

Urban Rivers in Tecate and Tijuana: *Strategies for Sustainable Cities*

by Suzanne M. Michel and Carlos Graizbord | *Institute for Regional Studies of the Californias 2002*

Cover photographs

Photographs 1, 2, and 3 (upper row, left to right) depict Tecate River.

Photograph 1 is upstream of the urban area and shows relatively undisturbed vegetation.

Photograph 2 is in the center of the city, where the river is channelized and vegetation removed.

Photograph 3 is downstream from Tecate's center, on the outskirts of the urban area.

Photograph 4 (bottom row) is of Tecate River in a relatively undisturbed area downstream from the urbanized area of Tecate. Photograph courtesy of Pronatura Península de Baja California.

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Glossary

Alluvium (or alluvial): General descriptive term for clay, silt, and sand transported by running water and deposited in sorted or semi-sorted sediment on a floodplain (Christopherson 1995: G.1).

Aquifer: A geologic formation that is permeable to groundwater flows. Aquifers store, transmit, and yield significant quantities of water to wells or springs (Water Education Foundation 1998: 20; Christopherson 1995: 197).

Basin: See watershed.

Biodiversity or Biological Diversity: The full range of variety and variability within and among living organisms and the ecological complexes in which they occur. Encompasses ecosystem or community diversity, species diversity, and genetic diversity. In simple words, it is the variety of life (Jensen, Torn, and Harte 1993: 4–5).

Detention Basins: Shallow depressions or open drainage areas into which storm water runoff is directed. They may be planted with grass or other vegetation that helps reduce runoff speed and absorbs rainfall. Detention basins are used in highway medians, parks, residential areas, parking lots, and many other landscaped or open space areas (Dallman and Piechota 2000: 28–29).

Dike: Use of dikes or temporary dams constructed of inflatable rubber or rocks and logs provide another means of retaining flows in the river channel. Temporary dams or dikes slow the velocity of flow, permitting water to pool behind them. When properly designed, the larger flood flows will safely spill over the dike without increased upstream flooding. Inflatable dams are in regular use in the San Gabriel River in Los Angeles County to direct water into spreading grounds now managed purposefully to capture storm water for groundwater recharge (Dallman and Piechota 2000: 24–25).

Ecohydrological Approach: Restoration of a river, including conservation of the riverbed, flora, and fauna, as well as flood protection with minimal structures such as gavions, dikes, and dams. The object is to create an open space with natural areas and constructed areas for multiple uses.

Ecosystem: The interacting components of air, land, water, and living organisms essential to life within a defined area that may be as small as a drop of water or as large as the whole planet (Bates et al. 1993: 204).

Erosion: Occurs when wind, water, and ice dislodge or remove the earth's surface material. Streams produce fluvial erosion, which supplies weathered sediment that is transported and deposited in new locations downstream (Christopherson 1995: 342).

Fecal Coliform Bacteria: Bacteria of a coliform group originating in the intestines of warm-blooded animals. Occurrence of coliform bacteria signifies contamination by human wastes and high levels indicate a potential health hazard (Texas Natural Resource Conservation Commission 1996: A-2).

Floodplain: The flat, low-lying area along a stream that is subjected to recurrent flooding. It is formed when the river overflows its channel during times of high flow and the floodplain is inundated (Christopherson 1995: 354).

Gavion: A structure utilized in the floodplain of a river, parallel to the river channel, to protect against flooding and erosion.

Groundwater: Water that has seeped beneath the earth's surface and is stored in the porous spaces within rocks or alluvial materials and in gaps between fractured hard rocks. Because groundwater is a major source of drinking water, there is growing concern over areas where agricultural or industrial pollutants or substances from leaking sewer lines or latrines are contaminating groundwater (Texas Natural Resource Conservation Commission 1996: A-4; Water Education Foundation 1998: 20).

Habitat: A repeating assemblage of plants and animals characteristic of the environmental constraints of a region or locale, such as oak woodlands, redwood forests, coastal sage scrub, or coastal dunes (Jensen, Torn, and Harte 1993: 55).

Hydrology: The science dealing with the properties, distribution, and circulation of water (Texas Natural Resource Conservation Commission 1996: A-4).

Natural Capital: Life-supporting services provided by the natural environment. These services include clean water, clean air, green spaces, groundwater recharge, flood control, soil erosion control, and so forth (Hawken, Lovins, and Lovins 1999: 9).

Nitrates: One of the most common contaminants found in California and Baja California's groundwater. Nitrate is common in agricultural fertilizer and can be found in animal manure. Nitrate is also present in groundwater sources as a result of leaking latrines, septic tanks, and sewage infrastructure. Soil does not break nitrates down, so water moving through soil, either from irrigation or storm water, can transport nitrate to water bodies and drinking water sources. High nitrates in drinking water can cause a potentially fatal condition in infants (by being mixed with infant formula) known as blue baby syndrome, which impairs the ability of the blood to carry oxygen, reducing the infant's oxygen supplies (Young, Dahan, and Shaffer 2001: 25).

Nonpoint Source Pollution: Water pollution derived from diffuse sources that do not have a single point of origin or pollution that is not introduced from a single discharge pipe or outlet (Texas Natural Resource Conservation Commission 1996: A-5).

Point Source Pollution: Pollution that is introduced to a stream, lake, or ocean from a single discharge pipe or outlet.

Potable Water: In the United States, water that is safe for drinking and cooking (Texas Natural Resource Conservation Commission 1996: A-6). In other countries, however, potable water does not necessarily mean that it is safe for drinking and cooking.

Recharge: Water flow to groundwater storage from precipitation, irrigation, spreading basins, wetlands, and other sources of water (Water Education Foundation 1998: 20).

Riparian Vegetation: Plants that grow along the stream, especially those whose roots reach down to water-saturated soil (Bates et al. 1993: 205).

Sediment: Solid material that originates mostly from disintegrated rocks and is transported by, suspended in, or deposited by water. Sedimentation is the process of sediment deposition and is influenced by environmental factors such as degree of slope of the watershed, length of slope, soil characteristics, vegetation cover, land use, and quantity and intensity of rainfall (Texas Natural Resource Conservation Commission 1996).

Streambeds or Stream Channels vary in width and depth. The streams that flow in stream channels vary in volume, velocity, and in the sediment load they carry. Given the interplay of channel width, depth, and stream velocity, the cross-section of a stream channel varies over time, especially during heavy flooding. Changes in the streambed or channel occur as the stream system continuously works toward equilibrium to balance stream discharge, velocity, and sediment load (Christopherson 1995: 348).

Total Dissolved Solids: A measure of dissolved materials in water that indicates salinity. Excessive amounts make water unfit to drink or use in industrial processes (Texas Natural Resource Conservation Commission 1996).

Watershed: The land area through which water drains to reach a stream, lake, bay, or ocean. In the United States, on a larger scale, watersheds for large rivers are often referred to as “river basins” (Bates et al. 1993: 205).

Wetlands: An area that is regularly saturated by surface or groundwater and is subsequently characterized by a prevalence of vegetation adapted to life in saturated soil conditions. Examples include marshes, estuaries, and riparian habitat (Texas Natural Resource Conservation Commission 1996: A-9).

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I Foreword

by Mario Salzmann*

Those who remember living and growing up in the city of Tecate, Mexico, as it was 50 or 60 years ago, also recall that tranquility was one of its outstanding features. People remember a pristine environment that included a clean, free flowing creek. This creek was a source of excellent drinking water, a place where kids could swim, and, given its excellent aquifer, also one of the reasons why the brewery set up its plant in the early 1940s.

It is this vision of a clean, healthy Tecate River that motivated the founding members of Fundación La Puerta, A.C. — a Mexican nonprofit foundation based in Tecate — to support the restoration of the river. The reasons why Fundación La Puerta, A.C., took this initiative, in light of the many changes that have taken place in Tecate, are described in this publication. An emphasis is placed on the benefits and the need for a clean river in an area where water scarcity is a major factor and so essential for human and natural communities.

The river today, and indeed much of the Tijuana River basin that lies along the U.S.-Mexican border, is severely threatened by rapid population growth and industrial activity in the region. Due to this growth, it has been proposed to channel portions of the river with concrete in order to make more land available for urban development, as well as to contain potential floods that, in the past, have had serious consequences in Tecate and in nearby Tijuana.

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As an alternative to channelization, Fundación La Puerta, A.C., is promoting the river-park concept because it also protects against flooding, while at the same time, and just as importantly, it retains and reinforces many of the benefits of natural stream courses. During public seminars in 2001, and as part of the advocacy role of Fundación La Puerta, A.C., experts were brought to Tecate to discuss the river park concept and to inform both the general public and the authorities on the benefits of this approach. As a result of these activities, there is more clarity in Tecate today about the river park concept, including its greater benefits as well as lower (financial) costs. And, just as importantly, there is clarity about the negative impacts of channelizing the river with concrete.

Still, there are reasons to worry that the proposal to channelized the river with concrete — which came to a halt as a result of changes in the municipal administration — could be considered again in the future. The reasons for concern are several, but go beyond the technical issues at hand and are related to the following:

- Citizen participation in deciding local issues is still weak in Tecate, and indeed in many other places as well.
- Because of the very fast demographic growth experienced in Tecate, most people do not have a recollection of what

the river was like years ago. Most people came to Tecate seeking new opportunities to improve their livelihood. They came for the promise of *maquiladora*-generated jobs. Their hope is to return eventually to where they came from. They have no emotional ties to the city and less so to a river that for most of the year is dry and whose banks and some of its previous floodplains are occupied by squatters.

- Saving a river is a long-term commitment, while the term for publicly elected officials in Tecate is for three years. Even if they had the possibility of staying longer in office, the actions required involve various political and regional jurisdictions, with the final technical, financial, and political decisions made elsewhere, usually in Mexico City. The process of decentralizing decision making is evolving slowly, while the process of degrading a river is unfortunately all too quick.

- For local politicians, any type of river restoration/beautification project involves moving squatters from the river area to other parts of the city. This is a delicate social issue, with uncertain and risky outcomes for politically elected officials.

- Improving the river and water quality also entails enforcement of existing laws regarding environmental cleanup and protection. This is an area where more efforts need to be undertaken in order to educate local citizens, a process that could take years. Most citizens still do not know how to claim their right to a clean environment nor how to file complaints.

- Urban developers are promoting their plans and acting as a strong pressure group to obtain construction permits and changes in land use regulations. As Tecate continues to grow and land values increase, a project that will expand the supply of land for urban development will seem more attractive and its costs can be recovered quickly, even if it is at the expense of further degradation of the river and the water supply.

- Urban planners and developers may not be fully aware of the environmental cost of channeling rivers, nor of their longer term negative impacts. Consequently, the value of natural capital is ignored in favor of other more obvious short-term economic benefits involving urban land.

The process of getting citizens involved can take a long time. This is an area where more urgent measures need to be taken. Fundación La Puerta, A.C., can disseminate information, but getting the people involved and organized to demand that their water supply be protected requires time.

These are some of the obstacles and challenges. More than a technical factor, the issues involve social and political variables compounded by a largely non-native population that lives in, but does not really feel any attachment to, the river or the city, and even less to the wider watershed region.

It is our hope that this publication will increase the awareness of citizens as well as that of public authorities, so that ultimately the correct decisions are taken that will preserve the water and promote the sustainable development of Tecate and the region.

II Rediscovering the Tecate River

by Suzanne M. Michel*

The Tecate River as Natural Capital

The natural environment provides services free of charge to the local economy. These include clean air and water, fertile soils, ocean productivity (fisheries), medicines from plants, and recreational opportunities. In addition, the natural environment utilizes biogeochemical processes to digest or breakdown air, water, and soil pollutants deposited on the urban and rural landscape. According to economists such as Paul Hawken, nature's services, consisting of trees, potable groundwater, wetlands, and so forth, constitute "natural capital" (Hawken, Lovins, and Lovins 1999). Natural capital is the foundation of local economies. In essence, without nature's free services, cities could not thrive from an economic or public health perspective. The value of natural capital is seldom accounted for in conventional economic texts or city accounting systems (Hawken, Lovins, and Lovins 1999), although a recent effort has begun to address these issues in the California-Baja California border region (Jerrett et al. 2002).

For all cities, large and small, clean water is natural capital that provides local businesses with a valuable input (for example, water with a particular chemistry that produces a uniquely flavored beer). Clean water is essential for a healthy society and supports healthy ecosystems. These healthy ecosystems, in turn, generate more natural capital by providing services (such as clean air produced by trees or water purification by wetland vegetation) to society and the economy (Michel 2001). The Tecate River[1] and the unconfined alluvial groundwater aquifer beneath it are examples of natural capital that support Tecate's local economy and community. As shown in Map 1, the large Tecate River watershed is a subwatershed of the Tijuana River that discharges into the Pacific Ocean. If natural resources within the Tecate River watershed are protected, then local residents and businesses—such as the Tecate Brewery—can maintain, and even increase, their supply of cost-effective, potable water.

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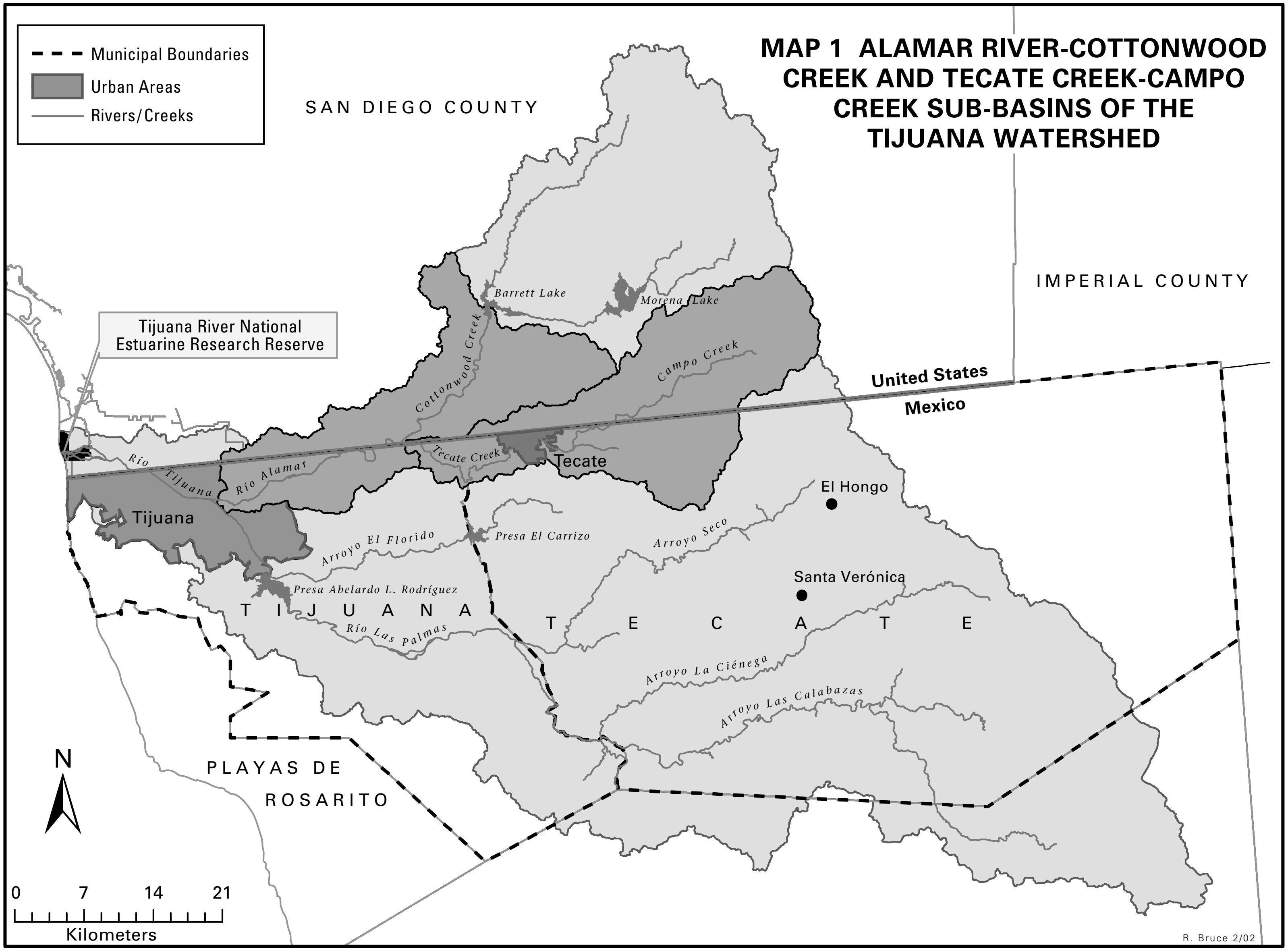
Tecate's Groundwater as a Valuable Resource

According to 1993 water use estimates, groundwater resources provided 80 percent of Tecate's potable water supplies. The aquifer beneath the Tecate River contributed 27 percent of potable groundwater used in the Tecate region (COSAE 1994). However, with more people, industry, and urbanization in the Tecate region, increasing amounts of contaminants are released into the Tecate River, negatively affecting not only the water quality of the surface waters, but also the quality of underground waters. This contamination


MAP 1 ALAMAR RIVER-COTTONWOOD CREEK AND TECATE CREEK-CAMPO CREEK SUB-BASINS OF THE TIJUANA WATERSHED
Municipal Boundaries
Urban Areas
Rivers/Creeks
SAN DIEGO COUNTY
IMPERIAL COUNTY
Tijuana River National Estuarine Research Reserve
Barrett Lake
Morena Lake
Cottonwood Creek
Campo Creek
United States
Mexico
Río Tijuana
Río Alamar
Tecate Creek
Tecate
El Hongo
Tijuana
Arroyo El Florido
Presa El Carrizo
Arroyo Seco
Santa Verónica
Presa Abelardo L. Rodríguez
TIJUANA
TECATE
Río Las Palmas
Arroyo La Ciénega
Arroyo Las Calabazas
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R. Bruce 2/02

will reduce useable groundwater resources that provide a low-cost potable water supply. Local residents and businesses will be forced to become even more dependent upon expensive and tenuous supplies of imported water from the Colorado River. At the same time, expanding the urbanized area and building concrete channels in the river floodplain will reduce the recharge area for the aquifer, thus reducing its water production. These activities also destroy the river's wetland vegetation, known as riparian habitat, reducing the number of plant and animal species in the region. The loss of riparian vegetation limits the ability of the plants to clean surface water.

The growing urban populations of Tecate and other places in Baja California faces a shortage of potable water. Steps must be taken to protect local water resources and to minimize reliance on expensive water transported over the mountains from the Colorado River. A cost-effective strategy to maximize local potable water resources is through protecting the natural capital provided by the Tecate River and the groundwater resources beneath the river. To protect the groundwater resources of the Tecate River and other rivers and creeks providing potable water supplies within the Tijuana River watershed, both Tecate and Tijuana should first coordinate a watershed-based management plan for ground and surface water quality enhancement. Within the Tecate River corridor itself, river restoration and the creation of a multipurpose river park is suggested. Such a river park would assure Tecate residents and businesses adequate water resources for the economic growth of present and future generations. A park along the Tecate River would dramatically expand green areas in Tecate, improving the appearance of the urban core for tourists and residents alike. A river park would also provide significant new recreation facilities for the city's residents.

Water Quality in Southern and Baja California

In Southern and Baja California, water quality is the common resource or glue that binds all resource protection efforts[2] together. If water quality degradation occurs, numerous other natural resources, such as a wetlands' acreage and avian biodiversity, decrease. Water quality degradation poses a health risk to both human and wildlife communities that depend on and come into contact with the water. When water quality degrades in local ground and surface water supplies, water agencies must either treat the contaminated water or find alternative water sources, such as imported water, to replace the water supply.[3] The result of these negative impacts on water quality is that the cost of the water supply increases, resulting in higher costs to local businesses, governments, and residents (Michel 2001). Loss of a natural capital asset such as clean water ultimately results in decreased biodiversity and increased economic burdens for the Tecate community.

In California, water quality stakeholders now recognize that controlling point source discharges[4] has substantially reduced pollutants present in water bodies. However, nonpoint source pollution, or pollution from water runoff from urbanization, industrial centers, and agriculture, continues to significantly degrade surface and groundwater quality. In turn, this pollution affects the coastal waters that receive cumulative loads of nonpoint source pollution from urbanized regions. Southern and Baja California's urban populations and land uses produce a wide variety of pollutants, including heavy metals, petroleum by-products, sediments, animal waste, pesticides, raw sewage, and trash. These pollutants are deposited onto the streets and sidewalks or into storm drains where they accumulate until the winter rains arrive. When the winter rain season begins, runoff from the storms, commonly referred to as urban polluted runoff, conveys and deposits these pollutants into small creeks. Ultimately, nonpoint source pollution in urban polluted runoff percolates into surface and potable groundwater sources. The pollutants found in storm water are known as nonpoint source pollution.

Table 1 lists major contaminants and sources of pollutants found in polluted runoff. In the 1996–1997 rainy season, researchers from San Diego State University conducted an analysis of urban polluted runoff in Tijuana and the Tecate River. Significant amounts of zinc, copper, and lead were present in storm water samples from Tijuana. Samples from the Tecate River revealed significant amounts of chromium and nickel (Gersberg et al. 2000: 36–39).[5] The study results suggest that as Tijuana and Tecate's populations and urbanized regions grow, the amount of urban polluted runoff flows will increase.

TABLE 1 Major Pollutants in Urban Storm Water

POLLUTANT	MAJOR SOURCES
Heavy metals *(chromium, lead, mercury, copper, cadmium, zinc, mercury)*	Automobile usage *(emissions, brake pad residues)* Atmospheric deposition Industrial activities Commercial activities
Hydrocarbons *(oil, grease, petroleum-based products, polycyclic aromatic hydrocarbons)*	Parking lots Roads Restaurants Household activities Automobile emissions Improper disposal of motor oil Illegal dumping into storm water conveyance systems
Nutrients *(nitrates and phosphates)*	Fertilizers Animal waste Detergents Atmospheric deposition Leaking sewer pipes

TABLE 1 Major Pollutants in Urban Storm Water *(continued)*

POLLUTANT	MAJOR SOURCES
Sediments	Construction sites Graded areas left unplanted Stream channels eroded by increased volume of runoff Agricultural lands
Toxic Organics *(pesticides, polychlorinated biphenyls [PCBs])*	Lawn care Agricultural use Industrial uses Household activities *(using paints and solvents)* Illegal dumping into storm water conveyance systems
Bacteria and other pathogens	Pet wastes Rotting organic material Washing down restaurants or other food preparation sites *(meat markets)* Sewage overflows, leaking sewer pipes

Source: American Oceans Campaign 1997; SANDAG 1997.

Threats to Underground Water Resources

Probably the greatest threat to Baja California's local groundwater supply is water pollution from urban and agricultural point and nonpoint sources. The aquifer that lies beneath the Tijuana River in urban Tijuana provides an example of the negative effects of pollution. According to Guzmán (1998), over one hundred wells draw from this aquifer, producing an average of five thousand acre-feet of water per year. Tests indicate that water in the Tijuana aquifer has high levels of total dissolved solids and nitrates as well as fluctuating numbers of coliform bacteria. These contaminants probably originate from uncontained wastewater and storm water flows that transport polluted runoff and untreated wastewater from leaking or overflowing sewer lines. The second contaminant category present includes heavy metals such as barium and silver. Heavy metal contamination in urban areas is usually from nonpoint source pollution and originates from industrial, commercial, residential, and automobile activities (Guzmán 1998). Upstream from the Tijuana aquifer, the groundwater basins beneath the Alamar and Tecate rivers demonstrate significant levels of nitrate contamination. One source of nitrate contamination is from agricultural activities such as dairy farm feedlots. A feedlot is located in the Tecate River bed and deposits untreated animal waste into Tecate River surface and groundwater resources. The extent to which the aquifers beneath the Tijuana, Alamar, and Tecate rivers have been contaminated from urban polluted runoff, however, is unknown.

Aside from producing more nonpoint source pollutants, expanding urban regions also result in paving and consequent destruction of a watershed's native riparian or wetland regions found in river and creek floodplains. This paving and the consequent destruction of river wetlands are evident in the Tecate region. Paving increases impervious surfaces that do not allow rainwater to be absorbed by vegetation or soils and thus produces storm water runoff flows in greater velocities and volumes (American Oceans Campaign 1997; SANDAG 1997). Impervious areas also greatly impede the natural filtration process of some pollutants that occurs when rainwater is allowed to percolate into the soil and accumulate in wetland regions. From a watershed perspective, water quality improvement occurs when pollutant loads are decreased and when river ecosystems are allowed to thrive and consequently clean local water resources. Such a perspective requires integrated resource management, a topic central to watershed efforts.

Water Quality and the Watershed Perspective

When precipitation falls to the earth's surface, the runoff results in surface and groundwater flows. These flows form small streams and eventually create a main channel or river that discharges into one location — a lake, lagoon, river, wetland, or ocean. The catchment area that encompasses the river and groundwater flows is known as a watershed, or an orographic basin, because the surrounding hills form an area much like the shape of an inverted umbrella (Zúñiga 1998). Watersheds vary in size and can be quite large, like the Colorado River drainage basin, or a small creek that supplies water to an oak grove. Most watersheds contain many smaller watersheds, or sub-basins, nested within them (Natural Resources Law Center 1996: 1–5).

Mexico's National Water Commission classifies watersheds into three orders or levels. The first order is *cuenca*, or watershed, including the principal large river basins, such as the Lerma, Bravo, Colorado, and Papaloapan. Second order watersheds are sub-basins, or smaller watersheds within first order watersheds. The Pacific Coast of Southern and Baja California contains numerous *microcuencas costeras*, or third order small watersheds, that encompass small territories and may contain intermittent streams (CNA 1998; Michel 2000). As shown in Map 1, Tecate is located in the eastern, or upstream, section of the Tijuana River watershed. The mountain peaks east and north of Tecate at their highest points form the headwaters of the Tijuana River watershed. Even though the Tijuana River watershed is considered a "small" third order watershed by the National Water Commission (Comisión Nacional del Agua — CNA), the watershed is actually large.

The rainy season peak flows are as much as 32,500 cubic feet per second.

Watershed-based efforts such as the development of plans and establishment of councils and/or organizations demonstrate a geographic approach resulting in governance or management of natural resources within the limits of a watershed rather than the conventional political jurisdictions such as a city, municipal, county, state, or nation. This perspective is advantageous because groundwater basins, surface water flows, ecosystems, and wildlife migration corridors do not adhere to conventional political jurisdictions. In addition, watershed-based efforts address numerous resource problems, including water quality and quantity, aquatic ecosystem restoration, groundwater management, flood hazards, and soil erosion control.

What is advantageous about addressing water quality degradation within a watershed perspective is that, unlike point source approaches that focus on collecting polluted water and treating it at one location, watershed-based approaches include multiple sources of pollution and causes of water quality deterioration within the watershed. These include: (1) point source discharges from industrial and municipal sources; (2) urban and agricultural polluted runoff; (3) wetlands and native vegetation destruction; (4) paving of land; (5) sand mining; (6) introduction of exotic plant and animal species; (7) erosion from upstream activities such as logging or cattle grazing in riparian areas; and (8) the deposition and recycling of pollutants from land, air, and water (EPA 1996).[6] Given these multiple sources of pollution, the watershed management approach encourages the application of *an expanded range of choice of management tools*[7] for water quality improvement. Watershed-based solutions draw from a variety of resource sectors (aside from wastewater treatment) and include urban river parks, economic developments, protecting/restoring wetland habitat, erosion control techniques, flood hazard management, and even increasing community green spaces. In land use planning terminology, integrating numerous resource sectors or "thinking watershed" entails actions such as creating a multiple purpose river park. In the case of the Tecate River, a key element of a multiple purpose river park plan is the protection of riparian habitat and, consequently, the natural capital or services furnished by riparian habitat.

The Value of Riparian Habitat in the Tecate River

As with other rivers and streams in Southern and Baja California, the Tecate River is comprised of a riparian corridor that includes the streambed and floodplain as well as a variety of assorted plants and animals. Riparian habitats — the jungle-like vegetation surrounding rivers, streams, and creeks — are a crucial component of a life-sustaining ecosystem and a local sustainable economy. The benefits of riparian areas for people, plants, and animals include services (or natural capital) such as flood control, groundwater recharge, and water purification (Michel 2001). During rainfall and flood events, riparian vegetation slows and dissipates storm water flows (Dallman and Piechota 2000). This dissipation of water first prevents erosion and sedimentation downstream. Second, it allows for floodwater to percolate into the soil and the aquifer beneath the riverbed, providing a critical source of potable water for residents and the local economic activities (Campo EPA

1994). In addition, riparian vegetation in the Tecate River corridor improves the water quality in streams, aquifers, and the coastal waters by filtering and breaking down pollutants discharged in urban areas (Husted 1997). With riparian habitat restoration, water quality benefits will occur not only in the Tecate region, but also downstream in the Alamar and Tijuana rivers and, ultimately, for the Pacific Ocean coastal waters in the United States and Mexico.

Unsustainable human activities in and near rivers and creeks in the Tecate region have resulted in the destruction of riparian habitat. This loss of riparian habitat or natural capital decreases biodiversity and reduces supplies of cost-effective potable water provided by the Tecate River watershed. Loss of riparian vegetation also decreases the amount of green space in the city, thus resulting in the loss of economic and social benefits derived from green spaces. There are numerous unsustainable human activities in the Tecate River corridor — such as sand mining, the introduction of exotic plants, and cattle grazing — that degrade riparian habitat and, ultimately, surface and groundwater quality. One particularly unsustainable activity, river channelization, has the potential to cause significant negative impacts on the Tecate River watershed ecosystem.

In Southern and Baja California, a channelized river removes surface and storm water flows as quickly as possible from the river basin and deposits them into the ocean. A similar project has been proposed for the Tecate River corridor that would include a concrete channel. The purpose of the project would be to quickly remove storm water to reduce flood events in the river floodplain and to increase the amount of land in the floodplain that could be urbanized. However, recent studies have shown that although the frequency of flooding in the location of the channel is reduced, the severity of flooding when the river is channelized is greater, particularly downstream in Tijuana (Dallman and Piechota 2000).

When a river is channelized, riparian vegetation is removed. Since there is no riparian vegetation to slow down surface water flows, ripple pool habitats are lost. During rainfall and flood events, riparian vegetation slows and dissipates storm water flows into ripple pools (Dallman and Piechota 2000). This dissipation of water first prevents erosion and sedimentation downstream. Second, it allows for the floodwater to percolate into the soil and the aquifer beneath the riverbed, providing a critical source of potable water for residents and local economic activities (Campo EPA 1994). In addition, concrete channel construction, along with urbanization in the river floodplain, alters the natural river hydrology. These two land use practices result in a significant increase in storm water runoff volume, velocity, and peak volumes in and around the river channels. This increases the potential for erosion and downstream flooding (Dallman and Piechota 2000; SANDAG 1997).

Watersheds in Southern and Baja California usually include three primary geological water-bearing formations: sandy alluviums, weathered tonalite, and fractured bedrock (Connolly 1997). These formations are important because they have the ability to hold and contain water, thus forming groundwater basins. In undisturbed watersheds, riparian vegetation in and near the river facilitates groundwater recharge by slowing the horizontal flow of surface and groundwater. Both trees and shrub vegetation keep water temperatures low, minimizing loss to evaporation (Connolly 1997). In addition, willows and cottonwoods assist in the growth of smaller vegetation. Other plants commonly found in restored or undisturbed riparian areas are watercress, nettle, duck weed, yerba mansa, sedges, celery, rushes, and cattails (Connolly 1997). Trees can form a canopy, facilitating formation of ponds by surface water and, through percolation, increase the water table elevation.[8] However, without sufficient riparian vegetation cover, storm water flows are neither slowed nor retained and groundwater recharge is greatly reduced.

Aside from pollution prevention and treatment of discharges into the river, wetlands or riparian habitats also can be utilized to improve water quality in the Tecate River. What makes wetlands uniquely suitable to improving water quality? The filtration of some pollutants is a natural function of wetland or riparian ecosystems. Wetlands improve local water quality by trapping sediment, digesting nutrients, and breaking down toxic contaminants (Husted 1997). Recent studies have shown that riparian vegetation even in small creeks removes significant amounts of nitrogen, a primary contaminant of surface and groundwater in the Tecate River corridor (Owens-Viani 2001). Because riparian habitat is positioned between water and land, it serves as a buffer zone that intercepts and even breaks down pollutants found in nonpoint source pollution or polluted runoff.[9]

Scientists estimate that concrete channelization and urbanization in river corridors have nearly destroyed 90 percent of riparian habitats in Southern and Baja California (Shapiro 1991). Unfortunately, when riparian or wetland habitat is destroyed, the quantity and quality of water inevitably deteriorates. An economic analysis from California determined that water purification benefits provided by the wetlands are worth approximately $6,600 per acre (Husted 1997 citing Allen et al. 1992). Destroying the natural pollution control (free of charge) or natural capital riparian habitat only imposes more costs to residents who use local water resources.

To summarize, riparian habitat destruction that comes with river channelization has led to a number of hazards and natural resource problems, including (adopted from Dallman and Piechota 2000 and Michel 2001):

- Decreased wildlife habitat and biodiversity
- Decreased groundwater infiltration
- Decreased stream base flows
- Decreased surface and groundwater storage
- Increased storm water runoff and volume
- Increased storm water peak discharge rate
- Increased stream channel erosion
- Increased frequency of local flooding
- Increased pollutant concentrations and quantities in storm water

Protecting Tecate's Aquatic Natural Capital through Watershed and Urban River Park Management

Essentially, a river park established within a watershed management plan (for the Tijuana River watershed) will help protect the natural capital provided by the Tecate River watershed. The watershed approach incorporates strategies for not only the Tecate River region, but also for the protection of headwaters upstream and the improvement of water quality downstream for designated users of the surface and groundwater resources of the Alamar and Tijuana rivers. In this context, water resource managers, water users, land use planners, and other stakeholders from both the cities of Tecate and Tijuana balance competing interests and determine how to satisfy human needs within the limits of available water resources. The first priority should be providing clean, reliable, and cost-effective water to every resident regardless of socioeconomic status. Aside from satisfying household needs, affordable clean water is needed for a sustainable local economy. Cost-effective and high quality water supplies are especially necessary for Tecate's brewery, tourism, and light manufacturing industries. Since river ecosystems and riparian habitats improve groundwater storage capacity and water quality, a watershed management plan would identify flexible minimum water needs to support riparian ecosystems in both urban and rural environments. This harmonization of domestic, economic, and environmental needs is reflected in Mexico's National Water Commission watershed council law that integrates the use, management, and administration of all natural resources (soils, water, flora, and fauna) in a watershed (CNA 1998; Michel 2001).

By applying the watershed approach, Tecate's potable water requirements can be augmented and even enhanced by first incorporating landscape architecture techniques to capture water on site at every possible location in Tecate, including residences, government buildings, and local businesses. Landscape architecture techniques that promote storm water retention on site include detention basins, infiltration basins, landscaping with native vegetation, and permeable pavements. These techniques increase groundwater recharge, thus enhancing the city's drinking water supply. In addition, these techniques reduce the incidence of flooding and sedimentation downstream. Preservation and restoration of the riparian habitat in the Tecate River and its tributaries will also foster groundwater recharge and reduce contaminants in the river and groundwater. The watershed approach, as opposed to conventional engineering methods of concrete channelization of rivers, advocates the use of multipurpose urban river parks for Tecate's residents.

Effective alternatives to river channelization have been developed and implemented in urban areas in a number of places around the world. One alternative, the urban river park, provides the protection of flood control without destroying the riparian habitat and its natural capital. The cities of San Luis Obispo and Santee in California and Denver in Colorado utilize riparian zones as multipurpose urban river parks. Unlike the concrete channelized river projects seen in Los Angeles and Tijuana, river parks protect local water resources and sustain local recreational and commercial activities. People fish, hike, picnic, bird watch, bike, and ride horses in these river parks in a peaceful natural setting. Urban river parks have proven to be a marketable amenity for developers of housing and commercial enterprises such as shopping malls, office/ industrial parks, and ecotoursim enterprises. Bird watching in both rural and urban areas generates nearly $25 billion of income in North America each year (Clines 2001). Property values rise near the river park area and improve a city's marketing image. Finally, as opposed to conventional engineering methods of concrete river channelization, the riverbed, riparian habitat, and the floodplain in river parks are utilized as green spaces and recreational sites (Michel 2001: 41).

An urban river project in Tecate would require a partnership with the private sector for development opportunities, parks, recreational assets, flood control needs, and water resources protection. In addition, Tecate's river park project could be incorporated into a larger watershed-based plan through coordination with Tijuana's efforts to create an urban river park for the Alamar River. Although there has been encroachment on the riverbed and recharge areas and some structures have been built to control floods, enough unaltered land remains to develop a high-quality river park along the Tecate River in urban Tecate. Government and nongovernment funding agencies (such as the Border Environment Cooperation Commission — BECC) are eager to support efforts that propose to restore and protect the many different natural resources that constitute the natural capital provided by the Tecate River watershed. Flood hazards, loss of local and low-cost water supplies, loss of natural areas through urbanization, a growing tourist economy, and other factors underscore the need for immediate action to protect the natural capital provided by the Tecate River watershed (Michel 2001). Integrated watershed management with an urban river park in Tecate can assure a legacy of natural beauty, parks, recreation, water resource protection, and economic vitality for present and future generations.

Endnotes

1 Within a geomorphologic perspective, the Tecate River would probably be classified as a creek, not a river. As such, scientists often refer to the Tecate River as *Arroyo Tecate*, or Tecate Creek. The term "river" is used here because "Tecate River" is the common name utilized by Tecate residents.

2 Or, to restate, efforts that protect the region's natural capital.

3 The economic burden of importing water is much greater than protecting local water resources. For example, in San Diego it costs $65 to produce one acre-foot of water from local groundwater resources. Water from the Colorado River costs approximately $550 per acre-foot, a nine-fold increase in water costs (Michel 2000). Imported water supply costs for Baja California were not available, but the costs differentials are probably similar in scale (Michel 2001: 18).

4 Point source discharge or pollution is water pollution that flows from a distinct identifiable source such as a pipe or channel (Water Education Foundation 1996: 5). Point source control in urban regions entails that waste from industry and households are deposited into a sewage collection system. The wastewater travels via the sewage collection system to a treatment facility, where it is treated at one place or point (Michel 2000).

5 Residential land uses demonstrated the highest levels of chromium, copper, and lead. This is surprising because the assumption has been that export manufacturing plants, or *maquiladoras*, are the primary source of pollutants (Gersberg et al. 2000).

6 For example, increasing nitrate levels found in Southern and Baja California water supplies originate not only from fertilizers, but also from automobile emissions into the air. This air pollution then is deposited via precipitation into local surface and groundwater resources.

7 Range of choice in water resources management is a phrase formulated by geographer Gilbert White over forty years ago. According to White, the range of choice principle is significant because "[unwise water resource] decisions often result from misperception or unawareness of potentially good alternatives" (Wescoat 1987: 41). The range of choice principle is similar to the alternatives analysis required by the U.S. National Environmental Policy Act of 1969 (NEPA). Under NEPA, the range of choice entails examining alternative means of completing a proposed project, plan, or action (Plater, Abrams, and Goldfarb 1992).

8 Along the edge of a pond, a canopy will help reduce evaporation of surface water and keep temperatures cool and favorable to wildlife. The restored river invites nesting ducks, red-tailed hawks, kestrels, migratory song birds, least bells vireo, as well as deer, bobcats, coyotes, and mountain lions, all of which are native wildlife species to the region. The diverse native vegetation and wildlife are important to this region because they have learned to adapt to one another and many have symbiotic relationships (Michel 2001: 32).

9 High levels of nitrogen, when combined with oxygen in water, form nitrates. High nitrate levels can cause methemoglobinemia, or blue baby syndrome, which is the inability of a baby's blood cells to fix oxygen. If nitrate levels continue to accumulate, blue baby syndrome can be fatal for babies and young children (Husted 1997).

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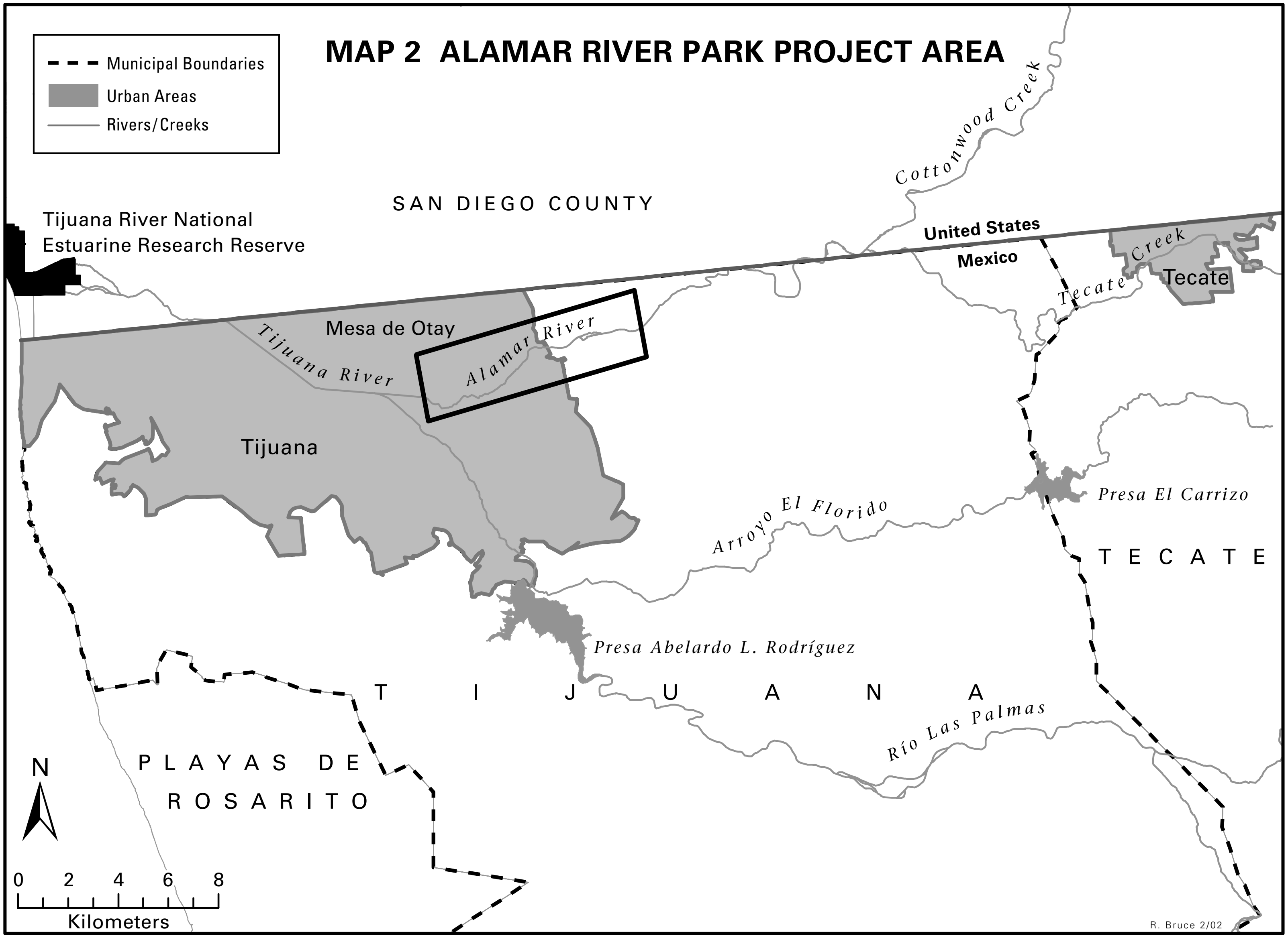
MAP 2 ALAMAR RIVER PARK PROJECT AREA
Municipal Boundaries
Urban Areas
Rivers/Creeks
SAN DIEGO COUNTY
Tijuana River National
Estuarine Research Reserve
Cottonwood Creek
United States
Mexico
Tecate Creek
Tecate
Mesa de Otay
Tijuana River
Alamar River
Tijuana
Arroyo El Florido
Presa El Carrizo
TECATE
Presa Abelardo L. Rodríguez
TIJUANA
Río Las Palmas
PLAYAS DE
ROSARITO
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III The Alamar River Project: An Urban Development Strategy for Baja California

by Carlos Graizbord*

Introduction

The Alamar River is located on the eastern edge of Tijuana's urban area and flows from east to west, linking the upstream Tecate River and Cottonwood Creek to the downstream Tijuana River. It is situated in the river valley to the south of the Mesa de Otay hills and tableland. The Alamar River belongs to a sub-basin that includes the Tecate River and the Cottonwood Creek in the United States. It is therefore a transborder sub-basin with transborder water resources. A study estimated that 70 percent of the water in the sub-basin permeates to the aquifer (or underground water deposit) on the U.S. side, while the remaining 30 percent enters the aquifer on the Mexican side (Ponce 2002). Downstream, the Alamar River joins the Las Palmas River to form the Tijuana River, which has been enclosed in a concrete channel that extends northwest to the international boundary with the United States. Map 2 shows the location of the proposed Alamar River Park.

The Alamar River shows varying degrees of disturbance by human activities that range from agriculture and grazing to sand mining, squatter settlements, and trash disposal, but retains considerable native and non-native vegetation.

Graizbord is Director of IMPlan, the Municipal Planning Institute of Tijuana.

The Alamar River has not yet been overwhelmed by the construction of a concrete-lined channel, roads, houses, or industry. It serves as a recharge area for an aquifer beneath it and the Tijuana River. Its wells provide a small, but critical, portion of Tijuana's water supply. The Alamar River, like the Tecate River, is an important landscape resource for the region. Like the Tecate River, the Alamar River also faces the threat of channelization and the loss of green areas and valuable groundwater. Although threatened, both rivers also present an opportunity for restoration and redevelopment that will enhance the quality of the rivers and adjacent urban areas.

Water Resources

Water scarcity is a worldwide phenomenon and in trans-border contexts it can become a source for international conflict. In the U.S.-Mexican border region, this is potentially the case at Ciudad Juárez-El Paso, the Sonoran desert in Arizona-Sonora, and California-Baja California. Water is scarce in California. Water for the region might be supplied in the future from the Colorado River through a binational aqueduct at a high cost. Other important sources of water include the regional aquifers and dams in San Diego, Tijuana, Tecate, and Mexicali. Desalination plants have been proposed for Baja California, but costs are still very high, especially for the initial construction and the high cost of energy for their operation.

Tijuana receives most of its water supply from the Colorado River, which is stored in El Carrizo dam, from rainfall captured by the Abelardo L. Rodríguez dam, and from groundwater. The water supply from the aquifer in Tijuana totals 20 percent of the city's water consumption and for Tecate this figure is much higher. Tecate is more dependent on its local aquifer than Tijuana.

If the aquifers are not managed appropriately, that is, if inputs from rain and their extraction are not balanced, the aquifer will be depleted and the water level will fall. When this happens, intrusion of saline water often occurs, particularly in aquifers located near the ocean. When that happens, even costly actions such as injecting fresh water cannot restore an aquifer to its full function. Simply stated, aquifers cannot be allowed to disappear.

Once waters are supplied, treatment plants for sewage for reuse must be built for irrigation, reforestation, and other uses. Water must also be distributed for agriculture, industry, and urban development, as well as marginal settlements. The cost of providing and maintaining such infrastructure is quite high.

River Rehabilitation versus Concrete Channels

The role of rivers as water recharge areas is eliminated when rivers are contained in concrete channels for flood control purposes. Concrete channels are expensive and their costs are difficult to recover. Concrete channels eliminate riparian ecosystems as ecological corridors. Ecological corridors bring the benefits of nature to urbanized areas. These benefits include oxygen, fauna, and the aesthetic values of natural environments, improving the quality of urban environments.

A concrete channel fractures the city in isolated sections. It divides urban areas in social, functional, and visual terms. Concrete channels also destroy the natural beauty of riparian systems. Natural rivers retain high water tables that sustain abundant native vegetation and fauna, which are especially valuable in desert and arid areas. These features are irreplaceable and are eliminated when concrete channels are built.

The Decision Process: The Alamar River Project

When the Municipal Planning Institute (Instituto Municipal de Planeación–IMPlan) began working on the Alamar River Project, another project was identified that proposed construction of a concrete channel for the Alamar River. This proposal's channel would be some seven miles long from the juncture of the Alamar River with the Tijuana River through the urbanized area of Tijuana on the southern part of the Mesa de Otay district (see Map 2). Concrete channels are usually proposed to protect urban areas from floods and, in Mexico, to eliminate large illegal settlements from river floodplains. The concrete channel proposal would confine the river to a narrow channel, eliminate natural riparian vegetation, and create new land for development on the former floodplain. The costs of construction would be recovered by the sale of land suitable for development that would be created in the area of the river's former floodplain. However, the amount of land to be made available could not be sold for enough to pay for the proposed infrastructure investment at the prevailing market land prices in Tijuana.

Instead, IMPlan proposed an ecohydrological approach for the rehabilitation of the Alamar River and flood protection of surrounding areas. In this proposal, some land could still be developed and investment costs could be recovered. Since the ecohydrological approach requires a lower investment compared to the concrete channel, some surplus funds could be generated. The ecohydrological approach is being applied around the world. In Mexico, the Mexican Water Technology Institute (Instituto Mexicano de Tecnología del Agua—IMTA) has already rehabilitated some rivers using this approach.

Competing interests that favor the concrete channel approach include engineers and concrete manufacturers as well as land developers. However, the scarcity of infrastructure funding has sparked concerns that the investments would not be recovered, propelling strong arguments against the concrete channelization project.

The Ecohydrological Approach for River Rehabilitation

The ecohydrological approach consists of the rehabilitation of the river's main channel, which is filled with sediment, as well as the restoration of native flora and fauna. For flood protection, gavions, dikes, and small dams are used, leaving the riverbed in its natural or rehabilitated state. In this way, the river is retained as a water recharge area and an ecological corridor, maintaining its rich natural flora and fauna and connecting the urbanized area to its natural surroundings. At the same time, it would form a large linear park for the community. Tijuana, like most other Mexican cities, lacks green areas and open spaces. As such, the river park would be a valuable improvement for the community.

The ecohydrological approach responds to a variety of objectives. These include flood control, protection of the water recharge area, creation of ecological corridors connecting cities to natural areas, enhancement and maintenance of the ecological equilibrium of a riparian system, creation of a large recreation and preservation area for the citizenry, and creation of an amenity for the city. Concrete channels, by contrast, primarily address the problem of flooding in the immediate area of the structure.

The riverbed as a water recharge area will protect the aquifer in a region that lacks water. This will retain the existing level of the water table, thus maintaining native vegetation. The river as an ecological corridor will help provide clean air and will provide residents of the city with access to the regional flora and fauna. The river as a linear park will partially eliminate the existing deficit of open spaces for the community and will become a landmark and an important amenity for Tijuana's population. The ecohydrological rehabilitation of rivers enhances the ecological and aesthetic qualities of riparian systems. Open spaces with vegetation tend to reduce or eliminate air pollution, thus improving the health of the community. Open spaces, especially riparian systems, are an urban amenity and educate people about nature as access to natural ecosystems becomes available. Additionally, rehabilitated rivers protect urban areas against flooding at lower costs than concrete channels.

Rehabilitated rivers foster good urban development, while concrete channels create squalor and fragmentation.

IMPLan presented the ecohydrological approach for the Alamar River to several federal and state agencies. Its main arguments were the comparatively lower cost of using an ecohydrological approach versus pouring concrete, preservation of the river as a water recharge area, and the value of the area as an ecological corridor and a large park for Tijuana. Additional arguments comparing monetary and nonmonetary benefits and costs of both options were not used. Nonetheless, participants were convinced of the benefits of the ecohydrological approach.

At the time that these arguments were presented, in other parts of the world, governments were allocating major investments to demolish concrete channels for various rivers. The argument was very useful, demonstrating that the new ecohydrological approach for river rehabilitation is a global phenomenon.

The Alamar River Plan

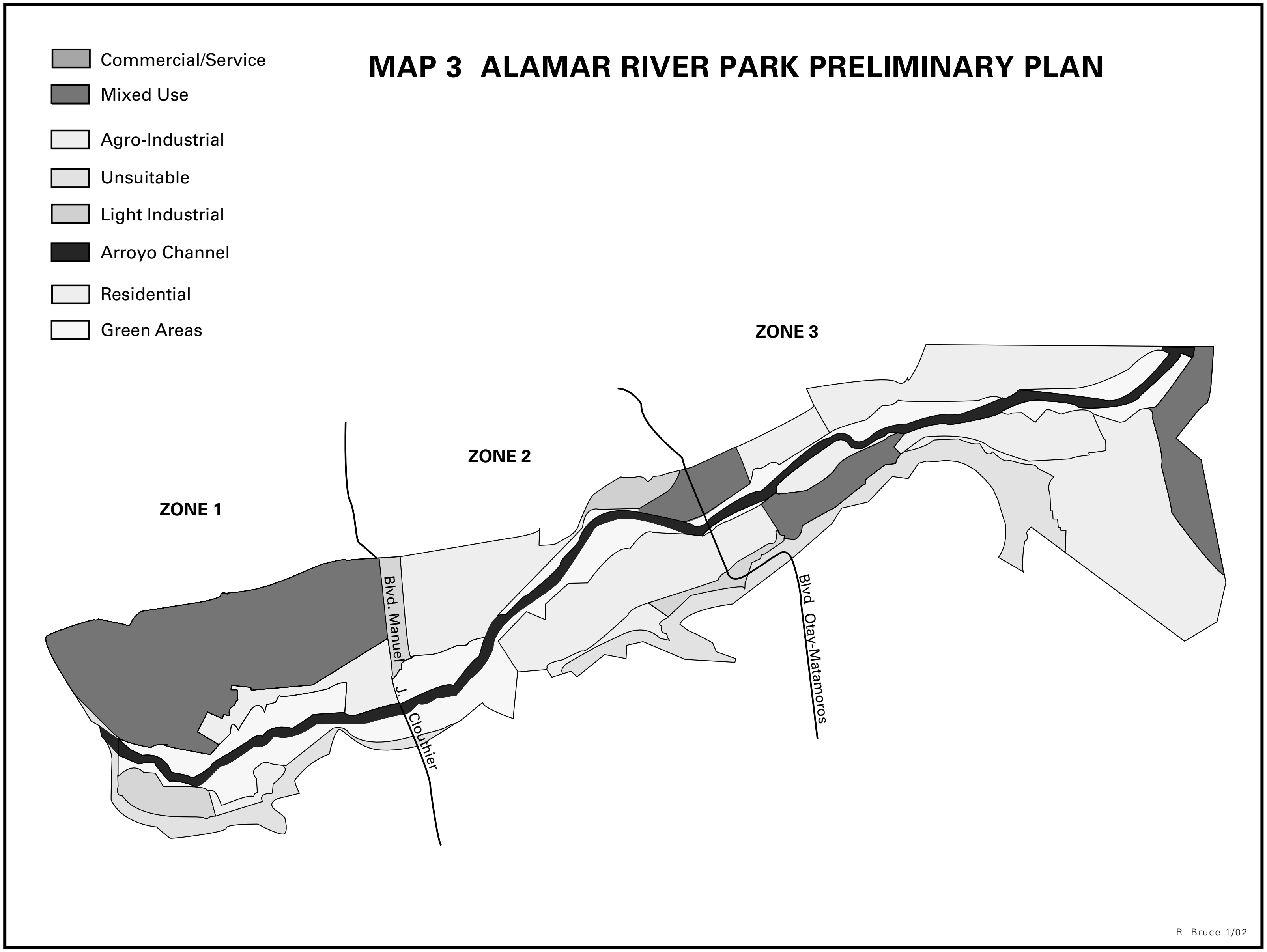
A number of items have been identified that need to be addressed in this plan. First, the sub-basin that includes the Alamar, Tecate, and Cottonwood rivers was delineated and the amount of water that it captured and recovered for the aquifer was estimated. Within the ecohydrological study, maximum flood levels for seven-, 100-, and 1,000-year periods need to be calculated to provide protection from this type of natural disaster that is typical to the climate and region. The location of all permeable soils within the sub-basins where water percolates into the aquifer also needs to be determined. All rehabilitation strategies for the river basin and its flora and fauna also need to be established.

An analysis was conducted by IMPlan in 2000 to identify suitable land uses for the seven-mile section of the Alamar River. Next, a financial analysis found that the ecohydrological approach, including gavions, dykes, and dams, is 40 percent less costly than the concrete channel. Thus, the sale of a smaller amount of new urbanized area would be required to recover the investment. Future studies and projects that will be needed were also identified, including a soils study; a topographic analysis; projections for seven-, 100- and 1,000-year floods; a detailed ecohydrological study; and a detailed project plan.

A land-use plan, a land-use program including preservation areas, recreational activities, areas for development, and all necessary urban services will also need to be completed. A detailed landscape and urban design project for the same area is likewise needed. A suitability or land-use potential study for approximately seven miles of the Alamar River was conducted using photo interpretation and site visits.

Finally, areas that are being polluted by illegal trash dumping and illegal settlements were also identified and some strategies to deal with those problems were developed. A detailed financial analysis of the project is now needed to proceed with the construction drawings.

These ideas were presented to the National Water Commission (Comisión Nacional del Agua–CNA) and the


Commercial/Service
Mixed Use
Agro-Industrial
Unsuitable
Light Industrial
Arroyo Channel
Residential
Green Areas
MAP 3 ALAMAR RIVER PARK PRELIMINARY PLAN
ZONE 1
ZONE 2
ZONE 3
Blvd. Manuel J. Clouthier
Blvd. Otay-Matamoros
R. Bruce 1/02

State Public Services Commission (Comisión Estatal de Servicios Públicos–CESPT) as a sustainable project that could be recovered financially. Directives similar to prohibitions were then drafted to protect the area from illegal settlements. These have to be processed by the state's urban development commission (Comisión Estatal de Desarrollo Urbano–CEDU). The new mayor and his staff have, in principle, adopted the ecohydrological approach. At this time, funding is not in place for these plans and projects. Preliminary funding is expected in 2002 and activity is expected to begin at that time.

The Interjurisdictional and Transborder Nature of the Plan

The geohydrological study covered a sub-basin with the Alamar River in Baja California, the Tecate River flowing in both countries, and the Cottonwood Creek in California. The preliminary ecohydrological study only covered seven miles of the Alamar River in urban Tijuana.

The Alamar-Tecate-Cottonwood sub-basin is an interjurisdictional, transborder sub-basin and requires a collaborative effort among Tijuana, Tecate, and San Diego. For that reason, the authorities of Tecate and San Diego were contacted, as was the Institute for Regional Studies of the Californias (IRSC) at San Diego State University. IRSC helped with the first study and contacted the Department of Landscape Architecture at the Arizona State University at Tempe, which worked with IMPlan staff to develop a local landslide rehabilitation project and a park project along the Alamar River. The surrounding neighbors are collaborating in the construction of the park on a voluntary basis.

The group from Tempe will be experimenting with other ecological solutions to specific problems along the river. The next project will deal with filtering polluted water along the river using ecological techniques. The College of Engineering at San Diego State University also conducted preliminary hydrological studies for the project. Funding for the Alamar River projects carried out by San Diego State University and Arizona State University was provided by the Southwest Center for Environmental Research and Policy and the William and Flora Hewlett Foundation.

Conclusion

IMPLan is very interested in further promoting a collaborative effort for this project with Tecate, public authorities in San Diego, and with state and federal agencies in Baja California and Mexico. IMPlan believes that the final project will become an asset to the region as a whole. The Alamar River within the urbanized Tijuana area will boast a preservation area as well as several recreational activities, such as a botanical garden displaying the fauna of Mexico, pedestrian routes, and space for other social and cultural activities.

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IV A Community Dialogue: Questions and Answers

After the presentations by Suzanne Michel and Carlos Graizbord, questions were invited from the audience. The principal points addressed in this community dialogue are summarized below.

QUESTION: Is there cooperation between Tijuana and Tecate in efforts to protect and restore the river and what other agencies and steps should be involved in this effort?

MICHEL: The best immediate step is a discussion between Tijuana and Tecate since the two municipalities are linked by the river and watershed. In addition, sharing information across the border is important. The Alamar Project described by Arq. Graizbord is absolutely outstanding. Unfortunately, integration of source water protection and land use planning is rare in Southern California. A good start would be to form a watershed council or to have stakeholders meet more often. We also need agency participation, including Tijuana and Tecate's State Public Services Commissions (Comisión Estatal de Servicios Públicos–CESPT and CESPTE) and the two municipalities' planning agencies. These agencies need to coordinate to work together to preserve the natural resources and the river water and also to begin planning for the river zone. While this sort of cooperation is difficult in the United States, I believe that it is possible in Baja California.

GRAIZBORD: I understand Suzanne's answer as basically saying that a coalition of all the interests, all the stakeholders, related to this project needs to present it to the appropriate government officials. A semiformal or formal organization should be created to present the basic arguments to all relevant local, state, and federal government agencies.

In Mexico, the National Water Commission (Comisión Nacional del Agua–CNA), CESPT in Tijuana, and CESPTE in Tecate are important. I feel that the CNA is very favorably disposed to the approach that we are using with the Alamar River. And, I believe that we convinced CNA with our presentation, but the agency is large and complex, particularly in Mexico City. We also have very good relations with CESPT and have discussed with them various issues, including future reserve areas for Tijuana. I think that it is necessary to form a group of interests to discuss and present these ideas. Specifically, we need to lobby for these ideas.

MICHEL: Let me emphasize that we also need a plan for Tecate's river zone. This river park plan should be integrated with a watershed approach.

GRAIZBORD: Another important point is that Suzanne is speaking of a regional project, the first phase of which is the sub-basin that includes the Cottonwood Creek, the Tecate River, and the Alamar River. If we carry out the ecohydrological project in the Alamar River, we must remember that much of the water that comes into the system comes from the Tecate River. The Alamar project cannot be successful without addressing the issues of water quality and quantity in the Tecate River, an area that is outside of the jurisdiction of the municipality of Tijuana. As a result, the State Secretariat of Human Settlements and Public Works (Secretaría de Asentamientos Humanos y Obras Públicas del Estado — SAHOPE) needs to get involved. The point is that it is necessary to take a watershed approach for these types of issues. In this case, the sub-basin that includes the Alamar, Tecate, and Cottonwood rivers requires the cooperation of Tijuana, Tecate, and the United States in order to establish a general plan.

QUESTION: Do retention ponds and absorption wells work equally well?

COMMENT FROM THE PUBLIC: In some Mexican cities, as part of the regulations for land use, developers are required to install an absorption well that works exactly the same as a retention pond. The well is filled with gravel and sand and serves to filter the water toward the subsoil and aquifer. Thus, for the amount of land that is paved over or is constructed on, a certain number of absorption wells are required. Evidently, the retention ponds are much more attractive. However, the absorption wells are often more efficient in use of space.

MICHEL: I think that the two options are equivalent. However, the retention ponds are constructed with each building, in each part of the city. It is very important that water be retained on the site as much as possible.

QUESTION: What would be the costs of channelizing the Tecate River and how would they be calculated?

GRAIZBORD: We calculated the costs of channelization and of the ecohydrological approach with gavions, dikes, and check dams. The main argument that we used in favor of the ecohydrological alternative was financial. The cost of concrete channelization would be high, although more land would be made available for development and sale. With the ecohydrological approach, the costs would be less, the area could be urbanized, and sales of land would be adequate to pay the costs of development.

We should remember that the channelization of the Tijuana River divided the city into two parts. Channelization of the Alamar River would divide the city into three pie-shaped wedges, dividing social life, dividing the amenities, and dividing the services. A friend in the municipality observed that planning means to plan now and to avoid excessive costs in the future. What is happening in Los Angeles now is that a much greater cost will be incurred to remove the concrete channels than if the ecohydrological approach had been used originally.

There are a number of other ways to look at the issue of costs. Most obvious is the issue of how much a project will cost and how those costs will be repaid. Another is related to the cost of transporting water from the Colorado River, which is very expensive. Clearly, it is more cost-effective to protect aquifers in Tijuana and Tecate and to avoid the extremely high cost of imported water.

There is another set of costs—costs that have not been determined in precise economic terms. These include things such as the aesthetic and quality-of-life value of the viewshed, the economic value of native flora and fauna, and the value of clean air and space for recreation. Recreation is extremely important to our urban residents, but we did not put yet a monetary value on recreation. We can easily determine the value of dense residential and commercial development that could be built on floodplain land; however, the studies to calculate a monetary value for recreation and other nonmonetary values were not done at this time. The ecological costs and benefits of the ecohydrological approach versus channelization have not been well developed and quantified. However, it is important to make these arguments.

These considerations add additional support to the basic argument that the development costs for the ecohydrological approach are less than for a concrete channel. In addition, the sale of developable land will pay for the costs of the ecohydrological project and that is not the case for the traditional concrete channel.

MICHEL: A recent study conducted by UC Berkeley students is relevant to this discussion. It demonstrated that one acre of wetlands or riparian vegetation provides natural capital or services (such as water quality improvement, wildlife habitat, recreational services, flood control, and aquifer recharge) worth, $6,600 per year. Over the long term, then, the value of restored and natural rivers is very significant. This is important information for conservation groups and policy-makers in Mexico and the United States.

Also, it should be mentioned that there are aspects of recreation that have significant economic impact. For example, the recreation activity of bird watching is currently a $25 billion industry in North America and quite important in the Tijuana River National Estuarine Research Reserve in San Diego at the mouth of the Tijuana River. Restoration and protection of riparian habitats as part of watershed management in the Tijuana basin would likely attract bird watchers to the Tijuana and Tecate areas along with associated economic impacts.

QUESTION: Are there ongoing discussions regarding the formation of a Watershed Management Council for the Tijuana River to support restoration and protection projects for the Tecate and Alamar rivers?

GRAIZBORD: The problem has a number of levels. One is binational and transborder, but there are also sub-basin, state, and regional levels. Another is at the level of the area of the seven or 10 kilometers upstream from where the Alamar River joins the Tijuana River. What is proposed for the Alamar River project, when all of the studies have been completed, is to establish a trust to control the development of the area. As far as I know, there are no other discussions to establish commissions to support development and the Alamar River project.

MICHEL: The state of California, under Proposition 13, has established a grant program to fund river restoration and protection of water quality. The County of San Diego is involved in a number of efforts to develop watershed management plans, including the Tijuana Watershed. The county is partnering with universities and other government agencies, and to be successful will need to collaborate with agencies and stakeholders in Tecate and Tijuana. This effort could eventually lead to the formation of a binational watershed council.

QUESTION: If the conclusion of the studies is that channelization of rivers is not good policy, why has this become apparent only recently, particularly in the United States?

GRAIZBORD: The Mexican Water Technology Institute (Instituto Mexicano de Tecnología del Agua — IMTA) employs the ecohydrological approach. This is not new on a worldwide basis because concern about channelizing rivers has been growing for the past ten years or so. In many parts of the world, rivers are no longer being channelized because local stakeholders and authorities realize the problems caused by concrete channels. Despite this understanding, there is a problem with inertia in many areas, where groups still think that the only option is channelization.

There are also practical reasons why the ecohydrological approach has not been more widely adopted. For example, in the case of the use of detention basins, we still do not have the regulations to control their use. And, in places like Tijuana, we do not have regulations for development in the floodplain and in aquifer recharge areas. Thus, not only do we have to protect these valuable and vulnerable areas, but we also need to control their development and at the same time develop regulations for their protection and then try to implement the regulations.

MICHEL: One problem in the United States with respect to the alternatives to concrete channelization is that the benefits tend to be most obvious over the long term. It is important that politicians, decision makers, and other members of the community think in terms of watersheds and the natural capital or economic benefits the watershed in its natural state provides over the long term. Politicians, in particular, tend to have a very short-term vision. For example, currently, the Board of Supervisors of the County of San Diego is authorizing and supporting development of industrial parks in the flat areas adjacent to the San Diego River instead of showing concern for the quality of water in the underlying aquifer, potential contamination produced by industry, and long-term benefits for residents of the area.

QUESTION: The city council of Tecate has the Executive Plan for Channelization of the River that could be carried out. How do you respond to that plan?

GRAIZBORD: I say, please do not channelize the river with concrete. I ask you not to do that because it will cost a lot of money and it will harm the well-being of the community and the residents of Tecate. Channelizing a river is a monumental work. The technology exists and it can be done. It is a spectacular example of infrastructure that serves for nothing. Why should we seal off the recharge zones for the aquifers? We do not have enough water in the region and it makes no sense to reduce local supplies. It is imperative that people from Tecate get together to compare the costs of concrete channelization and the ecohydrological approach, considering that with both approaches you can protect against flooding. This must be done for the area from Tecate to Tijuana because the river links these two cities.

QUESTION: Is participation by the private sector part of the plan for the watershed?

GRAIZBORD: I can speak for Tijuana, but am not informed completely about Tecate. In all aspects of planning, it is necessary to involve the private sector. It is important to include owners of the land that might be affected and it is necessary to include developers. These people have already been contacted. It is also imperative to involve all of the neighbors adjacent to the Alamar River.

Mission Valley, in the San Diego River Valley, is a good example of private sector involvement. The river was restored in Mission Valley, including native vegetation that attracted native fauna such as ducks. The attractive environment of the river restoration produced high-value condominium and apartment development. That is the idea of river restoration and the ecohydrological approach — to create positive economic impacts for not only the private investors, but for the government and the community as well.

Tijuana is lacking in attractive housing for the middle and upper classes. A Mission Valley-type development along the Alamar River would be an excellent possibility.

QUESTION: How do projects like the Alamar fit into urban development plans?

GRAIZBORD: The Urban Development Plan for the City of Tijuana *(Plan de Desarrollo Urbano de la Ciudad de Tijuana–PDUCT),* includes the idea of linking all the city's streams, even those that have been interrupted by legal and illegal development, into an urban network of green areas. The Alamar River Project would be a key part of this effort and is specifically contemplated within the city's master plan. We also are looking at the area to the south of the urban settlement and the streams that link that area with the urbanized area. We feel that it is necessary to develop strategies to accomplish this.

QUESTION: Isn't there an inconsistency with the position of not channelizing rivers with concrete and the plans to line the All American Canal with concrete?

MICHEL: The All American Canal issue is well known here and I am personally not in agreement with the decision to line the canal. Since the canal that brings water from the Colorado River to the Imperial Valley is not lined, water seeps from the canal and recharges a large aquifer in the Mexicali Valley. However, government agencies in the United States take the position that the water belongs only to the United States and that the current users in Mexico have no rights to it. Ironically, in California if a person uses water for a period of time, that person acquires the permanent right to use that water. This represents conflict between U.S. federal laws and California state laws and problems resulting from the lack of a treaty between Mexico and the United States regarding groundwater.

One issue that has been lost in this discussion over the All American Canal lining proposal is the impact of continued high levels of extraction from the Colorado River system by U.S. and Mexican users. These practices have had severe impacts on the birds, fish, and other wildlife and on the productivity of the Colorado Delta and the Upper Gulf of California biosphere reserve.

QUESTION: What was the result of the proposal to establish a landfill in Campo, California, that might have affected the aquifers of Tecate?

MICHEL: This is an excellent question. The proposal to develop a sanitary landfill on the Campo Indian Reservation was dropped and one of the reasons was concern that the development might contaminate surface and groundwater downstream in the watershed. This illustrates the connection between upstream land use activities and downstream water quality.

Tribal authorities at Campo have put into practice traditional techniques for stream restoration. By restricting access of cattle to the riparian areas and using check dams and other construction techniques, riparian vegetation has been restored and the water table has been raised to the point that water flows in the formerly dry stream throughout the year. This provides benefits to downstream users, including those in Tecate, Baja California.

QUESTION: What is IMPlan's proposal to restore the River Zone in Tijuana, which is already lined with concrete?

The enormous cost of restoring the channelized Tijuana River means that there are no such plans at the current time. Instead, the effort now is to protect tributaries of the Tijuana River, including the Alamar River.

QUESTION: Does IMPlan have the technical capacity and human resources to undertake the Tecate River project?

Tecate's various stakeholders need to join together to work for a common goal. IMPlan, the government of Tecate, SAHOPE, and other agencies should be involved. Stakeholders need to convene to discuss proper management of the entire sub-basin. We have adequate human resources, including staff at IMPlan and consultants.

However, it should be pointed out that the issue of the Tecate River is more than a task for Tecate, Tijuana, and Baja California. California and the County of San Diego are also involved since the basin is binational. For example, upstream activities in Tecate and Tijuana have a significant impact on the quantity and quality of water in the Tijuana Estuary.

MICHEL: As I pointed out earlier, there is growing interest in San Diego in addressing water and related issues on the basis of watersheds. At the same time, cooperation between authorities in California and Baja California on issues of mutual concern is closer and more productive than in any time in recent history. This suggests that initiatives by Tijuana and Tecate regarding San Diego's cooperation on watershed matters would be received positively north of the border.

QUESTION: When a river is channelized with concrete there is a negative impact on the groundwater deposits. Then, in the new land opened for development, concrete pads are placed for the construction of industry, which also affects the groundwater. Is that correct?

MICHEL: The goal of sustainable development for the Tecate River is to provide for protection of the river and to also provide space for industrial parks and other uses in the urban area. It is important, however, not to locate industrial parks and other types of development that prevent water filtration into the aquifer or contaminate the surface and groundwater in the floodplain and water recharge area for the aquifer. Tecate has the opportunity to protect its river and underground water supply and provide land in areas suitable for industrial, residential, and commercial development and not make the same mistakes that Tijuana or San Diego have made.

GRAIZBORD: The argument that land adjacent to rivers must be made available for industrial development makes no sense because that will also destroy valuable water resources. In Tijuana, for example, although land is limited and expensive, there is room for growth of industry and residential areas. There is a reserve of some 23 hectares for growth through the year 2020. It is not necessary, from the perspective of urban planning, to destroy rivers and streams to provide space for construction.

Another point that needs to be made is that although partial restoration of natural areas that have been developed is possible, it is very difficult to fully reconstruct damaged areas of native ecosystems and flora and fauna. Once a deer is killed, for example, it is impossible to reconstruct that animal.

There are good alternatives. Let me provide two examples. In Monterrey, concrete structures were built to protect against floods, but soccer fields were built in the floodplain. So when rains bring floods, the football fields fill up with water and serve to recharge the aquifer beneath the river and floodplain. Another example is a river adjacent to the Mexiquense Cultural Center in Toluca. The center is adjacent to a large river crossing an urban area. An iron fence was placed around the river basin and a few nonpolluting government offices were sited there. Native vegetation was protected and enhanced and walking and running trails were included. The result is a very beautiful linear park for Toluca. There are other similar examples in Mexico and elsewhere around the world.

QUESTION: What are the next steps to protect and restore river areas?

GRAIZBORD: In Mexico we have a serious problem with respect to our capacity to regulate land use. Although the process is open for individuals and entities to collaborate with the municipality to develop regulations for these sensitive river and stream areas, it is difficult to control land development. As you all can see, permission is frequently granted to build in the water recharge zones along rivers. Thus, we need to urgently develop enforceable regulations to protect these areas that are so critical to our water supply.

We also need to institutionalize the land use and urban-planning process through development of government commissions and citizen groups to support projects such as the Alamar River project. This is a general need throughout our urban areas and a specific need for the Alamar project.

MICHEL: Under the Mexican water laws, citizens can form a watershed committee to promote the protection of water resources and related actions. Education is also important. My dream is for the establishment of three education centers in the watershed. One would be in the Tijuana Estuary in San Diego, another would be in the Alamar River park development, and the third would be in Tecate. Students from both sides of the border could visit these centers to learn about biodiversity, water resources, the importance of habitat protection, and the critical nature of watershed protection.