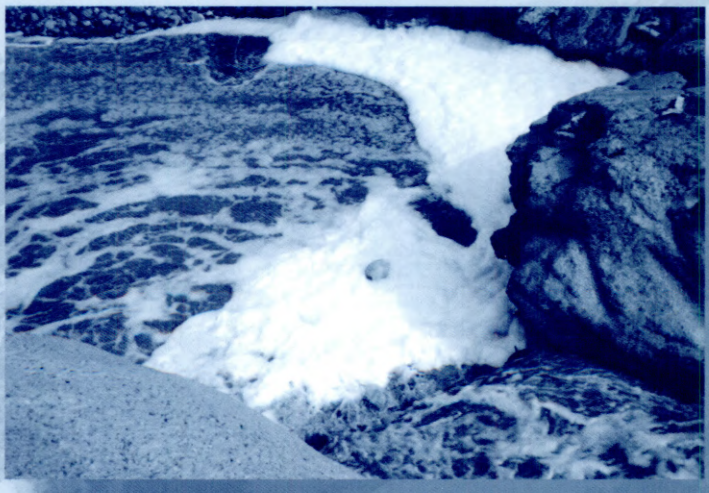
THE U.S.-MEXICAN border environment:

Economy and environment for a sustainable border region: Now and in 2020



Edited by
Paul Ganster

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The Southwest Center for Environmental Research and Policy (SCERP) is a consortium of U.S. and Mexican universities dedicated to addressing environmental issues of the U.S.–Mexican border region through applied research, outreach, and regional capacity building.

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The U.S.–Mexican Border Environment

Economy and Environment for a Sustainable Border Region: Now and in 2020

Edited by Paul Ganster

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Foreword

This volume marks the third in the SCERP Monograph Series. It is comprised of the papers and deliberations from Border Institute II, "Economy and Environment for a Sustainable Border Region: Now and in 2020," held in Rio Rico, Arizona, in April 2000. The Border Institute is an annual event convened by the Southwest Center for Environmental Research and Policy, the United States Environmental Protection Agency, and the Border Trade Alliance. The meetings are designed to bring together stakeholders from both sides of the U.S.–Mexican border to consider significant environmental and related issues facing the border region. While immediate problems are considered, the emphasis of the Border Institute is to stimulate solutions to longer term issues so that the region will have an adequate quality of life and a sustainable environment in the future. SCERP operates from the premise that long-term and comprehensive solutions require participation of all border stakeholders from both sides of the border—researchers, the private sector, government agencies at all levels, tribal authorities, nongovernmental organizations, and communities.

As general editors of the SCERP Monograph Series, we wish to recognize the efforts of Jennifer Fraser and Robert Cao-Ba of Arizona State University's Herberger Center for Design Excellence for the copyediting, design, and production of this volume and of the entire series.

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SCERP Monograph Series General Editors

I

Economy and Environment: Overview and Recommendations

Paul Ganster

Introduction

This volume is the product of the second Border Institute, held in Rio Rico, Arizona, in April 2000. Convened by the Southwest Center for Environmental Research and Policy, the United States Environmental Protection Agency, and the Border Trade Alliance, this annual series brings border stakeholders together to address significant issues that are critical to the sustainability and environmental quality of the U.S.–Mexican border region.[1] The first Border Institute, held in late 1998, examined the demographic, environmental, and economic features of this binational region and analyzed the challenges the region faces to achieve a sustainable environment by the year 2020.[2] The second Border Institute built on the vision developed for the border region in the first Institute by exploring the challenge of reinventing the economy to provide a solid base for achieving development, providing necessary environmental infrastructure, and enhancing quality of life in border communities.

Titled "Economy and Environment for a Sustainable Border Region: Now and in 2020," the meetings followed the format established at the first Institute. A number of briefing papers were commissioned from leading researchers and practitioners and distributed to participants along with abstracts several weeks prior to the actual meetings. At the Institute, authors presented short summaries of their papers that were

then commented on by panelists from local government, federal agencies, the private sector, and stakeholder groups. Participants were encouraged to take part in the lively discussions that accompanied each paper and panel. One afternoon of the conference was devoted to a field trip to Nogales, Sonora, and Nogales, Arizona, to observe environmental infrastructure and related issues and to participate in briefings by local subject experts. The final morning of the Institute was dedicated to a series of roundtable discussions by working groups, which digested the material presented during the previous days and produced a series of recommendations and conclusions. The Institute recommendations are included in this introduction and appear after the summaries of the conference briefing papers.

Sustainable Development in the U.S.–Mexican Border Region

The essay on "Sustainable Development on the U.S.–Mexican Border: Past Lessons, Present Efforts, Future Possibilities," by Alan D. Hecht, Patrick Whelan, and Sarah Sowell, summarizes environmental conditions and sustainable development issues in the border region. They begin with a useful review and analysis of environmental cooperation between Mexico and the United States on border environmental issues. They next raise interrelated questions of whether environmental sustainability can be achieved in the border region by 2020 and, if so, what are the principal challenges for sustainable development? The final section pulls together conclusions from the paper. Some of the most important conclusions include the following:

- The combined effects of increased population growth, unplanned economic development, and limited water resources are stressing border communities now.
- Continued and increased high-level attention to the border's needs is necessary; the United States must recognize the problems of the border as an issue of nationwide concern. Without international cooperation in support of the border, there is the possibility of international friction and conflict. Even with sustained effort on the part of governments and the public sector, serious challenges remain.
- The lack of local capacity to design and finance major projects underscores the need for greater attention on the part of gov-

ernments to build the stock of human capital in communities and regional authorities.

- Continued decentralization of authority from federal to state governments is essential for fostering this capacity and empowering local level officials.
- Greater public and private sector attention is needed to manage current and future growth in a way that is commensurate with available resources.
- The border's present economic mix is unlikely to promote sustainability or stability without diversification and new investment.
- Both countries depend heavily on federal subsidies for water infrastructure projects. This dependence is likely to continue in coming decades. The lack of such subsidies for non-water-related projects (such as solid waste) currently constrains the development of other needed infrastructure.
- Health threats present particular risks to the border population and threaten community well-being in addition to economic prosperity.
- The production, management, and disposal of hazardous waste remain major problems in the border area.
- The various water-use sectors, along with the private and public sectors, need to develop a strategy for water use that includes a binational component.

U.S.–Mexican Border Economy in the NAFTA Era

"The U.S.–Mexican Border Economy in the NAFTA Era: Implications for the Environment," by Norris Clement, Sergio J. Rey, Noé Arón Fuentes, and Alejandro Brugés, reports the outcome of research conducted by a group of Mexican and U.S. economists that belong to the Network of Border Economics/Red de la Economía Fronteriza (NOBE/REF). The basic purpose of the study was to test assumptions regarding the effects of NAFTA on the border economy by analyzing available data and conducting interviews with local Mexican and U.S. community leaders and experts.

The study, while not determining what the specific effects of NAFTA were in the border region, nonetheless clearly lays out pre–NAFTA and NAFTA–era economic and social trends. For U.S.

border counties, per capita income grew at a lower rate than the nation as a whole, although employment grew faster than the nation as a whole. This took place despite a much higher population growth rate in the border region. While NAFTA brought declining unemployment to the U.S. border counties, unemployment fell less rapidly than in the rest of the United States. Thus, although the NAFTA era brought increased bilateral trade and higher population growth rates to the U.S. border region, the border lagged behind the nation as a whole in economic terms. The elusive NAFTA promise of economic prosperity was not realized in U.S. border communities.

For Mexican border municipalities, however, the NAFTA era brought population growth rates and employment growth that were significantly higher than the nation as a whole. Of particular importance was that job creation increased by a factor of five since the implementation of NAFTA in 1994, from an annual rate of 3% to 15%. Nevertheless, the Gross Regional Product in the Mexican border region grew only slightly faster than the country as a whole.

U.S. border economies have increasingly been concentrated in sectors that are declining at a national level, such as manufacturing, or are growing slower than total U.S. employment, such as wholesale trade. Retail trade and services sectors have accounted for over half of the new jobs in the U.S. border region since 1994, underlying the basic problem of the failure to create high-value-added jobs in border communities. In contrast, the growth of manufacturing in the Mexican border economy has been significant.

In general, this study shows that NAFTA has not accounted for a significant economic improvement for the U.S. border communities. In contrast, Mexico's northern border has done quite well under NAFTA, relative to the rest of the country. Yet, perceptions of border residents reveal that U.S. border community leaders tended to be more optimistic than the economic data might merit. Ninety-one percent of U.S. respondents and 83% of Mexican respondents felt that their community's economy had improved, partly due to NAFTA and partly due to other factors such as the expanding U.S. economy. With regard to infrastructure, 47% of U.S. community leaders felt that infrastructure had improved while 18% saw it worsening. Mexican respondents were much more positive, with 77% indicating improvement in infrastructure and 9% indicating a worsening situation. With respect to the environment, 48% of U.S. respondents felt that their county's envi-

ronment had remained the same while 18% felt it had worsened. Mexican responses were 23% and 40%.

In addition to these findings, this study reached a number of general conclusions. First, the study noted considerable variation among the different economic subregions along the border. Second, although the U.S. border economies improved in some ways, the U.S. border counties continued a long-term decline relative to the rest of the United States. This, along with rapid demographic growth, raises serious concerns about the ability of the region to address infrastructure and environmental needs without significant state or federal assistance. On the Mexican side, the growth of industry, along with even more rapid demographic expansion, also raises serious questions about the long-term sustainability of these communities.

Natural Capitalism and the Border Region

While Clement and others—in their essay in this volume—characterize the border economy and discuss the perceptions about the economy and the environment by border leaders, Michael Kinsley, Hunter Lovins, and Mark J. Spalding lay out options for reinventing the border economy. They apply the concept of natural capitalism to the U.S.–Mexican border region. Natural capitalism suggests ways to reinvent local economies and to develop competitive businesses and economic activities while protecting natural resources for future generations. The goal is to develop ways of using natural capital—natural resources such as vegetation, ecosystems, water, and air—in a sustainable way while building prosperous communities. Central to natural capitalism are four shifts in the way business and economic development are conducted:

- *Dramatically increase the efficiency with which resources are used.* By changing technology and production design, farsighted companies are finding ways to drastically reduce inputs of energy, water, materials, and other resources.
- *Reduce or totally eliminate waste.* In the closed-loop production systems of industrial ecology, every output either is returned to the ecosystem as a nutrient or becomes an input into manufacturing another product.
- *Adopt a solutions-based business model where the sale of goods is*

replaced by the sale of services. One example is the case where a company leases its carpeting instead of buying it. The leasing company manufactures the carpet in square sections from old carpet and recycled plastic products and regularly replaces worn or unsightly sections of the carpet. Thus, the company paying for carpet always has high quality floor coverings and the flow of old carpet and plastics into landfills is dramatically reduced. In this case, business wins and the environment benefits.

- *Reinvest in restoring and sustaining critical ecosystems.* Both businesses and communities as a whole would provide the support needed to maintain the natural resources that, in turn, support community prosperity.

Although the concepts of natural capitalism may appear to be idealistic and theoretical, the authors of this essay offer specific cases from the United States and other areas of the world, as well as the border region. For example, in Ojinaga, a small Mexican community in the Big Bend region of the Rio Grande, SCERP researchers developed a project to reclaim salinated land by planting trees that are irrigated with partly treated wastewater that also supplies nutrients. The trees are harvested by the local community for sale to a paper mill, replacing biomass from natural forests. At the same time, a new habitat is created for native animals and human use. And the cost of infrastructure for wastewater treatment is reduced. The community, economy, and environment all win.

Environmental Accounting

"Environmental Accounting along the U.S.–Mexican Border," by Michael Jerrett, Sergio J. Rey, Christian Dufournaud, and Deborah Jones, also looks at the border economy in a very different way. The paper examines the prospects for establishing an environmental accounting system for use by border communities. Environmental accounting is a new methodology that attempts to place monetary values on environmental and resource losses and gains that are produced by economic growth. In other words, environmental accounting enables local officials to determine the true long-term impacts of development decisions.

This article presents a number of case studies in the San Diego–Tijuana area. The first estimates the total proportion of gov-

ernment expenditures made to defend the environment against human-induced changes in San Diego. This study reveals that those expenditures accounted for approximately 1.23% of total economic output and more than 21% of local expenditures for the San Diego region. A second study focuses on the area along the border where the Tijuana River National Estuarine Research Reserve in the United States is connected to Mexico by the heavily populated Cañón Los Laureles subwatershed in Tijuana. In this case, dense human settlements in Mexico, often constructed without adequate infrastructure or planning, produce direct impacts on the downstream critical ecosytems of the Tijuana Estuary. These effects are mostly related to sedimentation and nonpoint source pollution as the result of storm events. In this subregion, expenditures in Mexico are mainly made to protect against threats to human health and safety and totaled approximately $2.6 million in capital expenditures and $0.4 million in operating costs (in U.S. dollars). The expenditures in the United States address issues of recreational resources and ecosystem health, particularly with preservation of the Tijuana Estuary. On the U.S. side of the subwatershed, expenditures were $1.5 million for capital costs and $0.9 million for operating costs. Relative to the size of each country's regional economy and government expenditures, Mexico actually spends more proportionately, although some 90% of the watershed in question lies in Mexico.

Although there are significant issues regarding availability of adequate data for both Mexico and the United States and the methodology still needs to be refined, environmental accounting promises to be a very useful tool for local planners, development officials, elected officials, and other regional stakeholders. It provides a mechanism for evaluating the potential true costs of economic development projects to the environment, which will help guide decision makers in determining the long-term sustainability of large and small projects.

Environmental Infrastructure Needs Assessments

The next section of the volume turns to questions of border environmental infrastructure in "A Verification and Meta-Analysis of Past Border Environmental Infrastructure Needs Assessments," by D. Rick Van Schoik. Border population growth has outstripped the ability of

existing drinking water, wastewater, and hazardous waste disposal infrastructure to meet the demand for these services. The infrastructure deficit affects most border communities, but particularly those in Mexico and the smaller and poorer communities in the United States.

Van Schoik reviews past estimates of infrastructure needs to establish a credible estimate of current environmental infrastructure requirements and costs for the U.S. side only. He concludes that current investment needs range between $6 billion to over $10 billion to provide adequate services for today's population. Moreover, investments of $12 billion to $20 billion will be needed over the next 20 years to accommodate future growth. However, these estimates are for traditional technologies and Van Schoik suggests that low-tech, alternative technologies should be seriously considered for cost savings and enhanced sustainability.

Sustainable Water and Wastewater Infrastructure for the Border

Barbara R. Bradley elaborates on this theme and related topics in her essay "Sustainable Water and Wastewater Infrastructure for the U.S.–Mexican Border Region." Since aridity, growing populations, and expanding economic activities characterize the border region, new sources of water must be found to meet the needs of these active communities in the near future. The most obvious, and often the only, alternative is reclamation of wastewater. However, the cost of existing conventional water reuse treatment is high, from $450 to $850 per acre-foot, not including piping and distribution system costs. Thus, the costs of infrastructure and operation for reclamation systems would severely tax the ability of economically stressed local border communities to pay. These costs could also cause a reduction of expenditures in other areas of infrastructure, such as roads and schools, and negatively impact the quality of life of border residents. It is thus imperative that border communities begin now to develop alternatives to conventional infrastructure.

Bradley evaluates costs of centralized systems to treat wastewater and produce reclaimed water. She concludes that "in general centralized systems may simply be too expensive for full-scale treatment and distribution of reclaimed or repurified water. Thus, for both existing and new communities, decentralized treatment and reuse offer an

important approach to maximize the number of times water is used." It is clear that onsite and decentralized systems offer benefits to border communities, including lower costs, reduced energy consumption, promotion of reuse, and lowered demand on scarce fresh water resources. However, two significant hurdles must be overcome before substantial investment in these systems can take place. First, good cost data are lacking for conventional centralized systems. Typically, information is available regarding the cost of operating a wastewater treatment plant, but not available for the costs of the collector system. Second, there are a number of institutional barriers that must be overcome among water, wastewater, and public health agencies and their jurisdictions need to be reorganized to enhance cooperation and to enable these decentralized systems.

Finances for Border Environmental Infrastructure

The final essay, "Border Finances: Paying for Environmental Infrastructure," by Christopher A. Erickson and David W. Eaton, addresses the very basic financial challenge that most border communities face. The authors note that the most severe infrastructure problem is that of providing a safe and secure water supply for the region. While there are a number of significant impediments to meeting border environmental infrastructure needs, a key problem along with the lack of adequate financing mechanisms is the lack of human capital to plan, implement, and maintain environmental infrastructure. The human capital issue is critical for smaller U.S. border communities. It is also ubiquitous in all Mexican border communities due to historic issues such as predominance of centralized authorities, three-year municipal administration cycles and lack of large permanent staffs, and lack of municipal financial resources. A complicating factor is that by national standards Mexican northern border municipalities are well off, with higher per capita incomes and more positive economic characteristics than most other areas of Mexico. Thus, the northern border is not a high priority for allocation of the scarce infrastructure resources by the Mexican federal government.

There are a number of alternatives for financing environmental infrastructure. These include tax financing, general obligation bonds, revenue bonds, contracting with the private sector, and philanthropy.

Federal and state grants also play a role, but these are declining in the United States and are even less a possibility in Mexican border areas. There are also the two NAFTA institutions engaged in environmental infrastructure efforts. The Border Environment Cooperation Commission (BECC) helps develop and provides certification for appropriate projects. The North American Development Bank (NADB) arranges financing packages with a combination of its own funds and grant funds. However, to date, these two institutions have been only able to meet part of the needs, so other alternatives will have to be developed. In the case of Mexican border municipalities, the most likely scenarios are increasing reliance on private contracting and development of municipal bond markets. The authors recommend that serious efforts be made to develop a Mexican municipal bond market at this time. They cite a number of factors that justify this. First, municipal bond markets have been established in similar developing countries over the past few years. Second, the overall credit position of Mexico has improved dramatically since the 1994 peso crisis. Third, the northern border municipalities are prosperous, with the highest economic growth rates in the nation over the last two decades. This economic growth has created the economic depth conducive to the establishment of financial markets.

Border Institute II Recommendations and Conclusions

Stimulated by the analytical briefing papers and considerable discussion, conference participants developed a number of specific recommendations that were articulated during the final roundtables and plenary conclusion session. These recommendations are grouped in broad categories and are listed below.[3]

Border Economic Development Strategies

In identifying strategies for border economic development, participants considered the current border economic situation, in which border communities continue to fall farther behind the rest of the United States in per capita income terms despite the economic growth of NAFTA. They also took into account the need to reinvent the border economy in a way that creates more high-value-added jobs (economic

development) and embraces the principles of natural capitalism. Recognizing the need for better analytical tools to support sustainable development, participants produced three recommendations:

- Economic and environmental indicators and monitoring systems need to be developed to inform and motivate new investments and improvements. Border communities, decision makers, and economic development planners lack adequate data and analysis to support the immediate-term decisions and long-term planning needed to foster sustainable communities in the border region.
- Future economic development must address long-ignored needs such as raising real incomes of all sectors and valuing ecological services, the community, and individual health, all of which lie at the base of any economic potential. Depletion of resources and pollution have costs that have not been integrated into the overall economic engine. In addition, Institute participants recommended that a source book of successful examples of natural capitalism actions be compiled for use by private and public sector officials in the border region.
- Environmental accounting, which considers both the positive and negative contributions of economic activities to environmental health and ecological services, should be used by jurisdictions to help evaluate the long-term environmental costs of new industry, infrastructure, and other investments. Environmental accounting techniques and methods need to be developed for border communities as a decision-support tool.

Border Environmental Infrastructure Needs

A key theme in the papers and in the discussions was that the current shortfall in U.S. border communities of $5.8 to $10.8 billion in environmental infrastructure (water, wastewater, and solid waste) will increase to $12 to $20 billion by 2020 due to expanding population and economy. These projections are based on traditional technologies with heavy capital costs and maintenance costs. In order to reduce these costs, Institute participants recommended that alternative and sustainable technologies become priorities of the U.S. and Mexican local, state, and federal agencies involved in developing environmental

infrastructure. These approaches provide cost-effective options for many border communities and have significantly lower capital costs and operating costs, including energy efficiencies.

In many border communities, an inadequate water supply is a critical problem and existing water distribution and sewage collection and treatment systems are often managed independently of each other, resulting in a lack of coordination and the resultant synergies. In order to address these problems, reorganization of environmental management administrative structures in border communities needs to move forward. In addition, demand-side management, conservation, and reuse of water supplies must be priorities and these options should be exhausted prior to contemplating expanding supply within a region or transferring water from other regions. The BECC and NADB are well positioned to help build technical expertise and human capital required for these new administrative approaches.

The Border Environment Cooperation Commission and the North American Development Bank

A number of the papers and significant discussions at Border Institute II centered on the functions of the BECC and the NADB, both of which are critical to the efforts of border communities in meeting their environmental infrastructure needs and improving the quality of the environment. The Institute participants developed three recommendations regarding these agencies:

- The funding level and scope of activities of the BECC and the NADB must be expanded to include other needs and environmental media.
- The BECC and the NADB need to provide more assistance to professional management of utility operations to increase synergies and cost effectiveness.
- The BECC and the NADB need to expand emphasis on sustainable technologies and methods.

Infrastructure Finance

Clearly, the planned and anticipated transfers from the U.S. and Mexican governments to the border communities for environmental infra-

structure investment will not be adequate to meet the current and projected demands. New sources and mechanisms of financing such projects need to be developed to supplement the NADB. These discussions produced two specific recommendations:

- User fees for environmental services need to be implemented more widely in border communities. Not only do these provide incentives for more efficient use of the services, but the cash flow can provide the foundation necessary to attract more capital through bonds and other mechanisms.
- Structural bottlenecks for financing environmental infrastructure need to be addressed, particularly for Mexican border communities. Specifically, Mexican border communities need better structures for long-term planning, the ability to increase tax revenues, and the ability to borrow through bond mechanisms.

Additional Recommendations

The discussions at Border Institute II also produced a number of additional recommendations on topics beyond those specifically targeted by the briefing papers and panels. The range of these recommendations is indicative of the complexities of the border region and the significant needs of this dynamic binational zone. Additional recommendations include the following:

- All stakeholder groups need to improve and intensify transborder cooperation to resolve border environmental and related issues.
- The new national administrations must continue the bilateral cooperation on the environment of the U.S.–Mexican border region that characterized Border XXI, the BECC, and the NADB.
- Because government personnel turnover is exceptionally high in Mexican border communities, civil service reform and higher salaries for public employees are urged in order to increase tenure and continuity of planning and policy implementation. Improved human resources are critical to addressing the region's environment and development issues.
- Shortfalls in the border region of technical training and licensing, environmental education, local monitoring and enforcement, and accountability management need to be addressed.

- Deteriorating air quality needs to be addressed through funds to pave roads, build natural gas infrastructure, insulate homes, and tap alternative energy sources such as solar and wind power.
- The maquiladora industry is mature enough to implement recycling programs for waste materials, wastewater effluents, and waste energy.

These recommendations take into account the unique context of the U.S.–Mexican border region and the challenge of reconciling urgent infrastructure needs with limited resources. By bringing a diverse group of border stakeholders together to begin a dialogue and contemplate these difficult issues, Border Institute II is an important step on the path to sustainable development. The next step is for stakeholders to work together in finding innovative ways to implement these recommendations and develop solutions that lead to a sustainable environment and a higher quality of life in 2020.

Notes

1. A number of individuals provided helpful suggestions for the preparation of this summary chapter: Paul Rasmussen, Rick Van Schoik, K. David Pijawka, Jane Clough-Riquelme, and Elena Lelea.
2. The background papers and outcomes of Border Institute I were published as Paul Ganster, ed., *The U.S.–Mexican Border Environment: A Road Map to a Sustainable 2020.* SCERP Monograph Series no. 1. San Diego: San Diego State University Press, 2000.
3. These recommendations also appear in the "Executive Summary of Recommendations," compiled by Rick Van Schoik and others and issued by SCERP shortly after Border Institute II. This document is available on the SCERP Web site at <http://www.scerp.org>.

II

Sustainable Development on the U.S.–Mexican Border: Past Lessons, Present Efforts, Future Possibilities

Alan D. Hecht, Patrick Whelan, and Sarah Sowell[1]

Executive Summary

By the end of the 1980s, after decades of general neglect, awareness of environmental conditions on the U.S.–Mexican border and their effects on human health had become more widespread, in part because of increasing industrial development. Several cities lacked wastewater treatment facilities. Millions of gallons of untreated sewage flowed north, fouling waterways and beaches in the United States. In Nuevo Laredo–Laredo, about 25 million gallons of raw sewage per day were released into the Rio Grande, resulting in increased incidents of disease, including hepatitis. A sizable population of border residents suffered from other public health problems, such as asthma and high blood lead levels. Air emissions from vehicles, industrial sources, the burning of trash, residential heating, and dust from unpaved roads all contributed to poor air quality and threatened the health of border residents. Geographic clusters of disease and birth defects became local and, eventually, national issues.

Against this background, the United States, Mexico, and Canada moved toward creating a free trade agreement, which some advocates

saw as an opportunity to enhance Mexican economic growth and generate new resources to address border infrastructure and environmental needs. However, there was opposition to such an agreement from many quarters, including some environmentalists who predicted that the North American Free Trade Agreement (NAFTA) would make Mexico a pollution haven for foreign industry, that U.S. environmental standards would be lowered, and that environmental conditions on the border would worsen.

The resulting NAFTA debate focused attention on long-neglected border environmental problems and needed infrastructure (mainly wastewater, water, and municipal solid waste facilities). These problems, long recognized at the local level, gained new political immediacy as the trade debate intensified. Presidents Carlos Salinas de Gortari of Mexico and George Bush of the United States came to recognize that political support for NAFTA hinged on the extent to which environmental problems would be addressed within the context of the agreement. Since enactment of NAFTA, bilateral and trilateral environmental cooperation has increased, and new environmental and financial institutions have been created that have significantly increased the ability of the United States and Mexico to address environmental protection along the border.

While the mechanisms for improving border environmental conditions have advanced and are beginning to show results, they are far short of what is needed. Expanded trade and increased urbanization continue to constrain the ability of already stressed natural and civic systems to deal with the larger problems to come. The environmental consequences of expanded trade, combined with projected population and industrial increases, are outpacing current efforts to address border environmental problems. If current unsustainable trends continue, by 2020 conditions will contribute to greater domestic and international frictions attributable to environmental causes. Over the past 10 years, the tools to strengthen binational cooperation and enhance coordination to address transboundary environmental issues—such as the U.S.–Mexico Border XXI Program Framework—have become more sophisticated. By continuing to focus on the border and using and improving these tools effectively, governments and other entities can mitigate existing problems and help avoid additional ones.

To make effective use of border mechanisms, support from both the public and private sectors is required. The area's resource needs are

substantial; border environmental infrastructure needs alone, as identified by the Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADB) are conservatively estimated at more than $3 billion over the next 10 years (NADB 1999). Equally daunting costs are associated with hazardous waste management, air quality management, and pollution prevention.

Summary of Conclusions

- The combined effects of increased population growth, unplanned economic development, and limited water resources are stressing border communities now.
- Continued and increased high-level attention to the border's needs is necessary; the United States must recognize the problems of the border as an issue of nationwide concern. Without international cooperation in support of the border, there is the possiblity of international friction and conflict. Even with sustained effort on the part of governments and the public sector, serious challenges remain.
- The lack of local capacity to design and finance major projects underscores the need for greater attention on the part of governments to build the stock of human capital in communities and regional authorities.
- Continued decentralization of authority from federal to state governments is essential for fostering this capacity and building empowerment at the local level.
- Greater public and private sector attention is needed to manage current and future growth in a way that is commensurate with available resources.
- The border's present economic mix is unlikely to allow for sustainability or stability without diversification and investment.
- Both countries depend heavily on federal subsidies for water infrastructure projects. This dependence is likely to continue in coming decades. The lack of such subsidies for non-water-related projects (such as solid waste) currently constrains the development of other needed infrastructure.
- Health threats present particular risks to the border population and threaten community well-being as well as economic prosperity.

- The production, management, and disposal of hazardous waste remain major problems in the border area.
- The various water-use sectors, along with the private and public sectors, need to develop a strategy for water use that includes a binational component.

History of U.S.–Mexican Environmental Cooperation

The history of U.S.–Mexican relations is filled with misadventures, conflict, and eventual resolution. Few countries are as intertwined, and no other pair of neighboring countries shares the contrasting elements of the U.S.–Mexican relationship: vastly divergent cultures, histories, economies, and levels of prosperity. Along the border, these elements meet, blend, and, not infrequently, conflict.

When considering bilateral relations on the border, it is important to keep in mind that from the U.S. perspective, the border is an area—despite its many human and natural assets—of extraordinary neglect and need, with problems analogous, for example, to those in many U.S. central cities. From the Mexican perspective, in contrast, the border is an economic engine, loosely analogous to Detroit in its heyday or Silicon Valley today. Unemployment is low, wages are high (relative to the rest of Mexico), and infrastructure is not far worse—and in some cases is better—than in the rest of the country. This contrast has deep implications for the two countries' differing approaches to the border and, indeed, to their perceptions of the meaning of terms like *sustainable development*. The countries' differing perspectives go far in explaining why it is a perennial challenge for the United States to attract Mexico's attention or sympathy for the United States' singular concern for the border area's environment.

It is equally important to keep in mind certain facets of Mexico's political regime that impact environmental protection, such as the prohibition at the federal level against reelection of national political leaders and the absence of a real civil service, both of which have parallels at the state and local levels. While these features may inhibit bureaucratic empire building, they also diminish continuity and institutional memory, and allow for a spoils system of jobs and patronage. New presidents, governors, and mayors very often create new agencies, establish a new array of economic arrangements, and initiate sweeping

changes in the bureaucratic ranks to a degree unknown in the modern United States. These practices have many consequences, including the degree and duration of political uncertainty during campaigns and at the beginning of administrations, a decreased will to begin initiatives or projects whose completion or benefits will take place in a subsequent administration, an exaggerated reliance on personal affiliations with regard to the private sector, and diminished support for competition and appreciation for its benefits. Several key stages in the history of cooperation on environmental issues between the United States and Mexico are highlighted in Table 1.

The Focus on Water

The start of contemporary U.S.–Mexican border environmental cooperation can be traced to the late 1800s, when the governments of the United States and Mexico, under the Convention of November 12, 1884, adopted certain rules to handle questions dealing with the location of the boundary between the two countries. By the Convention of March 1, 1889, the governments established the International Boundary Commission (IBC) and charged it with applying the rules of the 1884 Convention. That convention was modified by the Banco Convention of 1905 to retain the Rio Grande and the Colorado River as boundaries.

In these early years, attention was focused primarily on water quality and quantity as well as on conservation issues. Concern about transboundary water pollution was clearly delineated in the 1944 Water Treaty, which created the International Boundary and Water Commission (IBWC), the successor to the IBC. The treaty extended the authority of the IBWC to the land boundary, and added all border water problems to its responsibilities. Under this treaty, all the uses of shared rivers are "subject to any sanitary measures or works which may be mutually agreed upon by the two governments, which hereby agree to give preferential attention to the solution of all border sanitation problems" (U.S. Dept. of State 1944).

Growth of the Maquiladora Sector

A new era of increased stress on the border environment began after the initiation of the Mexican maquiladora program in 1964.

Table 1: Key Stages in U.S.–Mexican Environmental Cooperation: 1889–1965

1889–1965	
1889	International Boundary Commission (IBC) created
1944	International Boundary and Water Commission (IBWC) created
1964	Maquiladora program initiated in Mexico
1965–1990	
1982	SEDUE established (Mexican environmental agency)
1983	La Paz Agreement signed
1986	Mexico joins the The General Agreement on Tariffs and Trade (GATT)
1988	Mexico General Law for Ecological Equilibrium and Environmental Protection enacted
1990	U.S.–Mexican border working groups established
Pre–NAFTA Era: 1990–1992	
1990	Presidents Bush and Salinas agree to pursue NAFTA
1992–1993	Negotiation of NAFTA and environmental side agreements begins
1992	First U.S.–Mexico border environmental plan initiated
1992	Secretaría de Desarrollo Social (SEDESOL) created
1992	Clinton administration begins
Early NAFTA Era: 1993–2000	
1993	Negotiations of environment and labor side agreements begin
1993	The Commission on Environmental Cooperation (CEC), the Border Environment Cooperation Commission (BECC), and the North American Development Bank (NADB) established
1994	Mexico joins the Organisation for Economic Co-operation and Development (OECD)
1994	Zedillo Administration begins; Secretaría de Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP) created
1995	Staff and operating procedures established for CEC, BECC, and NADB
1996	Second border environmental plan initiated: U.S.–Mexico Border XXI Program
1996	Mexico's General Ecology law revised
1998	*OECD Performance Review of Mexico* published
2000	*U.S.–Mexico Border XXI Progress Report* published
Post–2000	
2001	Next border environmental plan developed

Maquiladoras are product assembly factories, the majority of which are located in the border region. The program was established to help alleviate labor and immigration problems in Mexico, with the goal of increasing employment and generating export earnings. The program promoted the establishment of Mexican subsidiaries of foreign—mostly U.S.—firms. Most of the facilities were established near the U.S. border, in part to exploit proximity to the U.S. transport and distribution systems. The program has grown dramatically since its inception; in 1990, 2,100 plants operated under this program. By 1998, more than 4,000 maquiladoras were operating in Mexico, employing more than 800,000 people in the border region (Christman 1999). The expansion of the maquiladora sector, however, has occurred without any corresponding development of basic infrastructure, such as water and wastewater treatment plants, municipal and hazardous waste management facilities, or roads.

Although their wastes and resource demands were, and still are, considerable, the maquiladoras are not the only source of stress on the environment. The maquiladoras are a magnet for domestic migration. The resulting population growth with its associated urban sprawl, motor vehicle use and congestion, generation of waste, air pollution, and increased depletion of natural resources are other major factors in the equation.

In addition, the expansion of the maquiladora sector and the resulting population growth have fostered the creation of a cadre of other industries, vendors, and commercial ventures. These entities must also be considered when trying to identify the pressures on the environment. For example, the worst industrial pollution in the El Paso–Ciudad Juárez area comes from the small-scale brick industry, whose kilns belch smoke from combustion of scrap wood, old tires, used motor oil and toxic-laden sawdust—one of many examples of a local domestic problem affecting both sides of the border (World Bank 2000). The kilns were originally isolated in outlying areas, but as Ciudad Juárez expanded to surround the kilns, they became the largest source of community health complaints in the area (World Bank 2000).

The aggregate result of border region expansion is tremendous pollution, as well as demand for land, energy, water, and environmental services. These environmental consequences, however, were slow to draw the attention of the central governments. Particularly within Mexico, there prevails a perspective that its northern border, with its

low unemployment and high wages (by Mexican standards), does not merit particular attention. Moreover, since virtually all tax revenue from the maquiladora sector is federal, the decisions on resources for these investments are made outside the local context and are subject in large measure to federal-state politics. In addition, there are serious competing demands for these resources from elsewhere in Mexico. Compounding the problem is the fact that, since all materials are imported to the maquiladoras, the factories do not attract local suppliers. There are comparatively few entrepreneurial opportunities to affect locally generated profits that could be cycled back into the communities. Consequently, by the time of the NAFTA debate in 1992, it was estimated that $2 to $8 billion was needed for basic infrastructure improvement on the border (NADB 1999).

La Paz Agreement

By 1983, deteriorating border conditions had resulted in political pressures on the federal governments. U.S. President Ronald Reagan reacted in particular to growing concerns in California, largely focused on the sewage-ridden Tijuana River. President Reagan and Mexico's President Miguel de la Madrid Hurtado signed a new cooperative agreement in August 1983. The La Paz Agreement, as it is commonly known, initiated a broad range of environmental cooperation between the United States and Mexico.[2] By 1984, technical working groups had been established for each of the five annexes under the agreement.[3]

The La Paz Agreement did not provide new environmental legislation in either country, nor did it improve enforcement of Mexican environmental laws. It also did not result in increased U.S. resources for use in Mexico. The agreement did, however, institutionalize regular consultations among senior federal officials, and it created a framework for expert groups to meet, assess, and report on highly contentious issues. As such, it was a new and more extensive mechanism for facilitating trust and openness among officials of the two countries in the 1980s (Kiy and Wirth 1998).

The Pre–NAFTA Spotlight on the Border

Problems continued to mount, but political and governmental attention did not significantly return to the border until 1990, when Pres-

idents Bush and Salinas began to discuss a free trade agreement between the United States and Mexico. On September 25, 1990, President Bush announced that he intended to use fast-track negotiating authority to conclude a free trade agreement with Mexico. As a consequence of this decision, the governments were compelled to increase attention to environmental conditions on the border, recognizing that without addressing border environmental concerns, their plan would not have the necessary support to gain congressional approval.

At the federal level, it was Sergio Reyes, Undersecretary of the Secretaría de Desarrollo Urbano y Ecología (SEDUE) (Urban Development and Ecology), who first suggested developing a U.S.–Mexican integrated plan for environmental protection in the border region. Reyes believed that there was an urgent need to address border environmental problems in order to avoid greater problems in the future. This idea was endorsed by both presidents, who instructed their environmental authorities "to prepare a comprehensive plan designed to periodically examine ways and means to reinforce border cooperation.... State and municipal authorities of both governments and private organizations in both countries should participate in such task as appropriate."[4] This directive formally launched the U.S.–Mexican border program, first called the Integrated Border Environmental Plan (IBEP) and now called the U.S.–Mexico Border XXI Program.

The governments believed that an integrated border plan would put the United States and Mexico in a better position to address anticipated environmental concerns that would arise in the context of the NAFTA. The principal environmental focus was on air and water pollution problems and the increased production of hazardous waste in the steadily growing maquiladora industry.[5]

More importantly, the more farsighted representatives of the U.S. Congress, federal government, and nongovernmental organizations viewed the free trade agreement as not only an opportunity to clean up the border, but as the beginning of efforts to achieve sustainable development. Senator Paul Sarbanes (D-MD) said in a hearing on September 17, 1990, "Steps to improve economic integration of the hemisphere must also confront the issue of environmental sustainability in economic development ... we can no longer afford to separate the consideration of environmental issues from the consideration of trade and economic issues." Stewart Hudson, speaking for the National Wildlife Federation in testimony on January 15, 1991, said "the most basic test

of a trade agreement pursued in this era ... is not the impact that it will have in a specific area but, rather, how does it promote sustainable development."

Many environmental and consumer groups feared that a free trade agreement would result in a lowering of U.S. environmental standards, or "downward harmonization," or that companies would relocate to Mexico to lower their labor costs and to avoid strict environmental regulations. Critics viewed Mexico as a pollution haven and argued that, by promoting investments in Mexico with its limited enforcement and fewer environmental and labor standards, NAFTA would exert a downward pull on environmental and health standards throughout North America (Schneider 1993).

NAFTA negotiators reached agreement in August 1992. The task of selling NAFTA to Congress fell to President-elect Bill Clinton, who would take office in January 1993. As a candidate, Clinton had announced conditional support for NAFTA, dependent on the establishment of satisfactory side agreements on environment and labor. With respect to the border, a memo from environmental advisor Katie McGinty to President-elect Clinton (December 31, 1992) explicitly called for "adequate funding for environmental cleanup and for infrastructure necessary to handle increased development and traffic." A statement President Clinton made in October 1992 became the core of the U.S. negotiating position for the environmental side agreement:

> Before we implement the agreement [NAFTA], we must establish an environmental protection commission with substantial powers and resources to prevent and clean up water pollution. The commission should also encourage the enforcement of the country's own environmental laws through education, training and commitment of resources and provide a forum to hear complaints. Such a commission would have the power to provide remedies, including money damages and the legal power to stop pollution (Governor Bill Clinton, Student Center, North Carolina State University, Raleigh, NC, October 4, 1992).[6]

The First Border Plan: IBEP

The Clinton administration adopted President Bush's dual approach on border environmental issues. While some environmental issues were dealt with in the agreement itself as well as in side agreements that would be negotiated, the majority of issues were addressed in a "parallel track." The EPA and SEDUE jointly developed the first binational border plan, the Integrated Environmental Plan for the U.S.–Mexico Border Area (IBEP). The IBEP, released in February 1992, identified major environmental problems that both sides would address pending the availability of funding.

One of the major border issues addressed in the IBEP was the management of hazardous waste generated by the maquiladoras. Because Mexico had neither regulations nor the facilities to manage hazardous waste, Annex III of the 1983 La Paz Agreement was signed in 1986, allowing maquiladoras to return hazardous waste to the country from which the raw materials were originally imported. This process became a requirement under Mexico's 1988 General Ecology Law, which also banned the import of any hazardous waste into Mexico for disposal. In most cases, the United States was the country from which the raw materials originated.

A notable initiative of the IBEP was the development of a binational system, called the Hazardous Waste Tracking System (HAZTRAKS), which would track the movement of hazardous waste across the border. Under the IBEP, government officials and maquiladora owners began to address concerns about inaccurate accounting of hazardous waste shipped between Mexico and the United States and illegal waste disposal.

The HAZTRAKS was slow to get started; however, by 1993, the EPA began to see tangible results. Internal EPA data for 1993 showed a "clear trend of increasing quantities of maquiladora hazardous waste imports captured by the data base, both in terms of number of manifests and volume of waste represented."[7] The EPA report also concluded that these data "corroborate SEDESOL estimates of increasing compliance with Mexico's requirement to return maquiladora-generated hazardous waste to the country of origin for proper disposal."

In May 1992, several months after the IBEP was released, Mexico reorganized its environmental institutions, combining several federal agencies into a new agency, the Secretaría de Desarrollo Social (SEDESOL) (Secretary for Social Development). One objective of the reorganization was to coordinate the protection of the environment with poverty reduction and urban planning activities. SEDESOL was given a mandate to work with the EPA on the IBEP to tighten environmental laws and enforcement.

While the Clinton administration supported the concept of a border plan and argued for the increased resources President Bush had requested, it was critical of the existing plan. The IBEP was widely criticized by environmental groups and local and state officials for both its narrow scope and top-down manner of preparation, as well as the lack of identified resources for the program's implementation. Consequently, the incoming administration wanted to draft a new plan as soon as the 1994 elections in Mexico were complete.

The Environmental Side Agreements

In 1993, U.S. officials were focused on negotiating the environmental side agreements and on responding to concerns and imperatives expressed by Congress, the public, and others. It was clear that the success or failure of NAFTA in Congress depended to a large extent on these side agreements to address environmental and labor concerns, and that the public and legislative debates on trade and its impacts presented an opportunity to build support for North American cooperation.

Major public and governmental concerns about lack of environmental enforcement in Mexico were addressed through a trilateral side agreement, the North American Agreement on Environmental Cooperation (NAAEC). The Commission for Environmental Cooperation (CEC), created under a NAFTA side agreement, obligates countries to effectively enforce their environmental laws and regulations. Provisions of the side agreement (Article 14) allow for citizen complaints when this obligation is not met. The obligation is backed by a dispute settlement mechanism that can be enforced against NAFTA. The side agreement also provides for a council of environmental ministers and an independent secretariat to assist in implementing the overall agree-

ment, manage dispute settlements, and assess the environmental effects of NAFTA.[8]

U.S.–Mexican border infrastructure needs were addressed with the establishment of two bilateral institutions: the BECC to work with local communities to prepare and develop environmental infrastructure projects, and the NADB to leverage private-sector capital for financing construction of BECC–certified projects. The institutional design of the BECC and the NADB was a departure from earlier approaches to binational infrastructure development, which had heretofore been largely administered through IBWC. The NADB was capitalized with a total of $450 million in paid-in capital ($225 million from each country) and given the ability to draw on additional callable capital.[9]

The U.S. and Mexican federal governments, recognizing that most communities in the border area were not able to finance projects on their own, committed to providing construction grants—in addition to contributions for BECC operations and NADB capitalization—estimating the need at $1.4 billion over a 10-year period, with half coming from each country.[10] As the BECC and NADB evolved, the U.S. government, through the EPA, made the decision to administer much of the U.S. portion of these appropriations through the BECC (via its Project Development Assistance Program, or PDAP) and the NADB.

The Early NAFTA Years

The agreement founding the BECC and the NADB was signed by presidents Clinton and Salinas in November 1993.[11] Congress ratified NAFTA on November 17, 1993.

Mexico's President Ernesto Zedillo began his term in January 1995. Early on, his administration demonstrated attention to Mexico's environmental regime by creating a new cabinet-level ministry dedicated to pollution and natural resource matters, the Secretariat for Environment, Natural Resources, and Fisheries, or SEMARNAP. The creation of SEMARNAP, combined with the attention now focused on the border environment as a result of NAFTA, presented opportunities for additional high-profile action at the federal level. At a post-election meeting with Mexican officials in July 1995, U.S. officials discerned a

clear willingness on the part of Mexico's new environmental institutions to intensify border clean-up efforts.[12]

Prominent in Mexico's new environmental approach was recognition of the importance of sustainable development and the role of public participation in achieving environmental goals (although this new stance cannot be said to have been present, or endorsed, throughout the rest of Mexico's federal government). A 1996 SEMARNAP strategy document stated:

> One of SEMARNAP's main strategies is to promote social participation. Without it, environmental and natural resource use and conservation policies are not fully attainable. Strictly sustainable development must be assumed by society.[13]

These principles were made more explicit and more concrete in the eventual development of Mexico's 1996 General Ecology Law.[14]

Together, the Mexican and U.S. federal governments developed an aggressive outreach plan for developing a new framework for environmental cooperation on the border. At public meetings held throughout the border region and through public comment received in mid-to-late-1995, several themes were clear. The pubic desired a holistic approach to include natural resources and environmental health, public access to information, transparency and public participation, and an emphasis on pollution prevention.

In response to this public input, the bilateral plan—eventually called the U.S.–Mexico Border XXI Framework—would greatly expand the scope and direction of U.S.–Mexican cooperation including, for the first time, issues related to environmental health, data management, and sustainable development. The public called for an emphasis on long-term regional planning for sustainable development, a concept that would ultimately lead to the U.S.–Mexico Border XXI Program statement:

> The Border XXI Program ... is an innovative binational effort which brings together the diverse U.S. and Mexican federal entities responsible for the shared border environment to work cooperatively toward sustainable development through protection of human health and the environment and proper manage-

ment of natural resources in both countries (Framework Document, I.1).

The Border XXI emphases were an advance over earlier approaches. While the Bush-Salinas Declaration of 1990, which launched the IBEP, recognized the important role of states and local communities, this was not fully developed in the first border plan.

By contrast, at the beginning of the new century, the Border XXI Program has become an umbrella program under which the coordination of federal, state, and tribal activities is being enhanced. The partnership role that these entities play in the Border XXI Program was recently formalized with the signing of the document titled "The Coordination Principles between the Border XXI National Coordinators and the U.S. and Mexican Border States and U.S. Tribes for the Border XXI Program."[15] The document "lays out a framework for collaboration among partners to establish objectives, identify activities, and secure the necessary resources to meet those objectives" (U.S. EPA forthcoming). The signing of this document marked an important advancement in formalizing years of collaborative efforts between the two federal governments and the border states, and recognized tribal communities as having a long tradition of environmental stewardship, calling for their active participation in the Border XXI Program.

Another clear weakness in the first border plan was the absence of private sector participation. This too has begun to change, and federal and state efforts to promote responsible industrial management, environmental stewardship, and pollution prevention have yielded results. A joint effort by Texas and Mexico provided assistance on pollution prevention to 21 maquiladora plants, resulting in annual reductions by the end of 1998 of 1,540 metric tons of air emissions, 3.7 million liters of hazardous liquid, 17,000 metric tons of hazardous solid waste, and 2.7 million cubic meters of wastewater (TNRCC 1998). Comparable efforts have taken place in the San Diego–Tijuana region.

More recently, U.S. and Mexican environmental agencies, the BECC, and the U.S.–Mexico Chamber of Commerce endorsed the *Seven Principles of Environmental Stewardship for the Twenty-First Century* (see Table 2) (Sperling et al. 2001). The seven principles listed in this document call on companies in both countries to take voluntary action that goes beyond complying with environmental laws and reg-

ulations. Companies' top management are asked to commit to the goals of pollution prevention, energy efficiency, improved overall environmental performance, public accountability, and adherence to international environmental standards. In addition, they commit to ensuring that these goals become integral parts of the company's culture and day-to-day operations. The principles encourage industry leadership to work with other companies to improve industrywide environmental performance and to promote local sustainable development through investments in environmental infrastructure, health, education, and public awareness. In February 2000, 10 additional institutions signed on to the principles, including Cámara Nacional de la Industria de Transformación (CANACINTRA) (the National Chamber of Transformation Industries), Confederación de Cámaras Industriales de los Estados Unidos Mexicanos (CONCAMIN) (the Confederation of Industrial Chambers), Confederación Patronal de la República Mexicana (COPARMEX) (the Mexican Employers' Federation), Consejo Nacional de Industriales Ecologistas de México (CONIECO) (the National Council of Ecological Industries), Centro de Estudios del Sector Privado para el Desarrollo Sustentable (CESPEDES) (the Center for Private Sector Studies for Sustainable Development), and the Global Environmental Management Initiative (GEMI). Also endorsing the principles were the Border Trade Alliance, an association of border area industries and community representatives, as well as Mexico's Union of Environmental Groups, the Puebla Verde group, and the Environmental Law Institute of the United States.

A second agreement between SEMARNAP and GEMI (a consortium of multinational companies) will promote environmental management approaches among GEMI companies, their suppliers, and clients.[16]

Measuring the Success of Border XXI: 1995 to 2000

Because of the focus created by NAFTA, environmental conditions on the border have improved, although results are far short of what is needed. The U.S.–Mexican border has benefitted from NAFTA in various positive ways, both institutionally and by addressing real environmental problems.

The BECC and the NADB are now fully operational. As of March 2000, BECC had certified 33 water, wastewater, and municipal solid waste infrastructure projects (12 in Mexico, 21 in the United States).

Table 2: Seven Principles of Environmental Stewardship for the Twenty-First Century

1. Top Management Commitment	Make substantive top management commitments to sustainable development and improved environmental performance through policies that emphasize pollution prevention, energy efficiency, adherence to appropriate international standards, environmental leadership, and public communications.
2. Compliance Assurance and Pollution Prevention	Implement innovative environmental auditing, assessment,and improvement programs to identify and correct current and potential compliance problems and utilize pollution prevention and energy efficiency measures to improve overall environmental performance.
3. Enabling Systems	Through open and inclusive processes, develop and foster implementation of environmental management systems that provide a framework for ensuring day-to-day compliance in process operations, pollution prevention, energy efficiency, and improved environmental performance. Encourage the use of environmental audits, pollution prevention assessments, and employee training and involvement as integral parts of the company's culture at home and abroad.
4. Measurement and Continuous Improvement	Develop measures of environmental performance to demonstrate adherence to these Principles. Periodically assess the progress toward meeting the organization's environmental goals and tie results to actions in improving environmental performance.
5. Public Communications	Consistent with the sovereign host country's domestic laws and policies governing environmental protection and the protection of confidential business information: voluntarily make available to the public information on the organization's environmental performance and releases, as well as on the performance of its environmental management system relative to these Principles, based on established objectives and targets; and voluntarily provide avenues for receiving suggestions from and establishing dialogue with the public about the company's environmental performance.
6. Industry Leadership	Work with other companies operating in the same region or industry sub-sector to improve industry-wide environmental compliance, pollution prevention practices, energy efficiency, and overall environmental performance. For example, explore cooperative strategies such as by-product synergy, joint industry sub-sector efforts, or technical assistance to smaller enterprises, including in the implementation of environmental audits.
7. Community Environmental Stewardship	Promote and give support to environmental stewardship and sustainable development in the community in which the organization operates, for example through investments in local environmental infrastructure, health, education, and improving public environmental awareness.

Source: Sperling et al. 2001.

These projects represent a total investment of $680 million, benefitting approximately 6.7 million border residents (GAO 2000). NADB had authorized $183 million in loans, guaranties, and/or grant resources for 23 BECC–certified infrastructure projects. The vast majority of NADB participation has been in the form of NADB–administered EPA grants; only $11.2 million were in direct NADB loans. Several dozen more communities, many with BECC assistance, are developing projects for BECC certification, and most are expected to seek EPA grant funding. States and localities are now deeply engaged in the BECC–NADB process, as are community and nongovernmental organizations. Academic organizations—notably the Southwest Center for Environmental Research and Policy (SCERP) and its constituent institutions—are playing a role in supporting the BECC–NADB mission through development of information for long-term planning.

Since 1994, the U.S. Congress has appropriated $575 million to EPA for water-related border infrastructure grants to address health and environmental risks on both sides of the border—a recognition that problems on Mexico's side of the border are U.S. problems as well (as well as an understanding that a dollar spent in Mexico, where infrastructure is scant and land less expensive, buys more environmental protection than it would if spent on the U.S. side). Today, more than one million border residents are benefitting from an array of completed projects. The International Wastewater Treatment Plant on the U.S. side of the border north of Tijuana has also begun advanced primary treatment to reduce sewage flows to the Tijuana River and Pacific Ocean. In 1999, a $20 million project to improve the reliability of the Tijuana wastewater collection system was initiated. The first-ever wastewater treatment plants in Ciudad Juárez, which will serve more than 1.2 million people, began operations in mid-2000.

In the area of solid waste, progress has been more limited. In 1999, however, the NADB began a pilot program for municipal solid waste financing that will be funded from the NADB's earnings.

Overall, the Border XXI Program, through its nine working groups,[17] has built a sophisticated institutional architecture, allowing for cooperation in many areas, and this has yielded some concrete results along the border. Current summaries of accomplishments are available in the *U.S.–Mexico Border XXI Program: Progress Report 2000* (U.S. EPA forthcoming), as well as reports by BECC and NADB.

Several major binational environmental achievements were specifically aimed at strengthening institutional and binational capabilities to deal with long-term environment and development issues. These achievements include:

- Development of a 10-state agreement outlining coordination principles among federal, state, and tribal entities. According to the Good Neighbor Environmental Board's (GNEB) 2000 assessment of Border XXI, "the development of the Coordination Principles document has resulted in greater involvement of the Mexican state environmental authorities in the Border XXI Program. After years of being excluded by their federal government, the progress that is now occurring to engage them into the process is very gratifying and, in fact, is vital to address long-term environmental issues (GNEB 2000).
- Development of the *Seven Principles of Environmental Stewardship* between the Border XXI Program and the private sector to prevent pollution and improve environmental performance. Performance indicators will be developed to assess the initiative's impact, and training courses will shortly begin among participating firms.
- Development of environmental indicators for each Border XXI workgroup to measure the progress of border programs. Progress on the indicators, developed with Mexico, will be reported in the *U.S–Mexico Border XXI Program: Progress Report 2000.*
- Development of sustainable development guidelines for BECC–certified projects and promoting public participation in project development. This approach has had an important impact on Mexico. As stated in GAO's report (2000) "According to Mexican officials, the [BECC] approach to involving public participation in project development has facilitated its (Mexico) efforts to decentralize responsibility for environmental infrastructure. For example, a state water commission was recently created in Baja California to better plan and administer the water supply to the rapidly growing urban areas throughout the state."
- Agreement on a binational consultative mechanism to exchange information on potential siting of hazardous or radioactive sites on the border. This mechanism complements domestic efforts

in both countries to increase openness in decision making on environmental and health matters.[18] This agreement refers to the exchange of information between governments on commercial facilities that store, retreat, or dispose of hazardous, toxic, radioactive, or solid waste generated off-site and which are required to be permitted, licensed, or approved by federal, state, or local authorities.

- Implementation of a new manifest system for tracking hazardous waste. This system has helped reduce discrepancies that existed between Mexican and U.S. import and export data. In 1999, a new and improved HAZTRAKS reconciled most data differences between the United States and Mexico.
- The 1999 amendment of Annex II of the La Paz Agreement to allow cross-border responses to hazardous substances incidents. Prior to this change, cross-border joint responses were not permitted.
- Completion of the six Sister City Joint Contingency Plans to respond to chemical emergencies: Brownsville–Matamoros (1997); Eagle Pass–Piedras Negras (1998); Laredo–Nuevo Laredo (1998); and San Luis–San Luis Río Colorado, McAllen–Reynosa, and Nogales–Nogales (2000). Information on border contingency planning and emergency response is available on the World Wide Web at <http://www.epa.gov/ceppo/ip-bopr.htm>.
- Incorporation of the Paso del Norte Joint Air Advisory Committee (JAC) into the institutional architecture of the Border XXI Program. The JAC, established under the La Paz Agreement in response to local concerns, works with local institutions for cost-effective remedies to air pollution problems in the El Paso–Ciudad Juárez–Doña Ana County air basin. For the first time, JAC developed an air quality plan for Ciudad Juárez for the period 1998 to 2002; the plan is a joint effort by communities and local, state, and federal governments to control the air polution sources in the region.
- Development of the Tijuana Emissions Inventory, which helped in developing air quality programs in Tijuana and Mexicali in 1999. In addition, Mexico has assumed operations of air monitoring networks in Tijuana and Mexicali following two years of assistance from California; Arizona will publish a

report on emissions, sources, and health risks for the Ambos Nogales air basin.

Sustainable Development By 2020?

While politicians and economists predicted that NAFTA would stimulate growth in the border region, little was done to prepare for it. In the border region, moving jobs from one sector to another and educating people to capitalize on expanded markets and new technologies are not simple tasks.

There had been predictions that the border area would become a pollution haven; at this early date, there is no evidence to conclude that this has come to pass. In fact, cooperative efforts on enforcement have increased. Many U.S. and Mexican companies, business trade associations, and chambers of commerce are collectively promoting enhanced environmental stewardship through adoption of environmental management systems, voluntary environmental reporting, and adoption of pollution-prevention approaches.[19] What NAFTA critics failed to see was the interdependency of the United States and Mexico and the growing impact of globalization that was evident in 1990 and is today moving at a rapid pace. Nevertheless, continued advances are dependent on private sector responsibility and on improved compliance with environmental laws in both countries; without continued attention to enforcement, efforts will be seriously undermined.

The U.S. border with Mexico is on the front line of NAFTA. Yet, with the exception of San Diego, the border includes some of the poorest regions of the United States. A report of the Texas Comptroller of Public Accounts (Sharp 1998) effectively characterizes the poverty on the border by considering border counties in Texas as a fictional fifty-first U.S. state. This state would be the poorest in the Union: total personal income would rank thirtieth among all states and last in per capita personal income. It would have the country's highest unemployment rate at 8.0%, would rank third highest (behind Louisiana and West Virginia) in the rate of death from diabetes and second only to New Mexico in the rate of death from hepatitis and chronic liver diseases. It would be the twenty-fourth largest in population, but would rank second youngest in population age (in 1994, almost 36% of the region's residents were under the age of 20). This fictional state would also have the highest birth rate, and would lag

Table 3: Economic and Educational Statistics

Index	U.S. Average	U.S. Border States*	U.S. Border Region**
Population growth 1990–1996	6.6%	10%	15%
Per capita income	$14,420	$13,505	$10,648
Unemployment rate	4.8%	5.6%	7.4%
Median household income	$30,056	$28,610	$20,747
Persons in poverty	13.1%	16.7%	25.5%
Persons 25 years and over with high school education	75.2%	75.5%	61.2%
Persons 25 years and over with college education	20.3%	21.1%	12.3%

*Includes California, Arizona, New Mexico, and Texas.

**The U.S. border region is defined in Executive Order 13122 as the areas up to 150 miles north of the U.S.–Mexican border.

Source: Roland S. Arriola, University of Texas–Pan American, Edinburg, Texas, as cited in Hecht 2000.

behind the United States overall and the other U.S. border states as a whole in educational attainment.

Economic and educational statistics for the United States as a whole, for Southwest states, and for border communities are shown in Table 3. Income per capita in the U.S. border counties in 1995 was 79.2% of the national average, and if San Diego county is excluded, income per capita drops to 61.9% of the national average.

It is clear from these data that the economic and educational foundation on the U.S. side of the border is weak, and that the border will need a new economic strategy. The economic pattern until now has been characterized by manufacturing and assembly jobs, limited education, unsustainable use of natural resources, and an economy that grows, but which does not offer prosperity.

Despite these stark facts and figures, there is very limited public recognition outside the border area of the region's difficulties, especially as NAFTA's spotlight on the border has dimmed, with the notable exception of the attention paid to illegal narcotics and immigration concerns. This is unfortunate because, while the trading countries feel trade's benefits, the border, as a gateway, bears the brunt of the trade's less-beneficial consequences: congestion, stressed infrastructure, and pollution. There appears to be a failure outside the bor-

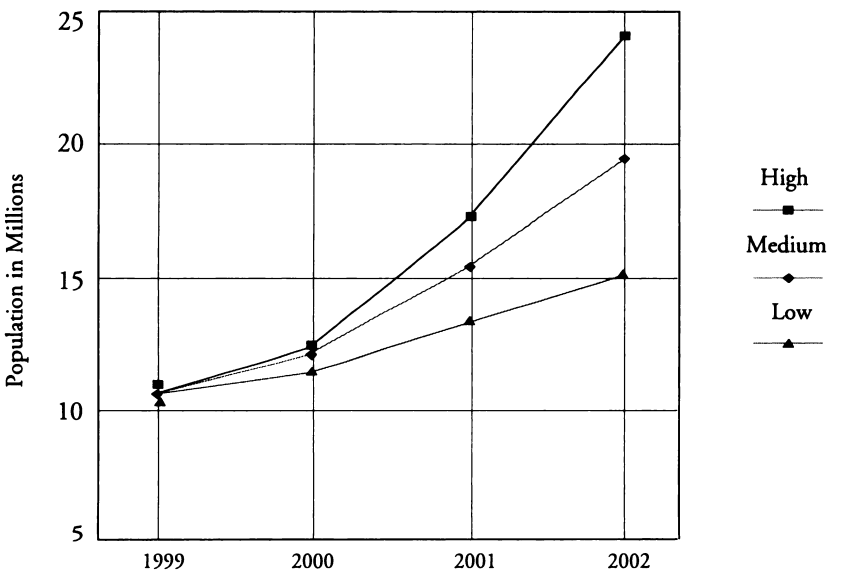
der region to fully appreciate the ways in which neglect of the border can impact a host of issues of nationwide concern, from health to public safety, and ultimately the trade agenda.

Challenges to Reaching Sustainability

In the period 2000–2020, three major factors will largely determine the well-being and environmental quality of the border region: population growth, patterns of economic development, and enhanced binational environmental cooperation and community empowerment. One major factor—water—will largely determine its livability.

Population growth is the most daunting factor; it is also the one that policies can affect least. With a current population of 12 million—6.4

Figure 1: Growth Scenarios for the Border Population



Source: Peach and Williams 2000.

million in the United States and 5.6 million in Mexico—the population already stresses the natural resource base. If current growth rates prevail (Figure 1), the border population could increase by as much as

an additional 12 million people by 2020, and the populations of most sister cities will more than double (Peach and Williams 2000). Even if migration were to decline significantly, the border would grow naturally by some three million people by 2020. Besides the increased stress on the area's environment, the 2020 economy will need to provide opportunities for the increasing population.

On the U.S. side, over 39% of the border population is less than 25 years old (compared to 35% for the total United States); in Texas and New Mexico this age group accounts for 42% of the population.

These demographic trends have important economic consequences, especially for the border. Over the period 1995 to 2030, Mexico's economically active population will increase from 55 million to over 90 million. Mexican population growth rates portend a growing gap between the size of the youthful work force and available jobs (U.S. Embassy 1998).[20] According to a recent study by Mexico's Consejo Nacional de Población (CONAPO), or National Population Council, as many as eight million Mexicans (a number equal to those currently living in the United States) will migrate north of the border by 2020, unless Mexico manages to create more jobs. The CONAPO says that Mexico needs to create one million jobs per year to meet population growth (U.S. Embassy 1998).

Pattern of Economic Development

Economic conditions differ greatly from one side of the border to another. Yet both sides, for different reasons, suffer from similar problems: an insufficient tax base to support needed infrastructure development, rapid and unplanned urbanization, and inadequate local capacity to design, plan, and manage needed infrastructure projects.

The maquiladora sector dominates the economy of the Mexican side of the border area, employing some 800,000, a figure that is slightly less than the annual increase in Mexico's labor force. Today, this sector is Mexico's most important legal source of job creation, exports, and foreign exchange earnings, exporting goods worth about $50 billion in 1998 (Vargas 1998).

While the maquiladora sector represents a critical element of the Mexican economy, it presents a serious dilemma for Mexican policymakers. Since Mexico has a young population, job creation is crucial, and the maquiladoras are an important source of employment. How-

ever, according to Peach and Williams (2000), Mexico will need to create the equivalent of a new maquiladora industry every two to three years—roughly 800,000 jobs every year nationwide—to maintain its current level of employment. While this would generate more jobs, simply increasing industry in the border without directing additional tax revenues to the local municipalities and states would only exacerbate current infrastructure problems.

At the same time, Mexico's centralized government system does not afford local officials or communities the capacity to develop or administer infrastructure. Most local communities have virtually no experience with debt financing and are prevented by Mexican law from incurring debt in foreign currencies or with foreign institutions. The lack of local capacity to design and finance major infrastructure projects underscores the need for continued decentralization of authority from federal to state governments and enhanced technical assistance and training to local communities.

What about the future? Because of the low cost of labor in Mexico relative to the United States, firms are continuing to locate production facilities in Mexico and they are unlikely to dramatically increase investment in the technology of the facilities. Mexican facilities are continuing to locate near the border because of its proximity to the U.S. consumer market and the U.S. transportation infrastructure. This growth will face limits, however. Sooner or later water availability will limit future growth. Much greater public and private sector attention is needed to manage current and future growth commensurate with available resources.

The continued existence of the maquiladora program is uncertain and dependent on the consequences of the full implementation of NAFTA by 2001. Incentives for the maquiladora program will diminish as tariffs are eliminated under NAFTA. Thus, it is difficult to predict whether the maquiladora sector will continue to grow as it has in the past. It is possible that fewer companies will register as maquiladoras, or even that existing maquiladoras will choose to drop their maquiladora status and operate as Mexican nationals, or relocate outside the border region or outside of Mexico. These possible changes have significant economic and environmental consequences as discussed in the next section.

In the United States, maquiladoras play a much smaller role in the overall economy than they do in Mexico. Nevertheless, a major share

of new jobs involves producing for the maquiladora sector, its suppliers, and its workers. According to Sharp (1998), border job growth in Texas through 2020 is likely to average 2.4% and will likely occur in the fields of construction, transportation, business, and health services. However, about two-thirds of new jobs created in the Texas border region from 1995 to 2020 are expected to be in the relatively low-wage sectors of wholesale and retail trade and services. Consequently, the next 10 years are still likely to be a period of low economic growth in the U.S. border area. Potential new U.S. economic sectors, such as health care and tourism, could be developed, but this will require dedicated attention from every sector and improved education and job skills.

Financing environmental infrastructure is difficult in the border area for a host of reasons. While U.S. border communities are better equipped with infrastructure than Mexico in the absolute sense, many are poor with a less educated population when compared to much of the United States.[21] Consequently, their ability to develop and finance new infrastructure projects is limited.

Recognizing that many border communities lack the ability to develop solid projects, EPA has provided $20 million in grants to the BECC to capitalize a BECC technical assistance program—PDAP—to develop water-related projects on both sides of the border. To build these projects, a total of $211 million in EPA grant funds is available via a cooperative agreement between EPA and NADB, establishing the program now known as the Border Environment Infrastructure Fund (BEIF). This has generated a flow of projects—in fact, there is more environmental infrastructure under construction today than at any time in the region's past. Despite this progress, however, the BECC and NADB have projected an additional need for $1–2 billion to keep pace with population and industrial growth. Where will these resources come from? While the NADB has made notable strides to move the border communities toward financial sustainable solutions, federal subsidies from both countries for infrastructure projects remain essential.

On the U.S. side, the federal government has benefitted from the attention to border issues raised by local community groups, individuals, and academic and nongovernmental organizations on health risks, economic challenges, and quality-of-life concerns. They have also come to recognize that local institutions very often have sources

of expertise and experience that the federal government must engage with for success. It was with this recognition that Congress authorized the creation of empowerment zones and enterprise communities across the nation, as called for by President Clinton, as tools to stimulate economic development. In 1994, the Rio Grande Valley became one of three rural empowerment zones. The Rio Grande Valley Corporation has leveraged more than $95 million for infrastructure projects, jobs and job training, educational services, and the development of health services and facilities.

After these interest groups presented border concerns to Vice President Al Gore, he asked border region empowerment zones and enterprise communities in the Southwest to develop a regional approach to economic and community development at the White House Empowerment Conference in April 1997. The vice president's request led to the creation of the Southwest Border Partnership, a unique consortium of empowerment and enterprise zones dedicated to achieving "a safe and economically dynamic community that celebrates the strength of our families, the diversity of our culture, and the preservation of our previous resources for generations to come." This goal is an important road map to the future.

U.S. federal efforts to ensure coordination of development with local communities has been enhanced by a presidential executive order creating an Interagency Task Force on the Economic Development of the Southwest Border.[22]

The task force has compiled an extensive inventory of federal programs on the border (President's Interagency Task Force 1999). The long-term goal of this effort is to "promote growth and opportunity specially tailored to the unique character of the Southwest Border" (President's Interagency Task Force 2000). This task force, along with other national and binational efforts (such as Rio Rico Border Institute conferences), has effectively compiled information on the work of federal agencies on the border, as well as information on the economic, social, and environmental problems of the border. Eventually, the task force will work with the local entities to identify and support specific projects; an important test of such efforts will be ensuring that these projects, and the group's efforts in general, promote activities and projects that contribute to sustainable growth compatible with the border's assets as well as its limitations. A critical ingredient in achieving long-term solutions to the economic and environmental problems

of the border is continued high-level state and federal political attention to them.

The Need for Binational Environmental Cooperation and Community Empowerment

The border region has tremendous assets, including communities made up of people of great vision who are justly proud of the region's heritage. Border community leaders have a long history of attention to social issues—whether farm worker safety, treatment of immigrants, the legacy of abandoned toxic waste sites, the impact of NAFTA–related job displacement on local communities, social and educational inequities, inadequate attention to women's issues, or the quality of life on tribal lands.

Rapid urbanization and industrialization on the border without commensurate development of health and environmental infrastructure have created serious environmental and health risks to populations on both sides of the border. These environmental and health risks tend to have a disproportionally high impact on children, women, and young adults.

In the next 20 years, authorities will be required to improve environmental and health conditions on the border, recognizing that an outbreak of a disease on one side of the border poses a potential threat to both countries because of the daily movement of people across the border (GAO 1996).

A graphic example of development outpacing the capacity of current systems to meet human needs is the growth, largely in Texas, of colonias. According to EPA, there are 42,000 colonia residents in New Mexico, and 390,000 in Texas. Seventy percent of Texas colonias are in the Rio Grande Valley, accounting for three quarters of all colonia residents.

Economic and industrial development, health issues, and community activism intersect on hazardous waste management issues. U.S. and Mexican efforts to track and account for all hazardous waste has greatly improved since the first HAZTRAKS was established. A comparison of the two countries' data for 1996 shows that, where the United States reported approximately 8,000 tons of waste imported from Mexico, Mexican data reported 72,000 tons for the same year. A careful analysis of these data has shown that the enormous differences were

due primarily to differences in the definition of hazardous waste in each country and systematic differences in waste tracking procedures. According to the Border XXI Hazardous Waste Working Group, the two data sets are now 95 percent correlated. In the future, additional improvements will occur as Mexico implements changes in their manifesting system (U.S. EPA forthcoming).

While efforts are under way to account for current transboundary shipment of hazardous waste, four major problems remain. First, Mexico does not have data on the total generation of hazardous waste by the maquiladora industry. Nearly all studies of hazardous waste production on the border point to inadequate information on the magnitude of the problem. "At this point we simply do no know what happens to a vast portion of the wastes generated by American firms in Mexico; data from Mexican authorities, including the fate of U.S. exports to Mexico, are not made public" (O'Neill 1999). The resulting picture points to a serious long-term problem in the safe handling of hazardous waste materials.[23]

Second, currently there is only a single site in Mexico for the final disposal of hazardous waste, located outside the immediate border area in the state of Nuevo León. Within the border region, Mexico has no permitted disposal capacity. Investments aimed at developing infrastructure that meets Mexico's needs for hazardous waste disposal is clearly needed.

On the U.S. side of the border, one commercial disposal site is located within the border area, in Westmorland, California. However, on a national level, the United States has a surplus of hazardous waste disposal capacity.

A third issue facing hazardous waste management in the border region relates to potential changes, previously referenced, in the maquiladora program due to the full implementation of NAFTA. Such a significant institutional change might bring about a decline in maquiladora growth, with more companies registering as Mexican national firms, changing the regulatory regime they face for hazardous waste. In this scenario, companies choosing to operate outside the maquiladora program might not be required to return hazardous waste to the country of origin. This would further tax Mexico's already overburdened waste management infrastructure and present serious enforcement challenges to Mexican authorities. This same situation does, however, present an opportunity for concerted bination-

al efforts to develop hazardous waste management infrastructure in Mexico in a sound, rational fashion with a focus on waste minimization and recycling.

Finally, a legacy of abandoned and health-threatening hazardous waste sites in Mexico has become a focus of community attention on both sides of the border. Officially, about one-half dozen sites are located in the border region (out of about 166 sites in Mexico). Community leaders on both sides of the border have raised the issue of cleanup of these border sites with national authorities and, indeed, Border XXI and NAFTA cannot be considered successful without addressing this issue. One border site, Metales y Derivados, was a U.S.–owned maquiladora that operated under Mexican law in Tijuana before its shutdown in 1994 by Mexico's Attorney General for the Environment. The owners fled to the United States, leaving behind large quantities of lead slag and other heavy-metal waste generated by the operation. While Mexico's regulatory regime for remediating such sites is just beginning to emerge, authorities are seeking to create a special fund from enforcement penalties to address toxic sites throughout the country. As these remedies are pursued, however, present conditions pose serious health risks to local communities.

Frustrated by the lack of progress in resolving the problems caused by the Metales y Derivados site, the Environmental Health Coalition (EHC) and its Mexican partner, Comité Ciudadano Pro Restauración del Cañón del Padre, submitted a petition in October 1998 to the CEC under Article 14 of the NAAEC. The petition asserts that Mexico has failed to effectively enforce its environmental laws. In addition to calling for a factual record under Article 14 of the NAAEC, the submission also asks for a report to be prepared under Article 13.

Water: Availability and Needed Infrastructure

Water itself is the major limiting factor for sustainable growth on the border. Urban and industrial water use is rising rapidly, while demand by the agricultural sector—in many areas the largest water user—remains stable. Because much of the border region is arid or semiarid, the water supply—independent of its treatment and eventual disposal after use—is sure to remain a dominant environmental issue on the border. Moreover, in many cases there is an apparent, but illusory,

abundance of water, dependent on expensive engineering works whose sustainability in the face of competing demands (e.g., recreation, habitat, and energy) is coming under increasing scrutiny. The problem is predicted to worsen and many communities face grave problems with the greater demand for water that the projected population will bring. The San Diego–Tijuana region, for example, imports over 90% of its water.

Water supply is also a critical issue for the El Paso–Ciudad Juárez region. The Hueco Bolsón aquifer provides most of the area's water, but it is estimated that this source will be exhausted as soon as 2030, forcing greater dependence on surface water sources, and in all likelihood creating friction between municipal and agricultural needs. Water contamination is also a problem, since supplies are often threatened by agricultural runoff and the dumping of raw sewage and industrial pollution in border surface waters.

The growth of the maquiladora sector and its need for water creates potentially serious conflicts with agricultural and municipal water users. The case study of Matamoros illustrates the problem: between 1994 and 1997, there was significant industrial and residential expansion, both planned and unplanned, in the Matamoros area, placing increased demand on the Rio Grande for northern Tamaulipas. As in Ciudad Juárez, the likely eventual consequence is reduced availability for U.S. and Mexican irrigators. In fact, a lengthy drought in the 1990s forced the Mexican government to limit agricultural withdrawals from the Rio Grande in order to safeguard availability for municipal use. Meanwhile, Matamoros's capacity to treat water from the Rio Grande is inadequate even for the city's current population. Domestic and international competition for water can only increase instances like that in Matamoros as the population and industry grow.

The border region needs a strategy for water use. Federal, state, and local officials, as well as the private sector, should make the first decade of the new millennium a decade of water conservation and planning, ensuring the most efficient water utilization by industrial, agricultural, and urban users. Financing the needed water and wastewater infrastructure projects for the border remains a serious economic problem. Sustainable economic growth is essential; under current conditions, poor communities simply cannot pay for needed environmental infrastructure.

Working with local communities, BECC and NADB have estimated needed future investment in infrastructure. For the period 1999–2003 the projection is $1.1 billion (NADB 1999, 8). Based on project population growth and industrial development, the equivalent projection for the period 2004–2009 is roughly $1 billion. Other estimates exist that project even greater needs.

The GAO's report recognizes that the EPA's "grant funding has been critical to the projects that have actually been completed" (2000). Since it is unlikely that the economic condition of border residents will improve sufficiently in the next 5 to 10 years to remove the need for financial subsidies, continued federal grant support will be necessary. The NADB estimates that a minimum of $500 million in new grant funds from the United States and Mexico, using the current funding formula, will be needed to defray projected construction costs. Additionally, the GAO recently called for congressional consideration of "amend[ing] the Bank charter to allow it to create lower cost financing mechanisms that make funding more affordable to border communities for environmental infrastructure" (GAO 2000).

EPA, BECC, and NADB funding have done more than buy concrete. Grant funding has gone a long way to enhance many communities' abilities to shape their own futures. The BECC provides technical assistance to local communities for project planning and design through the PDAP, capitalized with $20 million in EPA funds. The NADB, using $211 million in resources under a cooperative agreement with the EPA, established the BEIF for water supply and wastewater projects in both the United States and Mexico. Finally, the NADB established the Institutional Development Cooperation Program (IDP) to provide assistance to local communities to promote long-term financial health of utilities through management assessments and user rate studies.

Often overlooked during the analysis of design and construction of environmental infrastructure are funds needed to properly operate and maintain the facilities. These needs place a significant additional burden on users of the infrastructure. The NADB has estimated that operation and maintenance costs for infrastructure are typically 5% of capital costs per year. Unfortunately, many communities have not adequately planned for these costs in the past.

Conclusions

This paper has highlighted a number of challenges facing the border in the next 20 years. In summary, the combined effects of increased population growth, unplanned economic development, and water resource limitations have the potential to create serious national and binational conflicts. Myriad environmental and health issues remain to be addressed. New border initiatives must continue to identify the areas of greatest environmental risk and work to ensure that standards of environmental quality apply to all border residents. Local abilities and political will must be harnessed to meet these challenges; the private sector must become engaged in environmental protection efforts; and governments must provide resources, expertise, and other assistance. Local skills and abilities in managing growth—urban and rural, domestic and binational—must be fostered to deal with the explosive growth of past decades and to prepare to address the equally dramatic growth anticipated in coming decades.

The future well-being of the border requires more than addressing high-risk environmental problems. The larger issue is fostering economic development that leads to enhanced social and economic well-being. While some future improvements in educational levels, wages, and the general well-being of border residents are likely, major national and binational economic and policy issues remain to be addressed. In the authors' opinion, the most important factor for reaching a truly sustainable border is the capacity of local communities to design and manage their own futures and to enhance binational cooperation and biregional planning. The role of governments will be to work with other sectors to facilitate the change to a new border economy—one more geared toward sustained overall prosperity.

The Mexican decision to pursue a free trade agreement with the United States and Canada has deepened Mexico's globalization process. Mexico continues to open its economic and political regimes to foreign investment, increased privatization of state-owned industries, enhanced democratic processes, decentralized federal authority, and strengthened environmental and labor standards. These are consistent with the essential building blocks Hecht has argued are necessary foar a country to practice sustainable development (1999):

- An educated and informed public with free access to environmental information.
- Public participation in government decision making.
- Free-market economic policies.
- Risk-based and scientifically sound environmental policies.
- Strong, fair, and enforceable regulatory framework.
- A sound scientific framework for decision making.
- Political leadership and vision.

Mexico has done much to put these building blocks in place. *The Environmental Performance Review of Mexico* (COED 1998) concluded that Mexico has undertaken fundamental environmental reforms and launched new policies and programs that are going in the right direction and in many ways are exemplary. However, it will take time as well as considerable and sustained effort for these new measures to be firmly embedded in environmental management practices.

The immediate future will be telling in assessing the depth to which these reforms have rooted. Indeed, it is unclear whether the Fox administration will accord environmental protection the same attention it has received during the Zedillo administration. A decrease in Mexican attention would, of course, be felt throughout Mexico, but the effects would be felt on the U.S. side of the border as well. This paper has attempted to stress that the border's needs are immense. It would be disastrous to regress to less-intensive stewardship, to turn back on the progress that has been made, and to neglect enforcement of laws. Under such a dark scenario, industrialization will continue without concurrent investments in remediation and prevention of pollution, as well as enforcement. Increasing stresses on natural resources in each country impact and compound problems in the other country. The result is increasing bilateral friction, and its most profound manifestations are on the border.

Even if the countries advance border stewardship and the doom scenario is avoided, the challenges for the United States and Mexico will be profound. Mexico must find ways to strike a delicate balance between environmental protection and its imperatives to meet its growing population's needs. The U.S. population's tremendous appetite for cheap consumer goods and its consumption of natural resources has the potential to thwart incremental progress. To the extent that the countries can overcome their liabilities, there are

opportunities for residents on both sides of the border to enjoy a prosperous and healthy environment.

Without substantial engagement from the private sector, success will be limited. The more farsighted among the maquiladoras, their suppliers, and the rest of the commercial sector are already aware that their economic success depends on a prosperous, sustainable border economy, with healthy workers, an educated population base, and a predictable resource base. This awareness must become more widespread.

Cross-border alliances at all levels are essential to facilitate sustainable change. The U.S.–Mexican binational relationship is strong; it must be made stronger. Future conflicts are inevitable, but as noted by the GNEB: "In the broader context of trade, environment, and quality of life, the ultimate success of the NAFTA is heavily dependent upon the involved parties' ability to minimize, mitigate and, whenever possible, remedy the challenging environmental issues of the rapidly-growing border region. The importance of resolving these environmental issues in a binational cooperative manner cannot be overstated. The Border XXI Program is the only existing coordination mechanism to this end" (2000).

Notes

1. Views expressed in this paper are those of the authors and do not necessarily reflect official positions of the EPA.
2. The La Paz Agreement was signed in La Paz, Baja California sur, Mexico, on August 14, 1983, and entered into force on February 16, 1984 (see U.S. Department of State 1983).
3. Annex I of the agreement was directed at cleaning up the Tijuana River, which flows north into Imperial Beach and San Diego; Annex II created joint response teams to respond to accidents on the border; Annex III addressed issues of transboundary shipments of hazardous waste; Annex IV specifically focused on problems related to transboundary pollution from copper smelters along the border; and Annex V addressed more general issues of transboundary air quality (see U.S. Department of State 1983).
4. In November 1990, the U.S. Ambassador to Mexico, after meetings with SEDUE Undersecretary Reyes, reported to the Depart-

ment of State (U.S. Department of State Cable 31409, 15 November 1990): "In addition Sergio Reyes informed us that in the future all government agencies will have a budget column for environmental improvement and protection. In other words, all agencies will have to budget something for environment. Ernesto Zedillo Ponce de León, Secretary of Programming and Budget, has already agreed to this plan, and the Congress will likely approve it. Reyes notes that this is the beginning of a new era for dealing with the environment in Mexico."

5. In his book *Endangered Mexico*, Joel Simon states that, "the environmental uproar came as a surprise to President George Bush and the NAFTA boosters. They had expected the NAFTA to be widely popular with the American public" (212). However, this was not the case. The EPA administrator, William K. Reilly, accompanied President Bush on his trip to Monterrey to meet President Salinas. Also on the trip was Robert Stempel, then chairman of General Motors, Inc. According to Reilly, Stempel observed that he was glad the EPA was involved. Stempel believed that unless environmentalists were part of the NAFTA discussion, they could potentially defeat it. Former U.S. trade representative Robert Strauss also advised President Bush that he hoped the EPA would take an active role in developing environmental provisions NAFTA (testimony of William K. Reilly prepared for Subcommittee on Trade, Ways and Means Committee, U.S. House of Representatives, April 27, 1998).
6. For a contemporary report on Bill Clinton's 1992 position on NAFTA see Gwen Ifill, "With Reservations, Clinton Endorses Free-Trade Pact." *New York Times,* Monday, 5 October 1992, sec A1.
7. Internal EPA memo, by Lawrence Sperling, November 13, 1993.
8. Provisions of NAFTA direct the CEC to routinely assess the environmental effects of NAFTA, especially related to trade provisions, tariff reductions, sanitary and phytosanitary standards (SPS), and/or technical barriers to trade (TBT). The CEC has developed an analytical framework to undertake this assessment (see CEC 1999).
9. NADB's charter does not allow the institution to offer below market rate loans, a condition that has limited the attractiveness of its capital in both countries. While NADB has had some success by

pairing its funds with EPA grants, some observers have called for a re-examination of this limitation. The U.S. General Accounting Office (GAO) has stated that the BECC and the NADB's roles, "particularly the Bank's [NADB], are likely to continue to be limited unless there are changes in its loan rates, which have been unattractive or unaffordable for many border communities" (GAO 2000).

10. For the period 1995–2000, EPA grant funds that can be used for water and wastewater construction on both sides of the border have amounted to $425 million from the United States. Mexico also has provided significant grant funding.
11. *The Agreement Between the Government of the United States of America and the Government of the United Mexican States Concerning the Establishment of a Border Environment Cooperation Commission and a North American Development Bank* is available on the World Wide Web at <http://www.cocef.org/ englishbecc.html>.
12. State Department officials attending the meeting noted elements of a new Mexican approach: "The overall mood of the conference was cordial and positive. Many U.S. participants noted the new openness and cooperative tone exhibited by GOM [Government of Mexico] counterparts. Representatives from Mexico emphasized the importance of public participation in the decision-making process and affirmed the national objectives (sustainability) previously presented by President Zedillo and Environment Secretary Julia Carabias" (State Department Cable 14356, July 23, 1995).
13. *Promotion of social participation within the scope of SEMARNAP*, distributed May 1996.
14. *Ley General del Equilibrio Ecológico y la Protección al Ambiente*, or General Law for Ecological Balance and Environmental Protection.
15. The document is available on the World Wide Web at <http://bec.calepa.ca.gov/Documents/General/coord.htm>.
16. *International Environmental Reporter*, December 8, 1999: 985–86.
17. The nine groups are air, water, hazardous and solid waste, cooperative enforcement, contingency planning and emergency response, pollution prevention, environmental information resources, natural resources, and environmental health.
18. *Consultative mechanism for the exchange of information on new and existing facilities for the management of hazardous and radioactive waste within 100 km of the U.S.–Mexico border.* Agreement signed December 1, 1999, at Tucson, Arizona.

19. As discussed in the text, the U.S.–Mexico Chamber of Commerce, in cooperation with the EPA, SEMARNAP, and the BECC, has formally signed the document titled *The Seven Principles of Environmental Stewardship* to promote environmental responsibility among chamber members. A separate initiative in Mexico by GEMI aims to promote environmental management systems among its companies and suppliers.
20. For Mexico as a whole, data indicate that between 1985 and 1995, about two million jobs were added to the formal economy, leaving a demand deficit of about eight million. Even if the rate of job creation were to double from 1995 to 2030, there would be a deficit of about 29 million jobs (U.S. Embassy 1998).
21. U.S. *colonias* were especially disenfranchised. Colonias are unincorporated settlements that lack basic financial and institutional mechanisms available to U.S. cities. The colonias typically lack adequate potable water, sewage collection, and transportation infrastructure, and rely on contaminated water from the polluted water sources for cooking and drinking. These and other ill-housed and poor communities on the border face a host of health problems. Consequently, EPA grants funds were appropriated specifically to address colonia infrastructure needs. Through EPA, $200 million has been invested in colonia infrastructure improvements since 1995.
22. Executive Order 13122, May 25, 1999.
23. The top three industrial sectors in the maquiladora industry are textiles, electronics, and wood and furniture. According to the Environmental Health Coalition, the major solvents of greatest health concern are 1,1,1-trichloroethane, acetone, dichloromethane, methanol, methyl ethyl ketone, toulene and xylene.

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III

The U.S.–Mexican Border Economy in the NAFTA Era: Implications for the Environment

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Executive Summary

The North American Free Trade Agreement (NAFTA) among the United States, Mexico, and Canada was implemented on January 1, 1994. Since that time, trade and investment flows in the region have expanded rapidly, dramatically increasing demographic growth and economic activity in the U.S.–Mexican border region, which, in turn, has impacted the region's environment and infrastructure. The study reported here, carried out by a binational group of researchers belonging to the Network of Border Economics/Red de la Economía Fronteriza (NOBE/REF),[1] attempted to capture some of the main demographic, economic, infrastructure, and environmental changes that occurred in the region during the NAFTA era.[2]

At the national level, many studies have been carried out on the impacts of NAFTA. Yet, to date, very little has been written about the effects of NAFTA on the highly urbanized communities of the U.S.–Mexican border region, which constitute the main points of contact between these greatly contrasting countries. In 1993, when ratification of the agreement was being debated in those two countries, most border communities were led to believe that NAFTA would bring

them higher levels of prosperity, a cleaner environment, and better cross-border relations. This study, initiated in June 1998 and finished in July 1999, six years after the agreement's implementation, attempts to assess the validity of these expectations.

Objectives and Assumptions of the Study

The main objective of this study, which focuses on the county-municipal level, was to determine how the demographic, economic, environmental, and infrastructure conditions in both U.S. and Mexican border communities have changed during the NAFTA era. Another major objective of the study was to determine which kinds of demographic, economic, and quality-of-life indicators[3] and analytical tools are needed in order to enable these communities to monitor and analyze their own situations on an ongoing basis.

The study was also designed to achieve the following:

1. Assist local, state, and national decision makers in both Mexico and the United States to better understand the complexities of border communities, enabling them to develop more informed policies.
2. Assist academics and other researchers to identify issues and trends that deserve further study, as well as to develop the skills and contacts that will be required as NOBE/REF begins to implement its agenda of collaborative, border-related research projects.
3. Assist the private sector—especially businesses and organizations located in the border region—to make better decisions related to both day-to-day operations and long-term investments and strategies by providing a more comprehensive analysis of the various border economies, as well as an update of the key economic indicators.

A major assumption of the study is that, given the vast differences between each of the border twin cities, the impacts of NAFTA and of other factors have been and will continue to be different in each U.S. and Mexican border community. However, despite these differences, it is likely that there will be some common trends among all border communities.

Organization of the Study and the Methods Utilized

Border communities vary greatly in terms of economic and demographic structure and size. They also vary with respect to their geographic-strategic location and the functions they provide within the North American economy. Recognizing that it would be extremely difficult to isolate the effects of NAFTA from the other significant economic factors of this period,[4] it was decided to adopt a two-pronged approach. First, published data and studies on the region's changing population and employment patterns were analyzed in order to determine the changing structure and performance of the binational border economy. Second, a survey was conducted of knowledgeable persons from government, business, nongovernmental organizations, and academia in the largest U.S.–Mexican border communities in order to determine their perceptions regarding changes in the economy, environment, and infrastructure during the NAFTA era. The survey also included questions on the need for and current use of demographic, economic, and quality-of-life indicators and other analytical tools in the binational region.

The two-part study—developed by a core team at San Diego State University and El Colegio de la Frontera Norte (COLEF) in collaboration with other individuals participating in NOBE/REF—was organized in such a way as to utilize a common methodology on both sides of the border while maintaining the flexibility needed to take into account those differences.

For the purposes of this study, the border region was defined as the U.S. counties and Mexican municipalities directly adjacent to the international boundary. However, due to the many asymmetries in the collection and availability of data between the United States and Mexico, different variables and time periods were frequently used to describe demographic and economic patterns on the two sides of the border. While different survey methods were utilized in the United States and Mexico,[5] the same questionnaire was applied in the eight largest border urban areas, with 147 questionnaires completed in the United States and 148 in Mexico.

Changing Demographic and Economic Patterns in the U.S.–Mexican Border Region

As noted in the introduction to this report, given the multitude of factors influencing the region's evolution during the last decade, NOBE/REF researchers decided that it would be extremely difficult to isolate the effects of NAFTA itself. Therefore, it was decided to examine the published data and existing studies on the region's changing population and employment patterns in order to better understand the performance and structural changes of the border region economy during the NAFTA era.[6]

Due to the lack of data for the years since 1995, especially in Mexico, the NAFTA era has been loosely defined, depending on data availability. Comparisons with other time periods and with the situation in border states and the nations as a whole are made where relevant.

Expansion of Economic Activity in the 1990s

Since it is difficult to comprehend the dramatic increase in economic activity in the U.S.–Mexican border region during the NAFTA era, some illustrative data may be helpful.

Stimulated by dramatically lower tariff rates in Mexico, beginning in the late 1980s and by NAFTA reductions beginning in 1994, total U.S.–Mexican trade increased by 141% between 1993 and 1999 (Vargas 2000).

During the pre–NAFTA era (1990–1993), annual flows of total foreign direct investment (FDI) averaged $3.7 billion; however, during the 1994–1998 period, they averaged $11.4 billion, an increase of over 300% (Vargas 2000).

Stimulated by falling wage rates associated with the peso devaluation in December 1994 and new regulations for the maquiladora program as required by NAFTA, the number of workers in border maquiladoras increased by 57% between 1994 and 1998 as compared to only 14% in the period 1989–1993 (INEGI 2000).

Between 1990 and 1999, southbound truck crossings from Texas into Mexico—where a large proportion of U.S.–Mexican trade crosses the international boundary—increased by 278% while rail car crossings increased by 179% (TCBEED 2001).

The Changing U.S. Border Region in the 1990s

Tables 1 and 2, which were compiled by James Peach and Richard V. Adkisson (2000), provide a succinct overview of the eight Metropolitan Statistical Areas (MSAs) located in the U.S. border region in comparison with the four U.S. border states and the United States as a whole. These eight regions comprise approximately more than 90% of the region's population. Therefore, these two tables illustrate several important characteristics of the region.

Table 1: The U.S.–Mexican Border Region: Selected Characteristics—United States

Area	Population		Income 1997		Labor Force		Education
	1998 (1,000s)	Percent Change (1990–1998)	Per Capita	Percent of Nation	Participation Rate 1990	Unemployment Rate 1998	High School Percent*
San Diego, CA	2,780.6	10.6	24,965	98.7	68.4	3.5	81.9
Yuma, AZ	132.3	22.8	15,629	61.8	59.0	27.9	64.9
Tucson, AZ	790.8	18.3	21,068	83.3	61.8	2.7	80.5
Las Cruces, NM	169.2	23.9	14,923	59.0	60.5	8.5	70.4
El Paso, TX	703.1	8.0	15,216	60.2	61.3	10.2	63.7
Laredo, TX	188.2	39.9	12,999	51.4	57.7	9.2	47.8
McAllen, TX	522.2	35.0	12,005	47.5	55.0	17.7	46.6
Brownsville, TX	326.4	24.7	12,857	50.8	53.0	9.2	50.0
Non-MSA Border	525.6	23.2	15,123	59.8	56.1	18.6	57.5
Border Total	6,138.4	17.3	20,376	78.2	63.5	7.6	74.1
California	32,666.5	9.2	26,218	103.7	67.0	3.5	76.2
Arizona	4,668.6	26.9	21,996	87.0	62.9	4.1	78.7
New Mexico	1,736.9	14.3	19,249	76.1	62.8	6.2	75.1
Texas	19,759.6	15.9	23,647	93.5	66.0	4.8	72.1
United States	270,438.7	8.4	25,288	100.0	65.3	4.5	75.2

*Percent of population 25 years old or older with a high school diploma.

Sources: (1) Population estimates are from the U.S. Bureau of the Census, November 1999. (2) Per Capita Income estimates are from U.S. Department of Commerce, Bureau of Economic Analysis, 1999. (3) Labor Force Participation Rates calculated from the U.S. Bureau of the Census, 1993. (4) Unemployment rates are from the U.S. Bureau of Labor Statistics, 1999. (5) Percent High School graduates calculated from U.S. Bureau of the Census, 1993.

Table 2. The U.S.–Mexican Border Region: Selected Characteristics—Selected Growth Indicators

Area	Average Annual Percent Change in Population		Average Annual Percent Change in Per Capita Income		Percent Change in Employment		Unemployment Rate	
	1990 to 1993	1994 to 1998	1990 to 1993	1994 to 1997	1990 to 1993	1994 to 1998	1993	1998
San Diego, CA	1.28	1.46	1.57	3.35	-0.40	2.60	7.7	3.5
Yuma, AZ	3.50	2.53	3.83	2.26	1.40	1.96	27.8	27.9
Tucson, AZ	2.16	1.92	3.30	3.19	1.54	1.32	4.0	2.7
Las Cruces, NM	3.77	2.10	2.34	2.38	0.88	2.18	8.6	8.5
El Paso, TX	2.63	1.59	2.84	3.02	2.72	0.48	10.8	10.2
Laredo, TX	5.36	3.81	5.46	2.53	5.78	1.84	10.5	9.2
McAllen, TX	4.69	3.35	3.07	3.01	2.86	2.23	20.6	17.7
Brownsville, TX	3.36	2.47	4.01	2.35	3.86	1.12	13.5	9.2
Non-MSA Border	3.96	1.74	2.03	1.94	2.61	0.16	20.4	18.6
Border Counties	2.33	1.87	2.99	2.74	0.99	1.86	10.2	7.6
California	1.34	1.10	1.25	3.66	-0.94	2.13	7.7	3.5
Arizona	2.85	3.14	2.50	3.75	0.29	3.76	6.3	4.1
New Mexico	2.09	1.26	3.59	3.13	1.80	1.70	7.7	6.2
Texas	1.89	1.92	3.35	4.18	1.76	2.28	7.2	4.8
United States	1.11	0.96	2.69	3.66	0.41	1.67	6.9	4.5

Sources: See Table 1.

- Total population in the U.S. border counties increased by 17.3% during the period 1990–1998, almost double the rate for the U.S as a whole (8.4%).[7]
- While per capita incomes vary considerably within the border region (e.g., compare San Diego with McAllen), they are all lower than the U.S. average.
- Labor force participation rates and high school graduation rates in the border region are generally lower than in the United States as a whole while unemployment is higher. (San Diego is the major exception here.)

- Prior to NAFTA (1990–1993), per capita income growth in the border region (3.0%) was slightly higher than in the nation (2.7%); however, in the NAFTA era (1994–1997), it was significantly lower (2.7% as compared to 3.7%).
- Annual employment growth in the pre–NAFTA period (1990–1993) was more than twice the national average (1.0% compared to .4%) but in the NAFTA era it was only slightly higher than the nation (1.9% as compared to 1.7%), in spite of a much higher demographic growth rate.
- The average unemployment rate for U.S. border counties fell by 25% between 1994 and 1998, significantly less than for the nation as a whole (35%).

The Changing Mexican Border Region in the 1990s

Table 3 gives an overview of the effects of NAFTA on the Mexican side of the border by comparing certain aspects of economic development with the country as a whole.

- Between 1990 and 2000, the national population of Mexico increased by 23.7% while growth in the border region (border municipalities) was almost twice as high at 40.7%. From 1990 to 1995, the annual population growth rate of the Mexican border region was approximately 1.5 percentage points higher than the nation as a whole (3.5% versus 2.3%). In the NAFTA era (1995–2000), the rate was almost two percentage points higher than the national (3.6% versus 1.8%).
- Prior to NAFTA (1990–1994), the rate of employment growth was 4.5% at the national level in Mexico as compared to 5.9% in the border region, a difference of 1.5 percentage points. In the NAFTA era (1994–1997), the difference in growth rates rose to more than two percentage points (4.7% versus 6.8%).
- Prior to NAFTA (1990–1994), the proportion of workers earning less than the government-established minimum wage in the border region (border municipalities) was less than 15%, compared to 25% for the whole country. During the NAFTA era (1994–2000), the situation in the border region improved somewhat as the proportion earning less than the minimum wage dropped to less than 10%; however, at the national level

Table 3: The U.S.–Mexican Border Region: Selected Characteristics—Mexico and its Border Region

	Mexico	Border Region
Population Growth (annual rate)		
1990–1995	2.29	3.54
1995–2000	1.79	3.63
Employment Growth (annual rate)		
1990–1994	4.50	5.90
1994–1997	4.70	6.80
Percentage of Work Force Earning < Min. Wage		
1990–1994	25.00	14.00
1994–1998	11.20	10.00
Percentage of Population with University Education		
1990	5.05	6.22
1995	5.44	6.57
Unemployment Rate (urban areas)		
1990	2.74	2.10
1995	6.27	3.50
2000	2.29	1.24
Real GDP Growth Rate		
1993–1995	3.89	3.93
1996–1998	4.03	4.05
Maquiladora Employment Growth Rate		
1990–1995	4.74	3.23
1996–2000	8.04	6.40
Employment Percentage in Manufacturing		
1992	22.00	21.20
1998	22.20	32.60
Per Capita GDP (1,000s of 1993 Pesos)		
1990	13.78	15.35
1995	12.42	16.03
2000	14.18	19.58

Source: INEGI data for several years compiled by El Colegio de la Frontera Norte (COLEF).

the situation improved even more, dropping from 25% to approximately 11%.

- People in the border region appear to be somewhat better educated than in Mexico as a whole, as indicated by the percentage of the total population with a university education (6.2% for the border region compared to 5.1% for Mexico as a whole). However, that percentage has been rising during the 1990s.
- Throughout the 1990s, unemployment rates in urban areas were significantly lower in the border region than the nation as a whole. In 1990 (the pre–NAFTA era) and 2000 (the NAFTA era), the disparity between the border region and the nation was not as large as in 1995 (during the period of recession). Within the Mexican border region, the lowest unemployment rates are usually found in Tijuana, Ciudad Juárez, and Nuevo Laredo, while Matamoros usually has the highest rates.
- Gross Domestic Product in the border region grew only slightly faster than in the nation as a whole, despite significantly higher employment growth.
- One of the most important drivers of employment and economic growth in the border region is the maquiladora industry. Since the implementation of NAFTA, the annual rate of employment growth in this industry has risen to approximately 11% (1994–1998) from the 3% rate (approximate) of the previous five years.
- Most of the economically active population in the border region is employed in the tertiary (services) sector (66.3%), followed by employment in the secondary (industry/manufacturing) sector (27.6%). Employment in the primary (agricultural) sector is minimal (4.6%). Important differences exist among the border municipalities. For instance, in Baja California, the proportion of employment in both agriculture and industry is two times higher than in Coahuila; the proportion employed in services in Chihuahua is higher than the level found in Tamaulipas and Sonora; and the proportion of employment in industry in Nuevo León is higher than the level found for the border region as a whole.

A Shift-Share Analysis of Employment Change: 1985–1997

To provide a more detailed view of the nature of employment change in the border region between 1985 and 1997, a comprehensive shift-share analysis was conducted for all 25 of the U.S. border counties, as well as the six Mexican border states. Shift-share analysis is used to analyze how employment in the various sectors of a regional economy are changing in comparison with the national economy. A shift-share analysis of U.S. border counties and Mexican border states yielded the following results:

- U.S. border economies have become increasingly concentrated in certain industries that are (1) declining at the national level (e.g., manufacturing), or (2) growing slower than total employment at the national level (e.g., wholesale trade) yet growing in the border region.
- Retail trade and service sectors have accounted for over half of the new jobs in the U.S. border region since 1994.
- Farming employment in the border region, which had been growing at a faster rate regionally than nationally prior to NAFTA, is now growing at a slower pace in the border region than it is in United States as a whole.
- Manufacturing employment growth in the Mexican border states exceeded the level of total employment growth in the U.S. border region during the 1989–1994 period.
- Manufacturing growth along the Mexican border region exceeded the rate of growth for manufacturing employment in the larger Mexican economy.
- Manufacturing employment increased in the six Mexican border states, but declined in the U.S. border region during 1989–1994.
- The metallic products industry accounted for over two-thirds of the manufacturing employment increase in the Mexican border states from 1989–1994.

Main Findings from the Survey of Border Communities

The time period under consideration for this part of the study was

1994–1999. While there was not clear consensus among the respondents, the main findings can be summarized as follows:

The U.S. Border Communities

Economy
Eighty-eight percent of the respondents felt that their county's economy had improved or improved a great deal, with part of that improvement due to NAFTA and part due to other factors, such as the expanding U.S. economy.

Infrastructure
Fifty-one percent felt that the infrastucture of their county had improved or improved a great deal while 24% felt it had remained the same and 18% saw it worsening.

Environment
Forty-eight percent perceived that their county's environment had remained the same, 22% thought it had improved, and 18% perceived it as worse off.

Monitoring and Analytical Tools
Demographic modeling and infrastructure forecasting systems were considered to be most important, with systems for monitoring the economy and quality of life slightly less important. A system of indicators for monitoring the environment was considered to be the least important. Demographic modeling systems were the most available and most frequently used while quality-of-life and environmental monitoring systems were the least available and least frequently used.

The Mexican Border Communities

Economy
Eighty-three percent of the respondents felt that their municipality's economy had improved, with part of that improvement due to NAFTA and part due to other factors, such as the expansion of the U.S. economy.

Infrastructure
Seventy-seven percent felt that the infrastructure of their municipality had improved, while 12% felt it has remained the same and 9% saw it worsening.

Environment
Twenty-three percent perceived that their municipality's environment had remained the same, 33% thought it had improved, and 40% perceived it as worse off.

Monitoring and Analytical Tools
While all these tools were considered important or very important, infrastructure forecasting systems were considered to be the most important, while a system of indicators for monitoring the environment was considered to be the least important. Availability and use of these tools was significantly lower in Mexico.

Conclusions and Implications of the Study for the Environment and Further Research

Most careful observers of the U.S.–Mexican border region are well aware that the region's population and economy have expanded rapidly during the NAFTA era. Nevertheless, it is clear that by disaggregating the data into different time periods, industries, and subregions it is possible to better understand the changing structure and performance of this heterogeneous and complex region. Additionally, the surveys of knowledgeable experts provide further insight into the region's dynamics through the perceptions of those who are most familiar with each local community.

Before drawing conclusions on the findings presented earlier, it might be helpful to note how the proponents of NAFTA (drawing from mainstream economic theory) expected the agreement to impact the border region.

1. Given the smaller size of the Mexican economy, NAFTA would have a larger (positive) impact in Mexico than in the United States and employment and income would expand faster there than in the United States. This effect would ultimately reduce migration on both the U.S. and Mexican sides of the border. However, the December 1994 peso crisis had disastrous effects

on Mexico's macroeconomic performance throughout 1995 and 1996 and, therefore, could potentially override such developments.

2. Due to reduced tariffs, NAFTA would increase the volume and value of cross-border shipments of goods (i.e., exports and imports) from both the United States and Canada, impacting the border region's infrastructure and environment while providing more employment in associated industries, at least in those border communities located on or near the major north-south trade corridors.[8]
3. Due to the "rules of origin" imposed by NAFTA (i.e., domestic content provisions required to obtain NAFTA status in terms of low or zero tariff rates), foreign direct investment—from both NAFTA member and nonmember countries—would increase in border assembly and manufacturing facilities on the Mexican side, causing a complementary increase in investment in warehousing and other support industries on the U.S. side.
4. Due to reduced tariffs, and a more favorable environment vis-à-vis foreign investment and dramatically lower wages in Mexico, manufacturing employment would decline on the U.S. side of the border and rise on the Mexican side.
5. Lower tariffs and liberalized investment laws in Mexico would allow U.S. goods to be sold there in U.S.–style shopping malls throughout Mexico's northern states, thereby reducing Mexican retail spending in U.S. border communities.

Now, what do the findings of this study indicate with respect to these expected impacts? Due to incomplete data sets, especially on the Mexican side, it is difficult to confirm or reject these hypotheses. However, in general terms, many of the findings from the quantitative analysis of border economic and demographic variables support these expectations regarding NAFTA impacts on the border economy. The major exceptions are (4), where U.S. border manufacturing has grown slightly, and (5) where U.S. border retail trade also expanded (possibly due to the robust U.S. economy, and not to NAFTA).

What is probably most distressing here is the finding that incomes on the U.S. side of the border continue a long-run decline relative to the nation as a whole. This suggests that municipal governments dependent on these local economies will be unable to fund adequate

environmental protection programs. Thus, if the robust economic expansion of the U.S. border region is to be sustainable, there is a clear and pressing need for state and federal programs to implement and manage these programs.

On the Mexican side of the border, the rapid expansion of assembly-manufacturing activity certainly evokes similar concerns there regarding future sustainability. Nevertheless, one clearly optimistic finding from the surveys should be noted in conclusion: with respect to cross-border cooperation on environmental issues, 69% of the Mexican respondents and 68% of the U.S. respondents felt that such cooperation had improved.

Notes

1. This organization is based in the El Paso branch of the Federal Reserve Bank of Dallas and is supported by San Diego State University (SDSU) and El Colegio de la Frontera Norte (COLEF) in Baja California.
2. Negotiations on NAFTA began in 1991 and the agreement was approved in 1993 by all three countries. During this period, businesses began preparing to take advantage of the new business environment that they expected to be establish upon implementation in January 1994.
3. Economic indicators include price indices, unemployment rates, and various measures of production, sales, consumption, and banking activity. Quality-of-life indicators include measures of poverty, literacy and educational attainment, housing, health, and sanitation.
4. Other factors that intervened in the region's economic evolution during this period were the Mexican peso crisis of December 1994, the strong expansion of the U.S. economy, and global economic trends such as fluctuating oil prices and the Asian financial crises.
5. In the United States, completed questionnaires were obtained by phoning the respondents first and then mailing the questionnaires with follow-up phone calls, if necessary. In Mexico, the respondents were personally interviewed.
6. While studies at the national level have attempted to assess the overall impact of the agreement, very few studies have been devot-

ed to assessing its impact on the border region (see Patrick 1996 and Peach and Adkisson 2000).

7. Despite historically high in-migration rates, two-thirds of the border region's population change between 1990 and 1998 can be attributed to natural increase (Peach's calculations based on Census Bureau estimates).
8. For this reason, the NAFTA side agreement on the environment provided for two new institutions, the North American Development Bank (NADB) and the Border Environment Cooperation Commission (BECC).

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IV

Natural Capitalism on the U.S.–Mexican Border

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Executive Summary

Some commentators argue that the driving force behind the booming U.S.–Mexican border economy is low-cost labor and lax environmental controls. If they are correct—and there is certainly evidence to support their claims regarding labor—the resulting social and environmental distress rampant on the border suggests that an alternative is needed. However, alternatives are hard to come by. The border region by some estimations has already exceeded nature's carrying capacity. The environment and local natural resources can no longer continue to support so many industries, people, and their respective wastes. Clearly, assembly plants are ecologically ill-located in the binational zone that is bereft of water, energy, and most natural resources needed in manufacturing. At present, these assembly plants and agriculture predominate as the industrial base and, in some parts of the region, are the sole economic engine. In short, a complete rethinking of the type and intensity of economic activity and human settlement in the binational zone must be undertaken.

The good news is that there is an approach that can provide economic vitality without continuing to create unmanageable problems. The rapidly emerging practice of *natural capitalism* offers a new approach to business and economic development that improves profits and competitiveness while protecting living systems. Simple changes

to the way businesses are run, built on advanced techniques for using resources more productively, can yield startling benefits both for today's shareholders and for future generations. Also, straightforward changes in the way community decisions are made—making them more transparent, democratic, and based on realistic examination of the full range of benefits and costs—can result in greater social equity, environmental restoration, and economic prosperity.

This approach is called natural capitalism because it enables companies to behave as if the largest category of capital—nature's ecosystem services—is properly valued. Everyone knows that living systems provide us with indispensable products—such natural resources as oil, water, trees, fish, soil, and air. Less obvious is that they also provide us with such equally essential services as storage and cycling of fresh water, flood control, climatic stability, and detoxification of human and industrial waste. Though these services are fundamental to business and human life, some of the systems along the border that provide such services are already nearing depletion, and most others are declining, some rapidly. Many have no known substitutes. Unfortunately, the cost of destroying ecosystem services may become apparent only when the services break down, such as with the devastating 1993 Tijuana flood when many lives, homes, and businesses were lost in landslides precipitated by poor planning and development.

Fortunately, the practice of natural capitalism can protect living systems while offering superior opportunities. It involves four shifts in the way business and economic development is conducted.

The first shift is to dramatically increase the productivity with which resources are used. Through fundamental changes in both technology and production design, farsighted companies are implementing ways to make energy, water, and materials stretch many times further than they do today. Such savings pay for themselves and often yield higher profits. Similar increases in resource productivity also build local economies, but in ways that distribute benefits widely in the community by increasing self-reliance and reducing family costs. The very fabric of a local economy can become more productive and generate more wealth through such efforts as vendor matching, business mentoring, import substitution, increasing local business ownership, and managing growth. Fortunately, it seems that the binational zone's businesses are approaching a level of maturity such that "industrial

ecology" and systems approaches may be practical even though the vast majority are assembly-oriented.

The second shift in practice is to apply biologically inspired production models, not only to reduce waste, but also to eliminate the very concept of waste. In the closed-loop production systems of industrial ecology, every output either is returned to the ecosystem as a nutrient or becomes an input in manufacturing another product. Such systems often can be designed to eliminate the use of toxic materials. As waste and toxins are reduced—used as inputs or energy sources and eliminated—so are costs. Similarly, communities can identify business opportunities in local material, energy, and waste streams and match those opportunities with local businesses. Benefits include more jobs, lower costs, prolonged landfill life, and reduced pollution. Biological systems are powerful models for programs to retain and expand business, salvage buildings, and design and control growth effectively.

The third shift toward natural capitalism is to adopt a solutions-based business model. The traditional manufacturing model rests on the sale of goods. In the new model, value is instead delivered as a continuous flow of services. Companies that are part of the "solutions economy" provide what customers truly want: quality, utility, and continuous performance instead of just more goods. For example, most offices buy copying services, not copiers. Creative communities will begin to assist local businesses in shifting from product sales to service leasing.

In the fourth shift, business and communities reinvest in natural capital to restore and sustain ecosystems so that they can produce both vital life-support services and biological resources. The future's strongest competitors will be communities and businesses that recognize their success is based on a full complement of ecosystem services.

Pressures to move toward natural capitalism are mounting. As human needs expand, the costs engendered by deteriorating ecosystems rise and the environmental awareness of consumers increases. This is not philosophical speculation, but the reality facing most major businesses. Consumer perceptions of environmental practices are dramatically affecting the market positions of major companies and their suppliers. For example, Home Depot recently responded to public pressure to buy its lumber from certified sustainable forests.

As parts of international supply chains, industries along the U.S.–Mexican border are no exception to the rule that industry must

adapt to change. Regardless of whether Mexico's environmental regulations are poorly enforced, many of these suppliers will be required by their buyers to continuously improve their environmental practices. Increasingly, stockholder, consumer, and environmental groups are targeting individual corporations to demand changes in environmental practices, processes, and supply-chain relationships. Among the principal missions of engineers and middle managers in the most innovative multinational companies are to anticipate regulations and consumer perceptions worldwide, to redesign products and processes accordingly, and to notify suppliers that they also must change. Optimally, there would be a circumstance in which there was pretreatment of supplies to the maquiladoras so that no packaging, byproducts, or toxic materials were delivered or ever needed to be repatriated to their country of origin.[1]

Suppliers that have improved their practices ahead of these changes will be far better positioned in the world economy. They know that defining problems narrowly, without identifying their deeper causes or connections, merely shifts problems and obscures solutions. They are systems thinkers who uncover lasting, elegantly frugal solutions with multiple benefits, including strengthened competitiveness.

Natural capitalist economic development links people from industry, the local government, and the neighborhood. It optimizes the local wealth-creating capacity of the whole community. It does not merely seek to spin the local economy as fast as possible. Rather, it builds a web of business relationships to create more jobs, income, and savings; cleaner air and water; and a more equitable distribution of the fruits of local labor.

Supply Chains and Consumer Perceptions

It is fashionable for corporate leaders to believe that their futures are in their hands. All they have to do is run a tight ship and deliver value to their shareholders and they will prosper. The concerns of others outside the company are irrelevant to their jobs.

Such a belief is increasingly risky. In fact, the future of any company depends not only on the ability to sell its products for less than those products cost to make, but also on how its customers and others perceive the behavior of the company. Increasingly, customers are scrutinizing the environmental performance of companies. For exam-

ple, maquiladoras have found themselves under a spotlight for a number of years as environmentalists in the United States and Mexico have identified and pressed for change in inputs, processes, and waste handling. Thus, any company that wishes to remain competitive in global trade, even a small supplier located where environmental regulations are lenient or poorly enforced, is subject to rigorous environmental policies.

Likewise, until the NAFTA debates, the maquiladoras along the U.S.–Mexican border, as anonymous links in international supply chains, could hardly have been faulted for thinking that they were immune to such pressures. However, each link in the chain is vulnerable to public perceptions. Thus, during the NAFTA debates, social and environmental groups demonstrated against the environmental harm resulting from the lax environmental enforcement in the border free trade zone, calling the maquiladoras the key culprits (Spalding and Stern 1996). Since that time, things have begun to change:

> While maquiladoras do not account for a majority of toxic waste production in Mexico and are not the sole cause of environmental degradation in the binational borderlands, they represent one of Mexico's struggles for economic growth often at the expense of the environment. Maquiladoras have been agents of environmental degradation in the binational borderlands; however, due to strengthened environmental institutions, laws, and mechanisms the opportunity exists to improve efforts at environmental control in the U.S.–Mexican border region (Schauer 2000, 1).

Increased bilateral trade under NAFTA has led to economic growth, but this does not necessarily equate to sustainable economic development. Although there are now over 2,000 maquiladoras employing 1.2 million workers, these jobs have not brought a fair distribution of wealth to most border residents. An analysis demonstrates that while maquiladoras create jobs, they have minimal incorporation of national inputs (less than 2%), low value added, minimal technology transfer, and result in a contraction of regional wages. The companies that establish maquiladoras essentially capitalize on cheap labor while not producing a significant degree of integration with the larger Mexican economy (Schauer 2000, 2–3).

Recently, the Rocky Mountain Institute was invited to help a team of engineers and middle managers from a major multinational electronics firm. Central to the team's daily work is anticipating regulations and consumer perceptions across North America and Europe. When they see a change coming—a potential new regulation or a change in consumer perception—they look for ways to accommodate that change early, on their terms, and less expensively than a new regulation might require. This team knows that if they wait until a regulation is instituted or a boycott is mounted, the company's risk and costs will multiply. The latest challenge is to implement the concepts of environmental sustainability across the company, not because they are environmentalists, but because they believe this will underpin the company's future profits.

One of the team's chief responsibilities is notifying their suppliers that they also must change. Many suppliers have developed little or no capacity to improve their environmental performance, regardless of regulations. Such companies can suddenly find themselves in big trouble, scurrying to build capacity to respond. If they fail, they will most likely be cut from the supply chain.

This is not a temporary phenomenon. Ten years ago, *Business Week* reported that many corporations now regard government pollution limits as minimum standards. Such companies seek to do better than to simply meet minimal compliance levels and try to position themselves to meet future changes in policy (Smith and Cahan 1990). In 1993, *The Economist* argued that society is entering "the era of corporate image, in which consumers will increasingly make purchases on the basis of a firm's whole role in society: how it treats employees, shareholders, and local neighborhoods" (Advertising 1993).

Sooner or later, maquiladoras and other businesses along the border will be required by buyers of their products, including consumers, to comply with environmental conditions that are independent of, and often tougher than, governmental regulations. Border region businesses including maquiladoras and their suppliers, who anticipate these requirements can implement them on their own terms, less expensively, and without disrupting their operations. Smart companies are finding that this process also affords ways of increasing the efficiency and profitability of their operations because as they reduce inputs and waste while increasing use of byproducts, their operating costs go

down. Industry can do much to head off government regulation and enforcement, yet little to prevent rapid shifts in consumer perceptions.

Even industry giants are subject to this phenomenon. For example, Monsanto, a large company that is stunningly influential in several countries, may find that it has little influence in other countries that are home to thousands, even millions, of its consumers. If that second group of countries develops a strict new regulation, the company realistically cannot redesign its products for only that portion of its market. It must either give up that market or change its products for all consumers. This can happen even within countries. When California instituted energy-efficiency requirements for refrigerators, manufacturers were compelled to redesign all their products, not just those headed for the West Coast.[2]

So, what might buyers require border suppliers to do? Because the reports of border environmental degradation are now well documented,[3] it is a good bet that many actions will be required. For example, companies will be forced to find safe ways to store or dispose hazardous materials. They will have to demonstrate that they will no longer pollute the air, rivers, and groundwater. They may be forced to stop using hazardous materials entirely.

Managers of some border industries will probably regard such environmental pressures as threats. However, managers who have experience with these questions would disagree. Many companies regard environmental policies as opportunities, ways for their companies to improve competitiveness, upgrade products, and increase profits. And they are not alone. In *Costing the Earth: The Challenge for Governments, the Opportunities for Business*, Frances Cairncross, editor of *The Economist*, demonstrates that the rise of environmental concern is "perhaps the biggest opportunity for enterprise and invention the industrial world has ever seen" (1992). One encouraging sign of recognition of this opportunity in the border region is the *Seven Principles of Environmental Stewardship for the 21st Century*, drafted by the U.S. EPA, the U.S.–Mexican Chamber of Commerce, the Office of the Mexican Federal Attorney for Environmental Protection, and the Border Environment Cooperation Commission. These principles urge industries to take voluntary action beyond simply complying with environmental regulations, and to invest in natural capital outside their doors.[4]

Essential Services from Living Systems

One business opportunity arises from the recognition that long-term competitiveness depends not only upon the viability of manufactured and financial capital, but also of natural capital. Everyone knows that living systems provide indispensable products—such natural resources as oil, water, trees, fish, soil, and air. However this is only half of what makes up natural capital. Less obvious is that it also provides such equally essential ecosystem services as:

- Storage and cycling of fresh water.
- Cooling from shade trees.
- Flood control by root systems.
- Purification of water through wetlands.
- Purification of air by leaves.
- Storage and recycling of nutrients in roots.
- Sequestration and detoxification of human and industrial waste through wetlands and ground filtration.
- Pest and disease control by insects, birds, bats, and other organisms.
- Formation of topsoil and maintenance of soil fertility.[5]

Even in the arid border region, riparian and estuarine wetlands provide habitat, sources of nutrients, absorbent space during floods, nursery refuge for marine and fresh water species, and assimilation of in-stream toxins, contaminants, and sediments.

Most of these services underpin the ability of business to exist as well as to maintain human life. Unfortunately, along the border many of these ecosystem services are declining, or are being outstripped by population growth—some rapidly. Worse, many have no known substitutes. The only businesses that do not share the risk of losing these services are those that intend to simply move and leave their mess behind. Such behavior makes a company vulnerable to the market forces described earlier.

Unfortunately, the cost of destroying ecosystem services may become apparent only when the services break down. For example, in 1993 a flood devastated parts of Tijuana. On its face, such an event may seem like just another natural disaster. However, how natural was it? The area has been subject to occasional downpours for centuries, yet this time the volume of rainfall was more than typical. The result was more disastrous than past floods because cattle ranching, dry farming, sand

and gravel mining, and haphazard urbanization had removed the natural vegetation that had previously captured runoff upstream. The loss of life and property resulted because of the loss of these ecosystem services. With good intentions, people planted crops, raised livestock, mined, and built modest dwellings to improve their lives. However, while the value of these activities was obvious, the value of declining vital ecosystem services was not considered. Because the value of the ecosystem services is not counted on any balance sheet, each person optimizes his or her part of the larger system, ignoring the overall system. Ignoring the whole system is bad for people and bad for business.

Natural Capitalism

The rapidly emerging practice of natural capitalism offers a new approach for enhancing business profitability while protecting ecosystem services and the future. Because it improves profits and competitiveness, it is attractive to those who have not yet recognized the value of ecosystem services. Simple changes to the way businesses are run, built on advanced techniques for using resources more productively, can yield startling benefits both for today's shareholders and for future generations.

This approach is called natural capitalism because it enables companies to behave as if the largest category of capital—nature's ecosystem services—is properly valued. The journey to natural capitalism involves four strongly intertwined and synergistic shifts in business practices: dramatically increase the productivity of natural capital, shift to biologically inspired production models, move to a solutions-based business model, and reinvest in natural capital.

Dramatically Increase the Productivity of Natural Capital

Reducing the wasteful and destructive flow of resources represents a major business opportunity. Through fundamental changes in both production and technology design, farsighted companies are developing ways to make such natural resources as energy, minerals, water, and forests stretch 5, 10, even 100 times further than they do today. These major resource savings often yield higher profits than small resource savings do. Such investments are not only paid for over time from the

saved, but also in many cases may actually reduce initial capital investment. A few examples:

- Sony de Tijuana Este reduced the size of a component of one of their televisions, substantially reducing plastic material use, material costs, and wastes.[6]
- A new building in Bangkok was designed to save 90% of its air-conditioning costs with no additional building costs.
- Cost-effective retrofits to a California office saved 97% of its air-conditioning costs.
- A comprehensive efficiency retrofit of electrical motors typically saves about half their energy consumption and pays back in around 16 months.
- An innovative design developed by Davis Energy Group uses engineered wood products to reduce the amount of wood needed in a stud wall by 70%. The walls are stronger, cheaper, more stable, and insulated twice as well, enabling the elimination of cooling equipment in a climate that reaches 113° F.
- Skilled retrofits have saved 70–95% of office, warehouse, and retail lighting energy, yet the light quality is more attractive and the occupants can see better. Such measures typically increase labor productivity by 6–16%
- Pacific Coca-Cola reduced a can line's need for rinse water by 79% by using air instead of water to clean the insides of cans before filling.
- A north German manufacturer of paper products almost eliminated its water use by completely recycling its base supply in a sophisticated process that successfully sediments, floats, and filters the fiber and particulate loads from the water.
- Gillette reduced the water used in the production of razor blades by 97% and that used in the production of pens by 90%.[7]

Advanced resource productivity is driven by the same logic as was the Industrial Revolution. Mass production incorporated the use of ecosystem services and machines to make people 100 times more productive because the relative scarcity of people was limiting progress. Today the pattern of scarcity has shifted to just the opposite—abundant people and scarce natural capital. Profit-maximizing capitalists will now economize on the scarce resource—namely, natural capital.

Shift to Biologically Inspired Production Models

Natural capitalism seeks not merely to reduce waste, but to eliminate the very concept of it. In closed-loop production systems modeled on nature's designs, every output is either returned harmlessly to the ecosystem as a nutrient (e.g., compost) or becomes a material in the manufacturing process of another product. Such systems often can be advantageously designed to eliminate the use of toxic materials, which hamper nature's ability to reprocess materials. The following are some examples of corporations that have applied such models:

- Hasbro Manufacturing Services' Juguetrenes plant in Tijuana saved $230,000 per year by classifying, regrinding, and selling plastic wastes to recyclers.[8]
- Sony de Tijuana Este has increased its volume of recycled material by 45% annually since 1993. Combined revenue and cost avoidance in 1995 was $500,000.[9]
- Interface's Solenium carpet lasts four times longer and uses 40% less material than ordinary carpet, reducing its materials intensity by 86%, and it does not contain the toxic materials typically found in carpet. Sixty-seven million dollars of the company's 1994–1998 revenue increase is directly attributable to its 60% reduction in landfill waste. Interface intends to eliminate all waste in its traditionally waste-intensive business, power its factories with renewable energy, and get its feedstock from renewable materials.
- Productos de Consumo Electrónicos Philips in Ciudad Juárez donates wood and metal pallets, wood from crates, cardboard from packaging, and Styrofoam to needy families for use in home building. Philips employees donate their time to help build the structures.[10]
- In 1996, the U.S. remanufacturing industry reported revenues of $53 billion, more than consumer durables manufacturing (appliances, furniture, and audio, video, farm, and garden equipment).[11]

The emerging discipline of industrial ecology is closed-loop production applied at the scale of a facility or an industrial park. The following are some examples of such facilities:

- Namibian Breweries, the zero-emissions brewery in Tsumeb, Namibia, is a facility-scale industrial ecosystem that employs

four times the people and produces seven times the food, fuel, and fertilizer of conventional operations. It produces not only beer, but mushrooms grown on spent fermentation grain, and chicken feed made from earthworms. The fermentation process is fired by methane generated by a chicken-waste digester. The brewery also sells eight varieties of fish that are fed digester waste and reared in ponds filled with brewery wastewater.

- Kalundborg, Denmark, is the site of the leading example of an industrial ecosystem park consisting of several businesses in one community, each of which uses the waste from another business. It is being imitated in places such as Londonderry, New Hampshire; Chattanooga, Tennessee; and Monterrey, Mexico.

One cannot help but wonder what business opportunities lie in the waste and hazardous materials now being dumped along the border. One important task is to evaluate their usefulness as inputs into local businesses and determine ways to create closed-loop industrial ecosystems in the many maquiladora industrial parks within the border region.

Move to a Solutions-Based Business Model

The business model of traditional manufacturing rests on the sale of goods. In the new natural capitalist model, businesses instead deliver a continuous flow of services—such as providing illumination rather than selling light bulbs. Services are delivered, too, within a relationship that aligns the interests of providers and customers in ways that reward them for continuous improvement in implementing the first two innovations of natural capitalism—resource productivity and closed-loop manufacturing.

Companies that are part of such a solutions economy provide what customers truly want: quality, utility, and continuous performance instead of just more goods. For example, most offices buy copying services (i.e., use of a copier, service of the copier, and upgrades, paper supply, etc.,) not just copiers.

- Instead of simply selling elevators, the Schindler Elevator Corporation sells lease contracts to design, install, maintain, and upgrade internal transport systems.
- Under its Evergreen lease, Interface, Inc., no longer sells carpets but rather leases a floor covering service for a monthly fee,

accepting responsibility for keeping the carpet fresh and clean. Monthly inspections detect and replace worn carpet tiles. Since, at most, 20% of an area typically shows at least 80% of the wear, replacing worn tiles reduces the consumption of materials by 80%. Combined with savings through its Solenium product, Interface has achieved a 35-fold reduction in the flow of materials, reducing the extraction of virgin materials, and eliminating the production of vast quantities of waste.

The solutions model does not suggest that durable goods will no longer be produced. On the contrary, in the solutions economy, goods are so durable and valuable that companies prefer to keep and lease them rather than sell them. Smart companies will adopt this approach ahead of legislation like that now entering law in Germany and Japan, which requires manufacturers to take back their products after their useful life and recycle or remanufacture them.

When a company shifts from selling to leasing a product, it then owns the product throughout its life cycle. Thus, the company's relationship to the product shifts too. Durability, reusability, and nontoxicity become attractive attributes that enhance profitability.

Reinvest in Natural Capital

In some circles, damage to the environment is regarded only as the loss of non-essential amenities, or luxuries that are insignificant when compared to the benefits of business and economic development. Efforts to protect these "luxuries" have been characterized as elitist and as unrealistic constraints on business. However, while some environmental concerns may be aesthetic, the depletion of natural capital is increasingly being recognized as a limiting factor on future economic productivity.

Along the border, air and water pollution and the accumulation of hazardous materials have negative effects on human health, ecological systems, and business. As any prudent capitalist knows, businesses must reinvest in restoring and enhancing the natural capital so that it can continue to produce both vital life-support services and biological resources. Pressures to do so are mounting. As human needs expand, the costs engendered by deteriorating ecosystems rise and the environmental awareness of consumers increases. Fortunately, these pressures all create business value. Some examples include the following:

- Thousands of ranchers are improving both their range and their profits using a grazing technique developed by Allan Savory of the Center for Holistic Management in Albuquerque, New Mexico. Savory's approach raises the carrying capacity of rangelands, which have often been degraded, not by overgrazing, but by undergrazing and incorrect grazing. This technique keeps the cattle moving from place to place, grazing intensively but briefly at one site, so that they mimic the dense but constantly moving herds of native grazing animals that co-evolved with the grasslands.
- The Ecoparque project uses reclaimed water treated by a nonchemical, nonmechanical treatment facility for irrigation purposes. Thus, each liter of treated reclaimed water that is used frees up an equal amount of potable water for the people of Tijuana.
- The Ojinaga pilot study, highlighted in Figure 1, demonstrates a reinvestment in natural capital through better handling of wastes combined with land reclamation and habitat restoration.

Figure 1: Pilot Study for an Integrated Waste Treatment and Disposal System along the U.S.–Mexican Border: Land Reclamation and Habitat Restoration

Ojinaga Community as a Prototype
The full-scale design integrates waste treatment and disposal with simultaneous biomass production for energy and fiber. Using the border community of Ojinaga, Mexico, as a test case, local municipal wastewater and currently underutilized irrigation water is applied to areas planted with fast-growing woody crops like Eucalyptus. The result improved the quality of water discharged to the Rio Grande and enhanced growth of the biomass species. For this study, existing four- and five-year-old test plots of Eucalyptus are used as sites for wastewater applications. Monitoring systems provide data regarding quality improvement of the discharge water. Field plot measurements over a growing season detected any biomass yield improvement due to the irrigation with the enriched wastewater. Survival of the three species was excellent, averaging 99% for Eucalyptus, 97% for Robinia, and 93% for the Populus cuttings. The dried sludge from the old lagoon contains 35% calcium carbonate and only 8% organic matter. It is neither beneficial as a fertilizer nor hazardous from heavy metal contamination. Small communities can use this technique to reduce or eliminate contamination of waterways. In addition, this approach has the potential to generate a substantial revenue stream from the sale of the biomass.

- John Todd's biological "Living Machines" treatment facilities turn sewage and septage into exceptionally clean water, while creating flower gardens, an attractive tourist venue, and other byproducts, with no toxicity, no odor, and reduced capital costs.[12]
- A half century ago, Port Angeles, Washington, like many towns seeking development, built a seawall along the beaches, rocks, and wetlands that face the Strait of Juan de Fuca. Behind the seawall, an industrial site was created, which became home to a timber mill and its millpond, among other facilities. For years, rafts of cedar logs were towed to Port Angeles and into the millpond. However, a few years ago, the mill switched its raw material to cottonwood, which stinks. As trucks and forklifts inefficiently skirted the millpond, it became a $150,000 annual liability. However, Port Authority officials decided to take advantage of an opportunity: they would excavate a portion of the industrial site near the pond where there had once been an estuary, dump the excavated material into the millpond, and restore the estuary. The mill happily invested $180,000 moving the fill. Then the townspeople and the U.S. Forest Service restored the estuary. By reinvesting in natural capital, everyone won. The mill received a return on its investment of around 300% while creating land for an $8 million expansion, which created 30 permanent jobs. The restored estuary is not only a vital natural habitat, it is a town park and a buffer between the tourist areas of downtown and the industrial site.

Systems Thinking

At the heart of natural capitalism is an approach to problem solving called *whole systems thinking*. Designers and decision makers too often define problems narrowly, without identifying their deeper causes or connections. This merely shifts or multiplies problems and obscures solutions. In contrast, systems thinking typically reveals lasting, elegantly frugal solutions with multiple benefits, which enable decision makers to transcend ideological battles, cross the boundaries of occupation and discipline, and unite all parties around shared goals.

Port Angeles officials could have narrowly focused their tasks on optimizing the port's market position. However, as systems thinkers,

they sought ways to optimize the whole system and, in doing so, developed a brilliant yet simple solution that made all parties winners and restored an ecosystem.

Systems thinkers are hard at work at Interface too. They could run their business the way it has always been done—sell carpet and make money. Instead, they are exploring the entire value chain of carpet production, from virgin materials through to discarded materials. Instead of regarding the tons of carpet that usually end up in the landfill as someone else's problem, they embrace it and many other problems in their value chain as business opportunities. The outcome is more profit and a healthier environment.

Development and Expansion

Growth and industrial recruitment are the usual strategies chosen for economic development on the U.S.–Mexican border. New jobs, rather than increased wages or career advancement, are falsely considered the measure of success. While these strategies succeed in some circumstances, in others they generate substantial uncounted costs, such as pollution and loss in vitality of ecosystem services. Though these costs can undermine economic prosperity, they are seldom considered in decision making.

Even the creation of some new jobs may generate a net economic loss. According to one analyst, "entry level [jobs] often require more in government services than they contribute in taxes." Some of the government programs include very expensive social services, such as indigent health care and subsidized housing. Conventional strategies virtually never attempt to optimize the whole community as a system to be sustained over the long run (Ganster, Sweedler, and Clement 2000).

Systems thinking can inform this dilemma. It is just as applicable to a community's economy as it is to industrial processes. Unfortunately, like old industrial thinking, the conventional approach to economic development is to optimize an individual piece of the system. For example, some local officials will focus narrowly on recruiting a new company regardless of its effects on the community. This is not to suggest that business recruitment is always disadvantageous to a community. On the contrary, it has been and can continue to be beneficial in many circumstances. However, when tax breaks, land, and infrastructure are offered with the sole purpose of securing jobs without consid-

ering costs, the long-term consequences to the community and environment can be serious.

One area of confusion in the U.S. debate on growth is the word itself. Discussions about growth issues can proceed effectively only when the term is defined. In this context, growth actually has two meanings: *expansion* and *development*. Physical enlargement—more people, infrastructure, buildings, subdivisions, malls, etc., which may or may not benefit the community—is called expansion. In contrast, development means betterment: living-wage jobs, increased income, greater savings, and excellent quality of life. Ganster, Sweedler, and Clement (2000) distinguish between these two concepts in the paper, "Development, Growth, and the Future of the Border Environment."

Throughput

One concept that helps to clarify the distinction between expansion and development, and the health of such large systems as companies, ecosystems, and communities, is that of *throughput*. Throughput is the rate at which goods and services flow through an economy, and the rate at which resources are turned into waste. To help illustrate how throughput informs issues of development and expansion, consider the following exchange between a recently unemployed engineer and his wife:

> Undaunted by the downsizing of his company, an engineer buys a truck and a load of vegetables to sell by the highway. After a terrific day, he's sold out. Back home, he gushes to his wife about his success:
>
> "How much did you earn?" she asks.
>
> "Eighteen hundred bucks," he crows.
>
> "And how much did you pay for the veggies?"
>
> Punching his calculator, he hesitantly announces, "Two thousand."
>
> "Hmm," she says, "there seems to be a problem."
>
> Dreamily, he says, "Yeah, I need a bigger truck."

The engineer is intoxicated by revenue. However, most business people know that what counts is profit. Yet, even smart business people often neglect to calculate net gain when promoting economic development. They seek to spin the economy as fast as possible—harvesting more grain or trees, making more widgets, building more subdivisions,

attracting more tourists. Community leaders should ask themselves if increased throughput provides a net gain—that is, does it increase the well-being of citizens and strengthen the community? Does continuously increasing throughput leave a viable economy for their grandchildren, or is it an illusion that, like the case of the engineer, feels good in the short term but hurts later on? These are not simple questions. However, answers can be found by soberly comparing the economic, community, and environmental costs with the benefits of specific growth proposals. Increasing throughput does not necessarily lead to development, nor to community prosperity and a higher quality of life. This is especially true in the border region where much of the industry provides very little added value.

Unfortunately, community and environmental factors are seldom considered. Intoxicated by the prospect of an increase in throughput, growth boosters often ignore such costs as traffic congestion, declining schools and other public services, increasing taxes, groundwater pollution, depleted soils, and housing that residents can no longer afford. In a mature economy, each additional unit of industrial production can create a net loss that boosters assume will be made up in volume.

Natural Capitalist Development

The distinction between expansion and development, and the concept of throughput are important for two reasons: first, as mentioned, many expansion options increase throughput but do not improve the community or its environment. Second, and less obvious, many development opportunities require little or no expansion. Those opportunities are part of natural capitalist development.

Natural capitalism offers a unique way to bring a community together. It is attractive to business people because it offers ways to strengthen competitiveness while enhancing livability and reducing environmental impacts. And, in the border region, some of these quality-of-life issues and environmental impacts reach down to basic human health and survival. Innovative businesses can lead communities in adopting these principles and setting examples.

Natural capitalist development is a powerful strategy for economic development—a route to increased jobs, income, commerce, savings, equity, and community well-being that does not necessarily require community expansion. Because this kind of development proceeds

independent of increases in the size of a community, it is attractive to both booming and declining communities. Unlike conventional expansion schemes that concentrate benefits in one or two places assuming that benefits will trickle down to everyone, natural capitalist development distributes benefits widely across the community.

The journey to natural capitalist development involves four interrelated shifts in community decision making, similar to those described earlier for natural capitalist businesses. Listed under each are several representative community activities or programs. Many are well known, others innovative. Most of the listed activities require little or no community expansion. While not all apply to every community on the border, the length of this list indicates the untapped wealth-generating potential in virtually every community.

Invest in Resource Productivity

A local economy is like a bucket that the community would like to fill to overflowing.[13] Growth and business recruitments are attempts to do so. Yet, economic buckets invariably have holes in them through which dollars leak. Inefficiently using local resources—human, natural, and business—enlarges those holes.

Focusing entirely on more ways to fill the bucket ignores vast opportunities. Strategies that plug these leaks also increase self-reliance. They reduce the costs of doing business, and they also cut the costs of supplying the basic necessities, thereby becoming especially valuable in areas with large numbers of low-income people. Notice that "leaks" identified here are far more extensive than the narrowly defined "retail leakage."

Smart communities seek profitable ways to keep the bucket full by plugging unnecessary leaks in one or more of the following ways:

Water Efficiency

The Los Angeles Department of Water and Power had to find ways to squeeze more work out of their available water supply. They worked with a grassroots group called Mothers of East Los Angeles, who marketed a low-flush-toilet retrofit program that installed 270,000 toilets in three years; returned $4 million to the neighborhoods in jobs, water bill savings, and community programs; and saves over 3.4 billion gallons of water every year. Efficiency programs do not curtail use; they

make existing uses smarter. Well-designed community efficiency programs can cost-effectively reduce water use by as much as 40%. The border is ripe for efficiency investments. Del Rio, Texas, recently discovered that approximately half of its water was lost between the source and the household tap. Stemming this loss saved the community a significant amount of money that it otherwise would have had to invest in a new water system.

Energy Efficiency

Energy efficiency programs will create local jobs and save millions of dollars in any community. The city of Sacramento, California, invested $59 million to save electricity. This enabled utility customers to save nearly that same amount. The program created 880 direct jobs and increased regional income by $124 million. Though energy is a small portion of total costs, saving energy will provide a significant contribution to company profits and community economic progress. As energy shortages develop in Mexico's northern border cities and as rates increase dramatically, maquiladoras will realize big cost savings by investmenting in energy efficiency programs.

Local Business Ownership

Local ownership increases the wealth-creating power of each transaction. Land trusts and community stock corporations can ensure permanent local ownership of businesses by buying local buildings and renting only to residents (at cost). One example is the Green Bay Packers organization, which is the only publically owned NFL football team. The majority stockholders are Wisconsin residents who can never sell the team to another city.

Import Substitution

Replacing imports with local products and services also helps local economies while promoting the efficient use of resources. For example, high school students in tiny Tropic, Utah, who were seeking ideas for a business start-up, noticed tourists buying bottled water from France. They then bottled local spring water and labeled it with a photo of nearby Bryce Canyon. While import substitution was practiced in Mexico for years, it focused on closing out the global market and on the protection of domestic industries rather than the use of appropriate local products and services that are efficient economic substitutes for imports.

Vendor Matching
A program that links local buyers with local suppliers was implemented in Eugene, Oregon, creating 100 jobs in its first year without any physical expansion of the city. As the border region continues to mature, there will be greater opportunities to pursue vendor matching. Until now, the only matching done was finding labor for labor-intensive assembly operations. Thus, there was a delay while suppliers moved into the area, which had previously been lacking in industry of any kind.

Microcredit
Many low-income and impoverished people have the skills but lack the credit to start a business. Tailored to very small, often home-based, start-up businesses, microloans are not given by most conventional banks because each transaction is too small to be profitable. Usually offered by nonprofit organizations in conjunction with basic business training, microcredit often provides a way out of poverty. For the border region, perhaps some private firms could support such non-profit activity, which is currently much too small to meet the demand.

Downtown Revitalization
Such projects reduce economic leakage, build pride, encourage infill development, preserve culture, celebrate history, reuse resources, and reduce traffic congestion.

Community Supported Agriculture (CSA)
CSA providers contract directly with their customers, who receive shares in that year's produce. Such programs provide capital to preserve local farms, increase productivity, and reduce costs. Understandably, due to extremely limited water supplies, this concept will have limited applicability in the border region. However, those communities that can promote CSA should do so.

Business Mentoring
These programs enable veteran business people to "adopt" start-up businesses, giving rookie proprietors someone to talk with when things go wrong, helping them to understand and avoid pitfalls. Mentoring programs significantly reduce the high failure rate of start-ups. If this is done in a transboundary model, there must be an exercise in caution to avoid patronization and cultural insensitivity.

Community Development Corporations
Community development corporations employ business skills and tools to benefit the overall community through such efforts as developing affordable housing.

Business Visitation Programs
Visitation programs enlist local leaders to visit businesses to determine needs and concerns. Visitation also allows proprietors to offer suggestions to local governments and organizations regarding policy changes that could benefit local business.

Growth Management
In the United States, tax revenues collected from subdivisions in previously undeveloped areas are virtually never sufficient to pay for the needed public services. As a result, taxpayers in already established areas of the community unknowingly subsidize sprawl unless impact or user fees are charged to those newly developing areas. Local governments that do not charge for the full cost of expansion are degrading their economic future.

Local Currency
In Ithaca, New York, the local currency is accepted by 1,200 businesses and cannot be spent outside of the town. This encourages residents to support their local businesses and recycle dollars within the community. Community cash flow can also be captured through such community enterprises as locally based credit cards, debit cards, and phone service.

Shift to Biologically Inspired Economic Models (Biomimicry)

To be competitive, communities must pursue development strategies that analyze local material, energy, and waste streams; identify business opportunities; and match those opportunities with local businesses. Multiple benefits include more businesses and jobs, reduced resource inputs (and, therefore, lower costs), prolonged life of the local landfill, and reduced pollution. The transition to bioentrepreneurship has begun:

Waste Matching
The industrial ecology concept can be applied at the regional scale as well. Computer networks can make "virtual" industrial ecosystems by matching wastes with potential buyers; examples under development include state programs in New Hampshire and Michigan. Efforts by the Environmental Defense Fund in Ciudad Juárez and Brownsville–Matamoros seek "to develop a workable community of manufacturing and service businesses that promotes economic efficiency by facilitating interchanges of byproducts and wastes which one company discards but another can use as a production input." Another excellent border effort is the Waste Wi$e program in Tijuana–San Diego.

Building Salvage
Dismantling and reusing building components can be more cost effective than demolishing existing buildingsto rebuild new ones. Southern California Gas saved $3.2 million or 30% of construction costs on an office and education building by partly dismantling and reusing an existing building. The finished building was constructed from 80% recycled materials, keeping 350 tons of material out of landfills. The Environmental Services Department building of the City of San Diego was similarly salvaged and is now a green building.

Advanced Business Retention and Expansion Programs
Such programs are designed to mimic biological systems by enhancing adaptation, competition, interrelationships, and information flow. Littleton, Colorado's, program created jobs at six times the rate of its earlier business recruitment efforts by offering such services as problem research, competitor analysis, industry trend monitoring, video conferencing, training, and market mapping.

Flexible Business Networks
Several small businesses will form partnerships on contracts that are too big for any one of them, thus allowing them to compete with larger companies and expand their client list. These agreements mimic biological systems as a cooperative arrangement, similar to the hunting style of the coyote, who usually hunts on its own, yet will run in packs when seeking larger game.

Successful community design also mimics biological systems, as the following examples illustrate:

Community Expansion Design
Community expansions can be designed more effectively by mixing compatible land uses, clustering development, and infilling rather than simply allowing sprawling growth. These strategies combined with traditional community designs, multiple transportation modes, and natural infrastructure (e.g., for drainage and sewage) are especially crucial in such rapidly expanding communities as those along the border because they will reduce infrastructure costs by requiring fewer extensions. In requiring fewer road extensions, infill can also reduce air pollution.

Storm Water Capture
Encorporating storm water capture saves money, recharges groundwater, and reduces flooding. Developing structures to help rain soak into the ground where it falls rather than collecting it into expensive centralized systems will also help eliminate pollution caused by overwhelmed sanitary sewage systems. Examples of such design principles include using permeable materials for parking lot surfaces, utilizing natural swales, and reversing the channelization of streams. City planning department officials in Phoenix, Arizona, redesigned urban watercourses with earth berms and natural vegetation to maximize groundwater recharge while controlling floods.

Restrict Community Expansion
Tough zoning ordinances, urban growth boundaries, subdivision allotment systems (that control growth rate), and community land trusts are all means to restricting community expansion. Failure to do this can result in unmanageable, unfinancible megacities.

Join the Solutions Economy

This fundamental change in the relationship between producer and consumer boosts competitiveness by more directly addressing customer needs. It also reduces materials input and pollution output and enables the producers to increase profits while the consumer decreases expenses. Waste is reduced, and fewer raw materials are required.

Though the solutions economy is well underway, vast markets remain unexplored. Exciting opportunities remain available to communities that understand this new economy and assist appropriate local businesses in shifting from product sales to service leasing. These communities can offer incentives and support to local businesses that make the shift to selling solutions instead of products.

Reinvest in Natural Capital

The future's strongest competitors will be communities with a full complement of ecosystem services. The Tijuana floods of 1993 are an example of a community that suffered tragically, in part, due to the loss of crucial ecosystem services. The following are some communities that are working to improve their ecosystem services:

- Port Angeles, Washington, is an example of industry, community, and government working together to restore an ecosystem and strengthen business competitiveness and the local economy. (See page 87 for a more detailed description.)
- Cities such as Curitiba, Brazil, are creating urban ecosystems in the form of biodiverse parks that are home to birds, bats, and frogs that eat many insects. The parks also help cool the city, which improves the overall livability of the city.
- The city of Arcata, California, restored a 154-acre wetland and uses it to treat urban wastewater. Salmon are being reared in the resulting marsh. This wetland was created at a fraction of the cost of conventional energy-intensive wastewater treatment systems. Other communities are protecting and enhancing vegetative cover, maintaining watersheds for flood control and drinking water, and protecting groundwater from chemical contamination.

Building Community Capacity

How can the border region implement natural capitalism? How can its communities start on the road to a more sustainable development strategy? First, the United States and Mexico should rally to support the border region as has been done for other regions within the United States (the Everglades, the Great Lakes, the Hudson River Valley, and the Chesapeake Bay, to name a few). The border region is a trade

zone of national concern to both countries. However, a significant majority of maquiladoras and other business investments in the region are made by U.S. interests (i.e., this is a region of economic importance to the nation and should be "managed" accordingly). The low wage production center at the border benefits all U.S. consumers. NAFTA will not solve the environmental problems of the border region because of unequal geographic distribution of its benefits and harms. Thus, support and resources, including U.S. tax dollars, should be supplied and spent within the region on both sides of the border.

Second, everyone in the community needs to become better informed regarding current circumstances. Because Mexico lags behind the United States in waste emissions data collection and public dissemination of industrial waste management information, it is difficult to know the harms done to the environment, the culprits, or even the opportunities for solutions such as improving systems efficiency or waste matching. For example, as a result of limited funding and a severe lack of information, it is difficult for environmental officials to assist companies in complying with environmental regulations or to enforce Mexico's strict antipollution laws.[14]

Third, once properly funded and informed, the development of local and regional leadership that will effectively help communities take charge of the future and be a part of the new economy must be fostered. In contrast, the "good old boy" approach to local governance allows a small group to keep decisions to themselves and ridicules people who discuss innovative ideas. Communities that cling to this outmoded approach will be unable to keep up. Those who choose the first option will develop effective qualities and techniques.

Leadership and Civic Capacity

Through training, events, and organizations, every community should commit local resources to helping existing leaders understand new ideas and creative ways of making decisions. Also, existing leadership must nurture and train the next generation of leaders. "Currently, municipal officials in Mexico are limited to three-year terms with no re-election.... A solution to this would be to enact political reform to allow municipal politicians to be re-elected to subsequent term(s). This could have the effect of facilitating responsible long-term planning and coherent policy coordination" (Schauer 2000, 8–9).

Knowledgeable Management

Leaders in rapidly expanding communities should respond as though they were running an expanding company. Such leaders need to seek creative advice and support and hire planning and management staff who have experience with rapid change. Resisting change will not forestall change. It just means that the community will be changed at the whim of outside forces.

Collaborative Decision Making

Working relationships should be developed among public, private, and nonprofit sectors. People from all walks of life should be thoroughly involved in shaping important decisions, not just commenting on decisions as they are about to be made.

Alternative Indicators of Success

Rather than relying exclusively on such traditional economic measures as sales revenues and property values, community and environmental indicators should be developed to fully understand the effects certain decisions have and the direction in which the community is headed. If such important community characteristics as the health of local ecosystem services, noise, air quality, or newborn birth weight are not measured, they will not be fully considered in decisions. The border environmental indicators work of the U.S. Environmental Protection Agency and SEMARNAP is a step in the right direction, as are the sustainable development certification criteria established by the Border Environment Cooperation Commission (BECC).

Conduits or Communities

Conditions on the border are an excellent example of incrementalization and can be illustrated through the well-worn parable of the frog and the saucepan: dropped into a pan of hot water, the frog instantly jumps out. However, when placed in cool water that is gradually heated, the frog remains passive until it boils. Not noticing gradual change, it is incrementalized to death.

Though expansion of communities at the border is rapid by every standard, the actual changes affect residents incrementally. While "borderland residents are obvious stakeholders in the region in which they drink the water and breathe the air...they have traditionally been unorganized and lack a strong voice in binational borderland politics" (Schauer 2000, 4). For example, if water quality gets slightly worse each day, it is not enough to inspire consumers to organize to do something about it. Leaders in such communities, whether knowingly or not, are just letting the situation come to a head.

Current conditions and trends suggest that many border towns are regarded by decision makers as little more than conduits for international trade. Given the current capacity and willingness to tackle difficult problems, the projected 20-year population doubling will result in intolerable pollution and human misery.

Decision makers can choose instead to respect border towns as real communities. However, this path requires that important development decisions consider the whole system—communities, the environment, and the whole economy—and not just how to secure more jobs.

There are encouraging signs that such systemic thinking is beginning to take place. The last few years have seen significant improvements in cross-border cooperation regarding the environment. For example, the Waste Wi$e program is reducing solid waste in the Tijuana–San Diego border region with business assistance, training, and outreach, particularly to maquiladoras; U.S. agencies are supporting and even funding environmental efforts in Mexico; and U.S. and Canadian chemical engineers are reaching out to their colleagues in Mexico.

These efforts are moving beyond conventional pollution treatment measures. To reach full potential, they must include collaborations between governments and industries—for example, to redesign all regional industrial processes as a whole system (to make one plant's waste another plant's feedstock) like the efforts in Ciudad Juárez and Brownsville–Matamoros. Cooperation on all border issues must take place, not only across cultures and political jurisdictions, but also across occupations and disciplines. Well organized and supported, such efforts will significantly reduce material and energy inputs and waste output, and improve living conditions in industries' host communities.

While the approach previously discussed will benefit any community, it has special relevance to the border. Because the location of maquiladoras is based primarily on their relationship to the U.S. economy, many are poorly integrated into the local economies of their host communities. Their inputs come from outside the community and their outputs leave the community, which serves as a conduit rather than a partner. Though some newer plants are improving, many receive as low as 0.5% of their inputs from local sources.

In contrast, a natural capitalist whole systems approach to local economic development would optimize the local wealth-creating capacity of the whole community. Rather than simply adding one plant after another, it would integrate existing plants into the local economy. It would spin a web of business relationships through such efforts as vendor and waste matching, energy and water efficiency, import substitution, flexible business networks, advanced business retention and expansion programs, and increasing local ownership of plant suppliers. Each of these measures will create more local jobs, income, and savings, regardless of whether the community expands.

Natural capitalist development dramatically increases community productivity. It creates more wealth per unit of throughput, creating more jobs and income for each widget produced by local industry, whether or nor it is a maquila. It builds the local economy while minimizing and even reversing negative effects on the community and the environment. And, finally, it may be the only approach that can successfully tackle the magnitude of problems on the border.

Notes

1. The term maquiladora comes from the Spanish word *maquila,* which in colonial Mexico was the portion of grain millers collected as a processing fee. The word specifically refers to foreign-owned factories that assemble imported parts for export. The maquiladora program began in 1965 as a part of the Border Industrialization Program to attract labor-intensive export assembly industries to relocate to the border region.
2. Unfortunately, such success within the United States and its subregions is contributing to the problems in the border region. People there are "recycling" inefficient cars, refrigerators, air conditioners, etc.

3. See Spalding and Ganster 1999; Herzog 2000; and Ganster, Sweedler, and Clement 2000.
4. For more information or to see a copy of the *Seven Principles of Environmental Stewardship* see the Border Environment Cooperation Commission's Web site at <http://www.cocef.org>.
5. This list of ecosystem services does not include such services as noise abatement and peaceful sanctuary because some may regard them as nonessential. Neither does it include such services as protection against harmful cosmic radiation, distribution of fresh water, and regulation of the chemical composition of the atmosphere because some may argue that the depletion of these services is caused by factors too distant for community action.
6. For more information on Sony de Tijuana Este see <http://www.sel/sony.com/SEL/corpcomm/profile/business/STE.html>.
7. The success stories cited here and elsewhere in this paper are from two Rocky Mountain Institute books: Lovins and Lovins 1998; and Hawken et al. 1999. For more information see <http://www.naturalcapitalism.org>.
8. This company's accomplishment has been recognized by the EPA through its WasteWise Program (not to be confused with the San Diego–Tijuana Waste Wi$e program). For more information see <http://www.epa.gov/wastewise/>.
9. This company's accomplishment has been recognized by the EPA through its WasteWise Program. For more information see <http://www.epa.gov/wastewise/>.
10. This company's accomplishment has been recognized by the EPA through its WasteWise Program. For more information see <http://www.epa.gov/wastewise/>.
11. Simply stated, remanufacturing is the process of disassembling products during which time parts are cleaned, repaired, or replaced and then reassembled to sound working conditions.
12. For more information about Living Machines, Inc., see <http://www.livingmachines.com>.
13. For the border region, the authors are defining community in a regional fashion, with special recognition for the 14 international sister city pairs along the border that must cooperate and coordinate for natural capitalism to work well.
14. This, however, is an area of change. Mexico's 1988 General Law of Environmental Equilibrium and Protection was amended in 1996

to include a very basic pollutant release and transfer register (PRTR) to track some industrial emissions.

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V

Environmental Accounting along the U.S.–Mexican Border

Michael Jerrett, Sergio J. Rey, Christian Dufournaud, and Deborah Jones

Executive Summary

This paper examines the prospects for establishing an environmental accounting system along the U.S.–Mexican border. After reviewing the rationale for environmental accounting and developing a conceptual accounting framework, three case studies from the San Diego–Tijuana region are presented. In the first study, the authors estimate the total proportion of government expenditures made to defend the environment against human-induced changes in San Diego. This study reveals that defensive expenditures absorb approximately 1.23% of total economic output and more than 21% of local government expenditures. The second case study focuses on a smaller area along the border where the environmentally sensitive Tijuana Estuary on the U.S. side connects to the heavily populated Cañón Los Laureles on the Mexican side. Expenditures made in Mexico protect against threats to human health and safety, while those in the United States target the preservation of recreational resources and ecosystem health. The third case study estimates the value of agricultural land losses in San Diego between 1990 and 1995. Using the average price estimate for agricultural output and discount rates ranging from 0 to 5%, the present value of the losses ranges from 0.18% to 1.8% of the total economy.

INTRODUCTION

Background

This paper examines the prospects for establishing a binational environmental accounting system for the U.S.–Mexican border region. Environmental accounting is a relatively new methodology for quantifying and, where possible, placing monetary values on the environmental and resource losses and gains that accrue from economic growth (Brown 1993; Lutz 1993; Stahmer 1995; Bergh 1996; Atkinson and Hamilton 1996; Jerrett 1999). Environmental accounts usually rely on a standardized framework for reporting environmental and resource losses and, in most instances, they have linkages to traditional economic indicators through the social accounting matrix (Gilbert 1990). When environmental and resource losses are monetized and subtracted from the traditional measure of economic output—that is, the gross domestic product (GDP) for a given area such as a nation, state, or regional economy—environmental accounts can give decision makers an enhanced understanding of the true costs of economic growth, many of which are misrepresented and underestimated by traditional economic indicators (Bartelmus 1996).

The U.S.–Mexican border region is currently undergoing rapid changes due in part to NAFTA and to larger forces of economic globalization. The case studies presented in this paper focus on the largest border economy, the San Diego–Tijuana region. The once sleepy border city of Tijuana, previously considered the northern frontier of Mexico, has become one of the fastest growing economies in Mexico. The pull of the maquiladora industries, combined with the demise of traditional agricultural sectors in southern Mexico, has resulted in an estimated population growth of nearly 10% per year (Ganster et al. 2000). On the San Diego side, developments in the high-tech and biotechnology sectors have transformed this peripheral navy town into one of the most dynamic economies in the United States (Rey et al. 1998). Rapid growth and disparate levels of economic development have created tensions along the border, many of which center on environmental problems that transcend jurisdictional boundaries (U.S. EPA 1996; Schmidt 2000). In this tense atmosphere, a need exists for improved information on the environmental costs of economic growth. Environmental accounting

is one of the many tools available to increase understanding between the two countries.

Implementing an environmental accounting system in the border region raises particular methodological and data challenges. Despite these difficulties, environmental accounting is worth pursuing in this region-in-flux because it could lead to greater cooperation between the two countries in reaching agreements over which activities generate environmental costs, who pays to repair past damage and to prevent future damage to the environment, and, ultimately, how the benefits and costs of economic development along the border are shared. Once established, environmental accounts form the basis of environment-economy modeling aimed at predicting future pollution levels, resource losses, and the impact of given environmental and economic policies on economic output and infrastructure needs. These models rely on a computable general equilibrium framework. They can be developed using an extended social accounting matrix along with various assumptions about the way firms and individuals will behave to maximize profits and utility (see Dufournaud et al. 2000).

Research Objectives and Outline of the Paper

This research was guided by the following objectives:

1. Identify and describe key flaws in the United Nations' System of National Accounts (SNA), particularly ones that affect environmental and resource use.
2. Apply an environmental accounting framework to pilot studies in the San Diego–Tijuana region.
3. Discuss the problems encountered as well as the prospects for the establishment of an environmental accounting system for the entire border region, with emphasis on priority areas for future research.

The rest of this paper is divided into three sections. Section 1 shows how current economic accounts have five flaws that either create or reinforce economic incentives that lead to environmentally damaging development. Section 2 includes three case studies in regional environmental accounting from the San Diego–Tijuana region. Section 3 synthesizes some of the key results and methodological challenges found in the case studies.

Section 1: Incomplete Accounting—Environmental and Natural Resource Flaws in Traditional Economic Accounts

The GDP measures only goods and services exchanged on the market for money, and some have criticized its inadequacies and inconsistencies in this regard (Daly and Cobb 1989). The accounting system leaves many costs out, while other costs are counted as benefits. It also fails to value many nonmarket services that add to welfare. Each of these flaws either reinforces potentially destructive incentives already present in the market system or creates its own destructive incentive. Opschoor (1991, 40) identifies and summarizes the following five flaws in the GDP as a measure of current welfare:

Depreciation Asymmetry

The depreciation of natural resource capital (for example, replacement costs with respect to reductions in natural assets) is not incorporated, while the depreciation of reproducible capital is included in the calculation of the Net Domestic Product (NDP).

Example
Depreciation of reproducible capital equipment, such as machines that make automobiles, is subtracted from the GDP to estimate the NDP. Depreciation of natural resources, such as the harvesting of forests beyond a sustainable yield, is not taken into account. The examples and implications discussed below have been added to Opschoor's summary of the flaws to clarify the significance of each flaw.

Implications
GDP and NDP can increase while natural resource capital depreciates. Future economic welfare gains can diminish if natural resource shortages occur. This can cause considerable hardship for regions dependent on the sale of natural resource staples for their economic wealth. Many historical examples exist where regions and countries experienced a rapid decline in resource availability and a subsequent decline in their economic well-being (for example, in Newfoundland, Canada, the collapse of cod fishery put thousands out of work and cost governments billions in unemployment and social assistance).

Externalities Bias

The aggregation of contributions to the GDP through net value added in market price differs from the real net welfare contribution of a given activity. In other words, the activities of one economic agent (either a firm or a household) exert a cost on another agent, and this cost remains unpriced and uncompensated (Pearce and Turner 1990).

Example
A lead smelting factory emits air pollution that impairs the local air quality, harming the health of nearby residents. The residents have no say in the decision to emit pollution, yet they bear the cost of ill health. The market price for the product covers only the costs of the market inputs, that is, capital, labor, and materials. Health losses remain unpriced.

Implications
The GDP overvalues economic welfare gains and can encourage development that harms the environment (Tietenberg 1984). Specifically, when the price of a product is lower than it would be if external costs were included, the lower price encourages increased consumption of the product. Another problem relates to the disadvantage experienced by producers whose product is priced to reflect the total cost of production, including the external costs. In this way, the externalities bias works against production systems that take environmental costs into account.

Imputation Bias

Determinants of change in economic welfare other than those related to the net value added are ignored (for example, changes in unpriced flows and stocks such as most elements of environmental capital and the value of owner-used assets).

Example
The gradual depletion of groundwater supplies due to overuse by multiple users, which eventually results in water shortages and the need to seek a more expensive supply source.

Implications
The GDP overvalues economic welfare because changes in long-term environmental quality are not taken into account. This can slow economic development in the future as society allocates additional unproductive expenditures to compensate for the loss of environmental services.

Dimensional Bias

Not all activities and factors leading to welfare improvements are included. With few exceptions, the assessment is restricted to monetized sectors of the economy.

Example
Housekeeping and daycare services supplied by family members are excluded, while those supplied by private and public organizations are included.

Implications
The GDP underestimates economic activity and produces a bias in government policies and individual actions toward the use of services supplied in the market. This bias may encourage development policies that disrupt traditional economies in the developing world and, in the process, exert considerable social and environmental costs. The phenomenon can also make the comparison of the GDPs of industrialized countries to the GDPs of nonindustrialized countries misleading because nonindustrialized countries have larger nonmarket sectors (Kuznets 1953).

Output Anomaly

A variety of defensive expenditures undertaken by governments and households to prevent or abate the environmental damage caused by economic activities are counted as positive contributions to the GDP. This convention is both technically incorrect and misleading. First, it is technically incorrect because defensive expenditures represent the *cost* of defending the environment from damage caused by human economic activity. These expenditures should be excluded from the national accounts as are all other intermediate costs of production (for

example, pollution control expenditures by a private firm are excluded except for the value-added component). Second, it is misleading because it gives the impression that human welfare is improving when, in reality, scarce resources have been expended to maintain the status quo or slow the pace of degradation (for example, pollution control expenditures by a municipal government) (Jerrett 1999). These expenditures represent the costs, not the benefits, of economic activity and should not count as welfare gains (El Serafy and Lutz 1989; Hueting 1989; Leipert 1986). The GDP also fails to capture impacts on future welfare or losses of welfare potentials that accrue from activities that will make defensive expenditures necessary. This criticism applies mainly to expenditures made by government and households. Most of the defensive expenditures made by private firms are now treated as intermediate expenditures and are, therefore, excluded from the GDP.

Example

A pulp and paper mill directly controls pollution on-site and emits effluent to the local sewage treatment plant. In this instance, pollution control for the same plant is treated differently in the accounting system depending on whether a private or public entity makes the expenditures. In the case of the private expenditure, it is correctly excluded as an intermediate cost of production. Government expenditures on the sewage treatment plant are incorrectly counted as a positive contribution to the GDP.

Implications

These expenditures are interpreted as adding to welfare rather than to the costs of abating or preventing welfare losses. GDP increases when human activity causes environmental damage that prompts preventive or remedial action.

As Opschoor (1991) makes clear, the SNA suffers from many shortcomings in the measurement of human welfare. These deficiencies are particularly acute when accounting for environmental services and natural resources. Traditional SNA accounts, such as the GDP, measure monetary throughput in the economy with little differentiation between environmentally benign activities and those with harmful effects. Increases in economic welfare, as measured by the GDP, can mask larger decreases in social welfare. This is due to the social and ecological costs exerted by economic activities that remain outside the

statistical universe of the GDP. Likewise, governments often implement policies to improve environmental quality, leading to a smaller quantity of market goods and services, but also leading to improvements in environmental quality. The resulting "decrease" in economic welfare, as measured by the GDP, misrepresents increases in social welfare resulting from higher environmental quality (Hueting 1980). All of the flaws noted earlier can be incorporated into traditional measures of economic performance, and this task is pursued next.

Section 2: Applied Case Studies from the San Diego–Tijuana Border Region

This section of the report turns from the conceptual to the empirical with three case studies from the San Diego–Tijuana region. The first case study focuses on the defensive expenditures of municipal governments in San Diego County. The second compares the defensive expenditures made along the U.S.–Mexican border in a small subwatershed known as Goat Canyon–Cañón Los Laureles. The third involves an analysis of the changes in the natural capital stock due to agricultural land conversion over the 1990–1995 period.

The rapid population and economic growth in the San Diego–Tijuana region, particularly on the Tijuana side, makes it essential to complement traditional economic measures of success with environmental measures since failure to do so could result in key resource shortages that would limit future prosperity. On the San Diego side, the transition of the regional economy toward knowledge-based sectors increases the importance of the environmental amenities that contribute to a healthy lifestyle. Losses in environmental quality, if unchecked, could threaten the ability of the region to attract knowledge-based workers, who place a premium on the quality of the local physical environment.

Accounting for Local Defensive Expenditures in San Diego

The empirical analysis began with the following definition of defensive expenditures:

> Defensive expenditures comprise the actual environmental protection costs of preventing or neutralizing the adverse

> effects of environmental change thought to be caused by human activities and the actual expenditures needed to compensate for or repair the negative impacts human activities are thought to have exerted on the environment (cf. Heuting 1989; UN 1993; Jerrett 1999).

Specific criteria developed for identifying defensive expenditures has helped to operationalize this definition, including the following:

1. The expenditures must be avoidable (that is, not caused by natural baseline conditions such as climatic variation).
2. The expenditures are confined to those made to defend the biophysical environment, which is defined as water, air, land, buildings (and other physical capital attached to the land), plant and animal life (including humans), and any interrelationship between two or more of these elements.
3. Expenditures must be linked to the environmental damage caused by or reasonably suspected to be caused by human activities.
4. These expenditures include those made in response to first, second, and "n" party effects caused by human economic activities.
5. The original intention of these expenditures must have been to defend the environment.
6. The current intention of these expenditures must be to defend the environment.
7. The actual outcome of these expenditures is to defend the environment (Jerrett 1999, 119).

While these criteria still leave considerable room for interpretation, they allow for a traceable analysis. Capital was separated from operating expenditures to prevent periodic capital expenditures from dominating the results. In turn, these were disaggregated by environmental medium (that is, air, land, and water). In cases where information on specific expenditures was unavailable, the expenditures were excluded from the account. An example is police services. Police often respond to industrial accidents that can exert environmental effects. It is difficult to know the exact proportion of police expenditures that are defensive because it would require specific information on the number and severity of industrial accidents. This would also require detailed knowledge of how many officers and how much equipment responded

to each accident. Such a detailed accounting goes beyond the scope of this initial research and is therefore excluded from the defensive account. Thus, it is expected that future research will show these expenditures to be larger than initial estimates. This point is amplified by other problems experienced in data collection due to jurisdictional fragmentation and overlap.

Data for the 1995–1996 defensive expenditures account were drawn from a variety of public documents. The state controller's office (SCO) compiles an annual compendium of the expenditures made by all local governments in California (State of California 1997a, 1997b). This document provides data on the expenditures of lower-tier governments. Although useful, these data alone proved insufficient for the purpose of identifying all defensive expenditures for three reasons. First, some of the accounting categories grouped expenditures that were clearly defensive in nature with those that were not. Second, some categories lacked the detail necessary to assess whether defensive expenditures were contained in larger expenditure envelopes. Third, these data excluded expenditures made by the county government and numerous special purpose agencies that deliver water and sewer services. It is estimated that there are over 60 special purpose bodies involved in delivering water and/or sewer services. To overcome the limitations of the SCO's data, extensive field research was conducted on the individual budgets of each of the 18 municipalities, the county, and the special purpose agencies. This involved contacting officials at each jurisdiction and performing a line-item audit of each individual budget or annual report. Where information was not publicly available in budgetary documents, officials from the accounting or clerk's office were interviewed. In total, more than 60 officials were interviewed to clarify the specifics of their expenditures. The result of this process was an initial accounting of defensive expenditures both as they were presented in the SCO's report and in the individual budgets. Within each municipality, the figures derived from each method were compared to cross-validate the findings. While the exact same expenditures could not be compared due to differences in accounting conventions, specific municipalities were identified where the estimates showed significant differences between the SCO estimates and current field estimates. When the estimates differed by more than 25%, the individual budgets were reexamined to identify specific areas where further documentation may be required.

Results of the Defensive Expenditures Analysis

Table 1 shows the defensive expenditures accounting matrix for the city of San Diego. It provides a good example of the types of discrepancies found between the state controller's accounts and the accounts developed for this study that were based on individual municipal expenditure documents. The total defensive expenditure shown by the SCO is $676,728,777, while the total based on the municipal reports obtained directly from the city is $559,879,437 (variance of $116,849,340). On closer inspection, it is revealed that much of this discrepancy can be accounted for by different accounting conventions. The municipal reports include only expenditures for water treatment, but the SCO report includes expenditures for both water purchases and treatment. This amounted to a difference of about $182 million. Other differences were found in sewer, open space, and energy conservation expenditures, and these ran in the other direction, with the municipalities reporting higher expenditures than the SCO. Many such discrepancies and inconsistencies were found because their constituency's financial reporting requirements differ. Note in Table 1 how the defensive capital expenditures reported in various budgetary documents actually exceeds the summary total given in the city budget by about 5%. In general, it was found that SCO reports were more reliable sources for tracking capital expenditures than the budgetary documents from individual municipalities. The budgetary audits, alternatively, are more useful for operating expenditures, largely because of the level of detail available for identifying defensive expenditures. Given the variety of accounting measures, jurisdictional fragmentation, contracting out, and the possibility of lumpy capital expenditures inflating the totals, these estimates must be viewed as preliminary. Despite these potential limitations, these results still give

Table 1: City of San Diego Defensive Expenditures

City profile	Sources*
Population	1,179,400 (1)
Median Income	$40,837 (2)
Square area (miles)	342.4 (2)
Population density	3,445

*Sources: (1) State of California 1998; (2) SANDAG 1998.

Table 1–*Continued*

State Controller's annual report 1995–1996	Expenditures			
	Operational	Capital	TOTAL	Sources*
TOTAL expenditures	$964,128,867	$394,675,336	$1,358,804,203	(3)
Defensive expenditures				
Media group I: Land				
Solid waste	$60,840,432	$18,685,931	$79,526,363	(3)
Storm drains	$3,645,202	$0	$3,645,202	(4)
Storm damage	$0	$0	$0	(4)
Pedestrian/bike paths	$153,874	$0	$153,874	(4)
Subtotal	$64,639,508	$18,685,931	$83,325,439	
Media group II: Water				
Water	$155,092,287	$42,653,333	$197,745,620	(3)
Sewer	$135,036,994	$260,620,724	$395,657,718	(3)
Subtotal	$290,129,281	$303,274,057	$593,403,338	
Media group III: Air	$0	$0	$0	
Total defensive expenditures: State reports	$354,768,789	$321,959,988	$676,728,777	
Defensive total	37%	82%	50%	
Per capita defensive expenditures	$301	$273	$574	

*Sources (continued): (3) State of California 1997a; (4) State of California 1997b.

Table 1–*Continued*

Municipal reports	Expenditures			
	Operational	Capital	TOTAL	Sources*
TOTAL expenditures	$786,947,000	$326,797,000	$1,113,744,000	(5)
Defensive expenditures Media group I: Land				
Energy conservation (bus passes): General Fund	$442,000	$0	$442,000	(5)
Solid waste: General Fund (Envir. Svcs. dept.)	$25,781,000	$6,000	$25,787,000	(5), (6)
Solid waste: Enterprise Fund	$34,650,000	$18,685,931	$53,335,931	(5), (6), (3)
Open space and coastal: General Fund	$8,181,000	$23,275,000	$31,456,000	(5)
SD Open Space Debt & Servicing	$5,887,000	$376,000	$6,263,000	(5)
Environmental Growth Fund: Special Rev. Funds	$941,000	$93,000	$1,034,000	(5)
Storm drains	$3,645,202	$1,450,010	$5,095,212	(5), (6)
Pedestrian/bike paths	$221,065	$515,000	$736,065	(6)
Subtotal	$79,748,267	$44,400,941	$124,149,208	
Media group II: Water				
Sewer: Enterprise fund	$122,983,712	$297,497,000	$420,480,712	(5), (7)
<less: metropolitan expenses associated w/utility>	($61,741,222)	($4,868,151)	$0	(7)
Water treatment	$14,575,009	$674,508	$15,249,517	(8)
Subtotal	$75,817,499	$293,303,357	$435,730,229	
Media group III: Air	$0	$0	$0	
Total defensive expenditures: Municipal reports	$155,565,766	$337,704,298	$559,879,437	
Defensive total	20%	103%	50%	
Per capita defensive expenditures	$132	$286	$475	

*Sources (continued); (5) City of San Diego 1997; (6) City of San Diego 1996a; (7) City of San Diego 1996b; (8) City of San Diego 1996c.

a useful assessment of the likely magnitude of these expenditures as part of the regional economy and as a component of local government expenditures.

Table 2 shows the summary of the estimates for each municipality, for the county, and for the special districts. (Note: this table is an amalgamation of the SCO and municipal estimates; the operating expenditure estimates from the municipal reports and the capital expenditure estimates from the SCO have been used.) The findings indicate that these governments and agencies spent about $904 million on defending the environment from the adverse effects of human activity in 1995. Measured against the gross regional product (GRP) for the region calculated from the I-O model ($73.447 billion in 1995), this amounts to 1.23% of the total economy.

From the perspective of the public sector, the role of defensive expenditures is even more important, as defensive costs absorb about 21% of total local expenditures. This percentage varies considerably for local governments, ranging from 0% in Santee to 51% in Del Mar. An interesting question for future research is whether municipalities with either higher property tax takes or household incomes spend greater proportions of their budgets on defensive expenditures.

The results are sensitive to the assumptions made in accounting for water import expenditures. Residents of San Diego import much of their water. In particular, imports range from 0–100% of the total water supply, with a regionwide average of 74% (San Diego County Water Authority 1996). Some of the imported water arrives in San Diego in raw or untreated form, while a considerable portion of it arrives already treated. In cases where treatment has occurred outside the region, the price of water supply actually includes some defensive expenditures. Some of these expenditures are unavoidable given the semiarid climate of San Diego.

Table 3 shows the estimates sorted by environmental medium (that is, land, water, air). Water accounts for the largest proportion of the expenditures, with nearly 75% of the total. Land protection expenditures equal about 23%. Air protection expenditures account for only 1.5%, probably because much of the responsibility for abatement rests on the private sector and the federal government. State and federal agencies tend to take the lead on this issue as well.

Given the size of the water expenditures, it is important to resolve what portion of water import expenditures (if any) should count as

Table 2: Defensive Expenditures by Jurisdiction

Fiscal Year 1995–1996: Environmental Expenditures
San Diego County, California

	Total Expenditures			Environmental Expenditures			Environmental
Municipalities	Operating exp.	CIP*	Total	Operating exp.	CIP*	Total	as a % of total
Carlsbad	$76,023,694	$15,809,922	$91,833,616	$17,441,135	$2,559,768	$20,000,903	22%
Chula Vista	$107,153,026	$4,153,325	$111,306,351	$14,458,906	$149,418	$14,608,324	13%
Coronado	$22,168,856	$2,992,972	$25,161,828	$6,153,459	$407,489	$6,560,948	26%
Del Mar	$8,383,293	$3,183,334	$11,566,627	a	$1,625,078	$5,851,672	51%
El Cajon	$60,235,081	$2,310,193	$62,545,274	$12,486,768	$352,741	$12,839,509	21%
Encinitas	$28,189,854	$7,080,146	$35,270,000	$973,018	$0	$973,018	3%
Escondido	$73,593,865	$19,176,834	$92,770,699	$24,736,786	$6,501,401	$31,238,187	34%
Imperial Beach	$11,340,154	$596,658	$11,936,812	$4,039,433	$53,150	$4,092,583	34%
La Mesa	$36,678,978	$75,813	$36,754,791	$6,989,814	$0	$6,989,814	19%
Lemon Grove	$7,566,132	$1,837,671	$9,403,803	$3,033,574	$0	$3,033,574	32%
National City	$26,699,146	$3,521,555	$30,220,701	$6,169,955	$0	$6,169,955	20%
Oceanside	$225,545,783	$13,916,369	$239,462,152	$15,636,490	$0	$15,636,490	7%
Poway	$50,557,976	$155,041	$50,713,017	$15,233,668	$0	$15,233,668	30%
San Diego	$786,947,000	$394,675,336	$1,181,622,336	$155,973,199	$321,959,988	$477,933,187	40%
San Marcos	$18,121,124	$2,561,668	$20,682,792	$1,383,061	$0	$1,383,061	7%
Santee	$17,558,464	$3,429,866	$20,988,330	$0	$0	$0	0%
Solana Beach	$10,374,641	$912,255	$11,286,896	$2,735,744	$0	$2,735,744	24%
Vista	$35,984,336	$11,324,106	$47,308,442	$4,712,305	$1,203,637	$5,915,942	13%
Subtotal	$1,603,121,403	$487,713,064	$2,090,834,467	$296,383,909	$334,812,670	$631,196,579	30%
County	$1,996,722,036	$104,819,452	$2,101,541,488	$85,672,326	$4,448,842	$90,121,168	4%
Special Districts							
Air Pollution Control	$13,191,382	$609,955	$13,801,337	$13,191,382	$609,955	$13,801,337	100%
Drainage & Drain. Maintenance	$3,205	$0	$3,205	$3,205	$0	$3,205	100%
Flood Control & Water Conservation	$1,479,066	$0	$1,479,066	$1,479,066	$0	$1,479,066	100%
Resource Conservation Districts	$696,392	$3,993	$700,385	$696,392	$3,993	$700,385	100%
Pest Control	$34,212	$0	$34,212	$34,212	$0	$34,212	100%
Sewer	$65,274,820	$12,549,973	$77,824,793	$65,274,820	$12,549,973	$77,824,793	100%
Water (op. exp. = treatment only)	$6,735,354	$82,367,362	$89,102,716	$6,735,354	$82,367,362	$89,102,716	100%
Subtotal	$87,414,431	$95,531,283	$182,945,714	$87,414,431	$95,531,283	$182,945,714	
TOTAL	$3,687,257,870	$688,063,799	$4,375,321,669	$469,470,666	$434,792,795	$904,263,461	21%

*Capital Improvement Project(s)

Table 3: Defensive Expenditures by Media

Fiscal Year 1995–1996: Environmental Expenditures San Diego County, California							
	Total Expenditures			Environmental Expenditures			Environmental
Municipalities	Op. exp.	CIP	Total	Op. exp.	CIP	Total	as a % of total
Carlsbad	$76,023,694	$15,809,922	$91,833,616	$17,441,135	$2,559,768	$20,000,903	22%
Chula Vista	$107,153,026	$4,153,325	$111,306,351	$14,458,906	$149,418	$14,608,324	13%
Coronado	$22,168,856	$2,992,972	$25,161,828	$6,153,459	$407,489	$6,560,948	26%
Del Mar	$8,383,293	$3,183,334	$11,566,627	$4,226,594	$1,625,078	$5,851,672	51%
El Cajon	$60,235,081	$2,310,193	$62,545,274	$12,486,768	$352,741	$12,839,509	21%
Encinitas	$28,189,854	$7,080,146	$35,270,000	$973,018	$0	$973,018	3%
Escondido	$73,593,865	$19,176,834	$92,770,699	$24,736,786	$6,501,401	$31,238,187	34%
Imperial Beach	$11,340,154	$596,658	$11,936,812	$4,039,433	$53,150	$4,092,583	34%
La Mesa	$36,678,978	$75,813	$36,754,791	$6,989,814	$0	$6,989,814	19%
Lemon Grove	$7,566,132	$1,837,671	$9,403,803	$3,033,574	$0	$3,033,574	32%
National City	$26,699,146	$3,521,555	$30,220,701	$6,169,955	$0	$6,169,955	20%
Oceanside	$225,545,783	$13,916,369	$239,462,152	$15,636,490	$0	$15,636,490	7%
Poway	$50,557,976	$155,041	$50,713,017	$15,233,668	$0	$15,233,668	30%
San Diego	$786,947,000	$394,675,336	$1,181,622,336	$155,973,199	$321,959,988	$477,933,187	40%
San Marcos	$18,121,124	$2,561,668	$20,682,792	$1,383,061	$0	$1,383,061	7%
Santee	$17,558,464	$3,429,866	$20,988,330	$0	$0	$0	0%
Solana Beach	$10,374,641	$912,255	$11,286,896	$2,735,744	$0	$2,735,744	24%
Vista	$35,984,336	$11,324,106	$47,308,442	$4,712,305	$1,203,637	$5,915,942	13%
Subtotal	$1,603,121,403	$487,713,064	$2,090,834,467	$296,383,909	$334,812,670	$631,196,579	30%
County	$1,996,722,036	$104,819,452	$2,101,541,488	$85,672,326	$4,448,842	$90,121,168	4%
Special Districts							
Air Pollution Control	$13,191,382	$609,955	$13,801,337	$13,191,382	$609,955	$13,801,337	100%
Drainage & Drain. Maintenance	$3,205	$0	$3,205	$3,205	$0	$3,205	100%
Flood Control & Water Conservation	$1,479,066	$0	$1,479,066	$1,479,066	$0	$1,479,066	100%
Resource Conservation Districts	$696,392	$3,993	$700,385	$696,392	$3,993	$700,385	100%
Pest Control	$34,212	$0	$34,212	$34,212	$0	$34,212	100%
Sewer	$65,274,820	$12,549,973	$77,824,793	$65,274,820	$12,549,973	$77,824,793	100%
Water (op. exp. = treatment only)	$6,735,354	$82,367,362	$89,102,716	$6,735,354	$82,367,362	$89,102,716	100%
Subtotal	$87,414,431	$95,531,283	$182,945,714	$87,414,431	$95,531,283	$182,945,714	
TOTAL	$3,687,257,870	$688,063,799	$4,375,321,669	$469,470,666	$434,792,795	$904,263,461	21%

defensive. While it was not possible to address this issue, some possible options for sensitivity analysis are offered. One option is to remove water expenditures entirely on the grounds that the imports are unavoidable and, therefore, do not constitute a defensive expenditure. This represents the easiest solution from an accounting perspective, yet, it fails to address important substantive questions. For example, does San Diego waste water when compared to other economically developed regions in similar climates? If the answer is yes, then some component of the water expenditures could be considered avoidable and should thus be counted as defensive. Comparing Tucson (Arizona Department of Water Resources 2000) and San Diego, the data show that San Diego actually uses less water per capita than this near neighbor (230 cubic meters per person per year compared to 250 cubic meters per person per year for Tucson). What about international comparisons? The World Resources Institute's annual compendium of environmental data (WRI 1998) shows rough international comparisons for domestic water use. San Diego uses approximately 153 cubic meters per capita per year. Other economically developed countries such as France use 106, while Germany uses 46. For climatic comparisons, Spain uses 94, Greece 42, and Israel 65. These figures suggest San Diego could survive and prosper on far less water than it currently consumes. It appears that at least some portion of these expenditures should count as defensive. This is an important area for future research given the magnitude of these expenditures. This report has begun this task, including Appendix A, which conveys some of the challenges involved when the jurisdictional overlaps combine with the determination of avoidable expenditures.

Defensive Expenditures in the Goat Canyon–Cañón Los Laureles Subwatershed

By comparing the defensive expenditures of San Diego and Tijuana, the focus becomes the question of relative environmental priorities on each side of the border. This case study also illustrates the complexities involved in binational environmental accounting. Data were collected between January and June 1998 by personal interviews with agency officials in Mexico and the United States. More than 30 agencies were found with partial responsibility for some aspect of environmental protection in one small subwatershed that straddles the border.

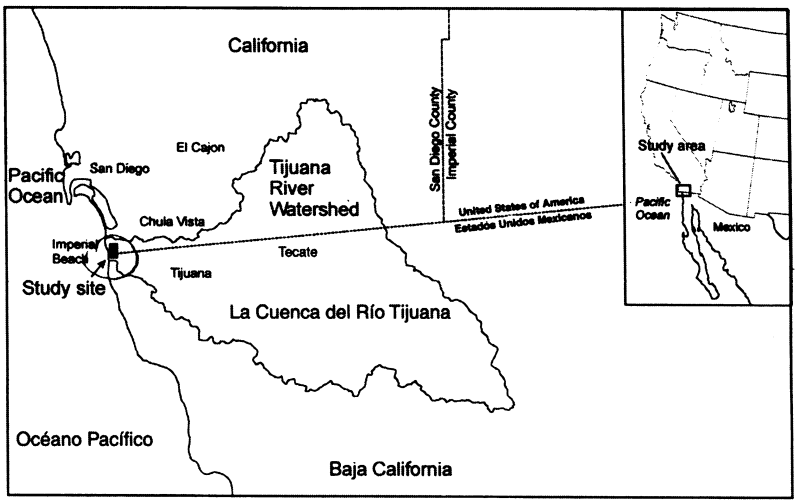
Before exploring the expenditures, a brief site description is provided to accent the environmental challenges faced in this area.

Site Description

Goat Canyon–Cañón Los Laureles is the southwesternmost part of the Tijuana River Watershed (Figure 1). The subwatershed measures approximately 4.6 square miles, 90% of which occurs in Mexico. Steep, rugged slopes, sandy soils with cobbles, small communities of coastal sage scrub and riparian vegetation, as well as a high level of human-induced disturbance characterize this subwatershed. Extreme variability of rainfall occurs on a storm-to-storm basis as well as an annual basis, meaning that the area experiences some very dry years and some very wet years. Furthermore, even in dry years, rainfall events are often extremely intense. As a result, considerable variability exists in annual flow, flood peaks, and sediment discharge into the Tijuana River and the Tijuana River Estuary.

Official development in Cañón Los Laureles occurred generally in the late 1960s when Laureles Creek was channelized (Rentería 1998). Dwellings constructed adjacent to the concrete channel at the bottom of Cañón Los Laureles have access to municipal services such as run-

Figure 1: Goat Canyon–Cañón Los Laureles



ning water, electricity, and sewage treatment. However, rapid population growth in the past two decades has resulted in squatter developments on the steep hillsides due to a lack of affordable housing in Tijuana, a pattern observed in many developing countries (Batterbury et al. 1997). Squatter housing generally consists of simple, self-constructed dwellings lacking basic sewage facilities. Landslides often occur during heavy rains, resulting in the loss of life and home. Furthermore, uncontrolled development on the hillsides, runoff from developed areas at the top of the mesa, dirt roads, and the nature of the soil all contribute to high rates of erosion and sedimentation. During storm events, debris and sediments often fill the concrete channel and clog the culverts. Moreover, the sewage collector and pump station at the basin of Cañón Los Laureles fill with sediments during storms and become inoperable. Therefore, to prevent damage to the collector and pump station, the facilities are shut down during heavy storms and sewage flow is diverted directly into Laureles Creek.

In the lower 10% of the watershed located in the United States, human-induced land alteration has also exacerbated the sedimentation process. Historically, the terraces at the crest of Goat Canyon and much of the estuary further inland were used for farming until approximately 1979. Natural regrowth of the vegetation has not occurred along the terraces because the land is scraped yearly to minimize coverage for undocumented immigrants attempting to cross the border. The U.S. Border Patrol also forges dirt roads along the border that have become default creek beds during rainfall events. In 1994, the U.S. governement's Operation Gatekeeper resulted in an increased number of Border Patrol agents in the area and an increased number of newly graded roads used by the agents. These roads serve as water conduits carrying sediment-laden flows out toward functional marsh areas within the Tijuana Estuary. Other land uses on the U.S. side of the border include a "worm farm," which functions as a solid waste dump site, located northeast of the estuary, and Border Field State Park, which is located south of the estuary.

Results of the Goat Canyon–Cañón Los Laureles Analysis

Tables 4a and 4b show the expenditures for this watershed on both sides of the border. The table also shows that approximately $2.6 million in defensive expenditures were spent on the Mexican side, with about $2.2 million in capital expenditures and $0.4 million in operat-

Table 4a: Defensive Expenditures in Goat Canyon–Cañón Los Laureles (1993–1998), Mexico

Identified Expenditures	Agency and Contact, Mexico*	Operating ($)	Capital ($)	Total ($)	Notes
Emergency road repair and cleanup	1	7,500	60,000	67,500	Intendente de Conservación #80-10-40
Pump station construction	2		582,209	582,209	
Annual pump station operating costs	2	111,000		111,000	
Plans, reviews, and meetings for the pump station	2	30,000		30,000	
Potable water plans in Laureles Projected costs for potable water project	2 2	3,000	 281,260	3,000 281,260	
Road repair and maintenance	3	49,021		49,021	Money spent from 2/9/98 to 3/6/98 in Laureles
Road repair and maintenance	3	125,000		125,000	Normal year annual budget for entire Playas Delegación
Disaster planning, erosion prevention education, emergency response, road repair	4	18,750		18,750	Annual budget, normal year. These actions are funded. L.C. 50% fed., 25% state, 25% mun.
Emergency event costs for cleanup in Laureles flood situations	4	29,820		29,820	Money spent from 2/10/98 to 3/9/98
Trash collection and debris cleanup in unincorporated areas	4	375		375	
Relocation of irregular canyon residents, funding	5			0	Planning dept. offered no information
Maintenance and cleaning of Laureles basin channel	6	9,375		9,375	Normal rainfall year
Maintenance and cleaning of Laureles basin channel	6	18,750		18,750	El Niño year/money spent from 1/98 to 3/98
Emergency planning	6	1,250		1,250	
Flood channel construction	6		1,250,000	1,250,000	Original figure was 9,660,000 pesos in 1993 (3p/$1).
Emergency response	6	297		297	
Total		404,138	2,173,469	2,577,607	

*Agency and contact, Mexico: 1. Caminos y Puentes, César Cáceres; 2. CESPT, Juan Arellano Leyva; 3. Municipio Playas de Tijuana, Delegado Alberto Almeca; 4. Tiuana Municipio Contr & Maint. of Public Works, María Egurrola R. and Elena Vásquez; 5. Planning Dept., no contact willing to help; 6. UMU, Luis Rentería.

ing costs. Most of the expenditures made in Mexico focused on protecting human health and safety. This priority was confirmed in numerous interviews with officials on the Mexican side (Rentería 1998). U.S. expenditures total about $2.4 million for the comparable period. Capital expenditures account for about $1.5 million and oper-

Table 4b: Defensive Expenditures in Goat Canyon–Cañón Los Laureles (1993–1998), United States

Identified Expenditures	Agency and Contact, U.S.*	Operating ($)	Capital ($)	Total ($)	Notes
Land-use planning, enviromental assessments, attending meetings for Goat Canyon (G.C.)/road maintenance	1	1,373		1,373	8–10 hrs. a month of Forsythe's time on G.C. issues/2 maint. ppl., 2 days per quarter, $14.83/hr
Grant to coastal conservancy	2			0	
Analysis for restoration of wetlands Jim King's time/money used in G.C. effort	3		1,000,000	1,000,000	350 acres south of the Tijuana river/ 50% of his time spent on G.C./Restoration of 20 acres
G.C. sedimentation study	4	15,000		15,000	
Stormwater pollution prevention plan	4	60,000		60,000	
Monument road repair	5	200,000		200,000	Unverified in budgetary documents
G.C. diversion	6		500,000	500,000	
G.C. diversion	6	500,000		500,000	
Operations and maintenance of G.C. diversion	6	30,000		30,000	
Road maintenance/public works	7	50,400		50,400	14 laborers, $15/hr, 20 days, 8 hrs/day + $15,800 for equipment
Meeting cost to decide not focus on G.C.	8	100		100	
Permit application/cost for G.C. diversion	8	160		160	
Attendance of NRDC attorney to G.C. meetings	9	36,526		36,526	Cost of meeting attendance
Restoration of channel	10		30,000	30,000	
Total (note: operating expenses for 1998 and capital for the 1993–1998 period)		893,559	1,530,000	2,423,559	

*Agency and contact, U.S.: 1. Border Patrol, Arnie Forsythe; 2. EPA, Jim King; 3. Coastal Cons./NOAA, Jim King; 4 MWWD, Rolf Lee; 5. NOAA, Tessa Roper; 6. IBWC, Charles Fischer; 7. City of SD, Don Bender; 8. Army Corps. Engineers; 9. NRDC, Jason Jackson; 10. USF&W, J. D. Young.

ating for $0.9 million. On the U.S. side, these expenditures tended to go toward preserving the Tijuana Estuary, although some expenditures were made to combat transboundary environmental health problems. Interestingly, both countries spend about the same amount on defensive expenditures. Relative to the size of each country's regional economy and government expenditures, Mexico actually spends more proportionately, although this conclusion must be tempered with the recognition that 90% of the watershed lies within Mexico.

The sheer number of agencies involved and the differing priorities between the two countries underscore the difficulties faced in estimating expenditures that, due to their environmental nature, transcend human administrative and political boundaries. The results here may appear sparse, but it must be emphasized that these estimates took a team of four people working twenty hours per week over six months to produce. Deriving estimates for the entire border economy would take much longer and may involve even more complexities as state-to-state differences would also become important.

Agricultural Land-Use Changes: Stock Accounting and Valuation

Data for this component of the analysis were drawn from the vegetation Geographic Information Systems (GIS) coverage provided by the San Diego Association of Governments (SANDAG 1999) and from various government reports on agricultural output. The latest years available were 1990–1995. These years corresponded to a lower rate of economic growth than the region currently experiences and, as a result, it is important to emphasize that a more recent accounting would probably show a different trend (that is, it is likely that the magnitude of land-use change would be greater). The Holland Classification System was used to assess land-use changes from 1990–1995. This system uses codes to classify different vegetative covers and land uses. For example, codes for agricultural land use range from 18,000 to 18,320. The intent is to provide an assessment of the direct monetary costs associated with agricultural land-use change. Agricultural lands may possess other aesthetic and habitat values that remain outside the realm of the study's monetary valuation, which is based solely on the market value of output produced on the land. These estimates, therefore, should be viewed as conservative.

For the purpose of this initial study, the vegetative coverages provided by SANDAG for the county of San Diego were used with no major edits or modifications. This means that calculations exclude lands within the city of Carlsbad. Data for Carlsbad were obtained, but this data did not include an accounting of land-use change between 1990–1995 and therefore had to be excluded from the analysis. Further, some areas that are considered important parts of the vegetative system for the multiple species preservation system yet lie

slightly outside the county's legal boundaries are included in the analysis. Agricultural preserves and a few areas where data are incomplete in the east county are also excluded from the estimates. Although these estimates will be refined in future research, it is not expected that such minor changes in land-use coverage will change the results significantly. Calculation of areas and other geographic manipulations of the data were performed using ArcView 3.2, a desktop geographic information system (GIS).

Results of the Land-Use and Valuation Analysis

Table 5 shows the initial stock of agricultural land in 1990 and the stock in 1995. The analysis shows that San Diego County experienced a net increase in its agricultural lands during this period. This increase amounts to approximately 2,306 acres between 1990–1995. This left the county with approximately 161,169.5 acres of agricultural land. In total, 3,366.5 acres were converted from other land uses/vegetative covers to agriculture. Yet, about 1,044.2 acres of agricultural land were converted to urban land. This amounts to about 12% of the 7,974.9 acres of land converted to urban land use from other land categories. A small remaining portion of about 15.8 acres was converted from agriculture to other uses.

Valuation of Changes in Resource Stock

Accounting for resource losses usually begins with an assessment of changes in the physical stock. As noted previously, San Diego experienced a net gain in agricultural land, but it also lost 1,060 acres of this land to urban and other uses. To assess the monetary value of these gains and losses, a crop output value per acre has been devised. Appen-

Table 5: Stock Accounting of Agricultural Land Conversions

Land Use	Acres
Agricultural land in 1995	161,169.49
Agricultural land in 1990	158,863.12
Difference 1995–1990	2,306.37
Other land to agriculture	3,366.46
Agriculture to all other uses	1,060.10
Agricultural to urban	1,044.25
Agriculture to other	15.85
All uses to urban 1990–1995	7,974.93

Note: Excludes Carlsbad

dix B shows the detailed accounting of agricultural output in San Diego County, and the last section of this appendix gives summaries of the dollar value per acre based on different crops. On average, each acre produced $6,072. The highest valued crop was produced in nurseries, and these uses were valued at $78,794 per acre. The lowest valued output came from field crops at $61 per acre. To assess the potential losses and gains of agricultural land conversion, each of these values was used to calculate the average, maximum, and minimum dollars of output per acre. There is some controversy in the environmental accounting literature about how to treat losses and gains. Repetto et al. (1989) suggests that only net changes should be taken into account, and these should be valued at market prices (which in efficient markets represent net prices, where the price is the total discounted present value of the resource). Others, however, have suggested that this method may undervalue resource losses (Daly and Cobb 1989; Hamilton 1991), because some resources are available in finite supply and are therefore irreplaceable. Agricultural land falls into this category. Once converted to urban or industrial uses from agricultural uses, it is unlikely that such lands will produce food again. The practical difference such assumptions make to valuation is considerable. Table 6, shows that simply accounting for the gains in agricultural lands results in an increase of about $14 million per year using the average value of all crops. The estimate ranges from a maximum of more than $181 million to a minimum of about $141,000.

If the alternate assumption is made that a land converted from agricultural to urban or other uses will never again produce food, those losses must be valued accordingly. In this case, it results in an annual loss of about $6.4 million using the average crop value. The sensitivity analysis shows the estimate ranges from over $83 million to about $65,000. Here, though, the loss of the revenue stream over the very long-run must be accounted for. Three discount rates were chosen to test various assumptions about the value of this resource. The first, a zero discount rate, suggests that the special value of agricultural resources should not be discounted in the future. This would agree with the concept of "strong sustainability" where resource allocations are considered sustainable only if a constant stock of resources is left for future generations (Daly and Cobb 1989). The other discount rates represent the approximate inflation level prevailing at the time of estimation (2%) and the long-term borrowing rate (5%), both of which

could represent reasonable discount rates based on market indicators. Applying discount rates to derive a present value estimate for the loss of agricultural lands is achieved by the following formula:
where, V_o is the net present value of the resource; p_t q_t the future income flow produced by the asset being valued (p_t is the unit net price and q_t the quantity produced); T the time the asset would last; and the income flow is discounted at rate r, which is usually assumed

$$V_o = \sum_{t=0}^{t=T} \frac{p_t q_t}{(1 + r)^t}$$

to be constant over time (Gervais 1990). If the conservative assumption is made that, in spite of technological innovations, the agricultural output will remain roughly the same for each acre lost, then the present value can be derived based on the annual losses shown previously. For each of these, Table 6 shows the total present value. Based on the assumption that agricultural lands lost to urban development are irreplaceable assets, a valuation was performed based on a very long-term (200-year) horizon. At a zero discount rate and the average output per acre, the total losses are nearly $1.3 billion for a five-year period, or about $260 million per year. The high end of the range reaches about $16.7 billion, while the lower end drops to about $13 million. The discount rate can have a dramatic impact on the results. Using the 5% rate cuts the average costs to about $129 million, while the upper end of the range drops to about $1.7 billion and the bottom end to a meager $1.3 million. Using the average price estimate for agricultural output and discount rates ranging from 0–5%, the present value of the losses ranges from 0.18% to 1.8% of the total economy.

Present value calculations for the agricultural land gains have not been performed for two reasons. First, these lands will produce output for some time, but it is uncertain whether they too will be converted to urban uses. Predicting the time frame for this would prove difficult if not impossible. Second, these lands have not experienced a one-time conversion that will render them incompatible for other productive uses in the same way as agricultural lands lost to urbanization. Because of its less intrusive nature than urban settlement, lands converted from, say, forests to agricultural land can be converted back again to this use. In fact, given a reasonable amount of time, agricultural lands can return to many other uses, while this is probably not the case when urban areas take agricultural lands. Thus, the gains have only been val-

Table 6: Market Value of Output from Agricultural Land Losses

Annual Losses and Gains Due to Land-Use Conversions in 1995 Dollars							
Losses and Gains in Acres		1995 Market Prices in Dollars			Losses of Agricultural Conversion Based on 1995 Market Values		
	Acres	Average	Max.	Min.	Average	Max.	Min.
Change 1990–1995 (Ag to Urb)	-1,060.00	6,065.20	78,793.67	61.35	-6,436,320.00	-83,521,295.11	-65,036.14
Gains of Agricultural Conversion based on 1995 Market Values							
Change 1990–1995 (Oth to Ag)	2,306.00	6,065.20	78,793.67	61.35	14,002,032.00	181,698,213.70	141,484.28
Net Present Value of Agricultural Land Losses							
					Average	Max.	Min.
Net Present Value @ 0% discount rate					-1,285,821,389.49	-16,704,259,021.44	-13,007,227.62
Net Present Value @ 2% discount rate					-321,759,733.43	-4,180,019,070.94	-3,254,886.04
Net Present Value @ 5% discount rate					-135,003,810.21	-1,753,850,599.41	-1,365,683.68

ued at current market prices. This analysis shows that the gross gains range from about $141,000 to $182 million. Net gains (gains minus losses) at market prices translate into about $76,000 to $98 million. Comparing net gains to present value losses produces net losses that range from about $13 million to $16.5 billion. Dividing these estimates by five gives a rough approximation of the annual cost of the losses for the period 1990–1995. At the lower end, the estimates amount to not much more than a rounding error on the GRP. At the upper end, the value of $3.3 billion amounts to nearly 4.5% of the GRP. This comparison underscores how sensitive the valuation methods are to alternative assumptions.

Section 3: Discussion and Conclusion—Prospects for Border Environmental Accounting

In this paper, the rationale for environmental accounting has been reviewed and three case studies from the San Diego–Tijuana region have been presented. The case studies illustrate the potential for environmental accounting along the U.S.–Mexican border. A number of key points arise from these studies. First, environmental costs, measured as defensive expenditures, represent a significant portion of the regional economy and total government expenditures. The size of these costs merits serious consideration in planning future development and in adjusting the calculation of the GRP. Second, the two countries have different environmental priorities, and any successful accounting system must accommodate these differences. Third, the data collection needs for implementing these accounts are labor intensive and time consuming because of the myriad of agencies involved on both sides of the border. Fourth, the valuation results are extremely sensitive to alternative assumptions. This creates a need to establish overarching accounting guidelines for implementing these accounts. It also suggests that all valuations should include sensitivity analyses to ensure decision makers are aware of the potential variation in valuation estimates. Finally, environmental accounts, such as the agricultural land account, can do much to inform current policy debates. For example, few policymakers are probably aware that the total quantity of agricultural land has increased in the county. Yet, it is shown that fairly significant economic costs are associated with the conversion of

agricultural lands to urban uses. It is also noted that, contrary to popular belief, Mexico makes significant expenditures to defend environmental quality, but the priorities of these expenditures differ from those made in the United States.

Much work remains to be done in refining the accounting parameters and assembling the data necessary to implement these accounts along the border. Given the resource commitment involved in such an enterprise, it must be considered whether the investment is outweighed by the benefits. The author would argue the benefits do outweigh the costs. Once established, environmental accounts can be used as a basis for "what if" scenarios that investigate the environmental and economic consequences of alternative development scenarios. More importantly in the short term, environmental accounting can improve relations between the United States and Mexico by reducing the rhetoric and focusing the debate on the facts.

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Appendix A: Water and Sewer Services in San Diego County: Jurisdictional Fragmentation

Providers of Water Only	Providers of Water and Sewer Services	Providers of Sewer Only
County Water Authority	County Water Authority	City of San Diego Metropolitan Wastewater
Helix Water District	Carlsbad Metropolitan Water District	City of Chula Vista
Olivenhain Metropolitan Water District	Fallbrook Public Utility District	City of Coronado
Rincon Del Diablo Metropolitan Water District	Otay Water District	City of El Cajon
City of San Diego	Padre Dam Metropolitan Water District	City of Imperial Beach
San Dieguito Water District	Rainbow Metropolitan Water District	City of La Mesa
Santa Fe Irrigation District	Ramona Metropolitan Water District	City of Lemon Grove
South Bay Irrigation District	Vallecitos Water District	City of National City
Vista Irrigation District	Valley Center Metropolitan Water District	City of San Diego
Yuima Metropolitan Water District	City of Del Mar	San Elijo Joint Powers Authority
Special Districts	City of Escondido	Cardiff Sanitation District
Canebrake County Water District	City of National City	City of Solana Beach
Cuyamaca Water District	City of Oceanside	County of San Diego Special Districts
Descanso Community Service District	City of Poway	Alpine Sanitation District
Jacumba Community Service District	Special Districts	4-S Ranch Sanitation District
Julian Community Service District	Borrego Springs Park Community Service District	Julian Sanitation District
Majestic Pines Community Service District	Borrego Water District	Lakeside Sanitation District
Pauma Metropolitan Water District	Lakeside Water District	Pine Valley Sanitation District
Questhaven Metropolitan Water District		Spring Valley Sanitation District
Riverview Water District		Wintergardens Maintenance
San Luis Rey Metropolitan Water District		Encina Wastewater Authority
Sweetwater Authority		City of Carlsbad
Tia Juana Valley County Water District		City of Encinitas
Wynola Water District		City of Vista
		Buena Sanitation District
		Leucadia County Water District
		Special Districts
		Encinitas Sanitary District
		Fairbanks Ranch Community Service District
		Lemon Grove Sanitation District
		Pauma Valley Community Service District
		Rancho Cielo Sanitation District
		Rancho Santa Fe Community Service District
		Whispering Palms Community Service District

Appendix B: Agricultural Output of San Diego County

Nursery Products						
Product	Acres	Quantity	Units	Total	Val/Unit	Val/Acre
Citrus, Subtropical Fruit Trees	202	488,975	Plants	8,250,000	16.87	40,842
Ornamental Trees & Shrubs	1,969	51,365,127	Plants	114,325,458	2.23	58,063
Bedding Plants & Turf	894			113,312,214		126,747
Herbaceous Perennials	128			8,120,058		63,438
Cactus and Succulents	179			17,987,400		100,488
Bulbs,Corms, Rhizomes, Roots, Tubers	195	39,258,254	Bulbs	2,258,456	0.06	11,582
Total Carnations	84			5,578,527		66,411
Carnations, Standard	43	31,857,586	Blooms	4,158,201	0.13	96,702
Carnations, Mini	41	1,124,001	Bunches	1,420,326	1.26	34,642
Roses	49	27,445,369	Blooms	8,280,006	0.30	168,980
Proteas	485	3,125,002	Blooms	3,425,231	1.10	7,062
Leptospermium	350	1,854,126	Bunches	1,945,256	1.05	5,558
Waxflower	630	2,758,458	Bunches	3,780,451	1.37	6,001
Christmas Trees (Cut)	325			2,701,985		8,314
Indoor Decoratives	490			254,458,127		519,302
Poinsettia	78	3,258,058	Plants	11,458,589	3.52	146,905
All Other	2,105			87,311,008		41,478
Total Nursery Products	8,163			643,192,766		78,794

Vegetable Crops						
Crop	Acres	Tons/Acre	Tons	US$/Ton	Total	Val/Acre
Beans, Snap	214	4.35	931	1,308	1,217,617	5,690
Bunch Vegetables	405				1,821,318	4,497
Cabbage	44	15.2	669	216	144,461	3,283
Cauliflower	5	7.86	39	619	24,327	4,865
Corn, Sweet	318	6.94	2,207	436	962,217	3,026
Total Cucumbers	990		16,032		5,711,781	5,769
Cucumbers, Field	983	15.95	15,679	321	5,032,911	5,120
Cucumbers, Hot House	7	50.38	353	1,925	678,871	96,982
Herbs	508	10.15	5,156	3,741	19,289,344	37,971
Mushrooms	21	201	4,221	2,625	11,080,125	527,625
Peppers, Bell	933	14.31	13,351	341	4,552,769	4,880
Peppers, Chili	53	12.68	672	1,399	940,184	17,739
Potatoes	1,007	18.92	19,052	162	3,086,495	3,065
Squash	302	11.25	3,398	420	1,426,950	4,725
Tomatoes, Total	2,436				14,619,031	6,001
Tomatoes, Fresh	2,296	19.05	43,739	301	13,165,379	5,734
Tomatoes, Cherry	140	17.81	2,493	583	1,453,652	10,383
Misc. Vegetables	879				16,852,957	19,173
Total Vegetables	8,115				81,729,577	10,071

Fruit & Nut Crops						
Crop	Acres	Tons/Acre	Tons	US$/Ton	Total	Val/Acre
Apples, Total	625	0	1,544		741,806	1,187
Apples, Fresh	625	1.45	906	687	622,594	996
Apples, Cider		1.02	638	187	119,213	
Avocados, Total	26,613		61,094		104,502,732	3,927
Avocados, Hass	23,427	2.29	53,648	1,819	97,585,403	4,166
Avocados, Fuerte	1,540	1.65	2,541	1,039	2,640,099	1,714
Avocados, Other	1,646	2.98	4,905	872	4,277,230	2,599
Citrus, Total	17,592				99,656,320	5,665
Grapefruit, Total	3,441	21.02	72,330		17,835,529	5,183
Grapefruit, Fresh Market	3,441	16.46	56,639	298	16,878,380	4,905
Grapefruit, By Product		4.56	15,691	61	957,149	
Kumquats	153	3.54	542	1,232	667,276	4,361
Lemons, Total	3,280	20.68	67,830		30,937,452	9,432
Lemons, Fresh Market	3,280	16.25	53,300	545	29,048,500	8,856
Lemons, By Product		4.43	14,530	130	1,888,952	
Limes, Total	798	9.7	7,741		1,773,794	2,223
Limes, Fresh Market	798	6.25	4,988	301	1,501,238	1,881
Limes, By Product		3.45	2,753	99	272,557	
Oranges, Navel, Total	1,497	13.53	20,254		7,541,018	5,037

Fruit & Nut Crops *(continued)*						
Oranges, Navel, Fresh Market	1,497	11.34	16,976	411	6,977,128	4,661
Oranges, Navel, By Product		2.19	3,278	172	563,890	
Oranges, Valencia, Total	7,425	17.25	128,081		35,720,933	4,811
Oranges, Valencia, Fresh	7,425	14.87	110,410	292	32,239,647	4,342
Market						
Oranges, Valencia, By Product		2.38	17,672	197	3,481,286	
Tangerines, Tangelos, Total	998	13.75	13,723		5,180,319	5,191
Tangerines, Tangelos, Fresh	998	10.6	10,579	457	4,834,512	4,844
Market						
Tangerines, Tangelos, By Product		3.15	3,144	110	345,807	
Grapes, Wine	187	2.85	533	220	117,249	627
Macadamia Nuts	250	1.21	303	2,586	782,265	3,129
Misc. Fruits & Nuts	825				1,821,417	2,208
Persimmons	495	5.97	2,955	665	1,965,175	3,970
Strawberries, Total	500		11,580		11,062,030	22,124
Strawberries, Fresh	500	16.15	8,075	1,083	8,745,225	17,490
Strawberries, Processing		7.01	3,505	661	2,316,805	
Total Fruit & Nut Crops	47,087				220,648,993	4,686

Field Crops						
Crop	Acres	Tons/Acre	Ton	US$/Ton	Total	Val/Acre
Barley (Grain)	2,100	1.42	2,982	103.85	309,681	147
Greenchop	129	23.25	2,999	21.45	64,334	499
Hay, Grain	6,400	1.93	12,352	81.54	1,007,182	157
Pasture, Irrigated	2,800			1,500.00	4,200,000	1,500
Range	95,000			4.85	460,750	5
Silage	35	15.9	557	24.26	13,501	386
Wheat	3,000	1.99	5,970	110.67	660,700	220
Total Field Crops	109,464				6,716,147	61

Apiary Products						
Item	Total					
Honey	1,001,259					
Bees Wax	19,001					
Bees and Queens	85,200					
Pollen	42,537					
Pollination	3,500					
Total Apiary	1,151,497					

Livestock & Poultry						
Item	# of Head	Total	Val/Head			
Cattle and Calves	29,850	13,432,500	450.00			
Hogs and Pigs	1,620	194,400	120.00			
Chickens, Misc. Meat	2006,101	577,757	0.29			
Rabbits	42,650	147,143	3.45			
Sheep	710	48,280	68.00			
Total Livestock and Poultry	2080,931	14,400,080	6.92			

Livestock & Poultry Products						
Item	# dozens	Wgt cwt	PerUn cwt	Total		
Milk, Market		1,567,386	12.17	19,075,088		
Milk, Manufacturing		138,411	11.93	1,651,243		
Eggs, Chicken, Market	100,258,459			60,155,075		
Total Livestock & Poultry				80,881,406		
Products						

Specialty Crops						
Item	Total					
Timber	87,658					
Firewood	585,000					
Total Timber Products	672,658					

Summary						
Products	Acres			Value		Val/Acre
Nursery Products & Flower Crops	8,163			643,192,766		78,794
Fruit & Nut Crops	47,087			220,648,993		4,686
Livestock & Poultry Products				80,881,406		
Vegetable Crops	8,115			81,729,577		10,071
Livestock & Poultry				14,400,080		
Field Crops	109,464			6,716,147		61
Specialty Crops				672,658		
Total	172,829			1,048,241,627		6,065.195

Source: Adapted from the 1995 Crop Statistics & Annual Report

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VI

A Verification and Meta-Analysis of Past Border Environmental Infrastructure Needs Assessments

D. Rick Van Schoik

Executive Summary

Drinking water, wastewater treatment, and solid and hazardous waste disposal needs of the current border population exceed the existing environmental infrastructure on both sides of the U.S.–Mexican border. Given the population projections for the area, water and wastewater system construction, improvements, extensions, maintenance, and upgrades suggest an even greater disparity in the future. Inadequate border environmental infrastructure is one cause of environmental degradation and a key focus for sustainable economic development.

This paper attempts to verify past needs assessments and to establish a credible estimate of current costs, future needs and costs, and risks if investment is not made in the binational region. The metaestimation was conducted in three phases. First, past environmental infrastructure needs surveys were collected and their results were collated, compared, and contrasted. Second, an independent questionnaire was sent to environmental infrastructure owners and operators to determine current and projected needs. Finally, the first set of surveys was analyzed with an intent to determine a credible cost estimate, validated by the needs sensed in the questionnaire.

The limitations of this study include time constraints and communities studied. The study examined U.S. needs only and is complemented by a study conducted of Mexican border communities.

Both quantitative and qualitative information was provided in the returned questionnaires and interviews. A summary of anecdotal information presents a mixed picture of the communities' abilities to address current and future needs.

Generally, wastewater system need was greater or more expensive than potable water need, which was greater or more expensive than solid and/or hazardous waste need. Solid and hazardous waste need was greater in Mexico than in the United States in all studies.

The savings afforded and risk averted by investment in environmental infrastructure are significant. If meters are installed, operation costs can be collected or rate structures imposed for conservation and savings. If distribution systems are repaired, potable water will be conserved; and if collection systems are repaired, pollution will be reduced. A study by John P. Lehman (1999) carried out for the NADB, indicates not only community doubts about their water security and "financial instability" from underinvestment in repairs, but also concerns about "spillover effects to other city services and operations, and stable job creation." One hypothetical case identifies $1.8 billion in additional revenues over 10 years if operations and maintenance investments are made.

The considerable risk, if investment is not made, spans many concerns. A Fundación México–Estados Unidos para la Ciencia (FUMEC) study (1998) indicates almost $1 billion in lost water in the region from contamination of surface and subsurface waters. There is probably another $1 billion in lost revenues due to decreased leisure and recreational use of water and an unknown but commensurate loss in wildlife, natural habitats, and biodiversity as measured in amount and types of intact communities.

The human health risk is the greatest and least affordable. The viruses, bacteria, and vectors of infectious diseases such as Hepatitis A abound and spread in contaminated water. The incidence of asthma in children increases in areas where standing wastewater is allowed to evaporate, releasing contaminated particulates to enter the air as dust. Cancer and birth defects are also associated with the hazardous materials, heavy metals, and toxins found in wastewater.

Introduction and Background

Border Institute I, "The U.S.–Mexican Border Environment: A Road Map to a Sustainable 2020," sponsored by the Southwest Center for Environmental Research and Policy (SCERP), the Border Trade Alliance (BTA), and the United States Environmental Protection Agency (U.S. EPA) in December 1998, discussed how to ensure the future environmental quality and economic development of the border by the year 2020. Papers, presentations, and plenary sessions focused on the region's population, economy, environment, and governance and developed both projections and a vision of a sustainable border environment in 2020. The overall findings include the following:

- Most border communities have only a short-term focus.
- The U.S.–Mexican border region population is currently about 12 million. If the population continues to grow at the current rate, the population will reach 24 million by 2020.
- The border's population is concentrated in 14 sister-city pairs.
- The North American Free Trade Agreement (NAFTA) has increased economic activity and generated jobs, but it has not improved the distribution of wealth.
- Asymmetries between the United States and Mexico remain high and likely will persist. The minimum wage in the United States is 8 to 10 times higher than the minimum wage in Mexico.
- If the population and the economy of the border region continue to increase at the same rate, 2020 will see greater traffic congestion, poorer air quality, water shortages, increased water contamination (rivers and oceans), loss of habitat and species, hazardous and solid waste crises, and insufficient sewage infrastructure.

The Border Institute I recommendations included:

- Incorporating binational solutions for binational problems.
- Promoting better transborder coordination of land-use planning.
- Promoting economic development, not just economic growth.
- Looking beyond immediate needs/solutions to long-term issues.
- Strengthening border-oriented institutions (Border Environment Cooperation Commission [BECC], North American Development Bank [NADB], and Border XXI).

Inadequate border environmental infrastructure is one cause of environmental degradation and a key focus for sustainable economic development. This paper attempts to verify past needs assessments and to establish a credible estimate of current costs, future needs and costs, and risks if investment is not made.

Herein "border" is defined as the communities within 100 km of the border. "Environmental infrastructure" includes drinking water supply, storage, treatment and distribution systems; wastewater collection, treatment and disposal systems; and solid and hazardous waste collection, sorting, storage, handling, and disposal systems. "Need" indicates underserved populations or inadequate capacity to provide for the population served.

Objectives and Methodology

The objectives of this paper are to conduct a meta-analysis of past environmental infrastructure needs surveys and studies, validate those surveys with an updated questionnaire, and estimate the current and expected need in 2020.

The three components of the meta-estimation exercise were conducted in three phases. First, past environmental infrastructure needs surveys were collected and their results were collated, compared, and contrasted. Second, an independent questionnaire was sent to environmental infrastructure owners and operators to determine current and projected needs. Finally, the first set of surveys was analyzed with an intent to determine a credible cost estimate, validated by the needs sensed in the questionnaire.

Review of Past Studies

A number of studies have been commissioned in the 1990s to determine the construction and operating costs of environmental infrastructure in the U.S.–Mexican border region for potable water storage, treatment, and distribution; wastewater collection, treatment, and disposal; and solid and hazardous waste disposal or storage.

The various studies were conducted with vastly different methods, region and population scopes, time frames, objectives, and, not surprisingly, results. Data from reports, by nation and environmental infrastructure type, were compiled into a table from lowest to highest

total cost. Collection and distribution systems were included. However, only capital expenses were considered as few operations and maintenance estimates were made. A summary of the reports is provided in the Appendix.

Questionnaire

A questionnaire was designed and reviewed by media and jurisdictional contacts as well as EPA, BTA, and other partners. It was then sent to utility operators, tribal nations, and municipalities along the border to collect sufficient data and insights to contrast large and small cities, urban and rural settings, local government, and tribal nations across geographical areas. Follow-up telephone interviews were also conducted.

The questionnaire was designed to determine the accuracy of past environmental infrastructure needs assessments, to gauge the trend in the difference in need and provision, to assess whether future costs are disproportionate to population growth, and to investigate resource management with market incentives. Surveys were sent to representative jurisdictions categorized by state and size in Table 1.

Limitations of this study include time constraints and communities studied. The study examined U.S. needs only and is complemented by a study conducted of Mexican border communities by Octavio Chavez and Enrique Suárez (2000).

Table 1: Jurisdictions Represented In Surveys

Jurisdiction Size	California	Arizona	Texas
Large >250,000	San Diego	Mesa	
Medium 250,000–50,000		Yuma	Brownsville, Laredo
Small <50,000	Brawley, Campo Tribe, Calexico, Imperial County	Douglas, Lukeville, Nogales, San Luis, Sells, Somerton	Eagle Pass, Harlingen, Rio Grande

Estimate of Current and Future Needs

Past survey data were updated according to the questionnaires. A single estimate of need was determined by extrapolating from the available data to include areas, types, and populations unaddressed, unmeasured, or unserved.

FINDINGS

In general, to present a coherent state of the border and indication of the quality of life of residents and jurisdictions, standardized border environmental infrastructure status and needs data must be collected and analyzed more systematically.

Review of Past Studies

Summarizing the nine border infrastructure needs assessments is possible only at the most general level. About the only common factor was the focus on current need. Little correspondence can be found among the studies and, thus, few conclusions can be reached. Overall needs range from less than $1 billion to over $8 billion.

There are orders of magnitude difference in estimates of need in some media. There are also differences in the sense of the need across the border. In some studies, the U.S. side was judged to be more expensive or have greater need than the Mexican side, while in other studies the opposite was true. However, in all studies but one, wastewater system need was greater or more expensive than potable water need, which was greater or more expensive than solid and/or hazardous waste need. Solid and hazardous waste need was greater in Mexico than in the United States in all studies.

A summary of past border environmental infrastructure needs surveys is provided in Table 2. Data is arranged in order from lowest to highest cost estimation. Some biases are suspected in the studies based upon the methodology. For example, the SCERP 1993 study, which was conducted by community fora, probably reports artificially high numbers due to the community's sense of the opportunity to attract grant funds by exaggerating its needs. Conversely, the NADB 1999 study looked only at projects requested by communities and probably underestimated need by omitting smaller communities that

Table 2: Summary of Past Needs Studies and Surveys

Study	Year	Parameters	Estimate (US$m) U.S./Mexico/Total	Qualifier
NADB	1999	Water	136/39/175	Committed Only
		Water/Wastewater	104/1/105	
		Wastewater	120/185/305	
		Solid Waste	0/17/17	
		Total	360/242/**602**	
CalBECC	1998	Water	–/–/764	CA and BC Only
		Wastewater	–/–/671	
		Solid Waste	–/–/16	
		Total	–/–/**1451**	
US ACOE–IBWC	1992	Wastewater	–/–/**2481**	Major Cities Only
TNRCC–WDB	1997	Water	1408/–/–	Texas Only
		Wastewater	1079/–/–	
		Total	2487/–/–	
SCERP–BECC	1999	Water	196/368/564	Use/Cost Model Only
		Wastewater	1739/771/2510	
		Solid Waste	65/245/310	
		Total	2000/1384/**3384**	
SCERP–BTA	1993	Water/Wastewater	4990/–/–	U.S. Only
		Solid Waste	46/–/–	
		Hazardous Waste	166/–/–	
		Total	5202/–/–	
Council Americas	1993	Water	501/497/998	Major Cities Only
		Wastewater	1475/2804/4279	
		Solid Waste	120/322/442	
		Hazardous Waste	0/750/750	
		Total	2096/4373/**6469**	
S.W. Voter Inst.	1993	Total	–/–/**7600**	
US GAO	1996	Total	–/–/**8000**	

Note: Only gross totals are bolded.

do not have the resources to present a claim to either the BECC or NADB.

Questionnaire

Both quantitative and qualitative information was provided in the questionnaire and interviews, however, little data on solid or hazardous waste was returned. A summary of anecdotal information presents a mixed picture of the communities' ability to address current and future needs. Those with regional or basin responsibilities tend to plan and implement infrastructure and service better than those with divided or segregated jurisdiction.

A snapshot view of the challenge is possible by looking at the region west of, in, and around the Colorado River. On the west coast, the two sister cities of San Diego and Tijuana are highly urbanized but encompass a large geographical area. In the desert to the east of San Diego and Tijuana are the cities of Calexico, California, and Mexicali, Baja California. Both are smaller and more rural than San Diego and Tijuana. Imperial County is highly agricultural and is a major water consumer. Further east, Yuma, Arizona, and San Luis Río Colorado, Sonora, are considered sister cities even though they are not directly across the border from one another. The West Cocopah Indian reservation is located along the Colorado River near the U.S.–Mexican border.

Water for the entire Imperial Valley as well as for the cities on the west coast originates from the Colorado River. There is little intentional ground recharge due to the arid setting and groundwater quality is poor due to agricultural runoff. Some seepage from canals on the U.S. side feeds local wells to irrigate small fields on the Mexican side, but the canals are being lined to reduce such seepage.

San Diego uses its 30 storage reservoirs, three treatment plants with a combined capacity of 300 million gallons per day (mgd), and almost 3,000 miles of pipeline to supply water to all sectors of a municipality that is expected to grow to almost 2.6 million by 2020. Most of the water (80% or 170,000 acre-feet) comes from the Colorado River because groundwater is underutilized and of poor enough quality to require treatment or desalination. Up to 50,000 acre-feet sustained yield could be extracted locally even though there is no active recharge program.

The current rate structure encourages conservation. Residential customers pay about 20% more for each subsequent 1,400 cubic feet and reclaimed water is discounted. The region faces $205 million in capital costs to meet current infrastructure need, a $38 million maintenance program, and a $435 million improvement program to meet estimated needs for the year 2005.

San Diego designed and built a wastewater collection, treatment, and disposal system a generation ago with capacity (139 mgd) for all the cities and user types in the common drainage area. It incorporates industrial pretreatment, advanced primary treatment, and some reclamation. A temporary waiver from secondary treatment may have saved San Diegans $3 billion but is currently being renegotiated. The city is encouraging densification of the core area. Nonpoint sources such as storm runoff persist as problems.

Calexico, with a population of 30,000 people, is much smaller than its sister city, Mexicali. The city of Calexico receives drinking water from the All-American Canal, has capacity to store 25 million raw gallons and eight million treated gallons, and serves its entire population (80% residential, 9% commercial, and 1% industrial). Current improvements, totaling $9.3 million for both plant expansion and transmission extension, are relatively expensive as is all expansion into the peripheral areas. There is no conservation plan and, even though all users are metered, a rate structure classifies users only by type, not consumption. By 2020, when 45,000 to 60,000 people are expected to reside in Calexico, drinking water costs will exceed $62.5 million.

Calexico's secondary wastewater treatment plant with disinfection discharges into the New River. It operates at about 60% capacity, so the only expense to be incurred in the near term is expansion of the current wastewater collection system, estimated at $3 to $5 million. However, a new plant with an estimated cost of $4.2 million will be needed by 2020.

The city of Brawley is also within Imperial County. Its current population of 22,500 is served by a recently completed $25 million, 15 mgd water plant and system that was designed to be increased with two 5 mgd-increment modules. A credit is being used to repair 60% of its lines and the rest will be serviced over the next 10 years. With that same credit, Brawley is currently facing a $7.5 wastewater plant and collection system upgrade.

By 2020, the first, if not both, of the 5 mgd modules will be needed at a cost of only $5 million each. The cost is relatively low because there will be no land acquisition costs, and the basic plant's design accepts the modules. The eight current wastewater digesters must be augmented from 3.9 mgd to 6.9 mgd in 10 years.

Imperial County provides services to the rural and unincorporated areas of the county. Its population is expected to grow from 142,000 in 1998 to 175,000 by 2020. The county operates a 1.8 million gallon storage tank and a 100,000 gallons per day (gpd) water treatment plant for its 160-acre border industrial and commercial park. Full build-out of the park to 1,700 acres by 2020 will be serviced by a 1.0 mgd upgrade. While the cost is unknown, most improvements are paid for by private development. Conservation is implemented only to agricultural users by the Imperial Irrigation District.

The county has no current wastewater treatment capacity but will need a 70,000 gpd sewage treatment plant to accommodate the full 1,700 acres of the industrial and commercial park. There are no plans or estimates for the cost of the plant; again, it is probably paid for by private development.

Yuma, Arizona, also receives all of its water from the Colorado River and operates conventional drinking water and wastewater plants. Its current service population of 75,000 is fully serviced and expected to increase to 100,000 for drinking water and to double to 150,000 for wastewater treatment. Costs for improving the drinking water plant and distribution system for the year 2020 are $240 million. An estimated $89 million will be needed to build a new 9 mgd wastewater treatment plant.

The Cocopah tribe in Arizona operates an iron and manganese removal plant for its groundwater source and a three-cell natural lagoon system to treat effluent. They use public funds to maintain a $667,000 water and sewer system and operates it with flat-fee revenues.

A comparison of some of the aforementioned communities (Table 3) yields a few insights:

Projected funding requirements outstrip capacity and growth projections.

The current needs of most communities are barely being met and near-term out-year budget requests reflect the current deficiency. With the

Table 3: Comparison of Surveys of Various Current and Future Needs

Community	Present Population Year 2000	Present Need Capital Cost ($m) Year 2000	Future Population Year 2020	Future Need Capital Cost ($m) Year 2020
San Diego, Calif.	1,900,000	Water 205.0 Waste 136.0 Total 341.0	2,552,000	Water 483.0 Waste 814.0 Total 1297.0
Laredo, Tex.	188,000	1.0/Year Operations	299,000	Water 120.0 Waste 70.0 Total 190.0
Yuma, Ariz.	75,000	Total <0.1	100,000 150,000	Water 240.0 Waste 89.0 Total 329.0
Calexico, Calif.	30,000	Water 9.3 Waste 4.0 Total 13.3	45,000 60,000	Water 62.5 Waste 4.2 Total 66.7
Brawley, Calif.	22,500	Total 7.5	35,500	Water 10.0 Waste 6.0 Total 16.0

exception of Calexico, the capital cost to address current water and wastewater system improvements and expansions can be measured in several dollars per capita or about the equivalent of operating costs. In other words, communities have been able to control costs by building systems that anticipated the past and current growth. However, communities are facing relatively large needs and associated costs in the next 20 years. The costs are measured at several hundred to just over a thousand dollars per capita. Utility operators use the rule of thumb of $1–3/gallon to build a plant and another $1–3/gallon to distribute or collect it, depending on whether they own the land and if the current plant can be augmented or if a new one has to be constructed.

While long-term planning is occurring, it does not have a distant enough horizon.

Even larger communities that have extensive capital plans only look ahead five to seven years and small communities operate their utilities with a shorter horizon. Security of supply issues concern them the most.

Operations and maintenance are being deferred.
Small communities, especially rural ones and colonias, have the greatest need and pay disproportionately more for water and wastewater service than larger communities and urban centers. Inadequate staff, a limited tax base, and a lack of technical expertise hamper their ability to serve their citizenry.

Only traditional sources, infrastructure, and operations are envisioned.
Increasingly, distribution and collection systems costs are exceeding treatment system costs. As communities grow and service is provided to the periphery and perimeter of the jurisdiction, the length of pipe required increases exponentially. In Texas, over 67% of overall water system cost and 61% of overall wastewater system cost is distribution and collection, respectively.

Overall infrastructure services have not been integrated.
Communities have not made the connection between their various service sectors, thus, they remain segregated or disparate. For example, if energy generation and water treatment plants were housed together, each might use the waste stream of the other. Reverse osmosis technology, which uses large amounts of power, becomes affordable when located near power plants.

Conservation and recycling are only being implemented experimentally or at the prototype scale.
Opportunities abound for implementation of projects using "appropriate" or "traditional" technologies. Lagoons, wetlands, and wastewater irrigation, in combination with solar disinfection and dessication, are ideal in the relatively land-rich region. Obviously conservation, alternative sources of water, and recycling/reclamation are mandated for the future.

Estimates of current need to cover unaddressed populations (reached by extrapolation of estimated costs) ranged from around $6 billion to over $10 billion.
To determine an estimate for the future is even more problematic and has much greater variance. Between $12 billion and $20 billion will be needed over the next 20 years. However, savings can be realized by

appropriate technology, conservation, and eco-efficient operations not considered by the surveys.

Estimate of Current and Future Needs

The current need was determined by multiplying the estimates found in the various studies by a factor that represents the unsurveyed portion of the border community or unsurveyed media. Table 4 identifies study foci (A) and areas not covered (B). By determining a ratio (C) between surveyed need and unsurveyed need, initial estimates (D) can be extrapolated to an estimate of complete need (E). For example, extrapolation was made to accommodate small, rural, and unincorporated communities when only large, urban communities were surveyed, or states or counties skipped when other states or counties are

Table 4: Standardization of Past Studies and Survey Estimates

Study	A. Focus	B. Areas not covered	C. Ratio A/B	D. Initial estimate ($m)	E. Extrapolated estimate
NADB	Commitments	Many projects esp. in smaller communities	1.0/10.0	602	10 × 602 = 6,020
CalBECC	California and Baja California	Eight other states and twice the population	1.0/4.0	1,451	4.0 × 1,451 = 5,804
US ACOE–IBWC	Major Wastewater	San Diego-Tijuana, plus water and solid waste	1.0/4.0	2,481	4.0 × 2,481 = 9,924
TNRCC–WDB	Texas	Other nine states	1.0/4.0	2,487	4.0 × 2,487 = 9,948
SCERP–BECC	National Use and Cost Patterns	Common use and cost patterns	1.0/3.0	3,384	7173
SCERP–BTA	U.S. Only	Mexico	1.0/2.0	5,202	2.0 × 5,205 = 10,410
Council of Americas	Major Cities	Smaller towns and rural areas	1.0/0.5	6,469	1.5 × 6,469 = 9,703
SW Voter Inst.	Early 1990s	Unknown, updated	–	7,600	1.25 × 7,600 = 9,500
US GAO	Complete	None	–	8,000	8,000

surveyed. A ratio of unsurveyed need to surveyed need was used to multiply estimates to obtain a cost estimate for the entire border. Estimates of current need reached by this method ranged from around $6 billion to over $10 billion, with a mean of $8.5 billion and standard deviation of $1.8 billion.

Determining an estimate for the future is even more problematic and has much greater variance. Border Institute I documented a likely doubling of the population in the border region from its current 12 million to about 24 million. However, as populations expand into periphery or unplanned areas (versus densifying the urban core and existing infrastructure suburban areas), the expense for providing distribution and collection systems grows exponentially. Costs per capita or per unit of capacity will also increase over 20 years, perhaps doubling as well. However, savings can be realized by appropriate technology, conservation, and eco-efficient operations not considered by the surveys. A realistic estimate can be found by extrapolating from the available data to a comprehensive, contemporary, and borderwide estimate.

Table 4 outlines extrapolations and identifies between $12 billion and $20 billion needed over the next 20 years. (Twice the mean of immediate need is $17 billion.)

Recommendations

Considerable risk exists if investment is not made. The savings afforded and the risk averted by investment in environmental infrastructure is significant. If meters are installed, operation costs can be collected or rate structures imposed for conservation and savings. If distribution systems are repaired, potable water will be saved; if collection systems are repaired, pollution will be reduced. The 1999 NADB study indicates community doubts about their water security and "financial instability" from underinvestment in repairs but also "spillover effects to other city services and operations, and stable job creation." One hypothetical case identifies $1.8 billion in additional revenues over 10 years, if operations and maintenance investment is made.

A FUMEC study indicates almost $1 billion in lost water in the region from contamination of surface and subsurface waters. There is probably another $1 billion in lost revenues due to decreased leisure and recreational use of water and an unknown but commensurate loss

in wildlife, natural habitats, and biodiversity as measured in amount and types of intact communities.

The human health risk is the greatest and least affordable. The viruses, bacteria, and vectors of infectious diseases, such as Hepatitis A, abound and spread in contaminated water. Incidence of asthma in children increases in areas where wastewater is allowed to stand open, dry and enter the air as dust. Cancer and birth defects are also associated with hazardous materials, heavy metals, and toxins found in wastewater.

Appendix

Past Border Environmental Infrastructure Needs Assessments

Title: Review of U.S.–Mexico Border Environmental Infrastructure Needs

Publisher: SCERP and Border Trade Alliance

Date: August 1993

Purpose: To review literature regarding environmental infrastructure needs and cost in the U.S.–Mexico border region.

Scope: Confined to environmental problems (mostly water and wastewater) that have been thoroughly examined and for which study results have been published.

Time Frame: October 1983–June 1993

Recommendations: $5,387,462 needed to correct specific pollution and prevention projects (92% of this amount directly related to water and wastewater treatment). Proposed infrastructure, particularly solid waste disposal and wastewater treatment facilities, must not only meet current needs, but also be designed for future expansion.

Methodology: Survey of 38 studies, eight of which covered the entire border; one covered New Mexico and Texas, while the remainder addressed specific states, e.g., Arizona (11), California (3), New Mexico (7), Texas (8).

Findings: Environmental conditions are deteriorating rapidly due mostly to the maquiladora industry. Air and water quality in most

border communities rank among the most hazardous in the United States. Mexican border communities typically do not have the tax bases to fund the large-scale projects required to solve problems caused by years of neglect.

Title: International Environment: Environmental Infrastructure Needs in the U.S.–Mexican Border Region Remain Unmet
Publisher: U.S. General Accounting Office
Date: July 1996
Purpose: To provide information on (1) the border region's current and projected unmet needs for environmental infrastructure, (2) financial and institutional challenges each country faces in addressing present and future environmental infrastructure needs, and (3) the way in which the EPA has identified and prioritized funding for environmental problems along the U.S.–Mexican border.
Scope: Principally water, sewer, solid waste.
Time Frame: 1991–2006
Recommendations: The EPA should, together with its Mexican counterparts, use the inventory of all environmental data for the border region to establish criteria within, as well as between, the nine working groups, use these criteria to set priorities, use the priorities to determine which activities are most urgent and merit funding, and link all funded activities to environmental indicators.
Methodology: Meeting with EPA officials; interviews with U.S. and Mexican governmental and nongovernmental officials; and review of pertinent documents, laws, and regulations.
Findings: Environmental infrastructure needs remain unmet, and providing them is estimated to cost nearly $8 billion over the next 10 years (1996–2006). In outlying Mexican communities, basic infrastructure for sewage and solid waste is either insufficient or nonexistent, which has contributed to water pollution leading to public health problems. Conditions are better in the United States, except in the colonias. There has been some progress in responding to some border environmental infrastructure needs (e.g., IWWTP in San Diego South Bay area). Border communities have limited financial and administrative capacity to finance needed infrastructure projects. NADB is seeking to alleviate this problem. Border communities rely heavily on federal resources for project financing and administration. However, Mexican states and com-

munities lack the administrative experience necessary to borrow funds. This is a problem that has only recently been addressed. The EPA needs to focus border related activities on the region's greatest needs. Between 1991–1995, the EPA invested $520 million for border water infrastructure ($411 million) and other projects ($79 million). Despite this investment, the desired results were not always achieved.

Title: U.S.–Mexico Border Ten-Year Outlook: Environmental Infrastructure Funding Projections

Publisher: NADB

Date: 1999

Purpose: To define and project environmental infrastructure funding needs over the next 10 years and to assist local, state, and federal institutions in their long-term planning and policies.

Scope: Wastewater, water supply, and municipal solid waste.

Time Frame: 1999–2009

Recommendations: In order to promote a clean, healthy border environment, border-related institutions should act as catalysts for change by strengthening local communities and their utilities, ensuring extensive local and state participation, establishing close coordination among border-related institutions, and implementing system reforms.

Methodology: Study by consultant with 40 years experience in the public and private sectors.

Findings: Rapid population growth and industrialization has severely impacted water supply, wastewater, and municipal solid waste infrastructure. The BECC estimates that environmental infrastructure improvements totaled $1.7 billion by 1999. This figure could more than double by 2009. Several state, national, and international institutions have addressed environmental infrastructure needs, such as the EPA, the International Boundary and Water Commission (IBWC), Housing and Urban Development (HUD), Secretaría de Desarrollo Social (SEDESOL), the World Bank, the Inter-American Development Bank (IDB), and so forth. NAFTA agreements have produced the BECC and NADB. Both the United States and Mexico each pledged $1.5 billion (totaling $3 billion) and of this, $450 million is paid in capital (cash contributions), while the rest is callable capital. An additional $1.1

billion is needed for border environmental infrastructure construction and maintenance for the 1999–2003 period. Approximately the same amount is projected for the 2004–2009 period. (It is easier to project for the short term [1999–2003] than for the long term [2004–2009].) Even without migration—an unlikely scenario—the population along the border will increase by 50% over the next 20 years (five million more people). Current immigration patterns—a more likely scenario—will cause a 100% population increase (12 million more people). Per capita income in U.S. border counties in 1995 was 70.2% (without San Diego County it was 61.9%). Six of the poorest U.S. counties are along the U.S.–Mexican border. NADB has required communities to increase user fees and user fee collection efficiently, a policy that is unpopular in the short term, yet essential to long-term viability, contingency, and operation and maintenance funding. In August 1993, an analysis by Carlos Mercer and others (1993) described the $6.5 billion need for water, sewer, and municipal solid waste ($4.3 billion for wastewater collection, $1 billion for water, $1.2 billion for waste collection). The 1993 nongovernmental organizations (NGOs) estimated $7.6 billion for border environmental infrastructure needs. Estimates vary, but billions of dollars are needed. By April 1999, NADB funding commitments for 21 projects totaled $200 million (34% of project costs come directly from NADB; the rest is funded through other sources, usually leveraged by NADB). Sixty-three percent of this total goes to Mexico and 37% to the United States, which usually has access to other funding sources, such as tax exempt municipal bonds.

Summary: During the 1999–2009 time period, environmental infrastructure needs totaled approximately $2.1 billion. A minimum of $1 billion in new grant funding from the United States (through the Border Environment Infrastructure Fund [BEIF]) and Mexico is needed to defray cost until border communities are able to carry larger credit components. To achieve a healthy ecology, border communities must promote local and state participation, coordinate among institutions, leverage all capital, combine project grants with loans, continue institutional support, and focus on long-term sustainability.

Comments: The study does not discuss appropriate alternative technologies, but summarizes what various studies project, then con-

sults with local officials and NGOs for their comments, assessments, projections, solutions, and suggestions. While future trends (population growth and environmental needs) may be predictable, costs may be less if appropriate technologies are factored in.

Title: California–Baja California Border Environmental Infrastructure Needs Assessment
Publisher: CalBECC (CalEPA and DGEEBC)
Date: April 1998 (revised from April 1995)
Purpose: To identify and promote complimentary environmental projects.
Scope: The border region of California and Baja California
Time Frame: Current only
Recommendations: None
Methodology: Letter survey to jurisdictions in region.
Findings: Twenty-five projects identified at an estimated cost of almost $1.5 billion. The BECC has certified $149 million of water and wastewater projects.

Title: Design and Cost Estimate Report Addressing International Border and Water Commission Sanitary Issues
Publisher: U.S. Army Corps of Engineers for IBWC
Date: December 1992
Purpose: To establish respective responsibilities for delivery studies and other services.
Scope: Eleven border twin cities excluding San Diego and Tijuana
Time Frame: Current need only
Recommendations: None
Methodology: Confirm wastewater discharge totals through site visits and cost estimates for infrastructure to maintain and correct.
Findings: Operating cost of $992,487 per year.

Title: U.S.–Mexico Border Environmental Infrastructure Need Assessment and Tool Kit
Publisher: SCERP for BECC
Date: 1999
Purpose: To summarize served and unserved demand and estimated costs for potable water, collection and treatment of wastewater,

and solid waste management. Results serve to help prioritize projects and better identify areas of critical infrastructure need.

Scope: Border region

Time Frame: Current only

Recommendations: None, modeling tool

Methodology: A CD and Web site using geographic information system, customized interactive tools, traditional and new databases, and project planning tools. Over 100 BECC projects were analyzed for per capita demand and costs under various population densities, land use, and cost scenarios. These data were compared to population projections. Low and high estimates are provided.

Findings: None, planning tool only.

Title: Texas Border Region Environmental Infrastructure Needs Assessment

Publisher: Texas Water Development Board and Natural Resources Conservation Commission

Date: April 1997

Purpose: To compile a needs assessment to describe the extent of water, wastewater, and solid waste needs on the Texas side of the border in order to meet minimum safety and state standards.

Scope: Texas side only

Time Frame: Current only

Recommendations: None

Methodology: Review and collation of internal files

Findings: Nearly $2.5 billion estimate for water and wastewater needs.

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VII

Sustainable Water and Wastewater Infrastructure for the U.S.–Mexican Border Region

Barbara R. Bradley

Executive Summary

In the relatively near future, fresh water supplies are predicted to be inadequate to meet the demand of the U.S.–Mexican border region's growing population. New sources of water must be found. One of the most obvious sources is treated wastewater, yet, within the context of the current conventional water and wastewater infrastructure, the cost to supply reusable water is high. For example, the cost of treating reclaimed water to meet California Title 22 standards is about $200 per acre-foot, not including secondary treatment, which runs about $250 to $650 per acre-foot. The cost of a distribution pipeline is even greater. These costs will compete for public revenue with schools, health services, and roads. Since people must have water first, these other services will suffer or the public will have excessive taxes and fees. Thus, the overall quality of life for these communities could remain impoverished, even if additional environmental infrastructure is provided. To avoid this future impasse, alternatives to conventional infrastructure are necessary now. Many solutions exist that reduce the cost of water and wastewater services by incorporating less costly centralized and decentralized wastewater treatment and reuse. These

options exist for both new and existing communities. New communities and subdivisions—or existing communities without a sanitary system—have many cost-effective options. Existing communities have fewer options since they are heavily invested in the existing centralized infrastructure, yet several options do exist.

Two common perceptions are that centralized systems cost less to treat wastewater and that they provide better water quality. An effort was made to evaluate both of these perceptions by examining data from both onsite and centralized systems. Using sustainability as the criterion, the "system" in either case should ultimately be a "closed loop" system comprising water treatment and conveyance, water consumption, wastewater generation, wastewater treatment and conveyance, and reuse. If the amount of water consumed can be reduced at any point along this system, then the system may become more socially and environmentally sustainable. Similarly, if cost reductions can occur at any point, the system may become more economically sustainable.

Concerning sustainability, centralized systems that require less energy or that can generate revenue (such as through tree farm irrigation) are very important for existing communities. But, in general, centralized systems may simply be too expensive for full-scale treatment and distribution of reclaimed or repurified water. Thus, for both existing and new communities, decentralized treatment and reuse offers a viable approach to maximizing the number of times water is used. In response to the many effective technological advances in onsite treatment, the EPA and some state and local health departments are expanding the number of technologies allowed for onsite treatment. While more expensive to install than conventional septic systems, some of these advanced systems provide secondary, and even tertiary, treatment levels. Some can even produce water that meets Title 22 requirements for body contact with treated effluent. To better define the value of onsite treatment and reuse within the context of sustainable water supply for the border, an attempt was made to (1) compare the cost of centralized and decentralized treatment and reuse systems and (2) identify how these costs are borne by the public. However, several factors have impeded the success of this initial effort. No studies were located that evaluated whole systems; they have generally compared only treatment costs. The cost of pipelines was not readily available for either wastewater collection or reclaimed water distribution

(however, it is generally known that the capital costs for pipelines are higher than for treatment facilities while the operating costs are much lower). An additional complication was that costs are measured in a variety of units, such as per gallon, acre-foot, person-equivalent, equivalent dwelling unit, or per foot. All of these units of measure are for treatment, except the latter, which is for pipelines.

Despite the lack of a credible cost comparison for the holistic system at this time, onsite systems have several benefits that make them worthy of widespread use. Producing treated effluent suited for onsite toilet flushing, landscape irrigation, and agricultural use can reduce the demand on scarce fresh water resources. Returning greater control over the cost of the infrastructure to the wastewater generator may also promote reuse, further decreasing demands on fresh water resources. Before communities along the border region can take advantage of these systems, several institutional barriers must be overcome among water, wastewater, and public health agencies. Institutional jurisdictions need to be reviewed to enhance cooperation and promotion of these systems. Currently, the most important step toward achieving onsite reuse is the development of maintenance, monitoring, and legal instruments to ensure that onsite treatment systems will reliably produce water quality that meets regulatory standards.

Introduction

Water is a scarce and precious resource everywhere, particularly along the U.S.–Mexican border. In considering how to best manage it, it is important to look at the context of the needs and the infrastructure developed to meet those needs. Does the infrastructure work in a way that will allow future generations to meet their needs? As values change and populations increase, perceptions of both needs and solutions change. This paper examines various water needs and identifies both conventional and alternative resources for sustainable water supply for present and future border communities.

An Economic Paradigm Shift

A basic economic premise that has driven capitalistic economies in the twentieth century was that increased growth led to increased economic prosperity. Growing populations meant increased productivity and a

larger public revenue base, both leading to prosperity. In the United States, this premise was ubiquitous in society, embraced by families, farmers, manufacturers, developers, and municipalities alike. While people were well intentioned, data now suggest that the net cost of growth is higher than previously calculated (Fodor 1999). This cost is seen, for example, when the residential tax burden of fast growing communities is compared to the lower tax burden associated with slower growing communities.

The cost of public services to meet the demands of growth is significant. A study of growth impacts for the state of Oregon found that the top three categories of costs were schools, sanitary sewerage, and transportation (Fodor 1999). The cost of growth to local governments manifests in five ways:

- increased taxes
- increased debt
- infrastructure deficit
- facility maintenance deficit
- reduction in services

In this case, water and wastewater infrastructure and facility deficits are of particular interest. Infrastructure deficit may result when a community falls behind in providing the new or expanded facilities needed to accommodate growth. Facility deficit occurs when funds are diverted to take care of the immediate needs of new developments. When growth diverts money from existing community obligations to pay for expanding services, the resultant prosperity does not match the projected level.

Regardless, the population along the border is growing. The challenge will be to provide infrastructure for all these people without concomitant consumption of natural resources, increase in costs, or decline in services. A look at current developments and U.S. forecasts for water and wastewater infrastructure provides insights into solutions for the border region.

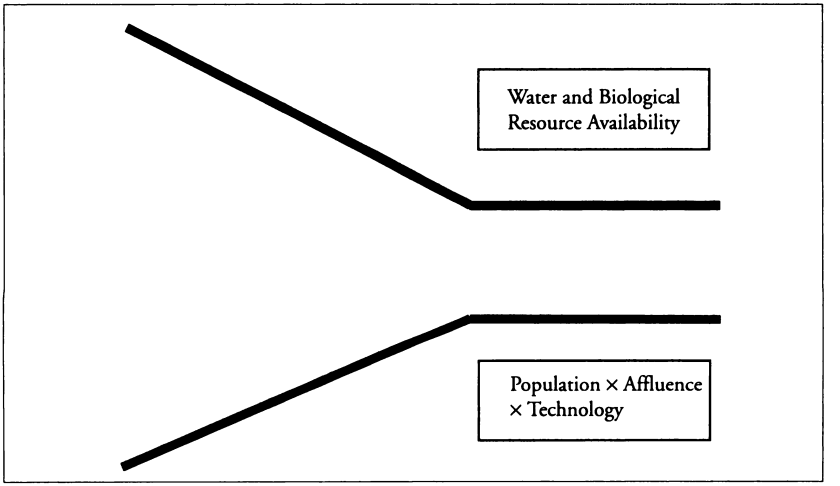
Sustainable Development

Sustainable development promotes vitality and health in the environment, in society, and in the economy. Without ecological effectiveness, the web of life that supports humankind is destroyed. Without equitable distribution of resources, social unrest may undermine

progress. Without economic effectiveness, environmental and social solutions may not be adopted or maintained.

The much-discussed issue of sustainable development is an attempt to address the needs of future generations by providing development in ways that use resources more effectively. Paul Hawken and others (1999) argue for "natural capitalism," a paradigm shift to more effective resource utilization. They use this phrase to differentiate between the typical emphasis on efficient resource use and an emphasis on effective resource use that promotes development without growth in resource consumption. Using this approach, both economic and ecological effectiveness become the measures for evaluating development that meets the needs of future generations while preserving the life of other living beings. At some point, as the current trends suggest, increasing world and regional populations will become unsustainable, with available resources diminishing like the narrowing end of a funnel (Figure 1). This analogy is used by The Natural Step, a nonprofit environmental education organization, to explain that the sum of natural resources available to meet the needs of people decreases in an inversely proportional relationship with the product of population, affluence, and technology.[1]

Figure 1: The Resource Funnel Concept



In the field of water and wastewater infrastructure, the concern is not to reduce population, nor to decrease affluence. The challenge is

to develop and utilize technologies that have a positive—or at least neutral—effect on natural resources. The familiar adage of reduce, reuse, recycle applies to water as much as to solid waste. Water demand can be reduced through conservation and new waterless technologies. Users can affect reuse through sequential uses before final disposal. Recycling can be done through reclamation and repurification. The benefits are obvious, yet bear repeating: effective water use makes more water available for ecosystems and for future generations at a reasonable cost.

The following sections examine water and wastewater infrastructure along the U.S.–Mexican border region within the context of sustainable development. This context allows a fresh analysis of economically effective water and wastewater infrastructure.

Future Vision

Water and wastewater infrastructure of the next two or three generations will utilize many of the conventional solutions. Undoubtedly, successfully accommodating a larger population will require substantial change if water supply and infrastructure is to be sustainable. Clues to how things will change are suggested in a white paper prepared in a workshop held by the Water Environment Research Foundation (WERF).[2] Five aspects of the wastewater sector were predicted for the year 2018. The most fundamental aspect was the concept that "water is water." In the workshop participants' vision for the future, water has inherent value as a natural resource, a product, a habitat, and for recreational use, yet all water must be managed collectively to be managed effectively. In 2018, most municipalities will have integrated water and wastewater utilities into a single focused entity. Both wastewater and drinking water plants will have become key control points, working in a complementary fashion, to ensure public and environmental health. The watershed will be viewed as part of the treatment infrastructure, with land-use planning managed at the watershed level. Optimizing water quality across the watershed will be a significant challenge. The grand challenge will be to extend capacity and meet new needs for infrastructure to handle multi-billion gallon flows in large metropolitan areas. Society will face enormous costs for collection system upgrades. It will be accepted wisdom that facilities must accommodate continuous upgrades and will have an operating

life exceeding 100 years. Governments will be keenly interested in developing technologies that minimize capital costs without reducing operating life. These needs, met by new technologies, will form a new system architecture.

Membranes, biotechnology, small package plants, point-of-use reclamation, repurification, and automated control systems will fundamentally change the architecture of the wastewater collection and treatment system. With more ways to treat wastewater, infrastructure economics will change, providing benefits to businesses, municipalities, farmers, neighborhoods, and even to individual households. A variety of very different, yet effective, reuse and treatment satellite systems will combine in an effort to get the full benefit of available water, whether for potable or non-potable use. Centralized wastewater treatment plants (WWTPs) will treat what remains after multiple uses. The sewer system will be used for partial treatment, and the plant itself will have to manage extremes of flows and concentrations.

The Border Context

Climate and geography dictate the character of the border region. Small and large communities punctuate large expanses of rural landscapes, many of them twin cities divided by the border. With little rainfall and high heat, the natural resources could easily be summarized as land, solar energy and, to some extent, wind energy.

If the future of the United States is like the one envisioned by the WERF Future Mapping Workshop, what will the future look like for the border region—an arid region shared by diverse U.S. and Mexican communities? Prosperity and quality of life varies considerably as measured by economic and social indicators. Many of the twin cities and other border communities have a large percentage of low-income households, high unemployment rates, and limited educational and employment opportunities. Limited public resources are stretched among education, transportation, environmental infrastructure, health care, and other social benefits. Conflicting demands for public expenditures already exist, such as sewerage versus schools.

The border has historically suffered from neglect in infrastructure development and already faces infrastructure and facility maintenance deficit. The grand challenge described by the Future Mapping Workshop—to extend capacity and meet the environmental infrastructure

needs of a growing population—already exists along the border. On top of all this, the population of 12 million is expected to double in the next decade. Transboundary watersheds and impacts exacerbate the challenge. If the needs of the border region can be met sustainably, the area will serve as a model for other regions as their populations grow and march down the narrowing funnel of increasing resource needs and decreasing resource availability.

More Infrastructure, Less Cost

If WERF's grand challenge of 2018 (or the Border Institute's grand challenge of 2020) must be met without creating an enormous public tax burden, then it becomes an even greater challenge for the border region. One significant difference between the border region and the larger United States is that the infrastructure for the United States is predominantly in place. This difference is important because, where infrastructure already exists, the community has committed significant financial investment and would be inclined to improve that infrastructure before adding something different.

Yet, where new infrastructure is needed, an expanding selection of technologies is available. This selection largely depends on the existing level of development, long-term funding, and cooperation by regulatory and municipal agencies. Economics is usually the driving force behind the adoption of new technology, but to achieve truly sustainable solutions, social and environmental forces must be factored in equally to produce long-term stability and quality of life.

Thus, two major categories of infrastructure alternatives exist:

1. Alternatives for communities with well-developed infrastructure—these communities have fewer choices because of the investment in the current infrastructure. In general, their challenge is to service more customers by expanding existing systems.
2. Alternatives for new infrastructure—this second category of alternatives applies to new communities, new developments, and existing communities that substantially lack infrastructure.

Water

Water service is generally provided through an existing system of conveyance, reservoirs, treatment plants, pipelines, and pump stations.

Because there is only one water system and only one quality of water provided, potable water is used for virtually all water needs including drinking, food preparation, bathing, laundering, irrigation, toilet flushing, cleaning, industrial processing, and manufacturing. The tendency is to perpetuate this inefficient system. However, opportunities exist to reduce water consumption and to provide alternative water sources.

Conservation

In conformance with the hierarchy of "reduce, reuse, recycle," the most important method for providing adequate water for future generations is to use less (starting now). Fully integrating conservation and institutional measures should be the priority. While some border communities have conservation plans and the equipment and fee structure to implement it, the majority does not. A typical conservation plan includes changing building and permitting codes, establishing incentive programs, and setting fees to accomplish relatively low-cost measures, which include the following:

- Mandated, community-wide conversion to low-water use fixtures, appliances, electromechanical systems, and landscaping.
- Public education programs for residences, businesses, and schools.
- Water meters for all customers.
- Billing automation with a graduated fee structure.
- Regional or state action to charge consumers for the true cost of water.
- Remote monitoring of public and private lines for leak detection
- Aggressive leak prevention and repair.

These measures deserve recognition as the least costly means to effectively use water. The data to substantiate this claim is often missing, but here are a couple of examples of water savings and costs:

- Scandic Hotels, a Swedish hotel chain, conducted an employee and customer education campaign before attempting any other water saving measures. The cost of the program covered employee notices and meetings, signage posted in the guest bedrooms, and the monitoring of water bills. The effect of the campaign was carefully measured by changes in the water bills. The hotel management set a goal of 20% water reduction within three years. Within the first year, the average reduction in all of their hotels had already reached 16% (Ivarsson 1999). Inci-

dentally, Scandic Hotels intends to include other water reduction measures, but they implemented the least expensive approach first.

- The BECC assisted the city of Brawley, California, to prepare a water conservation plan that included water meters and billing customers on a cost-per-gallon basis. The cost to prepare this plan was about $6,000. Table 1 shows the components of the plan and the percentage of water savings achievable through the implementation of the plan (Alvarez 1999). Implementation has associated costs, particularly installation of water meters. These costs would be spread over several years and would be partially paid for by growth and increased number of hookups.

Table 1: Percent Water Savings by Conservation Alternative

Alternative	Water Savings (%)
Installation of water meters	20.56
Irrigation ordinances	1.63
Installation of water conservation devices	0.42
Public education	0.04
Xeriscape implementation	0.54

Source: Alvarez 1999.

Other Water Sources—Even in Arid Climates

Rainfall Capture

Given the existing water supply system, there are ways to reduce the public tax burden for water by reducing the demand for potable water or by sharing certain costs with individual consumers. Rainfall capture and storm water use are practices that can be implemented in nearly all communities, although the effectiveness depends largely on the amount and duration of rainfall and the end uses. Rainfall capture generally refers to localized, onsite capture and use of rainwater, such as by rooftop catchment with onsite storage. The rainwater can be used for irrigation, toilet flushing, laundry, or other purposes. Issues for rainfall capture are the cost for the system, structural safety of tanks, public health issues for water use after extended storage, and the

types of onsite water demands that can be fulfilled using rainwater. Long-term storage and certain uses would likely require some treatment, probably filtration and UV disinfection. Since rainfall capture is usually performed by the property owner, the economic drivers for investing in the equipment would likely be high water bills, economic incentives, water shortages, and opportunities to earn income from the water use. Promotional campaigns and public health and safety education are the main institutional issues to be resolved by public agencies in encouraging rainfall capture. Few public funds would be required to institute rainfall capture.

Storm Water

On a municipal level, the storm water collection system can be modified to capture storm water as opposed to discharging it as quickly as possible. Rainfall amount, rainy season duration, available land for capture and treatment, and potential uses and their locations affect the value of this option. Detention basins are often integrated in parks for seasonal storage with percolation and evaporation emptying the basins. The very existence of these temporary water bodies can be a delight to children and a boon to wildlife. Storm water basins can also be used to recharge groundwater. Theoretically, captured storm water is a potential source of potable water. The temporary nature of this water supply and the cost of removing motor oil, pesticides, and other pollutants make groundwater an unsuitable source of water in urban areas. The likelihood of using urban storm water inside buildings at all is probably limited to a few industrial facilities or retrofitted buildings, and only if located near a storm water basin. Urban storm water is better relegated to other uses, such as recharging groundwater or irrigating public and commercial landscaping. Appropriate treatment technologies are passive oil/water separation and sediment settling.

Aquifer Storage and Recovery

On a regional level, sources of potable water can be augmented through programs such as aquifer storage and recovery. Surplus river flows, reclaimed water, and/or storm water are injected into underground aquifers to recharge groundwater supplies. The water is withdrawn, treated, and distributed to consumers as needed. This is an expensive technology, which is why it is more suited to regional endeavors with several communities supporting the program.

Reclaimed Water

If reclaimed water is available there are a variety of uses for it depend ing on the level of treatment. Filtration and disinfection following secondary treatment produces water suitable for a variety of purposes. In reality, centralized wastewater treatment plants are seldom located in the vicinity of would-be consumers of reclaimed water. The cost to install and maintain a second set of distribution pipes to customers is very high. Nevertheless, many of the larger U.S. cities along the border are proceeding to install this infrastructure, including municipalities such as Escondido in San Diego County. The cost of the delivered water is too high to recuperate from the customer and the surplus cost to produce the water is borne by the public at large through increased fees and property taxes. It is reasonable to expect that water recycling at this large municipal scale is a necessary part of sustainable water use, given the existing water and wastewater infrastructure. However, wastewater recycling at smaller, more localized scales may prove to be more effective because of proximity to generators and customers/consumers. Reclaimed and repurified water is discussed again in later sections.

Nonpotable Water Distribution

A final scenario for sustainable provision of water for communities that already have conventional water and wastewater infrastructure is to alter the quality of the water supplied in the distribution system. Changing water quality standards would allow more sources of water to be used, particularly repurified water. In this scenario, the water distributed in pipelines would be used for all water needs except for drinking and food preparation. This condition exists in many European countries where bottled water provides the quality of water necessary for safe drinking and food preparation. Many of these countries enjoy a high standard of living and health. Bottled water is distributed by truck to homes and retail outlets. The cost of bottled water is high but the amount used is very small. Interestingly, the high cost does not seem to matter to the many Americans who have caused the sales of bottled water to soar. Perhaps this is because of the low cost of bottled water compared to other retail food products. The advantages of this option are an increased supply of water and a decreased tax burden by omitting a duplicate pipe distribution network for reclaimed water. While this scenario may be unconventional and met with resistance, it has some clear sustainability benefits.

Wastewater

In-building Recycling

Typically, as populations grow, new sewer lines are installed and treatment capacity is expanded, either at existing or at new treatment plants. Where increased density is the result of growth, the primary opportunity for increasing sustainability is in the new buildings. Imagine all of the multistory commercial and residential buildings in a border city and the amount of wastewater that each one could treat and recycle for toilet flushing. This practice is common in downtown Tokyo commercial buildings because the cost of potable water is so high (Aya 1999). The building occupants are frequently unaware that the water is recycled. It is treated inside the buildings through chemical, biological, and/or membrane processes and disinfected before recirculating. The cost of these systems is borne by the building owner and tenants, not the public, with savings to all.

Gray Water Reuse

Gray water reuse systems are also a potential method for increasing water sustainability in well-developed communities. Gray water reuse requires separate plumbing for laundry, showers, and washbasins to capture that portion of the wastewater that has a low bacteria count. It typically requires filtration with or without disinfection before it can be reused. If used for toilet flushing, it will probably require disinfection by the health department. If used for landscape irrigation, disinfection might not be required, as is currently the case in California. At present, few residents reuse gray water because it requires expensive retrofitting of the dwelling. If performed, the cost is borne by the property owner unless an incentive program is used to help defray the cost. While a gray water system adds to the complexity of maintaining a household, it is only slightly more complicated than a water softener.

Industrial Wastewater

For industrial users, many processes require water for washing or product manufacture. Through municipal ordinances, economic incentives, or high cost for water/wastewater service, industrial users can frequently implement operational changes to reduce water. Separating wastewater streams and onsite treatment provides another means for onsite water reuse in areas with well-developed public infrastructure.

Sewer Mining

On a larger scale, sewer "mining" offers a potential source of recycled water. Sewers normally have available flow. Diverting the flow for local landscaping uses means that potable water demand is reduced, as is the capacity needed at the treatment plant. Parks, sports fields, cemeteries, roadway landscaping, and golf courses all represent potential end uses for mined wastewater. In each case, a small onsite treatment system and safe irrigation system are needed. There are many such systems available (these are discussed in more detail in the section titled "New Communities and Infrastructures"). As the sewer is recognized as a reliable source of water, it will be possible to increase the number of landscaped open spaces since this water can be used for maintenance. If the end-user is a municipality or other public entity, the cost for the onsite system will be borne by the public. However, in exchange, the communal quality of life will increase through the added recreational and aesthetic amenities. Thus, the overall effectiveness of the system increases. Note that unlike centralized reclamation, distribution piping is not needed.

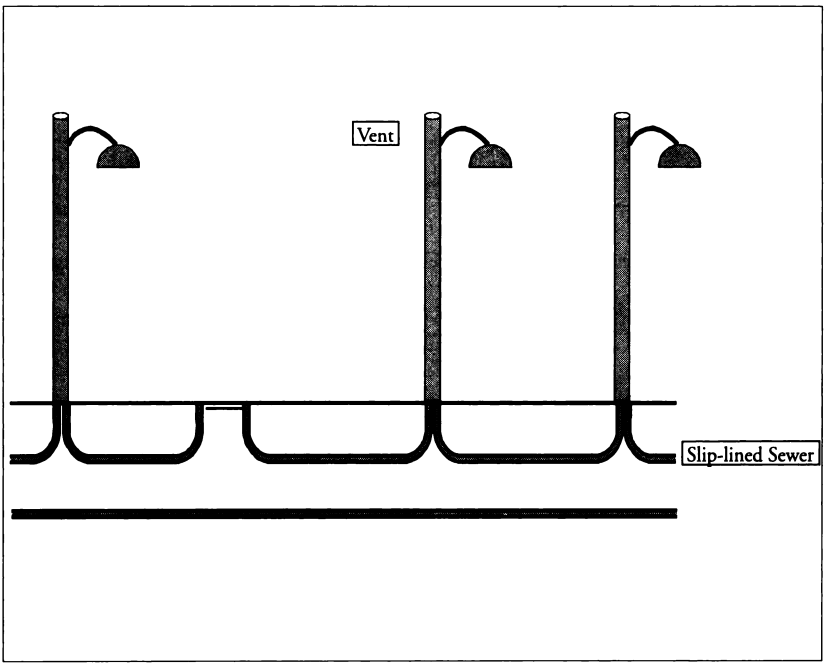
Trenchless Sewer Repair

Sewers represent a significant public cost burden since they settle, crack, and corrode. Since this problem is not new, many repair solutions are available to extend the life of sewer pipes. Slip lining is one example of how a watertight seal is restored by lining the pipe interior with a flexible membrane. Sewer repair can be very disruptive when long trenches interfere with local commerce and traffic. Trenchless repair technology, such as pipe bursting and jack-and-bore techniques, avoids these disruptions. Although these technologies do not necessarily affect the public tax burden, they do protect the local economy. In one example of sewer repair, the original sewers were placed at a flat grade causing sewage to stagnate and smell. Additionally, the old and cracked pipes were located in streets with no street lighting. Instead of installing new pipes at the proper slope, the pipes were lined with an impermeable membrane. The manholes were sealed to prevent odors at street level.

Since sewers must be vented, high vent tubes were evenly spaced along the street to disperse the odors. Odors disperse rapidly from the tall, sturdy vent tubes, which acted in double duty as light standards for new streetlights (Figure 2). This approach to sewer rehabilitation

prevented street disruption from trenching, reduced the energy consumed and pollution produced from heavy construction equipment, saved material cost on the pipes, reduced the nuisance caused by odors, and cut the cost of street lights. This is an excellent example of effective integrated infrastructure services.

Figure 2: Example of Integrated Infrastructure Services



Satellite Plants

Satellite plants for neighborhoods and industrial clusters are options that might be applicable where wastewater infrastructure is well developed. However, the drivers for these options are undermined by the fact that those who generate the wastewater play no part in maintaining the sewer system. Satellite plants will not likely be a common feature of these communities without drivers such as increases in the cost of services, economic incentives, government mandates, or revenue opportunities. Satellite plants for neighborhoods and industrial clusters are examined again as a viable option for new communities and systems.

Centralized Wastewater Treatment Options

Centralized Plant Technology

Existing treatment plants represent a variety of treatment processes. Centralized treatment plants offer economies of scale for treatment when the costs for sewers and redistribution are not included. Mechanical processes, typically with limited land requirements and high requirements for energy and chemicals, treat the majority of wastewater. These systems are well suited to urban communities where land is at a premium. Of these systems, activated sludge has become the standard by which wastewater treatment processes are measured. Many advances in activated sludge treatment allow for the effective removal of conventional waste parameters, such as biological oxygen demand (BOD) and total suspended solids (TSS), as well as important nutrients that over-fertilize and impact aquatic habitats. Activated sludge performs reliably and consistently where electricity supply and uniformity of influent wastewater are reliable. Another issue affecting technology selection is industrial pretreatment. Industrial pretreatment is required in both Mexico and the United States, although the program was implemented more recently in Mexico. It took about 20 years for the United States program to obtain the efficacy that it has today. Until Mexico's program accomplishes that level of efficacy, industrial compounds in wastewater will affect the reliability of compact electromechanical plants because their small size does not provide buffering capacity against spikes of toxicity. Similarly, in communities where electricity blackouts occur, electromechanical plants have little buffering capacity to maintain treatment performance.

Treatment Pond Systems

Another common treatment process used for small or low-income communities is a treatment pond. These scientifically engineered pond systems have not always treated wastewater reliably. However, recent advances in pond technology have greatly improved reliability and effluent quality while maintaining the low costs of construction and operation. These improvements make ponds more competitive for uses where only energy-intensive mechanical systems were once considered. Some existing pond systems have problems with odors and effluent quality. Advances in anaerobic zones, flow control, effluent weirs, sensors, and automatic controls can be used to retrofit existing ponds.

The tendency among small communities is to replace pond systems with mechanical systems when the communities grow. This substantially increases the capital and operating costs of the system. Unless the land used for a pond system must be replaced with a different land use, or the system must expand where no additional land is available, improvements to pond systems offer a substantially less expensive solution to growth.

Table 2: Cost Comparison of Activated Sludge and Advanced Pond for 25-mgd Wastewater Treatment Plant

Treatment System	Capital	Operation & Maintenance	Present Value*
Activated Sludge	$70,800,000	$5,300,000	$206,200,000
Advanced Pond System	$21,600,000	$2,900,000	$93,900,000

*Present value cost includes land cost of $550,000 for the pond system. Present value calculated for a 40-year plant life.
Source: CH2M HILL 1998a, b.

Currently in San Diego, California, the International Wastewater Treatment Plant treats wastewater from Tijuana to meet primary standards for discharge to the ocean. However, the wastewater quality requires additional treatment to secondary standards. Sufficient land was available for either an activated sludge or a pond system. An exhaustive study compared the reliability and cost of each system given the wastewater characteristics. Both systems would meet a discharge limit of 30 mg/L BOD and 30 mg/L TSS, the Clean Water Act standards. Because industrial wastewater is not pretreated prior to discharge into the Tijuana sewers, the performance by activated sludge was judged less reliable than an advanced hybrid pond system because of the potential for toxic upsets (CH2M HILL 1998a). Table 2 summarizes the capital cost, including land purchase, operating, and present value costs of the two systems (CH2M HILL 1998b). Based on these and other socioenvironmental factors, the pond system was selected for secondary treatment. It is noteworthy that the plant is much larger than most pond systems, treating 25 million gallons per day (mgd). This case demonstrates

the viability of pond systems for large municipalities, a role seldom considered in past decades. This pond system incorporates a submerged anaerobic cell followed by complete-mix-aerated cells and partial-mix-aerated cells. This particular technology produces a much smaller footprint for the plant, which meant that the available land was sufficient and affordable.

Wetlands

Few communities use wetlands as part of the treatment system. Wetlands offer many benefits, yet are often not feasible for large urban areas because of land constraints. When wetlands can be incorporated into the treatment train, the typical role in the United States is for polishing. Polishing follows and does not replace secondary treatment that must be performed, that is, by electromechanical or pond systems. In Mexico or other countries, this is not necessarily the case. Constructed treatment wetlands can be used with onsite systems. This use is discussed in "New Communities and Infrastructure" (p.184) because it is applicable for new developments. Treatment wetlands are an effective process. Wetlands reduce nutrients, provide wildlife habitat (such as for migratory birds), provide educational and recreational opportunities, and act as a carbon sink (i.e., to help offset the greenhouse effect partly caused by accelerated carbon dioxide emissions).

Centralized treatment plants eventually require upgrades to accommodate growth or to achieve a higher level of treatment. It is difficult to upgrade these plants without large costs that are passed on to the public. There are too many ways to upgrade mechanical plants to discuss here, particularly when these options generally represent high capital and operating costs.

Regionalization

Regionalization is an approach used to obtain cost efficiency from a single centralized plant serving more than one community. For immediate improvements in wastewater management, regionalization has obvious benefits. From a sustainability perspective, one disadvantage is that wastewater treatment plants are located far away from the generators and potential consumers. To offset this disadvantage, regional plants should be piped with both raw and reclaimed wastewater pipe systems. This increases the initial capital cost but probably saves money over the midterm. The challenge is justifying the initial cost of

producing and distributing reclaimed water from a centralized plant, especially if the per capita income of the community is low. Unless a regional plant is dual piped from the onset, the likelihood of reclamation of the plant effluent will be low. To help offset the operating cost of transporting both raw and reclaimed water, solar energized pumps should be considered. With typically sunny weather along the border, pumping costs can be reduced through the use of this limitless energy resource.

Reclamation and Repurification

Reclamation and repurification are terms used to describe the processes used to treat secondary effluent from wastewater treatment plants to levels that then allow the water to be reused according to public health standards. Current uses for reclaimed water are irrigation of public lands such as freeway landscaping, golf courses, and some industrial facilities. In Southern California, the cost of reclaimed water is about $200/acre-foot for treatment that meets Title 22 standards, not including secondary wastewater treatment. The present dilemma is that reclaimed water originates in a centralized plant and a distribution network does not exist. The distribution cost increases the reclaimed water cost considerably. By comparison, the wholesale cost of potable water is typically $20 to $150/acre-foot depending on the source (not including treatment and distribution). The cost of reclaimed water is much higher. The cost differential is borne by the public through taxes or increased fees on the water bill because customers for reclaimed water will not pay the true price.

Repurified water achieves an even higher level of purity through membrane filtration. In general, membrane filtration produces reliable water quality suitable for all uses. Repurified water could be blended with raw water from other sources, stored in reservoirs or aquifers, and treated in a water treatment plant before use by consumers. However, repurification faces a significant acceptance challenge. It could require a federal program of combined research and public education to overcome public resistance to repurified water blended into the potable water supply.

As alluded to in the discussion on regionalization, centralized plants of any type have the benefit of reduced treatment cost and the disadvantage of large distances separating water users from the treated effluent. The trend is to address water recycling at the effluent end of a cen-

tralized secondary wastewater treatment plant. As long as reclaimed water must be pumped and conveyed long distances before it can be used to recharge groundwater, the public cost burden for centralized recycling will remain high. For many communities, groundwater recharge is not economically feasible.

New Communities and Infrastructure

For new communities and developments, or for existing communities where the infrastructure will be new, the options for sustainable systems are much greater. Within this context, it is easy to see that "water is water." Regardless of the temporary designation as rainwater, potable water, groundwater, storm water, gray water, or wastewater it all should be managed as one integral resource.

Water Treatment by End Use

Starting with water demand, what would the infrastructure look like if the sources used to meet this demand were determined by the end use? The following are some common end uses:

- Drinking and food preparation
- Laundering
- Toilet flushing
- Bathing
- Housekeeping
- Cooling
- Wildlife habitat
- Agricultural irrigation
- Landscape irrigation
- Body contact recreation
- Aesthetics water features
- Fire suppression
- Manufacturing goods
- Industrial cleaning

For each of these categories there are treatment levels that are appropriate based on the scale and the associated environmental and health risks. Undoubtedly, drinking water must meet all existing standards, but toilet flushing and irrigation really only need treatment to a level that reduces risk to an acceptable level for limited human contact. Planning a new infrastructure system using the end-use approach could result in many system elements at several scales. The costs for these elements will vary, as will the parties who bear the costs. Table 3 illustrates how various water sources can be incorporated into the water/wastewater infrastructure based on end use.

Waterless Technology

An additional element not mentioned in Table 3 is waterless technology.

Table 3: Water Sources Based on End Use

Water Source	Scale of Infrastructure	Appropriate Uses
Surface water	Regional to municipal	Drinking and food preparation, some agricultural use, wildlife habitat
Groundwater	Regional to residential	Drinking and food preparation, agricultural (in some cases)
Repurified water	Regional to municipal	Drinking and food preparation, body contact recreation, laundering, bathing, housekeeping, cooling, industrial (if cost permits)
Aquifer-stored reclaimed water	Regional to municipal	Most uses where cost permits
Direct-use reclaimed water	Regional, municipal, and city district	Agricultural, public, and commercial landscape irrigation, fire suppression, wildlife habitat
Treated gray water	Large commercial to small residential buildings	Toilet flushing, onsite landscape irrigation
Onsite reclaimed wastewater	Large commercial to small residential buildings	Landscape irrigation systems with subsurface drip
Mined sewage	City district	Landscape irrigation of public spaces
Rainfall	Large commercial to small residential buildings	Landscape irrigation, toilet flushing
Storm water	Municipal, city district, possibly commercial and industrial	Aquifer recharge, wildlife habitat, non-body contact recreation use, landscape irrigation (possibly), toilet flushing, industrial processes

For many functions, removing water from the process is or may become a viable option. The most readily available technologies are sanitary waterless toilets. These include composting, electric, and solar-activated toilets. While waterless laundering is not yet available,

near-waterless laundry systems are being developed. Ultrasonic cleaning may be the next step in reducing laundry water.

Solar latrines come in many forms, including the Enviro Loo, a completely enclosed polyethylene system from South Africa. Solar heat pasteurizes and can even sterilize the waste, producing a very safe system for households, schools, and other applications. Figure 3 shows an example of a residential installation of the Enviro Loo system. The latrines use neither water nor energy and are inexpensive to install and operate. The community is not loaded with ongoing responsibility for sewer pipes or impacts to aquatic environments.

Figure 3: A Residential Installation of a Completely Enclosed Solar Latrine (Waterless)

Water Reuse Scenarios

The drivers for multiple cycles of water use and reuse stem from recent technological advances ranging from very large membrane treatment systems to small onsite systems. At the largest scale, repurification provides the promise of an enormous increase in the total available water supply. However, it is already known that natural water resources are finite, populations are growing, and many border communities are low income. The natural water supply cannot be aug-

mented by repurifying all of the water in a centralized system because the cost is simply too high. In Southern California, the cost of repurified water using a reverse osmosis process is about $500/acre-foot, not including distribution.

The cost of basic wastewater conveyance and treatment may already be higher than optimal to maximize prosperity and quality of life in some communities. For new infrastructure, hybrid alternatives can reduce the public's construction and operating costs. Imagine a scenario where residences and commercial buildings commonly have some level of onsite treatment. It could be membrane filtration in commercial buildings for toilet flushing or septic tanks in local households. Septic tank effluent would go through additional onsite treatment if used for landscaping or toilet flushing. Unused effluent would go into the sewer where it could be extracted to irrigate nearby playing fields, parks, and roadway landscaping after onsite treatment. Wastewater received at the treatment plant would undergo secondary treatment, nutrient removal, and disinfection at a minimum. Depending on the reuse options, filtration by granular media or membranes will produce water suitable for reclamation or repurification. Reclaimed water can possibly go to some industrial facilities, landscape or agricultural irrigation, and aquifer recharge. Repurified water can be blended directly with raw water for eventual treatment to potable water standards and supplied in the potable water distribution system. Alternatively, if use of potable water were restricted to drinking and food preparation, then the percentage of repurified water in the pipes could increase. Potable water produced solely from natural water sources could be delivered in bottles because the high cost of distribution would be offset by the low demand. These hypothetical scenarios serve to illustrate how multiple uses and points of wastewater treatment can increase water usage per gallon if the water supply system, wastewater collection and treatment system, and consumers are viewed as one whole system.

The cost of installing an onsite treatment system is borne by the property owner, who then benefits from both onsite reuse and the lower cost of running the treatment system. The cost of sewer-mined water treatment is borne by the public through an agency such as a parks and recreation department, yet this type of treatment provides an immediate and additional benefit. Treatment plant costs are borne by the public, but less water and less treatment will be required, thus

helping to control expenses. Reclamation costs, while initially expensive and borne by the public, can be offset through the purchase of water by agricultural or other users. Repurified water will cost the most, but may be unavoidable to augment natural water sources.

Centralized System Technologies for the Border

All centralized wastewater conveyance and treatment systems are technically feasible for the border. The systems identified here have lower costs but all are capable of meeting discharge standards. Some of the recent advances in wastewater treatment systems are particularly suited to the border because of cost or climate.

Wastewater Pond Systems

As illustrated in Table 2, lagoon or pond treatment systems offer a lower cost treatment solution. The traditional drawbacks to pond systems were large land requirements, lower effluent quality from algae solids, and odors. Advanced systems that use submerged anaerobic cells and/or subsequent trickling filters achieve improved effluent quality and odor control while remaining a low-cost alternative. The PETRO system developed in South Africa uses ponds with submerged anaerobic cells and trickling filters. These systems achieve effluent quality of 10 mg/L BOD, 10 mg/L TSS, 1 mg/L NH_3-N, 5–15 mg/L NO_3-N, and total phosphorus as low as 1 mg/L (Shipin, Meriting, and Rose 1997). Nine full-scale PETRO plants operate in climate ranging from subtropical, to Mediterranean, to highland.

Other advanced systems control algae production through mixing and aeration. Some of these systems have considerably reduced land requirements although the trade off is either more land (land use and purchase cost) or more aeration (energy cost) (CH2M HILL 1997). Some pond systems offer habitat and aesthetic benefits and all provide open space. Ponds also accommodate industrial discharges more reliably than mechanical systems.

Solar Powered Aerators

Solar-powered aerators for pond systems have been commercialized with many successful applications. In Bismarck, North Dakota, a municipal wastewater treatment system needed $500,000 worth of upgrades to reduce ammonia and generally improve effluent water

quality. Instead, the city purchased $176,000 solar-powered, gently mixing aerators and was able to achieve the necessary water quality improvements. In the first year, operating costs were reduced by $14,000 in energy savings (Volesky 1999).

Upflow Anaerobic Sludge Blanket

In addition to improvements in anaerobic pond technology, upflow anaerobic sludge blanket (UASB) treatment is becoming more common for domestic sewage treatment, particularly in Brazil. Its widespread application results from its high efficiency of organic material removal, its low construction cost, low land requirement, and simple operations (Van Haandel and Lettinga 1994). It is particularly suited to high strength wastes. In some of the border communities, water use per household is low and the strength of wastewater is high. For these communities, UASB offers an excellent treatment solution. In Brazil, the operating cost of a cluster-sized UASB treating 7,600 gallons per day for 285 inhabitants is about $3,960, although new advances may reduce the cost even further. Presently, UASB requires follow-on treatment to meet discharge standards of 30 mg/L BOD and 30 mg/L TSS (Chernicharo and dos Reis Cardos 1999). However, overall treatment cost is greatly reduced because anaerobic treatment does not consume large amounts of energy like the follow-on aerobic treatment. Since a UASB removes about 70% of the oxidation demand, the cost of aeration is proportionately reduced. If onsite reuse becomes common, UASB will be a prime candidate for managing the highly concentrated wastewater arriving at the central treatment plant.

Membrane Technology

Membrane technology is currently used for water treatment and for wastewater treatment following secondary treatment. Some of the most recent trials suggest that membrane systems may substantially reduce the treatment area, energy, and equipment needs for wastewater treatment. Preliminary results of a demonstration system in Pleasanton, California, indicate an effluent quality of 40 mg/L BOD, 0 mg/L TSS, and between 10 and 500 MPN coliform (Wilson 2000). This effluent is from a system that is composed of screening and membrane filtration only. The sludge is recycled until concentrated to 6% then digested in anaerobic digesters. The effluent will need biological treatment to reduce the BOD by 10 mg/L and will need disinfection, but

the cost of these additional processes will be much less than in conventional aerated systems.

Septic Tank–Centralized Systems

Combined septic and centralized treatment systems offer a cost-effective approach to wastewater treatment in communities that already have septic systems. Under a variety of circumstances, conventional septic systems are unreliable and may pollute groundwater or surface water. However, the septic tank itself is a remarkably simple, effective, and low-cost treatment process using anaerobic biodegradation and settling. If a community already has septic tanks but needs better treatment, pretreatment in septic tanks will reduce costs in advanced onsite systems, cluster-sized systems (neighborhood size), and centralized systems. With any of these approaches, the capacity—and therefore the cost—of the downstream system is reduced by maintaining the flow through the septic tanks. An added bonus for offsite systems is the reduced size of the sewer pipe resulting from this pretreatment. When a grinder pump or a biofilter and pump are installed in the septic tank, a two-inch diameter pressure pipe can greatly reduce the cost of sewer construction. The cost savings come from reduced materials and trenching costs as well as reduced treatment requirement at the cluster or central treatment system. Septic effluent pressure sewers cost about $5 to $10/foot. Where pressure sewers are appropriate, the cost is lower than the cost of conventional gravity sewers by about 18% to 50% (Cagle 2000).

Trenchless Sewer Rehabilitation

Other cost savings for conventional sewers will come from trenchless rehabilitation mentioned earlier. Trenchless technologies include pipe bursting, jack-and-bore, and slip lining. Although these technologies are more expensive to use for new pipelines, they are less expensive for rehabilitation (Reiland 2000). The economics of these technologies and the aging supply systems are creating a demand for these approaches. The cost of rehabilitation is sizeable, as is the environmental cost of deferred maintenance. In San Diego, deferred maintenance resulted in the city's worst sewage spill in 14 years when a pipe burst unnoticed and 34 million gallons of sewage spilled into a canyon and the ocean (Rodgers 2000). In response, the city will rehabilitate

the sewer line and spend an additional $250,000 for a computerized early-warning system. Aging sewers are a global concern. In Australia, the water industry operates and maintains an estimated 145,000 km of water mains and 80,000 km of gravity sewers and sewerage pumping mains. Conservative estimates indicate annual replacement costs alone at AUS$300 million (Stedman 2000).

Revenue from Wastewater

A sustainability analysis of wastewater treatment should include an assessment of community economics. In addition to agriculture, the following examples show three other ways to generate community revenue. Revenue can support other public services or help offset the public cost of treatment.

Benefits from Wetlands
Wetlands are a polishing system that can be added to any type of existing system to improve treatment. Wetlands provide several beneficial services: treatment, wildlife habitat, open space, aesthetics, and recreational uses. Wetlands frequently serve to reduce nutrient loads to receiving waters. Wetlands can also be used for revenue by harvesting water lilies and cut flowers such as cannas.

Tree Plantations
Tree plantations are another plant-based polishing system that provides revenue while protecting surface water. Tree farms should use tree species suited to the climate, such as mesquite, sycamore, and cottonwood, which are all indigenous to the border region. Mesquite can be harvested for production of charcoal.

Aquaculture
Aquaculture is a third source of community revenue from treated effluent. With control of ammonia and other good practices, fish yields should range between 5 to 10 metric tons per hectare per year in warm climates (Mara and Pearson 1998). Aquaculture is especially suited for treatment pond effluent because it contains algae, which is used to feed the fish, making the enterprise more economical.

Table 4: Onsite Technologies for Wastewater Treatment and Dispersal

Technology	Use	Description	Scale
Gray water systems	Reuse of water drained from showers, wash basins, and laundry for irrigation or toilet flushing	Separate in-building plumbing, sand or membrane filter, small pump for dispersal, disinfection by ultraviolet light sometimes used	Household or single building
Biotube filtration	Treatment of domestic sewage	Septic tank with biotube filter, effluent pumping, automatic controls, alarm system, may use disinfection	Household, small commercial
Intermittent sand filters	Domestic wastewater	Septic tank with biotube, pump, distribution manifold, optional pump to dispersal	Household, small commercial facilities
Recirculating sand filter	Domestic wastewater	Septic tank with biotube, pump, distribution manifold, optional pump to dispersal	Large commercial facilities, satellite plants for neighborhoods and industrial clusters
FAST system	Domestic and high strength organic commercial wastewater	Two-compartment septic tank, blower, aerobic treatment compartment with fixed and suspended growth, effluent pump to dispersal	Households, clustered subdivisions, high strength commercial wastes
STEP effluent sewers	Domestic wastewater	Septic tank, biotube filter, pump, one-inch diameter service lines, small diameter main lines	Commercial properties, neighborhood clusters, small and mid-sized communities
Mound system	Dispersal into ground of effluent from onsite systems	Soil mound, distribution manifold	Household, small commercial
Drip irrigation and spot irrigation	Shallow subsurface distribution of effluent from onsite systems for disposal or irrigation	Dosing control, distribution manifold, drip tubing or PVC pipe with evenly-spaced holes	Household, small to large commercial clusters
Constructed wetlands	Polish septic tank or other pretreatment effluent for treatment, wildlife value, aesthetics	Liner, gravel bed, distribution manifold, emergent wetlands vegetation	Household to small town

Onsite Treatment and Reuse

WERF identified four benefits of localized or onsite treatment:

1. Lower cost treatment than some centralized systems.
2. More control over water quality.
3. The ability to get maximum value from the water used.
4. Satisfaction in knowing that an individual's or community's actions are helping the environment.[3]

Over the last few years, a combination of factors resulted in onsite treatment and reuse receiving much needed attention. This attention translated into significant revisions of the EPA's guidance manual for onsite wastewater treatment, dispersal, and reuse, portions of which were released in draft form in 2000. Some states are also developing new rules for use of onsite treatment systems, such as Utah's Onsite Wastewater Systems Rule (Utah Department of Environmental Quality 2000). Even a few cities such as Malibu, California, have developed their own ordinances to allow for more types of systems. The types of systems now allowed varies considerably from place to place, but the intent is clear: these systems have the potential to play a much more significant role than conventional septic systems did in the past. The use of septic systems is replete with examples of failures resulting in contaminated water and health risks. New systems overcome the shortfalls of conventional septic systems in many ways. Some of the new technologies are described in Table 4.

Costs

The cost of wastewater infrastructure in any type of system should include the cost of both conveying the wastewater and treating it. Unfortunately, few studies report both. Additionally, costs for centralized systems are expressed differently than costs for decentralized systems.

In a study of 35 centralized wastewater treatment plants in California, the cost of treatment was shown for four types of treatment processes, two mechanical systems, and two lagoon systems. The operating costs are shown in Table 5.

Construction and operating cost comparisons for onsite and centralized systems are available, although differing scales of systems are complicated by the type of treatment process used, site conditions, and

Table 5: Operating Costs of Four Wastewater Treatment Technologies

Treatment System	1 mgd	10 mgd	25 mgd	100 mgd
Activated Sludge	$0.72/gal	$0.38/gal	$0.39/gal	$0.32/gal
Fixed Film (trickling filter and rotating biological contactor)	$0.59/gal	$0.52/gal	$0.26/gal	NA*
Conventional Pond	$0.35/gal	$0./gal	NA	NA
Advanced Integrated Pond	$0.26/gal	NA	NA	NA

*NA= not available
Source: Bradley 1993.

Table 6: Installation and Operating Costs for Onsite and Centralized Wastewater Treatment

Treatment System	Size Range in Person Equivalents (pe)	Approximate Construction Cost Range EUR(€)/pe*	Approximate Operations Cost Range EUR(€)/pe
Submerged Aerobic Filter	5–20	300–700 ($285–664)**	108 ($102)
Anaerobic Filter	5	380 ($361)	NA
Activated Sludge	5–20	420–800 ($399–759)	97 ($92)
Trickling Filter	5–20	700–1,150 ($664–1,091)	NA
Treatment Wetland (Reedbed)	5–20	500–1,150 ($474–1,091)	87 ($83)
Treatment Wetland (Reedbed)	50–22,000	370–850 ($351–807)	155 ($147)
Rotating Biological Contactor	5–20	420–1,150 ($399–1091)	NA
Rotating Biological Contactor	140–1,150	380–550 ($361–521)	12–25 ($11–24)

*Construction costs in range decrease with increasing capacity.
**Costs given in Euro first, followed by U.S. dollars in parenthesis.
Source: Geenans and Thoreye 2000.

Table 7: Installation and Operating Costs for Some Onsite Wastewater Treatment Systems

Treatment System	Size	Approximate Construction Cost	Approximate Cost of Operation
Conventional septic tank and leach field	600 gpd	$4,000–$5,000	$55*
Recirculating sand filter with subsurface drip disposal, constructed onsite	600 gpd	$12,000–$18,000	NA
Recirculating sand filter with subsurface drip disposal, modular construction	600 gpd	$8,000–$10,000	NA
Septic tank, effluent filter, small diameter sewer to communal recirculating gravel filter (138 equivalent dwelling units [edu])	25,000 gpd design flow 16,500 gpd average flow	$1,200,000 or $8,700/edu	$228/year/edu
Septic tank, effluent filter, pump, and conventional leach field	600 gpd	$10,000–15,000**	NA***
Septic tank, effluent filter, pump, and dosed drip system	300–1,200 gpd	$4,000–$25,000	NA***

*Assumes a cost of $165.00 for septic tank pumping once every three years.
**Cost of system designed by author in 1999.
***On two systems, owners report that energy costs are negligible and incremental costs go unnoticed in electricity bills. No other costs incurred over three-year period.

ancillary construction (such as for operations buildings, fences, and roads). One study looked at installation and operating costs for submerged aerated filters, wetlands, rotating biological contactors, activated sludge, trickling filter, and anaerobic filter processes. Table 6 summarizes the cost findings.

The cost data are difficult to interpret on a comparative basis because only two treatment systems are compared in the scales of both the onsite and centralized systems. In addition, the results do not represent the range of technologies available at either scale. For example, the following treatment technologies are not included: septic tank (anaerobic) treatment; fabric filter, tubular filtration, and membrane filtration; and dosed or drip irrigation dispersal systems. Most importantly, the results are not for whole systems because the cost of the sewer system is missing.

The cost of sewers is significant. The International Finance Corporation, a member of the World Bank Group, recently concluded that treatment of domestic sewage at the single household level was less

expensive than installing 20 meters of sewer pipe, exclusive of the cost of centralized treatment (Esmay 2000). This suggests that the economy of scale might not be the assumed trend of reduced cost with increasing flow, person equivalent, or equivalent dwelling unit (edu). Costs for some onsite wastewater treatment and disposal systems are provided in Table 7.

Institutional Changes to Accommodate the New Architecture

As seen in the previous discussion, technological changes have made sustainable water and wastewater systems and services along the border more feasible. Institutional changes are also needed to accommodate these changes.

The technical systems described are not readily implementable because many of them are not currently allowed. There may be reasonable cause for disallowing them at the present. For example, when a technology is emerging, issues of reliability are usually unresolved. In other cases, regulatory division among public health, water, and wastewater agencies causes the barriers. Sometimes restrictions have been imposed on earlier technology that still remain, but are not necessarily warranted. These barriers exist due to the lack of familiarity with new technical solutions among many regulators and local governments.

One of the most important issues for decentralized systems is how to safeguard public and environmental health; yet, these issues are the same for conventional treatment systems. In addition, like centralized systems, decentralized solutions include scheduled maintenance, performance monitoring, and legal action. These are ultimately the responsibility of regulatory agencies supported by managing entities that are yet to be established.

A paradigm shift to sustainability may be the most efficient way to address these barriers. Education, sustainability policies, and funded mandates for sustainability by state and local governments will allow the relevant institutions to adopt new solutions. The institutions will need to overcome their technical shortfalls and develop new regulatory and operational mechanisms to safeguard public health and the environment. The following list provides some examples of institutional

mechanisms that would support a sustainable water and wastewater program:

Municipalities and County Governments

- Expand the General Plan and planning and design criteria to include sustainable development (e.g., the sustainable development criteria for infrastructure projects imposed by the BECC). Include energy reducing measures, such as solar powered pumps and aerators as applicable.
- Develop new permitting conditions or requirements for real estate development to accommodate onsite rainfall, gray water, and wastewater treatment and use/reuse for residential and commercial properties.
- Develop standard engineering specifications and permit conditions for sewer mining, treatment, and reuse.
- Conduct open forums with the public to educate, respond to concerns, and receive ideas for implementation.
- Conduct the necessary environmental reviews at the programmatic level to allow the use of additional treatment technologies.

Local and State Level

- At the local or state level (depending on which state), establish a joint committee of water, wastewater, and public health officials to examine the institutional barriers within their own organizations and cross-organization barriers.
- Identify and recommend new institutional structures to eliminate barriers without eliminating the safeguards they represent.
- Resolve centralized management needs for decentralized systems through remote electronic monitoring systems, monitoring and maintenance contracts, reporting, fees, and enforcement.

Federal and State Agencies

- Conduct cost analyses for centralized and decentralized systems to more accurately identify the least expensive alternatives that provide the highest level of water sustainability. Conduct modeling for costs and water savings.

- Develop regulations for water sources and water quality determined by end use. Use the regulations as the basis for construction and operating permit conditions.
- Mandate municipal water conservation plans, emphasizing reuse.
- Together with federal or state agencies, develop financial incentives for local governments, developers, and property owners to adopt water conservation and reuse measures and implement public education programs (acculturation).
- Conduct environmental reviews at a programmatic level to allow for more types of treatment systems, including comprehensive engineering evaluations.
- Establish certification programs for engineers and contractors responsible for system monitoring and maintenance.

Funding Agencies

- Tie mandated water conservation plans and proof of implementation to funding for municipal projects.
- Tie loans to performance criteria and technological criteria where merited.

Academic Institutions

- Research and identify the cost of sewers and water distribution pipelines. Convert all costs to a cost-per-person equivalent to better understand the tax and fee impacts of the infrastructure.
- Develop a database of treatment system costs-per-person equivalent and effluent water quality for all types of systems. Develop cost curves for unit costs based on size.
- Conduct sustainability analysis of water and wastewater systems to better identify appropriate technology for a variety of border communities with varying socioeconomic factors.

Conclusions

- Viewed from a sustainability perspective, several scenarios exist for reducing costs while increasing water and wastewater services when appropriate technology is selected for centralized and decentralized treatment and conveyance.
- Many shortcomings of centralized wastewater treatment exist when viewed from a sustainability perspective. These short-

comings can be circumvented in areas where new infrastructure is needed. A sustainability analysis should be performed when planning infrastructure to avoid simply selecting the most common individual units without consideration of how that technology affects the whole system.

- Sustainability and a higher quality of life are achievable for lower cost through institutional and technological changes and in how funding is packaged.
- The cost of holistic water supply and use, wastewater conveyance and treatment, and reuse of treated effluent needs to be quantified. Without this quantification, it will be very difficult to proceed with defensible decision making to create a new and more sustainable system architecture.

Notes

1. For more information about The Natural Step and its analogy of resource demand and availability see "TNS Availability" at <http://www.naturalstep.org>.
2. This workshop was titled "Industry Endstates for WERF Future Mapping" and was held in Chantilly, Virginia, on January 15–16, 1999.
3. Included in the white paper produced at the "Industry Endstates for WERF Future Mapping" workshop held in Chantilly, Virginia, on January 15–16, 1999.

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VIII

Border Finances: Paying for Environmental Infrastructure

Christopher A. Erickson and David W. Eaton

Executive Summary

Growing environmental deterioration has prompted concern about promoting sustainable economic development. This concern is especially relevant in the fragile arid areas that characterize much of the U.S.–Mexican border region. Given the level of poverty in the border region, environmental protection measures must consider economic realities to be successful. Both Mexican and U.S. government agencies have recognized this and, consequently, have adopted policies that emphasize sustainable development that is both financially and environmentally sound (Thoms and Betters 1998).

The most severe environmental problem facing the border is the challenge of supplying the region with a safe and reliable water supply. Water is very scarce along the border and resources to finance needed infrastructure are in even shorter supply. In Mexico, all water belongs to the federal government. In the United States, water rights are controlled by a variety of states. The Comisión Nacional del Agua (CNA), or National Water Commission, is charged with administering water rights in Mexico. Mexico is currently undergoing a decentralization of the management and operation of water resources, although the process remains incomplete. The International Boundary and Water Commission's (IBWC) jurisdictions and responsibilities under the

Water Treaty of 1944 include responsibility for managing issues involving the waters of the Rio Grande and the Colorado River.

There are numerous impediments to meeting the environmental infrastructure needs of border communities. These impediments vary, but key among them is the lack of human capital to plan, implement, and maintain environmental infrastructure and the limited ability of communities to obtain affordable financing for the construction of needed projects. Given existing infrastructure needs and the expected population growth, environmental infrastructure improvements on the border are likely to be limited unless the key impediments are addressed.

The U.S.–Mexican border region faces a unique set of circumstances that arises from the juxtaposition of two economies at very different levels of development. The situation is complicated by the relative positions of the border communities within their respective countries. The northern frontier of Mexico is characterized by low income typical of developing countries, yet it is the wealthiest region in Mexico. The Mexican federal government, faced with constrained financial resources, has reasonably chosen to allocate limited infrastructure funds elsewhere. Consequently, the northern frontier will need to become less dependent on funds from the federal government and develop independent sources of funding.

By contrast, U.S. border communities are eligible for numerous federal and state programs aimed at mitigating the effects of income disparities on infrastructure. In addition, U.S. communities routinely access municipal bond markets to finance environmental infrastructure. This is not to say that there are no problems in the U.S. border region. Low incomes, rapid population growth, and more stringent national standards have all put strains on the financing capacity of U.S. border communities.

There are five major alternatives for financing environmental infrastructure:

- *Tax Financing.* Current tax revenues are often inadequate to finance environmental infrastructure, which requires large initial outlays while the receipt of user fees are delayed (Standard & Poor's 2000). Nevertheless, border municipalities without access to financial markets may be forced to utilize current tax revenues. The consequence can be inadequately maintained facilities and environmental degradation.

- *General Obligation Bonds.* General obligation bonds are secured by tax revenues and backed by the full faith and credit of the municipality.
- *Revenue Bonds.* A very common method of financing environmental infrastructure is with revenue bonds. Revenue bonds differ from general obligation bonds in that they are secured by a dedicated revenue stream generated from a particular municipal enterprise, such as a sewage treatment plant or a landfill.
- *Contracting with the Private Sector.* Contracting with the private sector to provide environmental infrastructure can be beneficial in two ways. First, to the extent that the private sector can provide services at a lower cost, the financial needs of the community can be reduced. Second, by privatizing services, the community can access the financial resources of the businesses providing the services.
- *Philanthropy.* Philanthropy is an appealing source of financing since it represents an actual increase in the funds available for the community for environmental infrastructure investment.

There are three institutions primarily concerned with border infrastructure:

- *International Boundary and Water Commission (IBWC).* The IBWC is responsible for maintaining the boundary between the United States and Mexico and managing issues involving the waters of the Rio Grande and the Colorado River. Its responsibilities include resolving water quality problems and designing, constructing, operating, and maintaining wastewater treatment facilities along the border. The IBWC also administers the EPA's Facilities Management Planning Grant Program, which provides technical assistance to communities attempting to develop water or wastewater projects for the Border Environment Cooperation Commission (BECC) certification.
- *Border Environment Cooperation Commission (BECC).* The primary roles of the BECC are to provide technical assistance to border communities and to certify environmental infrastructure projects in the border region for financing consideration by the North American Development Bank (NADB) and other sources.
- *North American Development Bank (NADB).* The NADB's primary purpose is to facilitate financing for the development,

execution, and operation of environmental infrastructure projects. Only projects certified by the BECC qualify for construction financial assistance from the NADB. The NADB provides direct financing in the form of loans or guarantees for BECC–certified environmental projects. The NADB administers grant funds provided by other donors through the Border Environment Infrastructure Fund (BEIF). This fund was originally financed with a $170 million contribution from the EPA. In addition to financing, the NADB also provides technical assistance to communities to help them develop the financial and administrative capacities of utility managers and their staffs.

Under the NADB's charter, it is required to make loans at a rate sufficient to compensate for the cost of funds and risk associated with lending on border infrastructure. These restrictions on the rate the NADB can charge often results in the NADB being priced out of the market. Larger communities on the U.S. side generally have lower cost alternatives to finance projects. Smaller communities cannot afford the NADB's interest rate. The U.S. Government Accounting Office (GAO) has recommended to the U.S. Congress that the NADB's charter be amended to allow the NADB to charge below market rates, which, in effect, would mean that it would be subsidizing loans to border communities.

Two important reforms that will likely continue to proceed in Mexico are increasing reliance on private contracting and the development of municipal bond markets. Mexico's wide-ranging privatization initiatives have resulted in the modernization and increased efficiency in numerous industries. Among the most promising areas for private investment are water and wastewater treatment projects. The government has demonstrated its commitment through the development of transparent bidding procedures and by learning from past mistakes. Mexico has taken these important steps to attract much needed investment to infrastructure projects that are key to ensuring the country's continued competitiveness. To create a viable financing package, the risks associated with water projects in Mexico must be carefully allocated among project participants. In general, the commercial risks associated with the completion and operation of the project should be allocated to the private sector participants while the political risks are increasingly being assigned to the federal, state, or municipal govern-

ments or to participating multilateral agencies.

There are several reasons to believe that the time is right for the development of a Mexican municipal bond market:

- Municipal bond markets have been established in a number of developing countries over the last few years. During a recent two-year span, Standard & Poor's (1999), for example, rated 13 municipal bond issues in emerging markets, mainly in Latin America and Eastern Europe. These municipalities were located in "middle income" countries with similar macroeconomic circumstances to Mexico.
- The overall credit position of Mexico has improved dramatically since the 1994 peso crisis. This positive trend has been reinforced by the sharp rise in oil prices.
- The favorable economic conditions that characterize the overall Mexican economy apply even more so to the northern frontier region. This region has seen the greatest economic growth over the last two decades. This economic growth has created the economic depth conducive to the establishment of financial markets.

While circumstances are favorable for movement toward the establishment of a municipal bond market, there are still considerable hurtles. An insufficient local tax base is a major problem. Under the Mexican Constitution, most taxes are deposited with the federal government. Local governments then depend on revenue sharing financed by federal and state governments. Another problem for Mexican border communities is the lack of adequate management institutions beset by administrative deficiencies, inadequate financial control, and a lack of legal authority to collect user fees and taxes. Underlying these management problems is the more fundamental problem of inadequate human capital needed to plan, implement, and maintain environmental infrastructure.

While many obstacles remain for the establishment of a fully functional bond market, the first steps toward the formation of such have already occurred. For example, in December 1997, the state of Guanajuato issued 10-year GTO bonds secured by revenue generated from Guanajuato–Silao toll road (Nacional Financiera 1997). The cities of Medina and Monterrey, and the states of Nuevo León and Durango, have all received positive reviews from Standard & Poor's.

INTRODUCTION

The U.S.–Mexican border is the world's longest and most frequently crossed border between a developing and a developed country. On both sides, world-class manufacturing coexists alongside third-world poverty. While rapid population growth, sprawling maquiladora plants, deficient urban planning, egregious poverty, drought, illegal immigration, drug trafficking, and environmental problems all characterize the region, it is also a place of dynamic change and growth. It is the contact point between two very different countries that share a past of conflict, but more importantly, that also share a future of trade and cooperation. Indeed, the development of broad-based/cross-border civil entrepreneurship is leading to greater cooperation between all sectors of the border community. These efforts should be encouraged and the resulting positive energy must be channeled into constructive solutions for sustainable development along the border.

Growing environmental deterioration along the border has prompted concern about promoting sustainable economic development. An important element in sustainable development is the provision of environmental infrastructure such as a safe water supply, wastewater treatment, and solid waste management (U.S. EPA and SEDUE 1992; U.S. EPA 1996). Indeed, the most severe environmental problem is the challenge of supplying clean, reliable sources of water, which is especially relevant in the fragile, arid areas that characterize much of the U.S.–Mexican border region. Given the poverty of the area, environmental protection measures must consider economic realities to be successful. Water is scarce along the border, but funds to finance much-needed infrastructure are even scarcer. Both Mexican and U.S. government agencies have recognized this and, consequently, have adopted policies that emphasize sustainable development that is both financially and environmentally sound (Thoms and Betters 1998).

This paper will examine the future of the U.S.–Mexican border region from the narrow perspective of the financing of environmental infrastructure. The authors worked under the assumption that current financing mechanisms for water infrastructure in Mexico will not be adequate to meet future demand. Most of this paper is devoted to examining two mechanisms that could be used to channel greater investment into water infrastructure along the border: private sector participation in Mexican water utilities through the granting of

Design, Build, and Pperate (DBO) concessions and the development of a municipal bond market. The advantages of each approach, as well as the barriers to the successful implementation of these reforms, are highlighted.

A Snapshot of the Border

The border region is experiencing explosive population growth, which is taxing existing social infrastructure such as schools, hospitals, and public transportation. The demands of a growing population are creating severe environmental problems. Specifically, governments are straining their resources to provide residents with potable water and to treat the growing quantities of wastewater. More than 10 million people live in the border region. If the 1990–1995 migration patterns continue, the border population will grow by more than 12 million people in the next 20 years. Two-thirds of this growth is projected to occur on the Mexican side of the border. For example, in 1978, Tijuana had only 400,000 inhabitants; today, it has almost 1.6 million. Growth rates for Matamoros, Reynosa, Nuevo Laredo, Piedras Negras, Ciudad Juárez, and other Mexican border cities are equally shocking.

Much of the population growth along the border can be attributed to the explosion of maquiladora plants in the border region. Maquiladoras are assembly plants that import parts primarily from the United States and then export assembled goods back to the originating country. As of 1998, approximately 2,500 foreign companies have established operations in the border region to take advantage of Mexico's competitive labor force, the geographic proximity to the United States, and the benefits of temporary importation programs. To date, the maquiladora industry has generated over 1.2 million direct jobs and many more indirect jobs in Mexico. Over 72% of all maquiladora jobs have been created along the border. Border officials have been quick to take credit for the rapid growth of the maquiladora industry, correctly pointing to the success of maquiladora attraction programs. Unfortunately, little urban planning has accompanied these very successful programs. The consequence has been increasing environmental degradation. In the press, maquiladoras have been blamed for many of the environmental problems facing the border region. While much of this criticism is justified, it should be noted that the managers of many maquiladoras have been willing to contribute to the development of

their region, but have not been presented with a general framework in which to do so. New efforts must be launched to incorporate maquiladoras into a sustainable growth model for the border.

While great efforts where undertaken to attract foreign-owned manufacturers to the region, little attention has been paid to constructing the social infrastructure necessary to meet the needs of maquiladora workers or to protect the environment. The border suffers from an acute lack of almost all basic infrastructure, including schools, hospitals, day-care centers, housing, potable water, electricity, paved roads, solid waste landfills, and so on. One of the most desperate problems is the lack of housing. The housing deficit in the border region is estimated at 500,000 units. Faced with the lack of options for housing, workers who arrive at the border from the interior of Mexico begin to form irregular housing developments, which eventually lead to social and environmental problems, including serious problems related to potable water and sewage treatment. These migrant neighborhoods lack almost all basic services. As a result, health problems and environmental damage are commonplace. The current urban development model in the border region is unsustainable.

Much of the U.S. infrastructure shortfall can be found in small, unincorporated communities located primarily in Texas and New Mexico called colonias, which often lack even the most basic services. While several federal and state programs are directed at providing colonia residents with basic water and sanitation services, colonias are generally located outside of established water districts. Colonias lack both the tax base and the administrative resources to qualify for bond financing or bank loans (GAO 2000). There are federal and state programs to assist colonias in obtaining basic services; however, program requirements often restrict the use of these funds. For example, federal funds cannot be used to improve property that is subject to ongoing litigation, which is often the case with colonias; many programs cannot be used to improve property located in flood plains, as many colonias are; and Texas does not allow funds to be used to establish septic systems if current plans call for connection to a sewer system, even if the plans are not expected to be executed in the near future. According to the GAO (2000), between 1989 and 1999, $579 million was allocated to improve colonia environmental infrastructure in Texas, but only $337 million was spent due to constraints on funds. The

NADB's Small Communities Initiative would dedicate $1 million in matching funds to small communities in each of the four border states, but no funds have yet been released from this program.

Population growth, industrial activity, and severe drought are rapidly degrading the border environment. Environmental problems include lack of municipal solid waste landfills, clandestine hazardous waste dumps, poor air quality, destruction of natural habitat, contaminated drinking water, and insufficient wastewater treatment capacity. Border environmental infrastructure needs (including water, wastewater, and solid waste) identified in early 1999 by the BECC and the NADB total approximately $1.7 billion. This figure could more than double in the next 10 years. Within the wide range of environmental problems, the most severe in the border region are the quantity and quality of available water. Since one of the most pressing issues is how to finance the millions of dollars needed along the border for water and wastewater infrastructure, this paper will look closely at the financing of water infrastructure on the Mexican side of the border. From this analysis, lessons can be learned for the financing of other types of environmental infrastructure.

The Need for Environmental Infrastructure

Most U.S. border communities already have access to clean drinking water. However, existing facilities require rehabilitation and expansion, and some communities need entire new systems due to neglect or lack of funds (BECC 1998). Many infrastructure needs faced by border communities arise from regulatory changes. For instance, satisfying the rules imposed by recent amendments to the Safe Drinking Water Act (SDWA) requires further treatment of potable water. Additionally, more stringent regulation under the Clean Water Act (CWA) has imposed greater controls on effluent quality, sludge disposal, and storm water overflows. The full cost of compliance with these standards is currently uncertain (Standard & Poor's 2000). With regard to waste management, residents of colonias and rural areas generally lack comprehensive solid waste collection. A major challenge for municipalities is complying with evolving state and federal regulations, which in some cases now require multiple liners, leachate collection and treatment, and methane gas collection (Standard & Poor's 2000).

On the Mexican side of the border, the problem is more fundamental, being one of basic access to services. Mexico's Comisión Nacional del Agua (CNA), or National Water Commission, estimates that only 88% of the population has access to safe drinking water, 75% have access to sewage collection, and 34% have access to wastewater treatment (BECC 1998). These estimates are probably overly optimistic, especially given the migration of population from the interior to the border in recent years. Collection, management, and disposal of solid waste are often done by institutions with administrative inadequacies and without adequate legal authority. Only 86% of households have waste collection and only 53% of that is deposited in sanitary landfills (BECC 1998).

The need for additional environmental infrastructure along the border is well recognized, yet finding funds to finance such investment is a challenge. Between 1994 and 1999, through various initiatives, the United States and Mexico have provided approximately $3.1 billion to address border environmental infrastructure needs (GAO 2000). Of these funds, approximately 80% has been provided by the United States, mostly by the EPA. While billions of dollars have already been spent, billions more need to be spent. The Southwest Center for Environmental Research and Policy (SCERP) estimated in 1999 that an additional $3.2 billion is required to meet existing infrastructure requirements on both sides of the border for safe water, wastewater treatment, and solid waste disposal. About 77% of this amount is needed for wastewater treatment.

The timely building of environmental infrastructure is a crucial element of sustainable development. Households have a high demand for safe and convenient water supply as well as for sewage disposal. Should the community not provide these services, individuals will often take action to secure them privately. However, the technology available to individuals is often not as cost effective nor as efficient as the technology available at the community level. Indeed, private actions can even compromise the public provision of services. For example, faced with a lack of a reliable public water supply, households will resort to private wells as supplements. If these wells are pressurized, as is often the case, it is possible that well water will be pumped into the community's water supply, thereby compromising the public water system.

The Benefits Offered by a Financial System

A financial system provides three key benefits: risk sharing, liquidity, and information services. The financial system allows risk sharing by making it easier for savers to hold a diversified portfolio of assets. Diversification reduces the risk faced by savers since a low return on one asset tends to be offset by a high return on another asset, allowing for a more steady return. Savers value liquidity because they may need to spend assets, and financial markets and intermediaries provide mechanisms that increase asset liquidity. Finally, a financial system can provide information services, which include both information gathering and information communication. These benefits make savers more willing to hold financial assets, increasing the municipalities' ability to raise funds at low cost.

Information services are particularly important in the development of a municipal bond market for financing border infrastructure. Financial markets quickly absorb information, incorporating it into the price of financial assets, thereby communicating the status of such assets to other market participants. The easiest way to understand this is through the following example: suppose that new information becomes public about employment generated from a new manufacturing plant located in ABC Township. Market participants will evaluate the effect of the employment on tax revenue available to service ABC's outstanding bonds. If the bonds are now more secure, the price will be bid up. Of course, the bonds might have been overvalued (perhaps the new employment generated was disappointingly small), in which case the bond's price will be bid down. In either case, information about the township's new situation is quickly incorporated into the bond's price. In general, municipal bond prices, like the price of other types of financial assets, will fluctuate to reflect risk, liquidity, and information costs. By so fluctuating, market prices convey information to market participants about the municipality backing the bonds.

Border communities will likely need help in overcoming information problems. Investment banking is an institution that helps to overcome information costs. These institutions specialize in advising on how to raise funds. Investment bankers may recommend that a municipality finance infrastructure through a bank loan, through private placement

of debt, or though a public bond issue depending on the credit characteristics of the municipality. While each situation is unique, generally municipalities with limited credit will have to use bank financing or private placement. Municipalities with better credit will be able to use bond financing. If the decision is to issue bonds, the investment banker advises on the term of the bond issue. An important function performed by the investment banker is to underwrite the public offering.[1] In underwriting the issue, the investment banker promises to purchase the unsold portion of the new issue, thereby guaranteeing the success of the issue. The fact that the investment banker is willing to underwrite conveys to the market information about the quality of the issue.

Given the specialized needs of the border, the development of an investment banker dedicated to border development may be appropriate. In recent years, the NADB has begun to develop into just such a specialized investment banker for the border, having shifted somewhat away from acting as a direct lender. For example, the NADB served as the investment banker, securing funding from other sources, as well as lender in the financing of the Agua Prieta Landfill project. Similarly, NADB served as financial "advisor" as well as lead lender on the Brawley, California, Wastewater Treatment Plant. By serving as an investment banker, the NADB is reducing the information cost of border financing and increasing available funds.

Another group of institutions that have developed to help overcome information problems are bond-rating services. Bond-rating services assign a rating to a bond issue that indicates the default risk associated with that bond. Highly rated bonds face little or no default risk while lower rated bonds face greater default risk. While bond-rating systems vary slightly, the rating systems are rather similar; for example, Moody's system ranges from least risky to most risky (Aaa, Aa, A, Baa, Ba, B, C, and D). Bonds rated Baa or better are considered investment grade and have little default risk. Bonds rated less than Baa are considered speculative and are sometimes referred to derisively as "junk bonds." Bonds rated D either are in default or thought likely to soon enter default. While bonds may also be unrated, many investors require that they be rated before they will purchase them.

Both investment bankers and bond-rating services will require municipalities to meet certain standards before they will certify credit worthiness. An example of this is the Institutional Development Cooperation Program (IDP) sponsored by the NADB. The program

provides technical assistance to local utilities aimed at enhancing the administrative and financial strength of the utility. The kinds of studies financed under the IDP include water rate studies, user registry update, and implementation of a management information system.[2] While programs like the IDP are helpful, the need for administrative reform among border municipalities remains.

Bond-rating agencies also offer technical assistance to improve the credit worthiness of a municipality seeking a rating. Below are listed in more detail the types of actions investment bankers and bond-rating agencies will likely require of municipalities if a bond market is to be established. The point here is that the requirements placed on municipalities by investment bankers and bond-rating agencies are the types of reforms consistent with good government and sound municipal finances. Regardless of the desirability of environmental infrastructure financing, reforms consistent with the establishment of a bond market are exactly the types of reforms that promote efficient and democratic local government.

Border Environmental Infrastructure Institutions

There are three institutions primarily concerned with border infrastructure. These are the IBWC, the BECC, and the NADB. The IBWC has been in operation for more than a century while the BECC and the NADB were established in conjunction with the North American Free Trade Agreement (NAFTA). The remainder of this section describes each of these institutions.

International Boundary and Water Commission (IBWC)

The IBWC was established by international treaty between Mexico and the United States in March 1889. Its jurisdictions and responsibilities were expanded under the Water Treaty of 1944 to include the U.S.–Mexican border and inland into the two countries where both countries have constructed international projects (IBWC 1998). It is responsible for maintaining the boundary between the United States and Mexico and managing issues involving the waters of the Rio Grande and the Colorado River. The IBWC's responsibilities include

resolving water quality problems and designing, constructing, operating, and maintaining wastewater treatment facilities along the border. The IBWC also administers the EPA's Facilities Management Planning Grant Program, which provides technical assistance to communities attempting to develop water or wastewater projects for IBWC certification.

The IBWC has developed a reputation of supporting the building of so called "cement edifices," that is, traditional, large-scale wastewater treatment facilities. The IBWC constructed and maintains wastewater treatment facilities in the South Bay area of San Diego, California, and in Nogales, Arizona. These two projects involved a total U.S. federal government investment of $321.9 million. The IBWC was also involved in the construction and maintenance of the international waste treatment plant in Nuevo Laredo, Tamaulipas. Many observers have criticized the IBWC's reluctance to consider alternative technologies that some view as more appropriate solutions to border infrastructure shortfalls. Others criticize the critics as inappropriately applying a politically correct criteria.

Under the 1944 Treaty, the IBWC was allowed to conclude international agreements, with the approval of the two national governments, in the form of IBWC Minutes. Between 1994 and 1998, the IBWC has concluded nine such agreements. Six of these concerned environmental infrastructure (IWBC 1998). Of these six agreements, four concerned IBWC's relationship with BECC. The creation of the BECC and the NADB have led to a reduction in the role played by the IWBC in transboundary environmental infrastructure (GOA 2000). Generally, the IBWC has taken on a supporting role in the post–NAFTA era.

The Border Environment Cooperation Commission (BECC)

The primary responsibilities of the BECC are to provide technical assistance to border communities and to certify environmental infrastructure projects in the border region for financing consideration by the NADB and other sources (BECC/NADB 1999). The BECC's assistance helps ensure technically sound and feasible projects, master plans, project design, environmental assessment, and local institutional capacity building. Approximately $15.5 million have been allocated by the BECC's Technical Assistance Program to aid in the develop-

ment of 107 environmental infrastructure projects and/or concepts related to water, sewage, and municipal waste in more than 78 communities on both sides of the U.S.–Mexican border.

Certified proposals must meet certain criteria for technical and financial feasibility. The projects must be environmentally sound, self-sustaining, and supported by the public (GAO 2000). The BECC also assists states and localities in the preparation, development, implementation, and oversight of environmental infrastructure projects in the border region. The BECC restricts its concern to water, wastewater, and solid waste disposal. It emphasizes the importance of project sustainability in its certification process since past projects have been built in poor communities with grants and other assistance that could not be properly maintained due to the communities' limited administrative capacity and financial resources. The BECC also provides technical assistance to border communities with project development activities, including devising plans, creating project designs, and performing environmental assessments. As of September 1999, the Border Commission had certified 31 projects—12 in Mexico and 19 in the United States. Twenty-eight projects were for water and wastewater treatment systems, and three were for solid waste disposal facilities. The total estimated construction cost of these projects is $680.2 million, and when completed they are expected to benefit more than six million people. The United States and Mexico provide annual appropriations to the BECC to cover operational expenses. The initial agreement creating the BECC required that the national governments provide full funding for five years. Despite continued need for environmental infrastructure, funding by the national governments has been reduced as of the fiscal year 2000. In addition, most of the EPA's technical assistance funding to U.S. and Mexican communities for water or wastewater treatment projects is channeled through the BECC.

North American Development Bank (NADB)

The NADB's primary purpose is to facilitate financing for the development, execution, and operation of environmental infrastructure projects. Only projects certified by the BECC qualify for construction financial assistance from the NADB. The Bank provides direct financing in the form of loans or guarantees for BECC–certified environ-

mental projects. To date, the NADB has made seven loans totaling more than $11 million. Three loans have gone to Brawley, California; Mercedes, Texas; and Ciudad Juárez, Chihuahua.; the other four loans were channeled through the Corporación Financiera de Desarrollo de América del Norte (COFIDAN), which was developed to finance projects sponsored by public entities in Mexico. These loans were made to Tijuana, Baja California; Agua Prieta, Naco; and Puerto Pensasco, Sonora.

The United States and Mexico agreed to contribute equally to the capitalization of the NADB. The agreement called for a total lending capacity of $3 billion with $450 million as paid-in capital and an additional $2.55 billion as callable capital. To date, each country has contributed $174.4 million (78%) of the paid-in capital, with the remainder to be paid by September 2004. The NADB's paid-in capital is available to support borrowing for its international programs. Callable capital is composed of funds that the governments are to provide—if required—to meet outstanding debt obligations or guaranties issued by the NADB (GAO 2000).

The NADB administers grant funds provided by other donors through the Border Environment Infrastructure Fund (BEIF). This fund was originally financed with a $170 million contribution from the EPA. The BEIF provides grants to communities to reduce the total cost of needed projects. These BEIF funds may be applied to water and wastewater projects on the U.S. side of the border; however, they are only available to finance water and wastewater projects on the Mexican side of the border if the infrastructure deficiency affects communities in both countries. If grant funds are used on the Mexican side of the border, Mexico must provide an equal border investment. As of September 1999, nearly 93% of BEIF funds had been committed. Without continued funding for BEIF grants, environmental infrastructure development along the border will be jeopardized. Through September 1999, BEIF grants accounted for 96% of NADB funds provided to U.S. projects and 88% of NADB funds provided to Mexican projects.

In addition to financing, the NADB also provides technical assistance to communities to help them develop the financial and administrative capacities of utility managers and their staffs. The IDP is designed to assist public utilities in the areas of institutional strengthening and financial development to ensure long-term viability of infra-

structure projects. So far, 75 projects in 58 communities have been funded. The NADB has recently initiated a program called the Utility Management Institute (UMI). UMI is designed to provide water utility personnel with the specialized knowledge needed to organize, administer, and finance water utilities.

Reforming the NADB

While the NADB has initiated a number of programs, it has had a limited impact on border infrastructure. In particular, it has made very few direct loans. As of September 1999, the NADB had obligated a total of $154.5 million in loans and grants to fund construction for 20 BECC–certified projects. However, direct loans represent only 3.2% of the NADB's current paid-in capital. The biggest source of the NADB's assistance has been through BEIF grants. All but four of the 20 NADB–financed projects had such grant funding. Since the creation of the BEIF, 93% has already been obligated.

Why has the NADB made so few direct loans? Under its charter, it is required to make loans at a rate sufficient to compensate for the cost of funds and risk associated with lending on border infrastructure. These restrictions on the rate it can charge often results in the NADB being priced out of the market. Larger communities on the U.S. side of the border generally have lower-cost alternatives to finance projects. Smaller communities cannot afford the NADB's interest rate.

The GAO (2000) has recommended to the U.S. Congress that the NADB's charter be amended to allow it to charge below market rates, which, in effect, would mean that the NADB would be subsidizing loans to border communities. Both the U.S. State Department and the EPA concur with this proposal, but the U.S. Treasury Department is opposed (GAO 2000). The Treasury Department argues that the problem is not that interest rates are too high, but that border communities are extremely poor. Moreover, border utilities do not have the technical capacity to manage financial resources and infrastructure projects. In addition, the Treasury Department stated that the NADB effectively has a mechanism that provides low-cost financing by combining loans with grants. While the Treasury Department is correct in its position that often a lack of expertise is as great (or even greater) an impediment to successful management of environmental infrastruc-

ture as is lack of financing, high interest rates also serve as a barrier to the border communities' ability to access NADB's capital.

Current financial theory emphasizes the fact that financial institutions provide information services, a role which was not mentioned by the GAO nor considered by the Treasury Department, and which cannot be duplicated by grant financing. Banks serve as information warehouses, gathering information about potential borrowers and using that information to determine which borrowers represent the best credit risks. Given the special information advantage enjoyed by banks, a bank loan conveys information about credit worthiness to other potential borrowers. By lending, a bank indicates that its information is such that it believes that the borrower is a good credit risk. Conversely, by declining to lend, a bank indicates that the borrower is not a good credit risk. Thus, other potential lenders, seeing that the bank is willing to lend to a borrower, will also lend to that borrower. This argument would indicate that the NADB can play a special role in border infrastructure finance; because the NADB is a specialist in lending to border environmental infrastructure projects, its decision to lend or not to lend provides a particularly important signal to other potential lenders.

Grants can also play a role in conveying information about the credit worthiness of an infrastructure project in that the NADB is unlikely to make grants for projects its sees as having no value. However, the information conveyed by grants is likely to be of lower quality than the information conveyed by loans. First, because grants are a one-time event, there is less incentive for the NADB to monitor the project on an ongoing basis. Thus, while a useful indicator of the current credit worthiness of a project, grants provide less information about future credit worthiness. Second, because grant recipients need not qualify for loans to receive a grant, the credit worthiness of the recipient, all else constant, should be less than for those receiving a loan.

There is one final reason for amending the NADB's charter to allow concessionary lending. Such a change in the law, if nothing else, increases the options available to the organization's management. The NADB will be better able to design financing packages that meet the needs of border communities if concessionary lending is allowed.

Sources of Funding for Environmental Infrastructure

There are a wide variety of methods by which environmental infrastructure can be financed. Here the focus is on some of the more important alternatives. These include tax financing and user fees, central government grants, general obligation bonds, revenue bonds, contracting to the private sector, and philanthropy. The exact combination of funding sources that are accessed by a particular community varies depending on circumstances. Not surprisingly, the set of options available to U.S. communities is greater than those available to Mexican communities. U.S. communities have access to the most developed financial system in the world while Mexican communities are embedded in an economy that has experienced periodic financial crises. Because municipal ratings are restricted to no higher than the national government (Moody's 2000), a lack of confidence in the financial stability of the Mexican federal government adversely affects the cost of funds to local municipalities. U.S. communities also have a larger tax base than their Mexican counterparts and have independent tax authority. In Mexico, the tax distribution is tilted toward the federal government and municipalities are dependent primarily on property taxes.

The following is an elaboration of each of the major alternatives in financing environmental infrastructure.

Tax Financing and User Fee

Current tax revenues, including user fees, are often inadequate to finance environmental infrastructure, which requires large initial outlays while the receipt from taxes and user fees are delayed (Standard & Poor's 2000). These problems are compounded by difficulties in collecting user fees in many border communities, which are characterized by extreme poverty. Nevertheless, border municipalities without access to financial markets may be forced to utilize current tax revenues. The consequence can be inadequately maintained facilities and environmental degradation.

Direct Grants

Both the Mexican and U.S. federal governments have provided direct grants to local governments. However, these programs have been reduced on both sides of the border. In Mexico, the funding mechanisms for water supply and wastewater infrastructure are currently in a state of flux. Traditionally, almost all monies came from direct federal appropriations to the CNA. As part of Mexico's larger process of decentralization, states and municipalities are now called upon to finance more public works projects. The federal government still plays a dominant role in the financing of water infrastructure, but it is moving away from direct grants and more toward loan programs. Most of these funds are still provided through the CNA, but non–CNA federal grants are also available under the so-called Ramo 33 program, which assigns resources directly to Mexican state and local governments for social programs, including environmental infrastructure. Unfortunately, Ramo 33 funds have been reduced as a result of the 1999 budget conflict.

There has also been a reduced emphasis placed on direct grants in the United States. EPA funds were once distributed directly to pay for the construction of wastewater treatment facilities. However, amendment to the Clean Water Act shifted funds from direct construction grants to state revolving funds (SRFs), which act as environmental infrastructure banks. Most states have used the SRFs to subsidize loans to local government.

Direct Loans

As previously indicated, an important source fund for direct loans for U.S. communities has been the SRFs, which, in effect, act as infrastructure banks. These SRFs often secure pooled loans that are then sold in bond markets. Another important source of direct loans for border communities is the NADB, which was discussed earlier. The Banco de Obras Publicas (BANOBRAS) (Mexican Public Works Bank) provides loans to state and municipal governments for water infrastructure projects. BANOBRAS created a special program called the Fondo de Inversión en Infraestructura (FINFRA) (Infrastructure Investment Fund), which is designed to provide resources for key infrastructure projects in Mexico. FINFRA was originally funded in

the amount of approximately $170 million through the privatization of state-owned enterprises such as the railroads. The fund provides risk capital and credit enhancement mechanisms for, among others, water and wastewater facilities.

General Obligation Bonds

General obligation bonds are secured by tax revenue, and are backed by the full faith and credit of the municipality. This type of bond is popular with investors because of their reputation for safety. Such bonds can be used to finance environmental infrastructure but there are certain disadvantages to doing so. For instance, general obligation bonds encumber the overall financing capacity of the municipality (Standard & Poor's 2000). Municipalities may not want to use general obligation bonds, which affect overall credit worthiness, when it is possible to use revenue bonds secured by dedicated revenue stream from a municipal enterprise. Moreover, for municipalities with poor credit, investors may view revenue bonds as more secure. A further constraint on using general obligation bonds for Mexican municipalities is the constitutional prohibition against the issuing of foreign currency denominated debt. This restriction severely limits municipalities' direct access to U.S. financial markets. Also, because Mexican municipal revenues are restricted to property taxes, their narrow tax base further limits access to financial markets (Standard & Poor's 2000).

Revenue Bonds

A very common method of financing environmental infrastructure is with revenue bonds. Revenue bonds differ from general obligation bonds in that they are secured by a dedicated stream of revenues generated from a particular municipal enterprise such as a sewage treatment plant or a landfill. Revenue bonds are a particularly promising way to pay for environmental infrastructure along the border since the revenue streams from infrastructure projects actually have better credit characteristics than do the overall communities.

The viability of revenue bonds is obviously dependent on the ability of facility managers to collect user fees. This can be difficult in communities that are characterized by extreme poverty, such as those

along the border. User-fee collection is further complicated by long-standing custom. For example, in Ojinaga, Chihuahua, approximately half of the population is connected to the sewer system. Of that one half, only half pay their hookup fee in any given month. When asked why this failure to pay user fees was tolerated, the system administrator responded that the Mexican Constitution prohibits the cutting off of basic services for nonpayment, yet municipal officials in other communities do not view the Mexican constitution as limiting their ability to withhold services for nonpayment. If revenue bonds are to become a significant source of financing for environmental infrastructure, constraints on user-fee collection—whether real or perceived—must be removed.

Contracting with the Private Sector

Contracting with the private sector to provide environmental infrastructure can be beneficial in two ways. First, to the extent that the private sector can provide services at a lower cost, the financial needs of the community can be reduced. Second, by privatizing services, the community can access the financial resources of the businesses providing the services. While contracting with the private sector can be financially advantageous, using private providers adds the need for oversight. Specifically, the provision of water, sewage removal and treatment, and solid waste disposal are public goods in the sense that they are nonexclusive and nonrival. Ensuring the social welfare requires that the community actively monitor service providers to ensure that services are provided at an adequate level (Cointreau-Levine 1994). Thus, hiring private contractors requires an extra layer of management not required for direct public provision of these services. The decision to contract privately then comes down to a comparison of the costs of contracting services versus the direct provision of resources.

Philanthropy

Philanthropy is an appealing source of financing since it represents an actual increase in the funds available for the community for environ-

mental infrastructure investment. The border presents several interesting issues from the point of view of philanthropic giving. First, by the standards of the third world, the U.S.–Mexican border is relatively prosperous. Thus, in the context of Mexico, philanthropic foundations may prefer to allocate resources to other areas of greater perceived need, such as the southern part of the country where poverty is more extreme than along the border. However, by standards of the industrialized countries, the border region is extremely poor. The colonias are among the U.S. communities most in need of outside support. Moreover, because of its proximity to the United States, any funds allocated to the Mexican border region will likely have relatively high visibility. High stock prices, which have inflated the endowments of many U.S. charities, coupled with U.S. tax laws that require charities to disperse a minimum percentage of their endowment each year, means that many U.S. foundations are looking for worthy projects. Thus, this may be a particularly opportune time to seek funding for border environmental infrastructure expenditures.

Water in Mexico

Mexico, taken as a whole, has a sufficient water supply, yet it is not equally distributed throughout the country. For example, central and northern Mexico receive only 9% of the country's annual rainfall while supporting 75% of the country's total population, 70% of its GNP, and 40% of its agricultural land (Table 1). Mexico's per capita water con-

Table 1: Water Supply and Consumption and Productivity by Territory

Territory	Precipitation	Population	Industrial Activity	Agricultural Land
Central Plains, North and Northeast	9%	75%	70%	40%
South and Southeast	70%	20%	Incipient	20%

Source: CNA.

Table 2: Water Demand by Sector

Country	Agriculture	Industry	Domestic Use
China	87%	7%	6%
Egypt	88%	5%	7%
India	93%	3%	4%
Mexico	**83%**	**3%**	**14%**
France	12%	71%	17%
UK	1%	78%	21%

Source: World Business Council for Sustainable Development.

sumption is very similar to other OECD countries (Table 2). However, Mexico tends to waste much more water than its OECD colleagues.[3]

Water Rights

Article 27 of the Mexican Constitution establishes that all water belongs to the federal government. The CNA, created in 1989, is charged with distributing water through the granting of concessions for both water usage and discharge. The CNA is a semi-autonomous agency of the Secretariat of the Environment, Natural Resources and Fisheries (SEMARNAP). Under authority granted by Article 20 of Mexico's Water Law, the CNA has granted usage and discharge concessions to approximately 300,000 states, municipalities, farming operations, and industries.

The right to extract and use water depends on the type of usage and the availability of water in the user's region of the country. "Regular" or qualified users are those who comply with the terms of the concessions granted to them by the CNA by paying extraction quotas and respecting discharge standards. Unfortunately, the list of "irregular" users is growing rapidly. Irregular users frequently do not pay for the water they use or do not comply with discharge standards. Furthermore, clandestine users, who do not have concessions to extract water from or discharge into the country's hydraulic system, are also growing in number. Mexico must work aggressively to more thoroughly regulate the use of its water resources and to implement systems that can promote the principle that the end-users must pay for the water they consume and contaminate.

To a certain extent, industrial users in Mexico are the only users who are paying the true cost of water service. Industry currently subsidizes both agricultural and domestic users. Agricultural users do not pay for the right to use water and domestic usage is highly subsidized. For industrial users, a fee is determined for every cubic meter of water used, while domestic users pay the same fee but for every thousand cubic meters consumed. In other words, industrial users pay 10 times more than domestic users. The current system does not promote the efficient use of Mexico's water resources.

Mexico is currently undergoing an impressive decentralization of the management and operation of its water resources. With greater frequency, responsibilities are being relegated to state and municipal governments. As municipalities demonstrate their ability to take on more responsibility, the CNA and the state governments are affording them greater authority. This has occurred in many border cities. For example, the CNA has granted a concession to the municipal government of Reynosa to operate the city's potable water distribution and treatment system. The city carries out this task through its water utility department, the Comisión Municipal de Agua Potable, Alcantarillado y Saneamiento (COMAPAS) (Municipal Commission for Potable Water, Sewage, and Treatment). Likewise, several other cities such as Nuevo Laredo and Matamoros operate their own COMAPAS departments. The state government of Tamaulipas also plays an important administrative role as overseer of the COMAPAS. Tamaulipas is one of several states that has formed an entity called the Comisión Estatal de Agua Potable y Alcantarillado (CEAPA) (State Commission for Potable Water and Sewage). The CEAPA is charged with overseeing the COMAPAS and coordinating water usage for the entire state. The objectives are to reach higher levels of efficiency in water usage, reduce contamination, and avoid conflicts between the various municipalities. The development of administrative capacity is an important component in achieving CEAPA's goals. The CEAPA also serves as a water utility for communities with fewer than 50,000 inhabitants. Both the COMAPAS and the CEAPA's systems are an integral part of the CNA's decentralization program.

The decentralization of water administration places the provision of this vital public service in the hands of local authorities, who are more in tune with the demands of city residents. This is a significant deviation from Mexico's traditionally centralized governmental *modus*

operandi. However, many municipalities are not prepared to take on the complicated task of operating a water utility. Specifically, local governments lack the tax base necessary to construct much-needed infrastructure. They also often lack adequate administrative capacity. Exacerbating the problem is the fact that the federal government recently cut appropriations to states and municipalities.

Wastewater Discharges

End-users must also pay to discharge wastewater into the national water system. Wastewater discharge charges are established primarily according to compliance or noncompliance with contaminant limits set by the CNA. While compliance problems are ubiquitous, poor billing practices mean that revenue generated from wastewater charges is almost nonexistent. The failure to enforce discharge charges creates incentives for continued pollution. Municipalities are required to treat their waste streams before releasing them back into national waterways, yet despite these requirements, the majority of municipalities do not treat their wastewater. This creates serious problems for downstream users. Untreated agricultural runoff is also troublesome given the large amounts of fertilizers and pesticides used by Mexican farmers. In the border region, these virtually untreated waste stream flows empty into common aquifers as well as surface waters, leading to serious cross-border environmental problems.

The Mexican agricultural sector uses an enormous amount of the border's water and significantly contributes to water pollution. The country as a whole is grappling with how to rationalize agricultural policies dating back to the revolution that create incentives for inefficient water use and continued pollution. The agricultural sector consumes approximately 83% of Mexico's water supply while contributing only 3% to the overall GNP. Complicating matters is the fact that

Table 3: Wastewater Generated by Sector

Urban /Residential	Industry	Agriculture
28%	10%	62%

Source: CNA.

agricultural users do not have to pay for the right to extract water. In addition, electricity used to pump water for irrigation is heavily subsidized. Finally, agricultural users generate the majority of the country's wastewater, yet they do not pay discharge quotas regardless of the level of pollution in their wastewater (Table 3). Free water and cheap energy for irrigation have led to the inefficient use of water by Mexican farmers. This is particularly important along the border where agriculture, industry, and human consumption compete for the region's scarce water resources.

Water on the Border

Water is becoming scarce along the border. The desert region is arid and problems related to water scarcity have been exacerbated by extreme drought conditions in recent years. Population growth, industrial activity, cattle ranching, and farming are increasing demand for water. At the same time, the lack of rainfall is leading to the depletion of existing reserves and has led to an overreliance on groundwater. The current depletion of groundwater reserves is unsustainable and the trend must be reversed. Infrastructure improvements must be made that will lead to more efficient water usage and conservation.

The scarcity of water in the region, intensified by the current drought, has highlighted the need for communities to make significant investments in water infrastructure for three principal reasons. First, investments must be made to reduce waste. Border communities traditionally lose up to 40% of their precious water reserves through leaks and poor management. Second, drainage system improvements are needed to capture runoff from torrential desert downpours. A significant percentage of the border's rainfall comes in the form of sudden and rapid thunderstorms. Current infrastructure does not allow for the capture of such rainwater and the opportunity to harness this vital supply is lost. Third, there is a need for more reservoirs to store water for times of drought. Many of the dams built along the border under the auspices of the IBWC were built precisely with this purpose in mind. However, more large scale and localized rainfall reservoirs are needed in most border communities.

There are four main competing users for the border's scarce hydraulic resources: human consumption, industry, agriculture, and habitat pro-

tection. Solutions to the border region's water problems, in order to be sustainable, must take into consideration all four of these uses. A balance must be struck that permits economic growth, protects the environment, and provides for safe drinking water for border residents.

The Vicious Cycle of Mexican Water Utilities

Before private investors will seriously consider participating in Mexican water projects on a broad scale, the "vicious cycle" of water utilities must be broken. Mexican water utilities are taking important steps to restructure themselves and to attract private sector investment. Nevertheless, much remains to be done.

Physical Infrastructure

Enormous investment in physical infrastructure is needed. Due to the dilapidated nature of existing infrastructure, much of the potable water provided to water utilities is lost. Both the U.S and Mexican governments must provide more grant monies to fund infrastructure improvements. Supplemental sources of funding, such as user fees, are the key to the long-term sustainability of water utilities. Nevertheless, as a result of the magnitude of the problem, grant monies are the only way to remedy the current infrastructure deficit. In some cases, sewer systems are in place, yet do not have the capacity to handle the demands of the border's rising population. Higher demand is stretching the limits of the current infrastructure, which, in turn, is accelerating the depreciation of infrastructure and leading to even higher capital needs.

Operation and Maintenance Costs

Mexican utilities struggle to keep up with rising operation and maintenance costs. Often times, Mexican utilities do not have the capital reserves needed for preventative maintenance and unexpected repairs. As a result, the system is beginning to break down more frequently and water is wasted. More importantly, delays in repairing the physical

infrastructure eventually results in the need to spend more on upgrading the entire system. Future financing packages and infrastructure designs must take into consideration operation and maintenance costs. For example, efforts must be made to guarantee that user fee streams are sufficient to cover operation and maintenance costs. Occasionally, state-of-the-art systems put in place in Mexican water utilities require prohibitively high operation and maintenance costs. Policymakers must select systems that attack the fundamental problems related to water quality while taking into consideration that operation and maintenance costs must be covered by user fees. This pragmatic approach may necessitate selecting less than ideal technology, yet will contribute to the financial sustainability of water utilities.

Collections Procedures

Mexican border utilities are working aggressively to improve their billing procedures. In fact, some of the nation's most efficient water utilities are found in the border region. For example, after years of hard work, Tijuana is one of the most successful utilities in billing and collecting for water service. Unfortunately, many border water utilities are not collecting from municipal end-users. Grant monies are necessary to put in place the proper collections infrastructure. Such grants would allow utilities to eventually become self-sufficient. For example, meters must be installed and computers and billing software must be upgraded. Most importantly, governments must demonstrate the political will to go out and collect from a populous that is not accustomed to paying the true cost of water service.

Human Resources and Institutional Memory

Constant employee turnover in Mexican water utilities inhibits their long-term viability. On average, employees stay for 1.8 years in border utilities. Today, the proper functioning of a water utility requires a core of specialized civil servants. The proper operation and maintenance of plants and equipment demands highly trained personnel. In addition, the lack of institutional information on consumption patterns and costs reduces the utilities' ability to plan for the efficient use of water resources. Accurate information on consumption habits, industrial pollution, peak demand times, groundwater reserves, and the true cost of service does not exist in many water utilities. In the

short run, federally funded programs, such as those administered by the NADB, that train water utility personnel and work on institution building must be expanded.

Ability to Pay—End-Users and Municipalities

Making the Mexican water sector more attractive to investors will most likely require an increase in water rates. To pay for the enormous capital investments needed, private investors or bondholders will most likely require raising rates for the end-users. Many of the border's poorest residents cannot afford higher water rates. Merit-based subsidies must be put in place that take into consideration the ability of the end-user to pay. Likewise, many politicians are hesitant to raise rates. As it stands now, municipalities struggle to collect from end-users and often times do not have the resources to pay the CNA for their water usage.

Willingness to Pay

After years of bad service and subsidized rates, many of Mexico's end-users are not willing to pay more for water. After generations of paternalistic governmental policies, many residents see water service as a fundamental right that should be provided by the government at little or no cost. This culture of nonpayment is in direct conflict with the interests of private investors. Obviously, private sector operators will have to win over consumers through improved service.

Political Will

Politicians must be willing to support moderate rate hikes in the face of public opposition. Water utilities in Mexico are faced with serious challenges when it comes to collecting from domestic users. Many politicians are reluctant to take the steps necessary to collect from delinquent customers. Faced with the electoral pressures of a young democracy, many political parties are unwilling to accept the consequences of rate hikes. Exacerbating the situation is the heated competition for limited public funds. Water utilities compete with other basic social needs such as schools, transportation, hospitals, and public safety. Often times, water infrastructure is not a hot button issue for voters and gets put on the bottom of the list of priorities.

Budgetary Restrictions

Frankly, water utilities are overwhelmed by the enormity of current infrastructure needs. Federal, state, and municipal budgets have all been cut back in recent years and governments are struggling to expand their tax bases. Despite these noble efforts, most water utilities' budgets are still too small. As a result, until user fee streams increase and local governments can diversify their tax base, grant monies will be necessary. The Mexican government should consider using portions of the additional revenue generated by the increase in the international price of petroleum to fund much needed water infrastructure projects.

Budgetary Fluctuations

In Mexico, the tax base available to municipal governments is very limited, which makes local governments overly dependent on federal subsidies for the development of water infrastructure. Much of the funding provided to municipalities for water projects are discretionary appropriations from the federal government and are based, to a large extent, on political considerations. Such funding schemes can vary with the political winds and make it difficult to plan. Likewise, most investors and lenders are hesitant to rely on these future revenue streams.

Moving Toward Greater Private Sector Participation

Two major reforms are recommended—the establishment of a municipal bond market and the use of private sector concessions. It is important to note that these reforms are not independent of each other. Many of the changes needed to establish a viable bond market are identical to those required to attract private capital funding of environmental infrastructure. Moreover, implementation of one reform will make the other reform more attainable. For example, bonds might be used to raise seed money for the establishment of a treatment plant that can then be administered by a private concession. By the same token, by allowing the private sector to take responsibility for the operation and maintenance of the plant, the municipality can improve its credit

worthiness. Current political and financial conditions are conducive to the implementation of these two reforms for a number of reasons:

- Municipal bond markets have been established in a number of developing countries over the last few years. During a recent two-year span, Standard & Poor's (1999), for example, rated 13 municipal bond issues in emerging markets, mainly in Latin America and Eastern Europe. These municipalities were located in middle-income countries with similar macroeconomic circumstances to Mexico.
- In addition to establishing bond markets, middle-income countries have also relied more on the private sector in providing services.
- The overall credit position of Mexico has improved dramatically since the 1994 peso crisis. This positive trend has been reinforced by the sharp rise in oil prices. As a consequence, Mexico's national credit rating has been upgraded to investment grade by the bond-rating agency Moody's, and Standard & Poor's is expected to follow suit (*Wall Street Journal* 2000). The bond rating of the national government is important because municipal bonds cannot receive a rating in excess of those of the national government (Moody's 1999). Mexico's improved financial condition, therefore, makes it easier to establish a viable municipal bond market.
- The favorable economic conditions that characterize the overall Mexican economy apply even more so to the northern frontier region. This region has seen the greatest economic growth over the last two decades; economic growth has created the economic depth conducive to the establishment of financial markets. Because the northern frontier is the most economically advanced region, it is likely that this region will be the area that first develops a municipal bond market, with the exception perhaps of Mexico City.

Municipal Bond Markets

While circumstances are favorable for movement toward the establishment of a municipal bond market and increased reliance on private concessions, there are still considerable hurtles. For example, one problem is an insufficient local tax base. Under the Mexican Consti-

tution, most taxes are deposited with the federal government. Local governments then depend on revenue sharing financed by federal and state governments. The legal basis for state and local government finance is the Municipal Reform Law of 1983 and subsequent amendments of 1990 and 1995 (Fallon 1999). Under the Sistema Nacional de Coordinacion Fiscal, 20% of income taxes, value-added tax, and special tax on production (which represents about 90% of all federal collections) are rebated to state governments. At least 20% of the states' shares are passed on to municipalities.

Another problem is that Mexican border communities often lack adequate management institutions and are beset by administrative deficiencies, inadequate financial control, and lack the legal authority to collect user fees and taxes. Underlying these issues is the more fundamental problem of inadequate human capital needed to plan, implement, and maintain environmental infrastructure (GAO 2000).

While many obstacles remain to the formation of a fully functional bond market, the first steps toward its formation have already occurred. For example, in December 1997, the state of Guanajuato issued 10-year bonds secured by revenue generated from the Guanajuato–Silao toll road (Nacional Financiera 1997). These bonds are not currently actively traded; nevertheless, the success of the issue indicates the potential for future bond issues. The cities of Medina and Monterrey, and the states of Nuevo León and Durango have all received positive reviews from Standard & Poor's. Figure 1 contains a case study for Nuevo León.

Private Concessions

Mexico's wide-ranging privatization initiatives have resulted in the modernization and increased efficiency in numerous areas of the economy, from a revival of its mining and steel industries to a sweeping overhaul of the country's telecommunications and transportation infrastructure. One of the most promising areas for private investment is water supply and wastewater treatment projects. Broad-based privatization plans in recent years demonstrate the government's continued desire to open its economy and to enhance Mexico's attractiveness as a destination for investment. The country has taken several important steps to attract much needed investment to infrastructure projects. This approach is key to ensuring the country's continued competitiveness.

Figure 1: Nuevo León Case Study

Nuevo León is located in northern Mexico and shares a small border with the United States. The majority of economic activity is located in the capital of Monterrey, 140 miles south of Laredo, Texas. Monterrey is home to many of Mexico's largest industries, including Grupo Alfa, Grupo Femsa, and Grupo Vitro. The economic strength and diversity of Monterrey contributes to a relatively high standard of living and healthy labor market. However, the intergovernmental relationship with the federal government limits Nuevo León's share of tax receipts generated from its economy. Nevertheless, the financial operations of Nuevo León are generally stable. In recent years, annual budgets have been virtually balanced, with revenues and expenditures within 1% of each other.

As a result of limited revenue raising flexibility and the limited ability of the states to benefit from any growth in the local economy, close oversight of the balance between revenues and expenditures is critical. Nuevo León has developed a good track record in its fiscal trends, which are backed up by timely independent financial audits. However, much of Nuevo León's budget is considered to be nondiscretionary.

Management structure, systems, and controls are satisfactory and the recently institutionalized rules governing debt and financial reporting have contributed to a greater ability to oversee the state's fiscal picture. The mandate for a balanced budget also provides some long-term stability. The state oversees 53 public entities as well as a pension system. Operating subsidies are 657 million pesos or 5% of the budget.

Nuevo León was recently rated by Standard & Poor's on its CaVal scale as mxBBB. According to Standard & Poor's:

The CaVal scale rating on the State of Nuevo Leon reflects:

- *A very high level of dependence on the federal government for revenues,*
- *High levels of fixed costs including outstanding debt and pension obligations, and*
- *A perceived lack of flexibility to raise nonfederal revenues, which combined with modest financial reserves, leaves the state vulnerable to outside fiscal shocks.*
- *Countering these concerns to a degree is the sound industrial base in Monterrey that provides for economically driven growth in local revenues (Fraser and Fallon 2000, 1).*

Standard & Poor's rating does not apply to any particular debt issued by the Nuevo León government, although it expected that it would be used by the federal Hacienda to evaluate the credit risk exposure of the national development banks and commercial lending banks.

Source: Fraser and Fallon 2000, 1.

This section of the paper is based on the premise that, as a result of the 1994 economic crisis, the subsequent banking sector bailout, budget cutbacks in 1999, and most importantly, competing societal needs such as education, public safety, and health care, the Mexican federal government is no longer able or willing to fulfill its traditional role as the principal developer of water and wastewater infrastructure. In order to guarantee that the current water and wastewater infrastructure deficit does not exacerbate environmental and health problems along the border, the private sector must join in the development and financing of these important projects. Failure to lure private enterprise into the Mexican water sector will only widen the disparities between the United States and Mexico, possibly jeopardizing economic integration in the NAFTA region.

Private sector development of water and wasterwater infrastructure in Mexico will be carried out through a series of international financing mechanisms such as Project Finance (which will be discussed in further detail later) and the development of municipal bond markets. Programs administered by the BECC/NADB, BANOBRAS/FINFRA, the IBWC, and by grant monies from national and international sources (such as the EPA) can substantially enhance Project Finance and bond market investment mechanisms. In fact, bilateral organizations, federal agencies, municipal leaders, and the private sector must all be engaged in a constructive dialogue designed to find creative solutions to infrastructure financing needs.

Three Steps to Financial Reform

There are several reforms a Mexican border water utility should initiate in order to make their project more attractive to private investors:

1. Develop a more reliable billing registry of end-users; analyze rate setting criteria in the operation and maintenance of the utility's infrastructure; establish a transframework that clearly defines water rights, rate setting authority, and the rights to sue for nonpayment; determine enforcement authority between federal, state, and municipal governments; and begin an aggressive water conservation campaign.
2. Invest multilateral and federal grant monies in computer equipment, meters, and collection systems; increase customer satisfaction through improved service (monitor customer sat-

isfaction); continue to update billing information and train technical staff; complete a detailed audit of the condition of existing infrastructure; identify and prioritize pressing infrastructure needs; quantify operation and maintenance costs for the infrastructure to be concessioned; and explain the objectives of the concessionary program to key leaders in the community.

3. Work to reduce operation and maintenance costs; invest grant monies in infrastructure repairs designed to reduce system inefficiencies, such as leaks; launch a public education campaign on the benefits of private participation in the water sector; generate computerized maps of the existing system; establish a transparent procedure for the granting of the concessions, which includes dispute resolution procedures; and internationally publicize the concessionary program.

Project Finance

There are several challenges faced by the private sector when trying to use mechanisms to obtain financing for Design, Build, and Operate (DBO) contracts with Mexican water utilities. The term *Project Finance* refers to a financing arrangement in which a lender or group of investors finance a specific infrastructure project rather than an entity such as a corporation. One important example of Project Finance is the use of revenue bonds issued by a municipality. Credit evaluation is based primarily on the adequacy of expected future cash flow from the project itself to service the debt and not on the overall credit rating of the corporation. Under this type of mechanism, the legal liability of the project sponsor is restricted and specifically contractually defined, which has given rise to the term "nonrecourse financing." This type of financing limits the sponsor's risk to the amount invested in the infrastructure project and to any other specifically defined guarantees. For this reason, the company is able to keep the project debt off of its financial balance sheet, which is why this type of structure is also referred to as "off-balance sheet" financing. These projects usually involve the development and operation of capital such that corporations would consider this level of debt to be an unacceptable capital structure. Thus, the ability to keep the debt off of

the corporate balance sheets is one of the primary advantages to the sponsor of this type of project.

Many infrastructure projects would provide an inadequate return if capitalized with a level of debt consistent with most corporate capital structures. In contrast, significantly increasing the financial leverage allows the owners to improve the rate of return on the capital invested in a project. Because of this ability to improve the return of large-scale capital investments and the ability to minimize risks, a company will often undertake an infrastructure project that would be considered too risky or to have an insufficient return given the debt burden if undertaken using traditional balance sheet financing schemes.

Project Finance allows a lender to monitor and exert certain contractually-defined control over the allocation and disbursement of funds needed for the construction of the given infrastructure projects. This allowed control is through relatively restrictive loan covenants and recourse against independent third party experts, such as property appraisers and construction advisors, who can be authorized to approve or reject actions of the project participants. Such enhanced degree of control is extremely important to lenders who assume the vast majority of the risks associated with the financing of an infrastructure project. In contrast, traditional financing mechanisms afford the lender much less control over management's selection of projects, methods of financing, and the use of funds. Also, because a Project Finance scheme generally carries a higher debt load as a percentage of total capitalization than most companies, the lender can place the funds at higher rates of interest than it could lending directly to a corporation. Thus, provided the lender can properly mitigate its liability exposure, it can realize high rates of return on a Project Finance scheme than it can on a traditional corporate lending transaction. Due to these higher margins and the increased oversight capability commensurate with this type of project, lenders have more incentives to provide funds to a capital-intensive infrastructure project in Mexico than it would for projects it considered a less-than-acceptable credit risk.

As a result of the benefits associated with Project Finance mechanisms, many water projects in Mexico could be undertaken that would otherwise not be completed if a corporation were forced to build on a balance sheet and with full recourse against the corporation. However, the high degree of leverage and the limited recourse present challenges

that must be overcome in order to create an acceptable credit risk. This is accomplished by carefully designing the project so that creditworthy project participants or other interested third parties assume the risks inherent in water and wastewater projects. An effective project is usually organized so that each of the risks is allocated to the party in the best position to mitigate that risk. The primary goal is to organize infrastructure developments in such a fashion that various parties can contribute their individual strengths supported by proportional guarantees while not exposing themselves to liability for the entire project. The combination of parties and their limited guarantees must be sufficient to create a creditworthy project in the eyes of international lenders. Logically, if a governmental agency, the NADB, or a creditworthy state government provides a full or partial guarantee, then this task becomes much easier.

Risks Associated with Private Sector Financing

Private investors will not participate in the Mexican water sector if risk is excessive relative to return. Each project has its own unique characteristics and associated risks; however, certain types of risks are common to most water projects in Mexico. Risks can be categorized as follows:

Participant Risk

In DBO water projects, participants can include design firms, construction companies, municipal water utilities, equipment suppliers, lenders, etc. In many financing schemes the individual participants in a water project are only liable for their particular part of the puzzle and not for the entire project. Therefore, it is very important that the proper mix of participants be assembled to ensure the overall success of the project. The following are two major factors that determine the eligibility of a participant for a project:

History

The key question here involves the participant's track record. Do they have the proven experience and expertise necessary to complete their

assigned tasks within the time frame allotted while also managing the types of risk that are allocated to them?

Creditworthiness

If a participant agrees to a contractually defined obligation, the sponsors and lenders must have confidence that the entity is capable and willing to comply with these obligations. In Mexico, there is a shortage of credit information on most private companies. Likewise, most municipal water utilities do not have documented credit histories that comply with international lending standards. This makes it difficult to determine the creditworthiness of many of the participants in a given project.

Permit Risk

Generally speaking, there are two types of permits: (1) preconstruction permits that lenders usually require before the project financing can be obtained, and (2) milestone permits or permits that, by their very nature, cannot be obtained until construction (and therefore funding) has commenced. Lenders typically require assurances from the project sponsor that each of the permits required will be obtained in time. A very important factor is the faith (or lack thereof) that the lenders and sponsors have in the transparency and objectivity of the permitting process. The subjective application of the permitting requirements oftentimes irreversibly damages the confidence of investors. In Mexico, the transparency and objectivity on the part of regulators who grant all necessary permits is vitally important to the success of a DBO project.

Design Risk

If there is a flaw in the design, the project is not likely to proceed successfully. A paradigm shift is needed with respect to the design of infrastructure in the border. Traditionally, projects have been designed without taking into consideration the limited budgets of most water utilities. For example, engineers are customarily called in to design a project that will solve a specific water supply or sanitation problem. Once the project is designed, construction, operation, and maintenance costs are calculated. As a result of the scarce budgetary

resources, engineers should design a facility that coincides with the funds available to the municipality.

Likewise, project design should incorporate realistic operation and maintenance costs given the limited revenue streams of most water utilities. One of the primary design considerations in Mexico is the choice of equipment. Using reliable and proven technology may reduce the risk of unexpected problems down the road. Nevertheless, top-of-the-line international technologies are not always appropriate for Mexican water utilities. Most Mexican utilities have very small operating budgets. Often high-tech solutions for Mexico's water problems do not take into consideration these budgetary shortfalls. For example, given the low water rates and poor collection practices, water utilities do not generate sufficient resources to cover operation and maintenance costs. Likewise, sophisticated equipment requires a high level of operator expertise, which is often not available to many utilities. Frequently, equipment is not properly maintained and tends to break down. This, in turn, leads to the need to prematurely replace equipment and exacerbates competition for limited municipal resources. Increased training and lower employee turnover would lead to a more efficient use of the border region's scarce water and budgetary resources.

In Mexico, the lack of standardization and certification for water technologies has led to the sale of inferior products such as meters, valves, and pipes. As a result, several multinational companies have sold inferior or outdated equipment to Mexican water utilities, which has resulted in unnecessary problems. Options must be available for the purchase of parts and equipment that are specifically designed for Mexico's needs and which can be purchased in pesos from local suppliers.

Construction Risk

Construction risk includes the possibility that the facility will not be completed according to design specifications, that construction is delayed and/or over budget, or that performance criteria are not met. In these cases, it may be necessary for sponsors to increase their investment or for lenders to increase the amount of or extend the terms of their loans. Construction risks come in many forms, including the following:

Completion Delays

The cash flow projections and agreements with the project lenders assume a specific date when the project will begin operating and producing revenues. A completion delay can increase capitalized interest, reduce the present value of future cash flows, and harm the project's ability to service its debt. A delay can also expose the project sponsor to contractually defined liabilities for failure to meet promised delivery dates to the water utility.

Cost Overruns

Cost overruns may be caused by many factors including mistakes in design, increases in the costs of key construction materials, regulatory or legal changes, and contractor incompetence. In Mexico, cost overruns are often caused by the sudden or gradual devaluation of the peso. A weaker peso can lead to cost overruns when the project budget is established in pesos and large percentages of the building materials are imported from the United States. Further, governmental entities, for reasons of sovereignty, tend to carry out public bidding procedures in Mexican pesos. To counteract the destabilizing factor of currency fluctuation, most construction budgets are now established in dollars. Despite the fact that budgets are calculated in dollars, cost overruns caused by fluctuations in the exchange rate are frequent.

Condition of Mexico's Large Contractors

In the construction of water infrastructure projects in Mexico, it is vital to retain a contractor who is experienced and financially sound. Several of Mexico's contractors are still reeling from the 1994 peso crisis, the ensuing recession, the disastrous toll road concessions of the early 1990s, and recent federal budget cutbacks for public works projects. Therefore, the choice of a Mexican contractor should be made with extreme care and a great deal of research. In addition, Mexican builders, especially the small- and medium-sized companies, are not accustomed to building under project finance schemes in which maintaining strict completion schedules is an integral part of the financial viability of the entire project. As a result, it is often difficult to maintain construction schedules on medium-sized projects.

Operating Risk

An assessment of operating risks focuses on the project's output levels, costs, and longevity. These are necessary to service the project's debt and meet its contractual obligations. The water utility should require that a builder's contract include post-completion guarantees with provisions for liquidated damages in the event of construction-related operational problems. Operating risk may be reduced greatly if management is experienced and competent. Nevertheless, even the most competent operator will not be able to control all of the factors that could affect the operation of the project.

A significant source of operating risk is inflation. Mexico's inflation rate has oscillated around 17% in the last few years. For this reason, many long-term operational agreements contain cost escalation provisions in line with increases in a published price level index.

Commercial Risk

All projects need to ensure that their supply of raw materials and/or fuel is assured at a reasonable price and that the output generated by the project can be sold at prices sufficient to cover debt service. The primary commercial risks are the availability and price of raw materials, transportation, and the market risk associated with selling the finished product. The principal market risk in Mexico is the fact that end-users are not accustomed to paying the true cost of water service and politicians are hesitant to raise rates.

Exchange Risk

International investors in most DBO concessions will want to convert collected user fees into their home currency. If the peso drops significantly in value, debt service payments and/or profits could be impacted. Therefore, it is extremely important that steps be taken to protect all project participants from sudden and drastic fluctuations of the pesos collected from end-users. This is especially true given that debt service payments are generally payable in U.S. dollars, while the principal source of repayment is generated from user fees based on the often volatile Mexican peso.

There are several mechanisms for reducing devaluation risk including forward contracts, hedging, forward swaps, and by matching receipts and payments by currency. Mexico's history of periodic devaluations causes investors and lenders alike to shy away from peso-based revenue streams. While some economists contend that severe devaluations are much less likely in Mexico today, effective hedging strategies will probably be necessary for several more years until the peso can demonstrate a stable track record. For this reason, the credit enhancement mechanisms offered by the NADB should put more emphasis on devaluation coverage for private sector DBO concessions.

Regulatory Risk

Regulations have a significant impact on the viability of private investment in environmental infrastructure projects. Regulatory changes can impose the need for expensive redesign or retrofitting. Arbitrary enforcement of existing regulation can also impose added expenses. Mexican environmental laws are progressive and compare favorably with U.S. laws. But in the near term, neither the resources nor the will exists to strictly enforce environmental laws. Long-term economic development and increased environmental awareness will likely result in stricter enforcement. How to establish a grandfather clause for projects built after environmental regulations were placed on the books, but before the laws were strictly enforced, is yet to be resolved.

Because of the changing political and regulatory environment in Mexico, there is the possibility that the government will make changes in laws or regulations that could render the project unprofitable. Such changes could include user-fee price controls, excessive taxation, the requirement to provide service to remote areas, and new environmental enforcement tactics. Recent democratic reforms in Mexico have given rise to a more equitable distribution of the development of legislation between the executive and legislative branches and between the federal, state, and local governments.

Despite the enormous benefits of Mexico's democratic reforms, the process of transformation can lead to regulatory uncertainty, confusing laws, and unpredictable jurisdictional lines. The current system for the establishment of regulatory guidelines for environmental infrastructure projects is in a state of flux. As a result, private participants in water projects are faced with a higher level of regulatory risk. This

dramatically changing regulatory framework is offset by many of the provisions found in NAFTA, Chapter 11, which are designed to protect investors and create a more transparent investment environment.

Legal Risk

The CNA is working aggressively to create a legal environment conducive to private investment in water projects. These reforms are creating more interest on the part of many international investors. Both DBOs and bond issues involve complex contractual relationships in which it is crucial that the relationship among investors, managers, and the municipality is clarified. It is imperative that the court system be adequate to resolve complex contractual issues in a consistent and predictable manner. In Mexico, the legal system is in the process of developing the resources to adequately resolve business and property rights disputes. Nevertheless, many investors are still hesitant to rely on Mexican courts in resolving disputes.

A well-developed body of commercial law that resolves disputes in a fair and timely manner is essential to promote greater investment. Mexico needs to promote the transparent and objective interpretation and implementation of its laws. Such efforts are important in order for lenders and project sponsors to effectively plan and identify the requirements and risks associated with projects in Mexico. Unclear laws and their subjective application expose all parties to additional risks. As a result, lenders will charge high interest rates and investors will seek higher returns to compensate for the additional risk. This ultimately raises the cost of environmental infrastructure to the end-user.

Contract rights of private parties participating in concession water projects in Mexico must be improved so as to provide greater legal certainty. The control, transfer, and mitigation of project risks associated with large water projects are often addressed through a complex series of contracts referred to as the "security package." These contracts bind the parties by specifically delineating the responsibilities of each of the project participants. These contracts are used to facilitate the debt financing by holding the project consortium together and allowing each project participant to take on the risks that it is best suited to manage and control. To obtain project financing, it is crucial for all contracts to interlock and form a "watertight" credit structure, since the contracts are the only real source of security to the lenders.

Lenders and project participants alike are weary of being subjected to the rigors of the Mexican court system, especially when their potential adversary is a Mexican governmental body who may have sovereign immunity. Thus, they seek to resolve disputes in a foreign country or through an international arbitration venue. As one can imagine, Mexican state and local governments are reluctant to agree to any dispute resolution mechanism other than national courts.

Political Risk

In Mexico, changes in municipal governments present political risks for DBO concession holders. Subsequent governments from different political parties may seek to revoke the concession granted by the prior administration. In recent years, Mexico has taken significant steps to create a more open and democratic society. However, the country's fledgling democratic institutions cause potential investors to be concerned that legal protections offered to foreigners will be restricted.

To avoid political opposition, it is recommended that investors require broad-based local participation in a project. This can be accomplished through a variety of mechanisms such as local equity ownership, inclusion of local banks in financing, and the use of local suppliers and labor. One of the most frequently overlooked advantages of the BECC–certification process is the development of community-based public participation forums. The BECC has created a vehicle for public participation in investment decisions in Mexico where one did not exist. This contribution to democracy and civil entrepreneurship should not be underestimated.

Political Will

While the need for private investment in environmental infrastructure in Mexico is obvious to most, there are still groups that strongly oppose privatization and liberalization efforts. Their influence can clearly be seen in the Zedillo administration's 1997 policy reversal concerning petrochemical privatization. If private investment is to provide the infrastructure that Mexico so desperately needs, then the government must demonstrate the political will to continue with promised privatizations even in the face of political opposition. Also, for certain types of projects, such as DBO contracts, it is important

that users be charged the true cost of the service provided in order to create viable revenue streams. Water tariffs in Mexico have traditionally been subsidized and it is not certain if the country's leaders have the political will to raise the cost to the end-user. The reality is that rates must be raised to levels that would support international mechanisms for infrastructure finance.

Water subsidy policies should be redesigned so as to promote more efficient water use while protecting Mexico's urban poor. The outcome of federal, state, and municipal elections in July 2000 will determine, to a large extent, the future of private participation in border water projects. Many parties, and citizens in general, are still very hesitant to relinquish governmental control over key public services such as water.

Notes

1. Meaning to underwrite the issue by itself but through a syndicate.
2. As of June 1999, 71 municipalities had participated in IDP.
3. For more information regarding the Organisation for Economic Cooperation and Development (OECD) and its member countries, including Mexico, see the OECD's Web site at <http://www.oecd.org>.

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SCERP Mission

The Southwest Center for Environmental Research and Policy (SCERP) was established by the U.S. Congress in October 1990 to "initiate a comprehensive analysis of possible solutions to the acute air, water quality, and hazardous waste problems that plague the United States–Mexico border region." SCERP is a consortium of five U.S. universities (Arizona State University, New Mexico State University, San Diego State University, University of Texas at El Paso, and University of Utah) and five Mexican universities (El Colegio de la Frontera Norte, Instituto Tecnológico de Ciudad Juárez, Instituto Tecnológico y de Estudios Superiores de Monterrey, Universidad Autónoma de Baja California, and Universidad Autónoma de Ciudad Juárez). SCERP carries out its mission through a cooperative agreement with the U.S. Environmental Protection Agency. A permanent administrative office is maintained by the consortium in San Diego.

Environmental Problems of the U.S.–Mexican Border Region

The border region lies 100 kilometers/60 miles on each side of the U.S.–Mexican border and encompasses parts of four states in the United States (Texas, New Mexico, Arizona, and California) and the six Mexican states of Baja California, Sonora, Chihuahua, Coahuila, Nuevo León, and Tamaulipas. Approximately twelve million people live in the U.S. counties and Mexican municipalities on the border. The high density of people and increased industrialization since the passage of NAFTA have placed an even greater burden on the inadequate infrastructure and environmental resources of the region. Exacerbating the problem is the fact that many U.S. counties along the border are categorized as "economically distressed," and few communities possess the resources needed to address environmental concerns. Some of the critical border environmental issues include, but are not limited to:

Rapid urbanization and lack of adequate infrastructure
Air pollution from open burning, vehicle emissions, and industrial operations
Contamination of surface and ground water from open sewers and industrial waste
Overutilization of aquifers and surface streams
Transportation and illegal dumping of hazardous wastes
Destruction of natural resources.

The SCERP Solution

SCERP utilizes a broad, integrated, multidisciplinary approach to address the issues of the border. SCERP's researchers collaborate with the U.S. Environmental Protection Agency and Mexico's Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT), as well as local and state governments, business and industry, nongovernmental organizations, and communities of the border region. SCERP organizes research, outreach, and training programs devoted to improving environmental conditions and to building capacity in the border region for resolving critical environmental problems. SCERP is pioneering a model of binational cooperation that brings U.S. and Mexican researchers together and introduces new skills and perspectives in binational environmental problem solving.

SOUTHWEST CENTER FOR ENVIRONMENTAL RESEARCH & POLICY