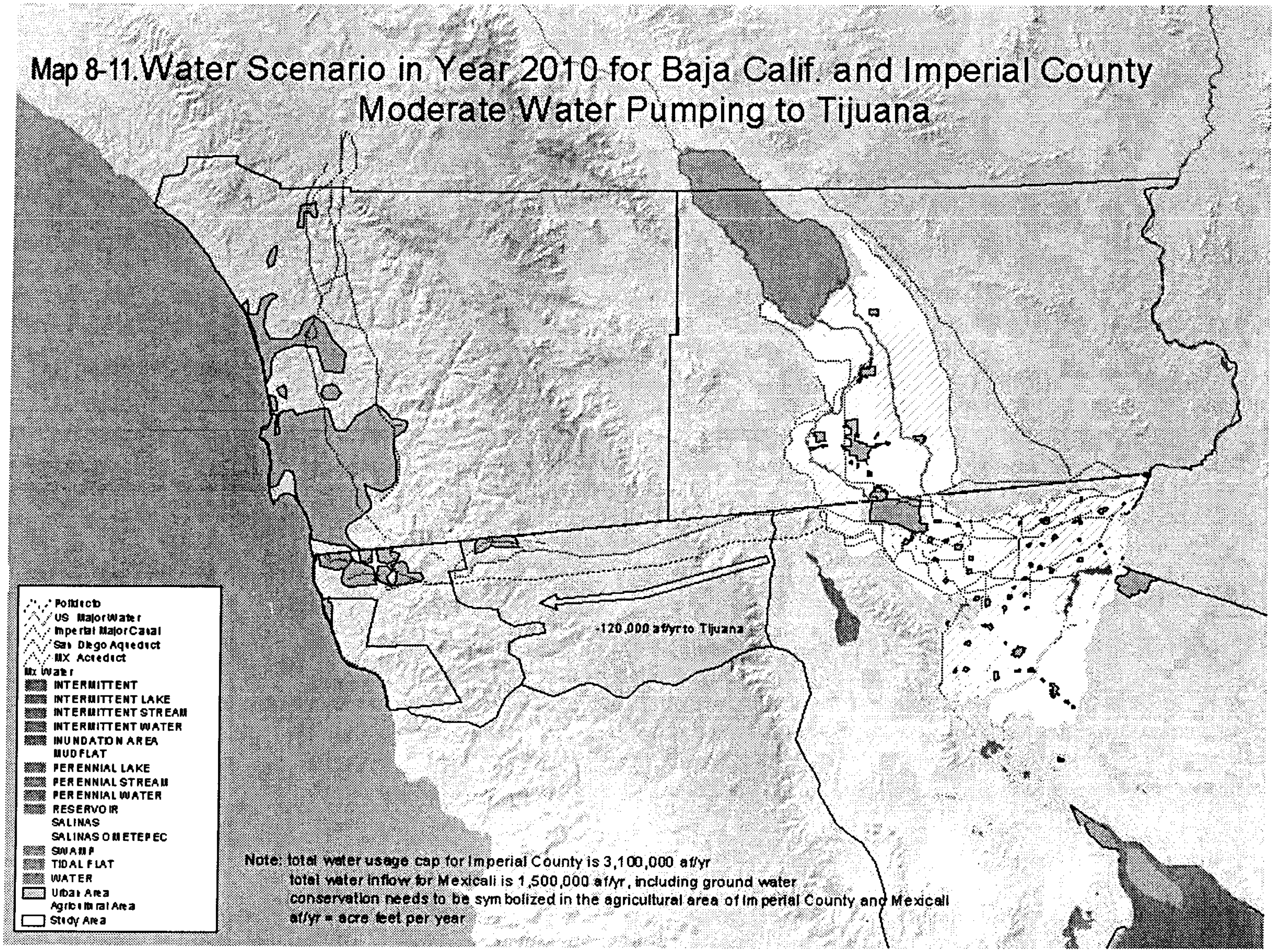


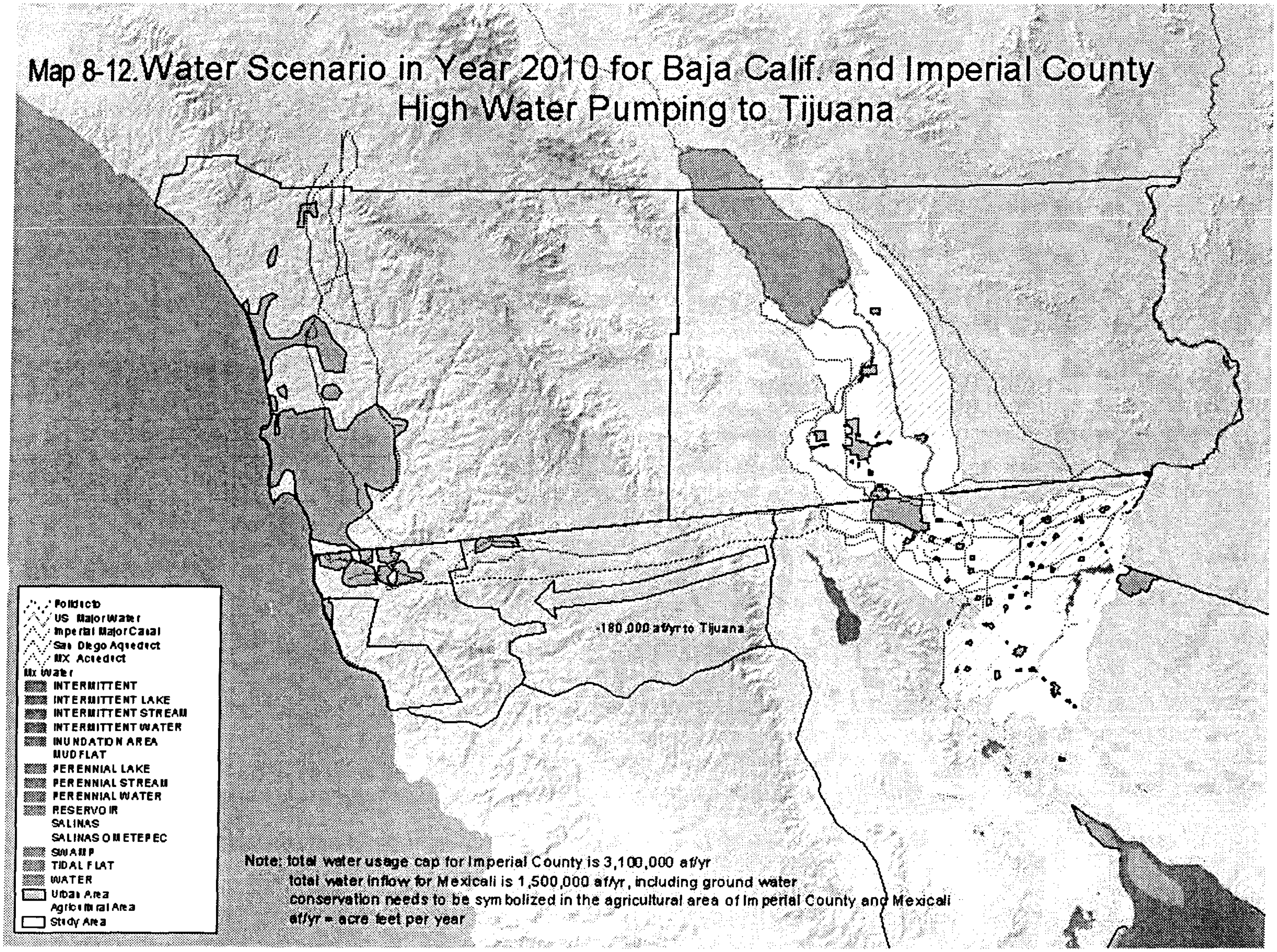
Map 8-8. Water Scenario in Year 2010 for Baja Calif. and Imperial County
Small Water Diversion to other S. Calif. Water Districts
(On-farm Conservation Improvements Only)

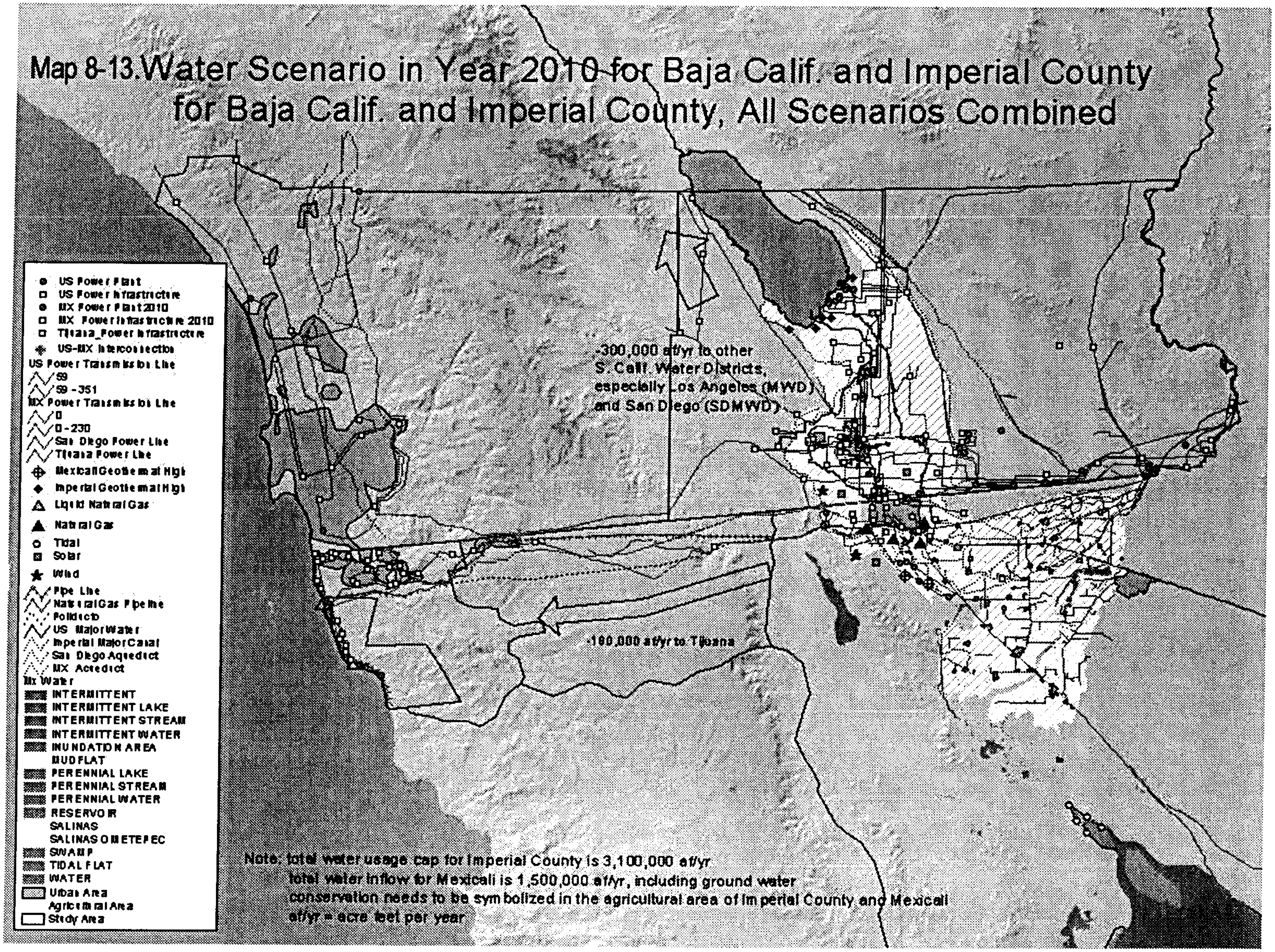
Note: total water usage cap for Imperial County is 3,100,000 af/yr
total water inflow for Mexicali is 1,500,000 af/yr, including ground water
conservation needs to be symbolized in the agricultural area of Imperial County and Mexicali
af/yr = acre feet per year


Map 8-9. Water Scenario in Year 2010 for Baja Calif. and Imperial County
Moderate Water Diversion to other S. Calif. Water Districts
-230,000 af/yr to other
S. Calif. Water Districts,
especially Los Angeles (MWD)
and San Diego (SDMWD)
INTERMITTENT
INTERMITTENT LAKE
INTERMITTENT WATER
MUDFLAT
PERENNIAL LAKE
PERENNIAL WATER
RESERVOIR
SALINAS
TIDAL FLAT
WATER
Note: total water usage cap for Imperial County is 3,100,000 af/yr
total water inflow for Mexicali is 1,500,000 af/yr, including ground water
conservation needs to be symbolized in the agricultural area of Imperial County and Mexicali
af/yr = acre feet per year


Map 8-10. Water Scenario in Year 2010 for Baja Calif. and Imperial County
High Water Diversion to other S. Calif. Water Districts
-300,000 af/yr to other
S. Calif. Water Districts,
especially Los Angeles (MWD)
and San Diego (SDMWD)
US Major Water
Imperial Major Canal
San Diego Aqueduct
MX Aqueduct
INTERMITTENT
INTERMITTENT LAKE
INTERMITTENT STREAM
INTERMITTENT WATER
INUNDATION AREA
MUDFLAT
PERENNIAL LAKE
PERENNIAL STREAM
PERENNIAL WATER
RESERVOIR
SALINAS
SALINAS OMETEPEC
SWAMP
TIDAL FLAT
WATER
Urban Area
Agricultural Area
Study Area
Note: total water usage cap for Imperial County is 3,100,000 af/yr
total water inflow for Mexicali is 1,500,000 af/yr, including ground water
conservation needs to be symbolized in the agricultural area of Imperial County and Mexicali
af/yr = acre feet per year


Map 8-11. Water Scenario in Year 2010 for Baja Calif. and Imperial County
Moderate Water Pumping to Tijuana
~120,000 af/yr to Tijuana
US Major Water
Imperial Major Canal
San Diego Aqueduct
MX Aqueduct
Mx Water
INTERMITTENT
INTERMITTENT LAKE
INTERMITTENT STREAM
INTERMITTENT WATER
INUNDATION AREA
MUD FLAT
PERENNIAL LAKE
PERENNIAL STREAM
PERENNIAL WATER
RESERVOIR
SALINAS
SALINAS OMETEPEC
SWAMP
TIDAL FLAT
WATER
Urban Area
Agricultural Area
Study Area
Note: total water usage cap for Imperial County is 3,100,000 af/yr
total water inflow for Mexicali is 1,500,000 af/yr, including ground water
conservation needs to be symbolized in the agricultural area of Imperial County and Mexicali
af/yr = acre feet per year


Map 8-12. Water Scenario in Year 2010 for Baja Calif. and Imperial County
High Water Pumping to Tijuana
-180,000 af/yr to Tijuana
US Major Water
Imperial Major Canal
San Diego Aqueduct
MX Aqueduct
Mx Water
INTERMITTENT
INTERMITTENT LAKE
INTERMITTENT STREAM
INTERMITTENT WATER
INUNDATION AREA
MUD FLAT
PERENNIAL LAKE
PERENNIAL STREAM
PERENNIAL WATER
RESERVOIR
SALINAS
SALINAS OMETEPEC
SWAMP
TIDAL FLAT
WATER
Urban Area
Agricultural Area
Study Area
Note: total water usage cap for Imperial County is 3,100,000 af/yr
total water inflow for Mexicali is 1,500,000 af/yr, including ground water
conservation needs to be symbolized in the agricultural area of Imperial County and Mexicali
af/yr = acre feet per year


Map 8-13.Water Scenario in Year 2010 for Baja Calif. and Imperial County
for Baja Calif. and Imperial County, All Scenarios Combined
US Power Plant
US Power Infrastructure
MX Power Plant 2010
MX Power Infrastructure 2010
Tijuana_Power Infrastructure
US-MX Interconnection
US Power Transmission Line
59
59 - 351
MX Power Transmission Line
0
0 - 230
San Diego Power Line
Tijuana Power Line
Mexicali Geothermal High
Imperial Geothermal High
Liquid Natural Gas
Natural Gas
Tidal
Solar
Wind
Pipe Line
Natural Gas Pipeline
Polliducto
US Major Water
Imperial Major Canal
San Diego Aqueduct
MX Acueduct
Mx Water
INTERMITTENT
INTERMITTENT LAKE
INTERMITTENT STREAM
INTERMITTENT WATER
INUNDATION AREA
MUD FLAT
PERENNIAL LAKE
PERENNIAL STREAM
PERENNIAL WATER
RESERVOIR
SALINAS
SALINAS OMETEPEC
SWAMP
TIDAL FLAT
WATER
Urban Area
Agricultural Area
Study Area
-300,000 af/yr to other S. Calif. Water Districts, especially Los Angeles (MWD) and San Diego (SDMWD)
-100,000 af/yr to Tijuana
Note: total water usage cap for Imperial County is 3,100,000 af/yr
total water inflow for Mexicali is 1,500,000 af/yr, including ground water
conservation needs to be symbolized in the agricultural area of Imperial County and Mexicali
af/yr = acre feet per year

Chapter 9

Economic Impacts of Scenarios

9. Economic Impacts of Scenarios

The energy and water scenarios have a variety of economic impacts within the Imperial County-Mexicali study area as well as on the broader region. This chapter analyzes these potential impacts. The objective is to identify the qualitative economic effects. Econometric analysis is beyond the current project scope. The chapter addresses Project Research Question 7, which concerns the future economic growth and its relationship to water and energy resources.

The chapter first looks at the economic impacts for each of the energy and water scenarios. Then it discusses the major economic trends in the region that do not depend primarily on water and energy resources, but are driven by other factors. Finally, it considers some general points about the economies within this region and what some limiting water and energy factors may be.

Economic Impacts by Energy Scenarios

The energy scenarios that were shown in **Table 8-1** all have economic impacts. The major impacts that this research has identified are the following:

Geothermal Scenarios (Geothermal Low Scenario and Geothermal High Scenario)

The direct impacts of power plant additions are workforce gains in construction and services to build the plants. There are minor gains in operational and maintenance workforce to run them. Another economic benefit is that some but not all the energy may be exported to the U.S. Over time, the Cerro Prieto geothermal plants have tended to retain more of their energy consumption in Mexico. The energy retained in the future can be beneficial economically to business and residential consumers in Mexicali and Tijuana.

Liquid Natural Gas Scenario

The construction of large-scale LNG degasification facilities, pipelines, transport, and extensive infrastructure improvements will lead to significant mid-term gains in construction and services in Tijuana, Rosarito, and/or Ensenada, depending on the exact coastal siting of the LNG facilities.

Workforce in these areas is needed in the long term to operate and maintain the facilities. Since the energy developer's intent is largely to export the energy to the U.S., the San Diego and coastal southern California economy may benefit in the long term.

Natural Gas Scenario

This scenario implies moderate job gains from plant construction and services in Mexicali, as well as operations and maintenance personnel in the long term. The energy would be largely exported to San Diego and coastal southern California, so their economies would benefit in the long term.

Alternative Energy Scenario

There would be moderate construction workforce gains from installing alternative energy facilities in Imperial County and Mexicali, as well as some long term operations and maintenance jobs. Most of the energy would be utilized locally, so it would benefit the local economies with local sources of energy. On the other hand, these types of energy projects need a high investment in facilities up front, so the benefits would require more years for break-even.

Economic Impacts by Water Scenarios

Water Diversion Scenarios (Small, Moderate, High)

These scenarios imply a steady state in agriculture and some jobs added for conservation. The largest payback comes from revenues provided to the IID in exchange for water diversion. Because the pricing of the diverted water may vary considerably, i.e. there are different ways that IID can allocate the revenues, it is hard to quantify what the benefits will be from applying the revenues that the IID gains.

The IID and its consultant CH2MHill modeled the changes in employment from the Small Water Diversion Scenario without fallowing (IID, 2002). As seen in **Table 9-1**, there would be an estimated net employment gain of 430 jobs, mostly in construction and services (IID, 2002). This is contrasted with the IID/CH2MHill modeling of changes in employment from High Water Diversion Scenario with fallowing (see **Table 9-2**), for which there would be a net loss of 1,330 or 1,400 jobs depending on the C or D alternative (C alternative provides all the diverted water to the San Diego Water District, while the D alternative provides 2/3 of the water to the San Diego Water District and 1/6 each to the Coachella Valley Water District and Metropolitan Water District). For either alternative, over 93 percent of job losses would be agricultural (IID, 2002). The percent of the entire Imperial County workforce lost would be between 2.7 and 2.8 percent.

Table 9-1. Net Employment Impacts by Economic Sector from On-Farm Irrigation System Improvements and/or Water Delivery System Improvements for Alternative 2, Program Year Block 7

Economic Sector	Change in Employment
Net Impact	430
Agriculture	0
Construction	170
FIRE	40
Government	0
Manufacturing	0
Mining	0
Other	0
Services	70
TCPU	10
Trade	130

Table 9-2. Net Employment Impacts by Economic Sector from Following for Proposed Projects C and D Program Year -Block 7

Proposed Project	Change in Employment
Net Impact	-1,330
Agriculture	-1,290
Construction	-10
FIRE	-10
Government	0
Manufacturing	-10
Mining	0
Other	0
Services	0
TCPU	-20
Trade	10
Net Impact	-1,400
Agriculture	-1,300
Construction	-10
FIRE	-20
Government	0
Manufacturing	-10
Mining	0
Other	0
Services	-20
TCPU	-20
Trade	-20

Source: Draft EIR, Imperial Irrigation District, 2002

The key factor identified by the IID/CH2MHill in employment impacts is whether fallowing is invoked. If it is, many more agricultural jobs will be lost (IID, 2002).

Moderate and High Water Pumping to Tijuana

These scenarios involve the construction of a second water aqueduct from Mexicali to Tijuana. There would be short-term construction jobs added, and additionally a small number of operational and maintenance jobs.

The positive economic benefits depend on how the new aqueduct project is financed and which governmental units receive the benefits. However, this aspect is unknown, since the prospective financial arrangements are not clear. The arrangements may involve one or more of the following parties: Mexican federal government, state of Baja California, Mexicali or Tijuana municipios, San Diego County Water Authority. Water revenue benefits would come to Mexicali to the extent that this municipio participates in the financing of the project.

Another impact would be if there were substantial losses of agricultural wastewater flowing into the Salton Sea. In that case, fallowing in Imperial County might be a necessity, implying similar losses in agricultural jobs to the other IID fallowing alternatives. This is a sensitive international political issue that may arise.

High Conservation with No Water Diversions

In this case there would be short-term gains in workforce on both sides of the border related to construction of conservation facilities. After construction of this infrastructure, there would be economic benefits, since more water would be available. On the U.S. side, the IID would eventually have additional revenues, which it could direct to economic benefit. In Mexicali, it is unclear which parties would receive the conservation benefits.

Major Economic Trends in the Region and Their Dependence on Water and Energy

Agriculture – Primarily Dependent on Water

Agriculture in Imperial County and Mexicali inherently depends on water resources and somewhat on energy, since it is irrigated. In the Imperial County economy, the agricultural sector is the most important one, although, as mentioned in Chapter 4, it is gradually being displaced by the retail and government sectors. In Mexicali's economy, agriculture is secondary to manufacturing. On both sides of the border, the agricultural sector will be impacted to the extent that water is diverted for coastal metropolitan consumption. Water conservation can only go so far in stemming these losses, because of the sensitive environmental situation with the Salton Sea. With less conservation, land will need to be fallowed, leading not only job losses but also to reduced agricultural production.

Maquiladora Sector in Mexicali and Tijuana– Some Dependence on Water and Energy

As we have discussed, the maquiladora sector has been the economic driver of the Mexicali and Tijuana economies. Some of its production depends critically on water and energy supply. This problem would appear more acute for Tijuana, since Mexicali so far has received more amply water and energy and has more control over the resources.

Important Sectors Not Primarily Dependent on Water and Energy.

A number of important economic sectors in the region do not depend primarily on water and energy. They are the following:

- ***Transportation and Trade***. This important sector for Imperial County and Mexicali is not dependent on water and energy supply in the region. Rather it is driven by the NAFTA agreement and international trade.

- ***Retail Trade***. This sector depends on the peso value, the extent of development of retail trade facilities and businesses in Imperial County, transportation, and ease of border crossing. There is also retail trade in Mexicali, including some from the U.S. customers. Imperial County's retail sector has been trending upwards. It is driven at the bottom-line by the rapid population growth of Mexicali. Boundary factors, consumer attitudes and "cultural distance" may also be important.

- ***Government***. In Imperial County, it has been expanding for reasons unrelated to water and energy. The reasons include growth in federal control of the border, homeland security, prisons, and need for more government services to serve a growing population. The drivers here are the area's population growth and increase in the complexity of government activities.

- ***Illegal Drugs***. Although not discussed in this report or part of the research, this sector of the economy in Mexicali is substantial, but unrelated to water and energy.

Concluding Points and Issues

In conclusion, there are linkages between the energy and water resources of the area and its economy. Among the key factors in the way this develops are Imperial County's economic weakness, the rapid growth of Tijuana and San Diego, needs for capital investment, and the issue of conservation.

Imperial County's economic weakness will not be cured by its positive water and energy situation. As has been discussed, the economic advantages of water diversion outside the county involve tradeoffs. Energy growth will be large on Mexican side, but not sufficiently so in Imperial County to constitute the basis for an improved economy. Ironically, there will be benefits to the County from supporting Mexicali's maquiladora industry, retail trade, and international transport. This should be planned for by the County to a greater extent.

Mexicali's has grown into one of the largest cities of Mexico, with the maquiladora industry as the growth engine. Mexicali's water and energy resources are crucial in both Mexicali and Tijuana to supply the maquiladora industry, other economic sectors, and the domestic needs of a growing population.

Tijuana and San Diego have grown rapidly without having assured sources of water and needs for energy in the future. They in many respects are the most dependent economically, on the water and energy scenarios that occur in the future in Imperial County and Mexicali.

The development of new energy resources and water pumping/diversion for Mexicali will require a lot of capital investment. For energy, the investment will comes from private companies and capital markets, which must be assured of the stability of the region. The Mexican government has made exceptions for this region by relaxing somewhat its stringent energy regulation as a pilot. The Mexican regulatory environment will be crucial. With respect to water diversion and pumping from Mexicali to Tijuana, shared investment may be the smart approach, but the Mexican federal government has not yet shown interest in such a border project, and U.S. investment would require delicate negotiation.

Finally, conservation is an important economic factor. For water in the area, conservation is two-sided -- it allows water to be diverted but causes reduction of outflow to Salton Sea. This tradeoff will have to be politically negotiated. In Imperial County, the conservation, i.e. lining, of the All American Canal is also controversial and politically charged. With respect to energy, Mexicali has a lot of potential to conserve more, since much of its housing stock has poor conservation design, especially during the hot summers. The Mexican federal agency CONAE is trying to stimulate better housing construction and energy conservation. By contrast, Imperial County does not have much need currently to stress energy conservation, since it has a more than ample energy supply.

Chapter 10

Environmental Impacts of Scenarios

10. Environmental Impacts of Scenarios

This chapter examines the environmental impacts of the eleven water and energy scenarios for Imperial County and Mexicali Municipio presented in Chapter 8 and 9. The section examines the impacts from each scenario individually. In the future, the environmental impacts will occur based on a mixture of scenarios, not just on a single one. However, for purposes of discussion, it is clearer to keep the environmental impacts separate.

The environmental impacts for each scenario will be examined, followed by a summary. The chapter also comments on the impacts, with respect to environmental policy in the border as a whole.

This chapter focuses on qualitative environmental impacts, rather than on quantitative ones. The evaluation is done by referring to prior research in the literature and through interviews and observation. It is beyond the scope of the research project to perform our own quantitative environmental impact analysis of the water and energy options. Nevertheless, the chapter is important, because the impacts affect the present and future quality of life in this region. Some may be severe enough to partially retard regional development.

Water Diversion Scenarios from IID Water System to Other Southern California Water Districts (Small, Moderate, High)

Environmental impacts for the three water scenarios are discussed together, since the same problems apply in differing extents to all of them. The Salton Sea impacts also carry over to the next section on impacts from Tijuana water diversion, since the Tijuana diversion also lowers the Salton Sea with corresponding results. The potential environmental impacts from water diversion away from the IID water system include water quality, biological resources, land use, agricultural resources, air quality, noise, recreation, and aesthetics (IID, 2002). Economic and social impacts were discussed in the last chapter.

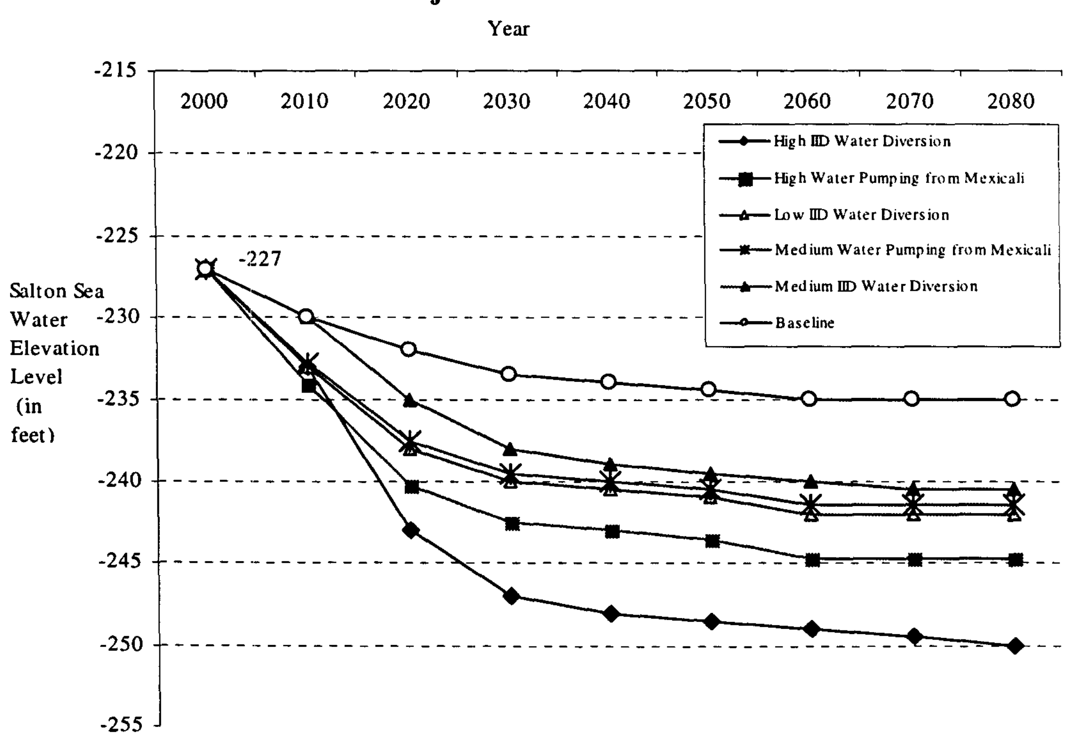
As was pointed out earlier in the report, the Salton Sea receives an average inflow of 1.34 maf/yr, mostly by agricultural wastewater (IID, 2002). Of this inflow, the Alamo River comprises 46.4

percent, the New River 32.9 percent, direct IID drains into the Sea 6.9 percent, and other inflows 13.8 percent (IID, 2002). In other words, the Salton Sea functions 85 percent as an agricultural waste sump.

The potential damages to the Sea are the result of increased chemical pollution, which can harm the biota; and reduced sea level and sea surface, which can expose sediments leading to a potential air pollution problem and also harm biota. The chemical pollution and water levels are a joint function of the inflows into the Sea. Over time, it is the inflows plus evaporation and sedimentation that determine the Sea's chemistry, level, and surface extent.

In the environmental impact report for anticipated IID water diversions (IID, 2002), the outside consultant Ch2MHill modeled the impacts of water diversion regimes on Sea level elevation, Sea surface area, and salinity levels. As seen in **Figure 10-1**, the present day Salton Sea level is –228 feet. The present salinity is 46 grams per liter (g/l) and the surface area is 364 square miles.

Figure 10-1. Estimated Salton Sea Water Elevation Levels Under the Project Water Scenarios and Baseline



Note: the Baseline refers to continuation of present trend with no diversion or pumping
Source: IID, 2002.

If there is no water diversion and present trends continue, the Sea level will drop seven feet to -235 feet by year 2077; the salinity will rise to 86 g/L; and the Sea surface will decrease by 7 percent (IID, 2002). Even the trend without diversion is a deteriorating one.

The 130 maf/yr diversion scenario results in 14 foot sea lowering, salinity of 110 g/L and a sea surface reduction of nearly half (IID, 2002). The Sea salinity level of 60 g/L is considered a threshold after which fish are seriously impacted (IID, 2002). With 130 maf/yr diversion, the threshold level of 60g/L would be reached in year 2013.

For the 230 maf/yr diversion scenario, all the impacts just mentioned are greater, with salinity rising to 136 g/L, sea level lowering to 172 feet, and sea surface reduction of 53 percent.

At the 300 maf/yr diversion level with equivalent conservation measures, the impacts become very adverse. The sea level falls to –250 feet; salinity rises to 160 g/L, and sea surface is reduced by 54 percent (IID, 2002). These impacts, including profound chemical pollution of the Sea, are not acceptable. Sea biota would be radically reduced and the potential air pollution problem aggravated.

The 300 maf/yr diversion with fallowing has more moderate impacts, because the fallowing encourages improved water flows into the Salton Sea. The sea level drops to –240 feet, with salinity of 100 g/L and Sea surface reduction of 45 percent. The critical threshold for fish biota would be reached in 2012. Benefiting from fallowing, this regime is similar to the 130 maf/yr scenario in its effects on the Salton Sea.

Biological species would exceed thresholds at different times, depending on different scenarios (IID, 2002). As seen in **Table 10-1,** all regimes go over the thresholds, in the near term, to sustain the rotifer and pileworm. A more hardy species, Copepod (A.dengizicus) exceeds its threshold between 2019 and 2063 (IID, 2002). This modeling does imply that all the regimes would eventually impact all the species shown, so the biological impacts are a matter of deferring, not eliminating adverse outcomes.

The Salton Sea is a wintering sport for 400 species of birds. The reductions in land areas from the scenarios would potentially harm these species. Land area in the water draw-down could not re-vegetate. Birds depending on fish for food would be impacted as fish species in the Sea succomb to excessive chemical pollution.

The chemical changes to the Sea include inorganic substances, pesticides and herbicides, metals, and nutrients (IID, 2002). Selenium is has been identified most frequently as adversely impacting animals and plants. Its origin in inflow is through the Colorado River, although it is concentrated by the Sea. Other potentially adverse chemical pollutants mentioned are the inorganic compounds, cadmium, copper, molydenum, nickel and zinc, and the organic compounds, acetone, carbon disulfide, and 2-botanone (IID, 2002).

Table 10-1. Projected Year at which Salinity would Exceed Tolerences for Invertebrate Species Under the Proposed Project and Alternatives

Rotifier	2005
Pileworm	2008
Barnacle	2017
Copepod (A.dengizicus)	2023
Copepod (A.dieters)	2035
Rotifier	2005
Pileworm	2006
Barnacle	2012
Copepod (A.dengizicus)	2016
Copepod (A.dieters)	2021
Rotifier	2005
Pileworm	2007
Barnacle	2013
Copepod (A.dengizicus)	2016
Copepod (A.dieters)	2026
Rotifier	2005
Pileworm	2007
Barnacle	2012
Copepod (A.dengizicus)	2015
Copepod (A.dieters)	2019
Rotifier	2005
Pileworm	2008
Barnacle	2023
Copepod (A.dengizicus)	2036
Copepod (A.dieters)	2063

Source: IID, 2002

The other impacts from IID water diversions besides biological and chemical impacts on the Salton Sea are as follows:

- *Colorado River. Salinity would rise somewhat higher for the lower Colorado River, which could be offset by mitigation, such as the Colorado River Salinity Control Project.*
- *Water flow into IID water service area. This flow would be somewhat reduced, since water would be diverted higher up in Colorado River.*
- *Agricultural resources. For most scenarios, there would be modest loss of agricultural land. The 300 maf/yr (fallowing) alternative would lead to a large amount of loss in agricultural land.*
- *Dust emissions/air pollution. The Salton Sea's seabed would be exposed under all the regimes. The seabed contains concentrated selenium, cadmium, and other pollutants. This could be dispersed into the atmosphere through "fugitive dust emissions," i.e. dust storms. Because the prevailing winds are from north to south, these dust storms could potentially adversely effect the region of Imperial County and Mexicali. Although the IID EIR does not consider that there is sufficient risk to identify this as an impact, more recent studies have pointed to it as a potentially serious risk (Salton Sea Science Office Workshop, 2002). Dust storms that would last for more than one hour would likely exceed federal tolerances for particulate matter (PM_{10}). There is a data gap issue that precludes knowing exact effects of the dust storms, although a similar serious problem has been present at Owens Lake, California (Salton Sea Science Office Workshop, 2002). Among the possible mitigation steps are: gravel covers on erosive areas, shallow flooding of erosive area, cementing sediment crust by water spraying, and controlling access to high emission "hot spots."*
- *Noise and transportation. The noise impacts would be temporary and the result of construction from mitigation.*
- *Recreation/aesthetics. Sport fishing would be impacted or eliminated, as would swimming and water-skiing. The aesthetics would be near the Sea by regimes exposing large sections of seabed.*

Impacts from Scenarios of Water Pumping to Tijuana

As discussed earlier, greater pumping of water to Tijuana is likely because Tijuana's population is growing rapidly and few other water sources are available to it. Because the Mexicali Valley is in the watershed of the Salton Sea, the diversions would proportionately reduce the Salton Sea inflow and lead to the entire range of Salton Sea impacts that have already been discussed. **Figure 10-1** also show the level of impacts from the two Tijuana-water-pumping scenarios. The first scenario of 120 maf/yr water pumping, is nearly the same as the 130 maf/yr (on farm improvements only) scenario in its Sea impacts. The 180 maf/yr Tijuana-water-pumping scenario has impacts in between the previously discussed 130 maf/yr and 230 maf/yr scenarios. The date projected to reach the biological threshold of 60 g/L is 2012, and the eventual salinity level of 123 g/L.

Table 10-2. Proposed Salton Water Surface Elevations Under the Proposed Project and Alternatives of IID Water Conservation and Transfer Plan

Year	High IID Water Diversion	High Water Pumping from Mexicali	Low IID Water Diversion	Medium Water Pumping from Mexicali	Medium IID Water Diversion	Baseline
	Elevation					
2000	-227	-227	-227	-227	-227	-227
2010	-233	-234	-233	-233	-230	-230
2020	-243	-240	-238	-238	-235	-232
2030	-247	-243	-240	-240	-238	-233.5
2040	-248	-243	-240.5	-240	-239	-234
2050	-248.5	-244	-241	-241	-239.5	-234.5
2060	-249	-245	-242	-241	-240	-235
2070	-249.5	-245	-242	-241	-240.5	-235
2080	-250	-245	-242	-241	-240.5	-235

Besides the water impacts, another adverse impact is indirect, in particular increased energy demand from Mexicali. In year 2000, the proportion of Mexicali's energy consumed by aqueduct pumps to transport water from Mexicali to Tijuana was 13 percent or 94 MW (Flores Magon, 2001). If pumping is tripled, as in the second Tijuana scenario, then the additional energy expended to pump 120 maf/yr more water is estimated at 188 MW. Hence the energy environmental impacts of this amount of additional capacity to support it must be considered. Those impacts will be given later.

The new aqueduct would also imply construction through habitat areas, with impact on the biota. However, since a new aqueduct would likely follow the same right-of-way as the old one, the impacts would be marginally less. The possible physical incursions include erosion, debris, and some tailings. The point is that the present aqueduct route has already affected certain biota including endangered species. The new aqueduct on the same route would not be expected to upset this situation much further.

Geothermal Scenarios

Among the environmental impacts from geothermal energy are cooling water consumption, disposal of hot water, reinjection, noise, odor pollution, and land use. The cooling water consumed by the current Mexicali capacity and by Imperial County plants is small versus the overall water supply. It should not present a major issue with the energy build-up anticipated, although it will register more in the future in Mexicali, as water becomes more scarce. The hot water issuing from a geothermal plant can be utilized, or disposed of, in a variety of ways. For instance, hot water can be put to industrial indirect use in factory processes or building heating. This has not been done to any extent so far in the study region. The water can be run out into ponds, which has been partly the case for Mexicali. This practice causes damage to the biota and influences the surface land. The damage would be more extensive with a 400 MW plant capacity expansion. Another way to dispose of geothermal brine is through reinjection back into the earth. This also might impact the subsurface, but it constitutes a much more satisfactory option. This approach is utilized in Imperial County.

Geothermal plants are moderately noisy, which can influence the surrounding inhabitants. However, the anticipated geothermal expansion facilities on both sides are located away from populated areas, so although more noise will be present, it will affect a much more limited population. Smell pollution depends on the chemical constitution of the brines pumped up from the earth. Both the Cerro Prieto and Mexicali future plants can produce this type of pollution, but again the impacts will be limited because of lack of habitation.

Land consumption from geothermal well sittings is a relatively small one (Butler and Pick, 1982), and has negligible effect on agriculture. The power plants themselves would only take up several acres.

Natural Gas Scenario

The design of combined cycle plants for natural gas has the environmental impacts of need for cooling water, air pollution, noise pollution, and land uses. The modern combined cycle plant, under the best circumstances, is one of the cleanest types of fossil plants (Hinrichs and Kleinbach, 2002). The cooling water consumption will be modest. It will have more relative impact on the Mexican side, due to future water scarcities there. The extent of air pollution depends on how much the energy company invests in modern catalytic converters and scrubbers. With the best modern technology, the new plants can avoid serious air pollution impacts (Hinrichs and Kleinbach, 2002). The difference between the best air pollution control and worst is in the order of 10 fold. There is a policy question on whether or not the plants will be held to U.S. environmental standards. At this point, it is not likely they will be. The noise pollution and land use considerations are similar to those discussed for geothermal energy.

Liquid Natural Gas Scenario

The environmental impacts in the region would be located in Tijuana and areas further south. The regasification facilities expected to be built would run the hazards risk of spillage of super-cooled and compressed natural gas. This would be a serious safety hazard that could have terrible consequences. In the post 9/11 era, security would likely be tightened on such a plant or plants.

If the natural gas is piped to other locations, then the land use impacts of new or enlarged pipelines must be considered.

If the natural gas is utilized for electrical energy generation in combined cycle power plants, then the comments about environmental impacts from such plants are relevant and apply here, in proportion to the capacity installed.

Environmental Policy Implications for Environmental Impacts

There are several binational policy implications that are important to consider. In the water arena, the environmental impacts stem from increasing pressure being put on the water systems. This, however, would seem to be true of the entire border (Mumme and Barajas, 2002). There is a long-term drought situation throughout the border. The groundwater levels are quite low, and all renewable water has been utilized. The type of environmentally compromised solutions seen with the Salton Sea are applying to other areas in the border (Mumme and Barajas, 2002).

The environmental organizations to respond to increasingly urgent shortages are numerous and do not necessarily work together well (Ganster, 1988). These agencies consist of the International Boundary and Water Commission (IBWC), Border Environment Cooperation Commission (BECC), and the Commission on Environmental Cooperation (CEC), and the U.S Good Neighbor Environment Board. Another layer of environmental policy consists of international agreements over water and environment. These include the 1944 Water Treaty, the Integrated Environment Plan for the Mexican-U.S. Border Area (IBEP), and Border XII. The 1944 Water Treaty split up the surface waters between the U.S. and Mexico. Unfortunately, it did not address groundwater. Since the time of the treaty, and because of the increasing water scarcity, groundwater has become a more important resource, but is not regulated to any extent.

The environmental impacts discussed in this chapter are complex and varied. There are a variety of mitigation steps that can be take, ranging from putting advanced scrubbers on natural gas power plants, to taking steps to reduce the air pollution emitted from the potentially exposed seabed of the lowering Salton Sea, to increasing indirect uses of geothermal energy, so the hot wastewater flows into beneficial uses. For mitigation to be effective, there needs to be more accurate information and data collected on environmental impacts. For positive actions, it is essential that the environmental organizations of the border work together more strategically. Right now, they are a scattered "hodgepodge" of organizations, which do not tend to communicate with each other or coordinate their activities (Mumme and Aguilar, 2002).

Chapter 11

Conclusion

11. Conclusion

This project has examined the population and economic growth within Imperial County, Mexicali Municipio, San Diego County and Tijuana Municipio. The conclusion returns to the research questions and provides answers. Then the chapter turns to policy recommendations for the key governmental entities in the region. Lastly, the chapter discusses what future research is needed.

The research questions were addressed in the specific analyses presented in the ten chapters preceding this conclusion. This section gives the major findings to answer each research question.

What is the extent of population growth in Imperial County and its cities and of Mexicali Municipio, and what will be the projected population growth and its spatial array in the county?

Imperial County grew in population at a high rate in the 1990s. Mexicali has grown rapidly for the past 50 years. Based on adjusted projections (SCAG, 2002; Peach and Williams, 1999), future growth is projected to continue to grow at rates of 2.3 percent for Imperial County and 2.2 percent for Mexicali. In year 2020, Imperial County will have a population of 224,000 and Mexicali Municipio will reach 1.19 million. The spatial array will be similar to that at present, with most of the Imperial County population located in a system of cities in its southern Valley area, especially in the cities of El Centro, Calexico, and Brawley. Because of its rapid growth in the 1990s and proximity to the border, Calexico should grow somewhat faster and eventually surpass El Centro in population. Mexicali will expand further in land area to support its much larger population.

Why hasn't the Imperial County system of cities, adjacent to the border, developed in base size to the extent of other U.S. border cities, such as San Diego and El Paso?

Imperial County has had a weak economy, agricultural focus, and a low educational/skills level for over 50 years, compared to the state. These have served as push factors in the large net outmigration that prevailed from 1930 to 1990. The migration situation has only turned significantly positive in the past decade. The county's economy has historically been dominated by agriculture. However, the wealth from the agricultural production mostly has not remained in the county. In the 1990s, this long-term trend reversed and there was net immigration. Several explanations are the growth in the border trade and commerce, which have stimulated more retail trade and governmental activities. However, it is now so many decades after other U.S. border cities began to grow significantly that Imperial County will not easily catch up in size. For instance, its projected county size of 224,000 in year 2020 is much smaller than the present day cities of El Paso and San Diego.

Do indicators and trends present in the late 1990s and 2000 point to a substantially larger urban complex in Imperial County and Mexicali Municipio?

The projections we have utilized (SCAG, 2002; Peach and Williams, 1999) and adjusted point towards a much larger sized urban complex in the future. From 906,963 population in the urban complex today, our analysis indicates a population of 1,410,639 in 2020, a growth of half a million persons. This complex will have much more manufacturing, commerce, retail trade, transport, and will generate more traffic, noise, and pollution. Although only 62,000 of the increase will be in Imperial County, its system of cities will be larger and its environment will change, with so many more people present in the area.

What county industry sectors have benefited by the influence of Mexicali and the border, and how have they benefited?

The sectors that have benefited the most in Imperial County from the Mexicali influence are retail trade, government, and transportation. Retail trade has grown through increasing volume of customers from Mexicali who visit Calexico and El Centro to purchase retail goods. Hence, more retail facilities from a wider range of companies have arrived in Imperial County. Federal, state, and local government have benefited by having more border transport, trade, and movement to monitor, regulate and control. An additional homeland security layer has been added to these government activities since the 9/11/01 terrorist attacks. Transport has increased through the influence of NAFTA trade stimulus and the opening of the new East Calexico Port of Entry, which has led to increasing truck transport through the area. The high expectations to build a substantial commercial/industrial park near the new POE, with a focus on servicing this transport has not yet occurred. However, the increasing transport has had more limited benefits to subsectors serving transport such as vehicle maintenance, customs brokerage, and warehousing.

How are those border-influenced sectors arranged spatially in the county, and what factors are influencing their future spatial pattern?

The larger businesses and organizations of retail trade, government, and transport are located predominantly in El Centro, Calexico and in the southern unincorporated, agricultural areas between El Centro and Calexico. This makes sense because these entities can be located within easy access of the two border ports of entry. In the future, this pattern will likely increase, with much more developed commercial/industrial corridors connecting these two cities.

What are the effects on the urban structure of Imperial County and Mexicali Municipio from the NAFTA-driven growth in cross-border trucking and transport?

The opening of the East Calexico POE has stimulated border truck traffic and value of freight. This port is designed to have an eventual truck capacity of 19,000 trucks daily in two directions. However, the traffic is today at little more than half that level. Since the new POE opened in 1996, there have not been significant increases in related workforce, including transportation, public utilities, and services. Although it hasn't become the "Gateway to the Americas," the connecting the East Calexico POE with U.S. 8 has undergone some build-up, which we estimate will continue to grow, even if it doesn't become the huge "Gateway" originally anticipated. It is likely to have more retail, government offices, warehousing, distribution, and vehicle support services along its access route.

In Mexicali, there is commercial and industrial development that has taken place in the area broadly surrounding the new POE. It has served as a stimulus to industrial and commercial development on the Mexican side.

What are the potential environmental impacts of the border-influenced economic sectors on the environment of Imperial County and Mexicali Municipio? In particular, of major analytical interest here are the effects of population and economic growth in Imperial County and Mexicali on availability of water supply to Imperial Count and Mexicali Municipio? What are the spatial proximities of future population and economic growth and water supply locations?

There are environmental impacts from a variety of scenarios of energy and water development. We examined them qualitatively over the next 20 years for each scenario of water and energy. Water diversion with conservation but without fallowing will have the most detrimental impacts, particularly on the Salton Sea. The sea level will drop, which will be adverse to fish in the sea and other biota in and near the sea including many bird species dependent on the sea at its present level and salinity. Another potentially adverse impact is dust emissions and air pollution from the seabed exposed by the lowered sea level. This could release into the atmosphere pollutants such as selenium, cadmium and others, which usually blows south towards the border city complex. Water diversion with fallowing does not lead to many differences from the present day, since the amount of water entering and leaving the agricultural system is similar.

The water scenarios of pumping from Mexicali to Tijuana involve building a second aqueduct over the mountains. If built near the old aqueduct, the environmental impacts would be only marginally more. Since water normally flows south in Mexicali to drain eventually as wastewater into the Salton Sea, a more serious impact would be the same lowering of the Salton Sea and all the associated adverse impacts just detailed. This would be hard to control and resolve from an international political perspective.

Each energy scenario also has a variety of environmental impacts. Geothermal build-up can lead to noise, smell, and thermal water pollution, as well as aquifer pollution. LNG has potential risks of explosions and large release of pollutants. One degasified, the natural gas has normal environmental problems of NG including potential air pollution and water consumption for cooling. NG is often regarded in the U.S. as a cleaner type of fossil fuel, since combined cycle plants with scrubber equipment are good environmentally. However, the energy company operators in Mexicali may relax U.S. combined cycle standards leading to the release of more air pollution. The alternative energy options of solar, wind, and tidal are less polluting, because they are using the earth's natural processes to generate energy. Nevertheless, they can cause certain types of pollution. For instance, wind and solar energy require large amounts of land, which displaces some natural habitat. Tidal energy involves increased flooding at certain times of areas, which may damage natural habitat. Wind energy causes noise impacts under certain circumstances.

We have analyzed the spatial distributions of water and energy in relation to the 2-county/2-municipio region, for each of the eleven scenarios. This analysis indicated that the coastal cities are linked into the overall issues for both water and energy. Within Mexicali and Imperial County, there do not appear to be major spatial proximity problems in generating and supplying the energy. The main exception is the problem of the Salton Sea and particularly the effects on it from reduced agricultural wastewater flow.

What are the effects of population and economic growth on the availability of energy supply to Imperial County, Mexicali Municipio, Tijuana Municipio, and San Diego? What is the spatial distribution of energy supply for Imperial County and its population centers, Mexicali Municipio, Tijuana Municipio, and San Diego, based on the southern California-Mexico energy grid?

We examined energy build-up scenarios and asked how they affect the regional population centers. It is evident that energy entrepreneurs are being given opportunities to generate substantial amounts of energy on the Mexican portion of this region which will be provided at higher prices to the coastal southern California and Tijuana markets. The large population growth of the region is driving this energy development in Mexico. The reason this large energy development in the region is occurring on the Mexican rather than U.S. side relates to lower construction cost, easier permitting, and much less environmental regulation. Imperial County does not have to worry about providing energy since it has abundant energy, and more than satisfies its internal consumption.

Policy Recommendations

It is evident that the energy and water resource issues in the region are complicated and relate to many layers of government on both sides of the border. It is not possible to know in advance all the key policy issues 20 years from now. Nevertheless, in this section, we present several recommendations for local, state, and federal government entities on both sides of the border. It is important in this to recognize that for energy and water resources, and generally, in Mexico the federal government is much stronger than the states, and the municipios are relatively weak.

Imperial County

The county should consider the growth and opportunities offered by Mexicali in its long-range planning. It is over five times the size of the county and is growing as rapidly. The county could benefit by taking advantages of the growth.

The county can attempt more joint planning with government units from Mexicali. There are advantages of shared culture and common language (Spanish and English) that encourages communication and joint efforts. There is also an educational parity, since as pointed out in Chapter 3, the two sides of the border in the region have large highly educated segments. A constraint to binational local planning is that the two federal governments often feel obligated to oversee, manage, or sometimes terminate such local joint efforts. The answer may be local political will on both sides to get things going and accomplish results.

It should emphasize educational advancement and skills training. The county has a reduced level of education that can benefit a lot by strong programs to make improvements. These will add more highly skilled workforce that will help to lift the county economically.

State of California

The state needs to re-evaluate its help to economically depressed counties such as Imperial. The county is crucial to the state agriculturally and also because of its increasing role in border and NAFTA-related trade and exchange. Up to now, the state has not emphasized help to its lowest economic rung of counties.

State of Baja California and Mexicali Municipio

The state and municipio should consider more joint planning with Imperial County governments.

These governments should emphasize energy conservation to a greater extent. Particularly important is to improve housing and building construction to prevent energy losses especially in the summer. Such programs might be done in conjunction with CONAE.

The state and municipio should take leadership in planning a new water aqueduct from Mexicali to Tijuana. They should seek a modern design plan and start discussions with a variety of interested governments and parties, including on the U.S. side.

Mexican Federal Government

The federal government should emphasize solar, wind, and other forms of alternative energy for region, since the region is amenable to them. This could help diversify the energy portfolio in the region.

It should consider more investment in the infrastructure of the region. Mexico City is far removed from Mexicali and Tijuana. However, it needs to recognize that they have become among the major cities of the nation, yet have backward infrastructure. Some of the water and energy investments discussed in this report can be included in new initiatives.

The federal government, in particular the Comisión Federal de Electricidad, should consider making more stringent requirements for air pollution emissions of power plants in the region. The reason is the proximity to U.S. cities and the potential political problems and disputes that will arise if lower air pollution standards contribute to dirty air over U.S,. cities. This might fit in with the government's okay to pilot more entrepreneurial energy development in this region, which was an exception to its usual stringencies.

Policies on water and energy conservation should be encouraged. Energy conservation programs can be carried out by partnering with CONAE's national initiatives. Water conservation is supported by CNA and other agencies. As already pointed out, a tricky aspect of agricultural conservation is that it may have deleterious environmental impacts on the U.S. side.

In summary, this report analyzed the population and economic growth of this border region and projected it into the future. It studied water and energy supply and pointed to key challenges and issues related to supporting the supplies to the region in the future. These issues are ones that apply in many respects across the whole U.S.-Mexico border, which is growing rapidly everywhere.

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