BAJA CALIFORNIA

- THE STREAMS OF BAJA CALIFORNIA

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INTRODUCTION

The Peninsula of Lower California, located off the west coast of mainland Mexico from 23° North latitude to the United States, is commonly referred to as Baja California (BC) or just Baja. It is comprised of two states, *Estado De Baja California Sur* from 23° N latitude and a northern state *Estado De Baja California* that some have called *Baja Sur* and *Baja Norte.* Debate exists as to the proper use of these names in the scientific literature and/or the specific locality of scientific collections (Snelling 1982, Clark and Westcott 1992). In this article, we follow Clark and Westcott in that latitude and longitude should be used for locality data to avoid confusion and have attempted to locate running water habitats accordingly. These properly located streams can then be used to verify past data collections of type specimens or document new collections. Our use of Baja or Baja California in this article refers to the whole peninsula, although Baja by itself may not be proper regardless of common usage in the U.S.

Much of the interior of Baja California has remained relatively remote and inaccessible for centuries. A couple of biological expeditions overland were made in the past (see summary of major field work by Truxal, 1960), but, until recently, all but the hardiest of off road travelers were probably restricted to the northern part of the peninsula and the extreme southern cape, which is accessible by ferry from mainland Mexico. All this changed with the completion of Mexican Highway #1 (the Transpeninsula Highway) and an increasing population of tourists and naturalists are now traveling through the once remote interior.

We first became interested in Baja California while trying to pinpoint certain obscure mayfly and water penny beetle collection sites. Reliable information on any permanently flowing water was difficult to come by. We were able to travel the entire length of the peninsula for two weeks during May-June 1978 and most of the peninsula for two more weeks in late May 1979, looking for streams and collecting aquatic insects. Since then we have tried to catalog what information we could gather on the lotic water habitats of the peninsula. It seems likely that not only more and more stream biologists, but any biologists who want to collect around aquatic habitats, will be visiting the peninsula. Some of the locations may be of interest to other scientists, such as anthropologists. Hopefully our data presented herein will save some time and effort and minimize the chasing of rainbows up stream canyons.

There are many permanent flowing water habitats in BC, some easy to find and others found only with great difficulty. Previous experience with sampling of streams in arid areas would prove most helpful to those biologists traveling in the peninsula. One can develop an instinct for finding springs or short permanent stretches of water in an apparent dry canyon. Water may appear in the most unlikely places. We have seen springs in places that make one want to rewrite groundwater geology texts. Also, it is possible to be within a few meters of a stream and never see or hear it.

Many stream channels in Baja California are dry most of the year, bearing water only during and immediately after a rain and are truly ephemeral streams. Our interest in these is minimal. Permanent or perennial streams which carry water the year round and are fed by a stable groundwater flow are rare. There are many streams in BC which are truly intermittent, carrying water part of the year and dry the other part, but which receive flow from the groundwater (Morisawa 1968) and sections of these streams have permanently flowing water.

Our judgement as to whether a stream area or habitat is permanent is based on the fauna we found and/or local information. In some cases, it was difficult to tell, especially when aquatic insects were absent and the water looked polluted. Some of the streams in the northern state had higher than normal amounts of water. A hurricane in 1978 caused serious flooding and several stretches of highway were washed out. One span of a rather impressive concrete bridge near the mouth of the Rio Santo Domingo collapsed and tons of sand were deposited in the lower reaches of this stream producing braided conditions. The river had still not completely exhumed itself in this area by the following year. Also, we were told that the rainfall in northern Baja in 1978 was the highest in over 50 years. Most of the precipitation in BC comes during the winter as snow in the higher elevations (Yruretagoyena 1992). The driest months are May, June, July and August.

A summary of temperature and rainfall data is available in a travel guide (Anonymous 1980). Individuals contemplating travel there should consult this guide for its wealth of concise information. Travelers should also talk to someone who has been there as there are a number of important do's and don'ts. Firearms are taboo and night driving can be risky. Cattle and burros on the road or a washed out bridge with a few warning rocks in the middle of the road and a small peligroso (danger) sign might not be seen. Some individuals, who could be good sources of information for some B.C. localities, are described in the acknowledgements.

The maps presented in Figures 1 and 2 show some 96 locations based on our own work, literature records, or reliable information. We've drawn a square around those locations that have permanent water habitats or a high degree of probability of permanence. Those sites within a circle are either doubtful or require further exploration. Follett (1960), in a paper on the fresh water fishes of BC, listed several sites. Our references to fish collection records refer to this paper. We list these sites

under permanent streams, but agriculture and other practices may have altered the situation since those records were made.

Edward W. Nelson and Edward A. Goldman traveled the entire Baja peninsula during 1905-1906 and the results of this expedition from the Bureau of Biological Survey of the U.S. Department of Agriculture was published in 1921 and reproduced more recently (Nelson 1966). This paper has perhaps gone unnoticed by many due to its age and title, *Lower California and its Natural Resources.* We know of at least a dozen biologists/geologists who traveled in Baja and never heard of it. Robert R. Miller brought it to our attention. Anyone planning extensive work in Baja and/or those with a love of wilderness adventure should consult this paper. Nelson made detailed observations on streams and springs and we attempted to follow Nelson and Goldman's path through BC by reading Nelson's journal and using his map, along with several others. Some habitats were impossible to pinpoint, so we have given approximate locations. Also, natural and/or human events may have significantly altered the water flow since 1906.

Generally streams are numbered as we learned of them, with the general stream locality noted on the maps (Figs 1 and 2). Several other maps are cited for additional detail, including:

1) AAA Automobile Club of Southern California Road Map of Baja California,
2) Nelson's map of the Nelson-Goldman expedition,
3) the Clark Map, copyright 1975 by the Arthur H. Clark Co., which shows the northern portion, the central portion and the southern portion of Baja California,
4) the McMahan Map of Baja California Mexico, McMahan Brothers Desk Co Inc., 3131 S. Figueroa Street, Los Angeles, California, 90007, and
5) the 1:250,000 scale topographic maps (hereinafter referred to as Topo map) published by the Mexican government.

A 1:1,000,000 scale map of Baja California was recently purchased for seven dollars. It is not cited in this paper, but it would make an excellent companion to the AAA map. It is published by International Travel Map Productions, P.O. Box 2290, Vancouver, B.C., V6B 3W5, Canada.

Maps have been a problem. Some streams or valleys or villages may be called by more than one name. We have put the second name in parenthesis when this is known. There is variability in the presence or absence of names on the maps cited above, so we worked with all of them. The Clark Map is valuable in that it has some very old names which may not be found on other maps, but we could not locate a copy for sale. Ours was borrowed from a geologist.

Figure 1: Stream locations in Estado de Baja California. Squares signify locations with permanent water; circles signify sites without permanent water or information to confirm water is present.

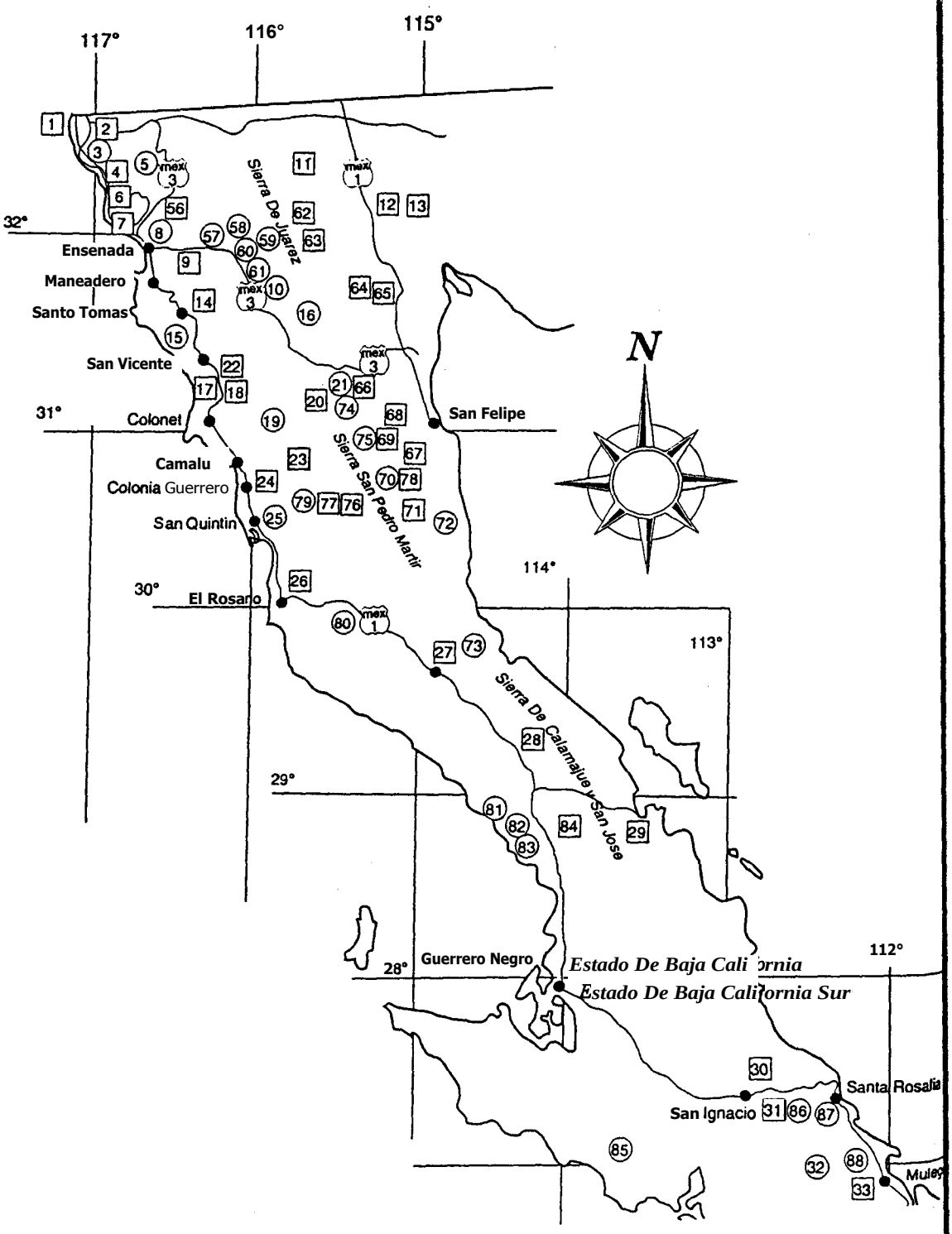
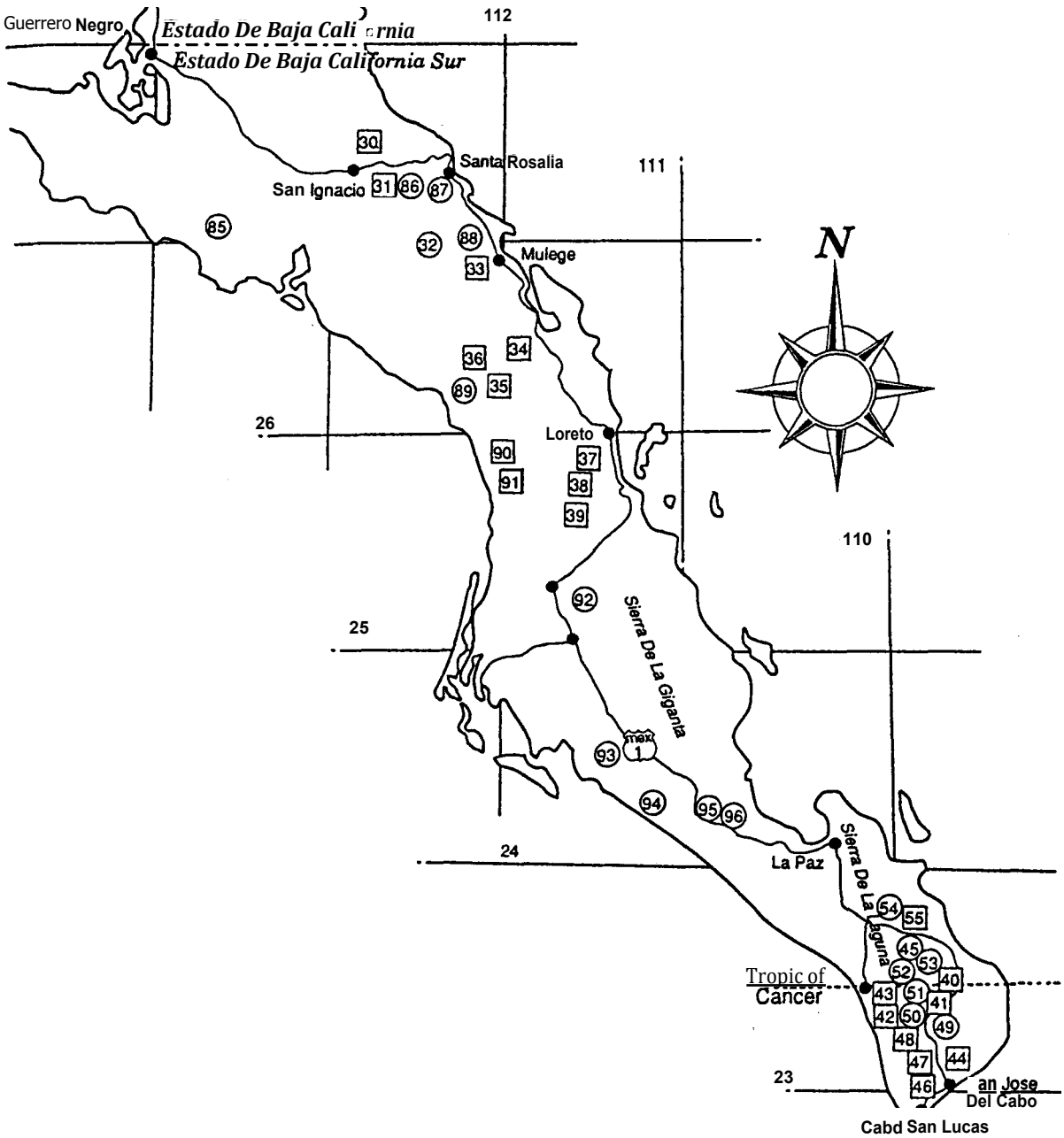


Figure 2. Stream locations in Estado de Baja California Sur. Squares signify locations with permanent water; circles signify sites without permanent water or information to confirm water is present.



Excellent topographic maps published by the Mexican government are available, but for some time, one had to go to Ciudad, Mexico to purchase copies. The Map Center, Inc., 2611 University Avenue, San Diego, California, 92104-2894, and perhaps other outlets unknown to us, purchase them in Mexico. We bought the 1:250,000 scale series of Baja California and replotted all of our localities (including latitude and longitude) on these topo sheets. Other Mexican government topographic maps, such as the large scale 1:50,000, are available.

A few years ago we purchased a book of large scale topographic maps called the *Baja Topographic Atlas Directory*, but have referred to it only when necessary in this paper since it is now out of print. There are over 200 maps in this atlas which are based on the Mexican government 1:50,000 maps. The Map Center Inc, (phone: 619-291-3830) had several copies available as of November 1993 for about $28.00. Other bookstores that sell maps may also have copies available. The May 1985 issue, page 86, of Sunset Magazine gives names and addresses of several bookstores in southern California. The topographic atlas (hereinafter referred to as "the large scale Topo atlas") would make an indispensable companion to the AAA map in finding one's way through the BC peninsula. Much of Baja California, away from the highway, is as wild and remote as ever and detailed information about roads and locations would be a boon. The back country is somewhat similar to parts of the state of Nevada. There are numerous junctions without signs, and one feels like Christopher Columbus, not knowing where you are or where you're going. The topographic atlas here would be invaluable.

ANNOTATED LIST OF BAJA CALIFORNIA STREAMS

1. TIJUANA RIVER. (Approximately 32° 30 N lat. 117 W long.) Fresh water fish have been reported from the Tijuana River, two miles east of Tijuana (Follett, 1960: 227, 228). Nelson (1966: 78, 80) reported permanent water in some parts of this system.
2. WILD CAT CANON. (Approximately 32°30' N lat. 117°N long.) There is a fresh water fish record in this tributary to the Tijuana River (Follett, 1960: 223). We cannot locate this stream on any map.
3. RIO ROSARIO. (Canada Rosarito) (32°19' N lat. 117°03' W long.) A stream was flowing at Highway 1 in late May south of Rosarito. This location is close to or the same as the Rio Rosario location on the AAA map. We did not find a road leading upstream and did not collect here. The Topo map (1:250,000) does not show the Rio Rosario by name, but does show a stream flowing west from Canada El Rosarito to San Paricio, Cementeria. A dirt road leads from Cementeria upstream to San Paricio. This must be the "...shallow stream emptying into the ocean at Rosario (= Rosarito), about 15 miles below the boundary line and near the Coronado Islands" (Smith, 1883: 235; Follett, 1960: 223). This fresh water fish record suggests the stream is permanent near the ocean. We have no information as to water availability upstream.
4. ARROYO MEDANO. (Approx. 32°14' N lat. 116°55 W long.) Fresh water fish record. We cannot locate the name on our maps, but it is 2.5 miles (4.2 km)

north of Arroyo Descanso (Follett 1960: 217, 223). It must be at or near El Médano east of Cantamer off Highway 1.

5. RIO DE LAS PALMAS. (Approx. 32°23' N lat. 116°45' W long.) This area was said to be dry. We did not have time to investigate upstream near Santa Alicia, Valle de las Palmas, and El Testerazo near Highway 3 south of Tecate. This stream and its tributaries drain a significant area west of the northern part of the Sierra Juarez. All maps show a lot of dirt roads into this general area. Las Calabazas (Cancio) is supposed to have permanent water somewhere in part of its course (Nelson, 1966: 78). This stream is tributary to Rio de las Palmas and is found east of El Testerazo (on all maps) on Highway 1 south of Tecate and Valle de las Palmas.
6. RIO DESCANSO. (32°13' N lat. 116°53' W long.) A dirt road ends at the stream just beyond the mission site near El Descanso. Villagers said the stream is permanent. Not suitable for collecting lotic insects at this site. We could not find any road into the canyon upstream, although the Topo map shows a dirt road part way up the canyon from El Descanso to Alvarez.
7. ARROYO CARMEN. (31°55' N lat. 116°44' W long.) This is 7.6 miles (12.7 km) north of Ensenada. Fresh water fish record (Follett, 1960: 17). The name does not appear on most maps, but El Carmen and Cañon El Carmen are in the large scale Topo atlas.
8. CANON EL CARMEN. (31°58' N lat. 116°38' W long.) Location is near Villa Juarez (not on the Clark map) about 8 miles (13.3 km) northeast of El Sauzal on Highway 3. Poor aquatic insect habitat, but some mayflies. This is the type locality of *Baetis byblis* (Allen & Murvosh, 1983). Water permanence here is doubtful even though a considerable flow was present in May. We originally thought this to be a tributary to the Rio Guadalupe, but it must be part of Cañon El Carmen.
9. RIO (ARROYO) SAN CARLOS. (31°48' N lat. 116°27' W long.) At San Carlos about 12 miles (20 km) east of Maneadero. Sandy shifting stream bottom with very few rocks and a small but poor riffle habitat. The mayfly *Baetis caelestis* was collected here by Allen & Murvosh (1983) but no other insects were seen. The stream is probably permanent here and may be polluted. Elevation 600' (183 m), water temperature 70°F (52.2°C). This is one of the main drainages flowing to the Pacific Ocean from the Sierra San Pedro Martir range (Nelson, 1966: 80).
10. EL GATO (SANGRE DE CRISTO). (31°51' N lat. 116°05' W long.) East of Ensenada on Highway 3, a good flowing stream crosses the road where Highway 3 turns south below Ojos Negros. The name El Gato is only on the AAA map and is indicated as the Rio (Arroyo) San Carlos on our other maps, except it is called San Salvador on the 1:250,000 Topo map. The water west of the road is used for irrigation and the flow may be diverted. East of the road, the stream seems to originate from springs and may be permanent.
11. ARROYO EL TAJO (AQUA GRANDE). (32°22'N lat. 115°48'W long.) General location is southwest of Mexicali and due west of Laguna Salada. Cantu Palms appears on Clark, and McMahan maps and La Poderosa on AAA,

McMahan and the Topo map. A biologist reported water in the canyon above Cantu Palms. This must be Canada Cantu De Las Palmas and about 1 km north of El Tajo (Aqua Grande). Arroyo El Tajo on the McMahan and Clark maps is called Aqua Grande on the Topo map for a stream flowing east out of the Sierra Juarez to La Poderosa and Laguna Salada. Perhaps this is Arroyo Tako briefly mentioned as being north of Cañon de Guadalupe (Nelson, 1966:79). We cannot locate an Arroyo Tako and this may be misspelled. Between Tajo and Guadalupe, the McMahan and Clark maps show Arroyo Carrizo (not named on the Topo map).

12. RIO HARDY (Approx. 32°08' N lat. 115°15' W long.) Southeast of Mexicali. Fresh water fish records (Follett, 1960: 219, 225, 227, 228).
13. COLORADO RIVER (Ca. 32°05' N lat. 115°W long.) Fresh water fish record (Follett, 1960: 227).
14. RIO SANTO TOMAS (31°33' N lat. 116°26' W long.) This is one of the main drainage channels flowing west from the Sierra Juarez (water temperature 79°F, 26.1°C). We collected two miles (3.3 km) southeast (upstream) of Santo Tomas. A dirt road here goes to the river from Highway 1. The stream was so deep and wide in 1978 that we thought it was a permanent flow until we found only black flies, snails, and three species of baetid mayflies (Allen & Murvosh, 1983), nothing that would suggest water permanence. A woman who lives here said that the river dries up. An individual who owns a leather shop said that streams are running this year that have not flowed for 50 years or more. There are fresh water fish records from the Rio Santo Tomas (Follett, 1960: 223, 227), perhaps downstream between Santo Tomas and the ocean where we did not collect. This stream is known to have places higher up the canyon with permanently flowing water (Nelson, 1966: 78, 80). However, we could not find an open road leading into the canyon. A view via binoculars suggested such a road or trail, but the area was fenced and we could not locate property owners. One might walk into one of the headwater tributaries from El Alamo. Nelson (1966: 16) talks about this general area and the mining camp here, but does not mention any water. The location of San Angel and the road leading to it (McMahan map) suggest it is on or near the river up the canyon, but it is not. San Angel is farther south. The Clark map shows a road going a short distance upstream. Reliable local information and sufficient time is a must for anyone planning to enter this area since the canyon is some distance from the highway.
15. UNKNOWN STREAM. (31°24' N lat. 116°19' W long.) Location is 10 miles (16.6 km) south of Santo Tomas along the west side of Highway 1 near the turnoff to San Angel. There is heavy cattle use along the stream with considerable fecal pollution. We found no aquatic insects that live in permanent water.
16. SANTA CATARINA (31°40' N lat. 115°50' W long.) Between the southern end of the west slope of the Sierra Juarez and Highway 3 southeast of Ensenada are many villages and numerous dirt roads. We did not explore this area, but the villages must have a water supply and a view with binoculars shows some interesting canyons that might support spring streams. Pepper (1973) says that

the mission at Santa Catarina was located on a stony knoll above a stream. Nelson (1966: 75) reported a small stream in the arroyo at Santa Catarina and described the drainage as westerly via the Santo Tomas River. The 1:250,000 Topo map indicates this actually drains farther south into Cañon San Isidro (Arroyo San Vicente) (on Clark and McMahan maps) past San Vicente to the Pacific Ocean.

17. RIO SAN ISIDRO. (ARROYO SAN VICENTE) (31°20' lat. 116°15' W long.) This stream is called Arroyo San Vicente on the Clark and Mc Mahan maps, Cañon San Isidro on 1:250,000 map and Rio San Isidro on the AAA map. Follett (1960: 223) lists this stream for a fresh water fish record. Nelson (1966: 78, 80) described it as one of the main westerly flowing drainage channels with some areas of permanent water. More specific information is needed. The Topo map indicates a road east of San Vicente part way into the canyon. Above this, the main stream is called Cañon Dolores. The Clark and McMahan maps show a road, originating south of San Vicente, which appears to go up into the canyon to Los Alamos and Aqua Caliente. These names and the roads do not match those of the Topo map. Reliable local information would be important before wasting time driving all the back roads.
18. ARROYO SALADO. (31°12' N lat. 116°10' W long.) This stream is incorrectly called Rio San Antonio on our AAA map. It picks up a lot of tributaries in the Valle de Trinidad region near Highway 3, and flows westerly crossing Highway 1 at El Salado (not shown on AAA, Clark and McMahan maps) about 10 miles (17 km) below (south) of San Vicente and 5 miles (north) of Edido Bonfil where Highway 1 curves sharply west to Colonet. At Llano Colorado (not on the Topo map) we tried to drive up a dirt road to the river, but locals told us none of these roads led to water or streams. The situation here is very confusing without reliable information. The AAA, Clark and McMahan maps show a poor, simple road connecting Valle de Trinidad with Highway 1, but the Topo map does not show a complete road here. Nelson (1966: 78, 80) lists this stream as one of the main westerly flowing drainages with areas of permanently flowing water. In his description of Trinidad Valley (pp. 17, 76), he mentions a small stream that flows a few miles at the extreme lower end of the valley and drains through a rocky canyon heading to the west coast. There seems to be no way to locate this.
19. RIO SAN RAFAEL - LOWER VALLEY. All maps show a road originating at Highway 1 near Colonet (see detailed discussion at the end of stream No. 20) that goes part way up the river to Jocertes (probably Potrero on Topo map). We don't know if there is permanently flowing water near Jocertes, but its likely. This is one of the major west flowing channels in Baja (Nelson 1966: 56, 78, 80). Note the description of another and completely different San Rafael Valley (Nelson, 1966: 16). Note also fresh water fish locations (Follett, 1960: 215, 223). One listing is for Cabo Colonet suggesting permanent flow near the sea.
20. RIO SAN RAFAEL - higher reaches. (31°08' N lat. 115°39' W long.) The coordinates given are for Mike's Sky Rancho (AAA, Clark and McMahan maps, San Rafael on 1:250,000 Topo map), which is on the river at 3700' (1138 m) elevation. The stream here is excellent habitat for mayflies, some caddisflies,

water pennies, and a few stoneflies. Water temperature was 22°C and pH 7.3. The hurricane of 1978 produced much flooding and deposited a great deal of sand here. The best route to the Rancho is to take Highway 3 from Ensenada to the turnoff about 8 miles (13.3 km) south of Valle de Trinidad. Follow the dirt road to Mike's Rancho beyond El Burro (not on McMahan map). The road is maintained and Mike's Rancho signs appear at Highway 3 and on the dirt road. With care, an auto or camper van can negotiate this road during the dry season, but the river crossing at the rancho could be a problem. One could park in the camping area on the other side of the river and walk the 50 meters or so to the rancho. This would make an excellent base camp for anyone wishing to study this part of the Sierra San Pedro Martir. Some food and motel lodging is available as well as camping. Those interested could write ahead to Mike's Sky Rancho, Number 1000 Revolution Ave. Phone: 5-35-34, Tijuana, Baja California, Mexico and/or Chula Vista, California, Phone: 420-85-36. This address is old.

An alternate route is to use 4-wheel drive, leave Highway 1 at San Telmo (30°59' N lat. 116°10' W long.) south of Colonet, and drive up the Rio San Telmo Valley road toward Meling Ranch (= San Jose). This is the road to the observatory in Sierra San Pedro Martir National Park and the dirt road to the Meling Ranch was in excellent condition. Below Meling Ranch is a turnoff to the left heading northeast. We saw a worn and faded Mike's Rancho sign at the turnoff. Somewhere in the vicinity of Cerro de Castillo (not on Topo map, but there is El Castillo Creek) and El Coyote, road conditions became poor, confusing and finally disappeared. We were able to drive up the canyon and over the boulders only because we had a high clearance, short wheel base, 4-wheel drive pickup. It seems unlikely we could have taken a suburban through here. We did not know the road had been washed out by the hurricane and was considered impassible, so we do not advise driving here unless reliable sources indicate that repairs were made since then. Dick Baumann and Boris Kondratieff collected aquatic insects in this area several years ago and could provide information on road conditions. Coming out of this arroyo, we came to an excellent, well-graded dirt road that went in two directions. A large arrow painted on a boulder suggested going left. We did, which was a mistake, and we backtracked to take the right fork which led to the top of a hill where we could see the river valley and buildings of the rancho. People at the rancho said we should not have taken that road and wondered why we did not take the good road from Highway 3. We replied that it was not on our map. To save the time of going all the way back to Ensenada via Highway 3, we left the same way we drove up. It was easier this time although we strayed onto another road and became "lost" for about half an hour. We somehow lost our supply of drinking water going down the canyon but survived on fruit juice and beer for two weeks. Also, had we driven up this canyon one week later, we would have wound up in the middle of the Baja off road vehicle race which is held near the rancho. It would be advisable to check the date (approximately June 6-8) of this event since Highway 3 out of Ensenada is closed temporarily.

There are some discrepancies when comparing the 1:250,000 Topo map to the other maps. The Topo shows a road from Highway 1 near Colonet following the river to Potrero (not on other maps) then overland to Buena Vista, El Coyote and San Rafael. The AAA and McMahan have a good road originating at Edido Bonfil, about Colonet and going up the river to Jocertes. The Clark map has this road but it originates at Colonet. Jocertes is probably the same as Potrero. The Topo map shows no connection between the upper part of this road (El Coyote) and the San Telmo observatory road near Meling Ranch.

21. EL HUICO. (31°11' N lat. 115°40' W long.) This is probably El Huico on the road between El Burro (= San Antonio on Topo Map) and Mike's Rancho, about 5 miles north of the rancho. El Huico is 3800' (1158 m), water temperature 23°C, and pH 7.8. Good habitat with small riffles but only a few black flies, mayflies and a couple of caddisflies. Drainage originates high in the mountains and is north toward Valle de Trinidad. We are somewhat doubtful that this spot has a permanent flow of water.
22. ARROYO SAN JACINTO. (31°25' N lat. 116°17' W long.) Fresh water fish record (Follett, 1960: 215). This is tributary to No. 17, Arroyo San Vicente = Rio San Isidro.
23. RIO SAN TELMO. (30°58' N lat. 116°06' W long.) Coordinates are for the village of San Telmo on the river. General location is south of Colonet and north of Camalu. In 1979, water was flowing near Highway 1, but the arroyo was dry in late May - June 1978. This is one of four main streams draining west to the sea from the middle part of the Sierra San Pedro Martir (Nelson, 1966: 56, 78). Permanent water exists in parts of the course and a strong flow of water occurs in the head waters (Nelson, 1966: 80). At Meling Ranch we saw a small valley that probably contained some flowing water. The AAA book Baja mentions a fresh water stream above Meling Ranch in Sierra San Pedro Martir National Park. Dave Faulkner suggested that the ranch would provide excellent access to the Sierra San Pedro Martir. Also, we have the names of Mexican fisheries biologists doing research in this area. They would be a valuable source of information. The whole lower part of the river channel is dry except during rains but Nelson (1966: 70) said that a small permanent surface stream flows at the village of San Telmo.
24. RIO SANTO DOMINGO. (30°44' N lat. 116°00' W long.) Coordinates are for Colonia Guerrero south of Camalu on Highway 1. Water temperature was 28.5°C and pH 7.7 at this elevation, which is almost sea level. The stream was somewhat braided in places and in 1979 still re-establishing itself from the 1978 hurricane. Tons of sand were deposited all along the lower reaches and one large concrete span of a bridge at Highway 1 was destroyed by the flood. The best collecting for aquatic insects is in the vicinity of the mission ruins and further upstream. The better riffle like habitats with exposed rocks are along the edge of the stream. This is true from Highway 1 to beyond the mission where the road ends. None of our maps show a road or trail beyond this point even though it seems the road crosses the river here. One can walk upstream from here a couple of hundred meters to section more characteristic of a mountain stream.

This is the largest stream we saw in Baja. It is probably one of the few streams that flows continuously throughout most of its course (Nelson, 1966: 78, 79, Yrurentagoyena, 1992: 123). We have no information as to hiking conditions directly upstream but an alternative route may exist. See No. 76, Arroyo San Antonio. Mexican fisheries biologists have been working in the Sierra San Pedro Martir in recent years and aquatic biologists seriously interested in this area should consult them. Contact the senior author, Phil Pister, or Bill Clark for names. See the acknowledgements in this paper.

25. RIO SAN SIMON. (30°28' N lat. 115°53' W long.) Coordinates are for the village of San Simon at Highway 1. General location is Highway 1 at Bahia San Quintin south of San Quintin. This is one of the four main streams that drain westward from the central part of the Sierra San Pedro Martir, and permanent water occurs in parts of the course. This stream is unnamed on the Clark and McMahan maps and is called Rio Santa Maria on our AAA map. The apparent correct name for the lower part of this stream is Rio San Simon. A number of major tributaries form this stream. They are named (on Topo map) from north to south, El Caballito, Aqua de Monte, San Pablo, Las Patadas, Aqua Escondito, El Morro, and El Rosarito. From San Simon (Topo map) and Santa Maria (AAA and McMahan maps) poor roads lead up into the lower reaches of the stream. A road originates at Santa Maria (Clark map) or Nueva Odisea (Topo map) that traverses much of the back country to villages along and near several of the southern tributaries. It seems inadvisable to enter this area without time, a topo map and good local advice. Follett (1960: 227) lists a fresh water fish record for Laguna Santa Maria (San Simon).
26. RIO DEL ROSARIO. (30°07' N lat. 115°44 W long.) Coordinates are for El Rosario on Highway 1 south of San Quintin. Floods in 1979 destroyed the pavement where Highway 1 crosses. The river rises in a dry bed a short distance above the village of Rosario and is one of the few streams in the Peninsula which is supposed to reach the sea all year, a distance of less than five miles (Nelson, 1966: 24, 80). Fresh water fish records indicate the water is permanent somewhere near El Rosario (Follett, 1960: 215, 223). It might be worth while to make the short trip up the arroyo to Porvenir (AAA and McMahan maps) but if Nelson is correct, it is probably dry. The Topo map shows a dirt road going up the river from La Estrellita about 4 miles (6.6 km) below (east) of El Rosario.
27. ARROYO DE CATAVINA. (29°42' N lat. 114°43' W long.) Location is Catavina (Santa Ines and San Luisto on Topo map) on Highway 1 southeast of El Rosario. The arroyo crossing Highway 1 is called La Bocana on the 1:250,000 Topo map. A stream with a small trickle of water crossed Highway 1, two miles (3.3 km) north of (above) Catavina. We found nothing but snails. The same situation occurred one-half mile (0.8 km) south of Catavina except we found an empty caddisfly case. In the arroyo above, close to Rancho Santa Inez, is a small flow of water. A *Helichus* beetle we found does not necessarily suggest water permanence. This palm tree lined arroyo may have some small sections with a little flowing water. Bill Clark collected baetid mayflies in Arroyo Catavina. Nelson (1966: 27) September 9, described the arroyo as a dry broad sandy wash

with the presence of ground water close to the surface and that a stream flows a short distance where a trail crosses the canyon. We estimate that the trail on his map parallels present Highway 1. The only map with the name Arroyo Catavina is the Clark map and that location is north of Catavina, where the Topo map shows Aguaje Guillermo flowing west across Highway 1 then south to join La Bocana Arroyo at La Bocana, west of Catavina. All maps show a road into here. This area is in the center of the hot dry desert with its peculiar Cirio (boojum) trees. William H. Clark has been to this area many times and should be contacted for detailed information.

28. ARROYO CALAMAJUE. (29°25' N lat. 114°12' W long.) Coordinates are for where we collected aquatic insects about 10 miles (16.6 km), elevation 1300' (396 m) into the valley by dirt road from El Crucero at Highway 1. El Crucero is about 10 miles (16.6 km) north of the turnoff east to Bahia de Los Angeles. The name appears in all our maps except the McMahan map. The first few miles of the road from Highway 1 are excellent. But then the road and river cross several times with the road following the river and being an intregal part of the river bed for 7 or 8 miles (13 km). The water flow is permanent forming pools and some small riffles. We collected some mayflies and aquatic beetles and little else. The river originates from a number of springs and pools, one of which bubbles out of the base of a boulder at the edge of the road. Nelson (1966: 27, 79) listed this as one of the prominent drainage courses on the east side of the peninsula. He reported the water as mostly undrinkable and charged with soda, iron and other minerals. One particular spring we collected was quite unappetizing and smelled of sulfur bacteria. This is a very desolate, strange, somewhat beautiful but eerie place. We did not drive all the way out to Bahia Calamajue on the Gulf of California. The road ahead leaves the valley, then goes southeast back toward the stream, then north again to the gulf. About 4 miles (6.6 km) from where the road leaves the stream is another one going northwesterly to Bahia, San Luis Gonzaya and then north to San Felipe. The area along the river bottom is sandy enough that we recommend 4-wheel drive, although we did not use it. Geologist Bill Fiero assured us it is unwise to take anything but 4-wheel drive to either of the coastal sites or up to San Felipe.
29. MISSION SAN BORJA. (28°45' N lat. 113°45' W long.) General location is about half way between Rosarito and Highway 1 and Bahia de Los Angeles on the Gulf of California (Sea of Cortez). In 1978, we drove from Highway 1 southeast down Alternate 1 to the Bay of Los Angeles. About 12 miles (20 km) from (northwest) the bay is a south trending road from a dry lake bed (Valle Aqua Amarga on the Topo map) to the mission. The roads became confusing so we turned back. The only water we saw in this area was a pool of blue green water where a spring (AAA map) or water hole (McMahan map) is indicated. This is Aqua de Higuera on the dirt road south of the dry lake bed. Another road goes east to the Mission from Rosarito on Highway 1. In 1979, a gas station attendant said there is permanent water at the mission but it consists of a hot spring coming out of the ground into a dammed or ponded area. Nelson (1966: 81) said that there is a small stream at San Borja which was used for

limited irrigation. This does not sound like a promising place to collect lotic insects and a recent description of the mission site and it's water supply confirms that (Grismer and McGuire 1993).

30. SAN PABLO CANYON. (27°37' N lat. 113°W long.) This location is on Highway 1 south of Guerrero Negro near El Tablon (on all maps). The whole area east of El Tablon to the Gulf, south of El Arco and north of San Ignacio on Highway 1 is remote and difficult to understand without a topographic map. Accessibility at one time was by foot, mule or helicopter, but a recent edition of the AAA map and the large scale Topo atlas now show a road into this area from Highway 1 about 7.5 km south of Los Angeles and 1 km north of El Porvenir. The 1:250,000 Topo map shows a trail, originating at Highway 1, about 4 miles (6.6 km) east of San Ignacio and going north into an area of several villages in the Sierra de San Francisco. The Clark map shows two trails (not on the Topo map) originating near El Tablon, one going to San Pablo (only on Clark map) and one to San Francisco (Clark, McMahan and Topo maps).

    Arroyo San Pablo originates near San Francisco and Guadalupe in the Sierra de San Francisco and flows in a northwesterly direction. This is the unnamed stream originating on the north side of Pico Santa Monica (AAA map). It picks up a couple of tributaries, La Prosperidad from the east, and El Mezquite from the northeast. Stream flow for this point is to the southwest and crosses Highway 1 into the Viscaino Desert about 8 miles (13.3 km) north of El Tablon or about 5 miles (8.3 km) above (north) the turnoff west to Diaz Ordaz. A National Geographic article carries a photo of Arroyo San Pablo (Crosby 1980). Long (1972) published a picture of the mountain village San Francisco. Pepper (1973) reported on this region and described water in one of the canyons. Nelson (1966: 32) reported a small clear stream just below, but close to the ruins of the San Pablo Mission which was about 12 miles (20 km) up San Pablo Canyon. The Topo map shows San Nicholas at this approximate location.

    Nelson (1966: 60) thought this to be the most important canyon of several that originate near here and flow to the border of the Viscaino Desert. "All of the larger canyons have water somewhere along their course but none carries a permanent running stream to the edge of the desert." The stream at the mission site is apparently permanent, and a few of the other canyons have small streams near their heads. Nelson's Plate 9, Figure 2 shows a photo of the canyon. Anyone visiting this remote area should carefully record stream locations, ecological conditions, and if possible collect a sample of stream organisms. Grismer and McGuire (1993) have worked here and published a photo of a stream in this area. They should be contacted for detailed information about access to streams in this remote pristine area.

31. RIO SAN IGNACIO. (27°18' N lat. 112°55' W long.) Coordinates are for San Ignacio on Highway 1. Elevation is 360' (110 m), water temperature 22.5°C, and pH 7.6. Underground water surfaces to form a large pool near the junction of Highway 1 and the road into town. This water probably originates from Arroyo

Lopez (AAA map, called Santa Marta on Topo map) northeast of San Ignacio, and Arroyo Victor (AAA map = Santa Lucia on Topo map) southeast of town. A small stream can be found farther up the road. Follow this road which passes over a small dam that imponds the water. The El Presidente Hotel is on the left and the stream is across the road on the right. A dirt road leads to the stream but it can be tricky to locate. An alternative is to park in the hotel lot and walk into the stream. Several riffles and nicer sections of this small stream are hidden upstream in dense vegetation. Water penny beetles occur here with other aquatic insects that live in permanent water. Also, see (Nelson 1966: 33, 77, 78, 81). A fresh water fish record is listed for San Ignacio (Follett, 1960: 217). Also see the description and photo by Grismer and McGuire (1993).

32. MISSION GUADALUPE (RUINS). (26°55' N lat. 112°24' W long.) North of Mulege, a dirt road leads west to the mission (AAA, Clark and McMahan maps). The Clark map shows the last part of this as a trail but the large scale Topo atlas shows a road. Pepper (1973) in describing the missions of Baja talked about a series of spring-fed aquaducts and pools here. We have no other information.

33. MULEGE RIVER (ARROYO EL POTRERO). (26°53' N lat. 111°59' W long.) Mulege is on the Gulf of California south of Santa Rosalia and north of Bahia Concepcion. "Along the entire gulf coast the only stream, except the Colorado, which permanently reaches the shore is at Mulege, where a great spring rises in the bottom of the Arroyo El Potrero, about 3 miles above the sea, and flows enough to irrigate the fertile bottom, and thus support this town. For about 18 miles above the spring the bottom of the arroyo is dry and thence up to its source among the mountains a small amount of water rises at intervals and flows short distances along the bottom" (Nelson, 1966: 74, 79, 81). Nelson and Goldman camped at an abandoned cattle ranch called El Potrero (not shown on AAA and Topo map but on large scale Topo atlas is 5 miles south of Cabeza de Vaca) southwest of Mulege. Above the old ranch, the canyon bottom contained some tanks and potholes of good water, with a "trickling stream here and there" (Nelson, 1966: 36).

    The mouth of the Mulege River, where it enters the ocean is rather large. There are fresh water fish records from the mouth and upper part of town, above tide level (Follett, 1960: 219, 224, 226). A description of the Mulege Oasis is given by Grismer and McGuire (1993). The owner of the trailer park here spoke excellent English and directed us how to reach the river under the bridge at Highway 1. We found nothing but snails and amphipods and the water seemed polluted. We could not locate a road that would take us up the palm lined arroyo above Mulege. There is a road on the Topo, Clark, McMahan, and large scale Topo atlas that go up the arroyo to Potrero. This area requires more exploration. The owner of the trailer park said there is lots of water in the hills back of Mulege, but we would need a horse to get there.

34. TRIBUTARY TO ARROYO DE LA PURISMA. (26°22' N lat. 111 50' W long.) About two miles (3.3 km) below Rosarito (on all maps) on Highway 1 south of Bahia Concepcion, a road goes west past Canipole (all maps) about 12

miles (20 km) to a confusing area with a four-way unmarked junction. We drove west down the valley thinking we were on the road to Commondu. A farmer told us we were on the road to La Purisma and that we should have gone left (south) at the junction. We backtracked, and took a left road that led up either Mesa Calagua or Mesa San Felipe (Mesa La Puerta) on a rough road. This is the road to Commondu. With binoculars, we searched the upper La Purisma Arroyo below for a stream seen by geologist Bill Fiero in January. We saw no water except for a silvery reflection which turned out to be a small pool on our return. The rest of the stream bed was dry except for this permanent pool. This is the type locality of a new mayfly species (Allen & Murvosh 1983). We saw small, minnow size fish in the pond.

Our coordinates, above, are given for Calagua near the road junction west of Canipole. We are not certain of the exact location of the pond we found, but believe it to be near or downstream from Calagua in the stream called Commondu Viejo. The stream pond may also have been closer to El Crucerito (AAA and large scale Topo atlas) in the upper part of this stream about 7 or 8 km east of Calagua. We advise looking over this area, during the dry season, from the mesa, as we did with binoculars, or get directions from one of the local farmers. We probably would have trouble finding it again. *Fundulus lima,* the only endemic fresh water fish species in Baja was collected in a creek near Carmel, between Canipole and Commondu. It was also collected in a lagoon 22 miles (35.5 km) northeast of Commondu (Follett, 1960: 217). We cannot locate Carmel but the Topo map suggests that most of the drainage in this area and along the road is tributary to the same system as the pool we described.

35. ARROYO COMMONDU. (26°03' N lat. 111°50' W long.) Location is at San Jose de Commondu. This is almost in the middle of the peninsula northwest of Loreto. We have several reliable reports of permanent stream water from springs in the canyon above (east) Commondu. We've seen a photo of the stream but did not have time to collect here or in No. 36, at Purisma. *Fundulus lima* was collected from Commondu (Follett, 1960:217). Large springs above Commondu give rise to a stream which flows about 8 miles (13.3 km) down the canyon. A photo of Commondu Valley appears on Plate 13, Fig. 2, and general descriptions of the stream given by Nelson (1966: 38, 77, 78, 81). Grismer and McGuire (1993) should be contacted to get a recent update on the stream conditions in the Commondu area.
36. ARROYO DE LA PURISMA. (26°13' N lat. 112°03' W long.) Location is for San Isidro which is shown on all maps. This is about 18 air miles (30 km) northeast of the Pacific Ocean at Punta San Juanica. Carl Hubbs collected *Fundulus lima* in La Purisma Canyon 5 miles (8.3 km) above Purisma and in the arroyo 13 miles (21.6 km) east of La Purisma (Follett, 1960: 217). This last locality may not be far from our stream pool site No. 34. There is a large amount of stream water in La Purisma Valley. The stream in the bottom part of the valley may provide the most abundant water supply in any of the canyon valleys of the peninsula (Nelson, 1966: 77). An excellent description by Nelson

(1966: 81) is as follows. "This stream flows 12 or 15 miles along the canyon and for a considerable part of its course the bed is characterized by a series of water holes which are always full. These water holes sometimes reach a length of several hundred feet and are reported in some instances to have a depth of 100 feet or more. During dry periods, a trickling stream connects these holes while the main part of the stream bed is dry. The water supply of Commondu comes from two large springs rising close together in the upper part of the canyon. This stream has a course several miles in length and irrigates hundreds of acres of fertile land along the stream bottom." Many parts of the stream at La Purisma Oasis were heavily polluted by livestock waste in 1988 and 1990 (Grismer and McGuire 1993). Nelson (1966: 38) also described a small stream rising in the bottom of a deep box canyon at San Vicente Ranch, which is not on our maps. This is about 6 miles (10 km) southeast of La Purisma on a trail to Commondu. Nelson and Goldman probably saw a branch of a stream called San Antonio on the Topo map. This stream, though unnamed, shows on the Clark and McMahan maps and flows southwest toward El Porton (AAA and Clark maps).

37. LAS PARRAS (RIO POZO). (25°59' N lat. 111°25 W long.) This location is for a permanent stream about 7.2 miles (12 km) southeast of Loreto on the dirt road from Loreto to Mission San Javier. We found this road 0.7 miles (1.2 km) south of the turnoff from Highway 1 into Loreto. This stream, called Rio Pozo by a highway worker (Las Parras on AAA and Topo maps) crosses the road in the bottom of a canyon. The presence of water penny beetles and other insects suggests water is permanent here with pools and small riffles that drain east to the Gulf of California. Elevation is 680' (207 m), water temperature 23.5°C and pH 7.7. There are also spring pools along the edge of the road up the hill which traverses the Sierra de la Giganta. We are not positive that these pools are permanent. The road up the hill was steep and very rough but it can be driven with care in a 2-wheel drive pickup truck. This is a beautiful palm lined canyon from which one can see the Gulf of California. At the time of our trip, the government was doing extensive work on the road, apparently to make the mission and the village there more accessible to tourists. This is one of the few standing missions in Baja. Grismer and McGuire (1993) give a brief description of the Las Parras water system.
38. RANCHO VIEJO. (25°56' N lat. 111°33' W long.) Coordinates are for Rancho Viejo which is shown on all maps. A stream close to this location can be found adjacent to the road 5 miles (8.3 km) northeast of San Javier. The water is just below the top of the divide separated by the Sierra de la Giganta and flows toward the Pacific Ocean. This may be a spring formed from the surfacing of waters from the confluence of Arroyo La Zorra (Topo map) and Arroyo San Javier (large scale Topo atlas.) The stream was a trickle 30 cm wide in spots with very small riffles during late May. The presence of *Psephenus* water penny beetles is good evidence for permanent flow. Evaporation marks on nearby bed rock suggest there is much more water at other times. One could drive by and miss the stream during the low flow. The spring flow is located in a very shallow, not extensive volcanic basin, near the top of the divide.

39. SAN JAVIER. (25°51' N lat. 111°33' W long.) Location is for a stream in Arroyo San Javier, about 2 miles (3.3 km) below (south) Mission San Javier and 20 miles (33.3 km) southwest of Loreto. In May this was a small but permanent flow draining to the Pacific Ocean. It is adjacent to the road in the higher reaches of Arroyo San Javier. This is near where El Triunfo Arroyo flows in from the east. Nelson (1966: 78) gave a brief reference about Arroyo San Javier. Also see the description of the San Javier Mission Oasis System (Grismer and McGuire 1993). The Clark and McMahan maps incorrectly refer to this arroyo as Santo Domingo, which is the name for the lower reaches after another tributary joins from the northeast.
40. CANYON DE SAN JORGE. (23°29' N lat. 109°42' W long.) Coordinates are given for Santiago, which is about one third of the distance between Bahia de Palmas on the Gulf south of La Paz and San Jose del Cabo near the bottom of the peninsula. Santiago shows on all maps except, strangely, the Topo map. The turnoff from Highway 1 is on the Topo map. The road from Santiago froms a southerly loop back to Highway 1 at Mira Flores and Caduano after coming close to the base of the Sierra de la Laguna (AAA map = Sierra Victoria on Clark Map). The Topo map does not show that the loop road is complete. We drove 5 miles (8.3 km) from the village of Santiago up the arroyo to where the creek is dammed up. Beyond the dam is a narrow canyon and a permanent water flow with small riffles. The Topo map shows Arroyo San Jorge as originating high in the mountains and flowing to Romerillal, Santiago, and northeast to the Gulf south of Bahia las Palmas.
41. AQUA CALIENTE. (23°25' N lat. 109°48' W long.) This is 7 miles (11.6 km) from Highway 1 or about 5.5 miles (9.2 km) southwest of Santiago at and above Aqua Caliente, named for an impounded pool of water (92°F, 33.3°C). A huge granitic looking rock formation at the edge of the pool actually oozes hot water as if it were as porous as a sponge. There were no noticeable fissures in the rock. Immediately above can be found a cool water stream with riffles and pools that drain into the hot water pool. This stream is permanent here and seems to contain a greater diversity of aquatic insects than most Baja streams. Aqua Caliente seems to be part of the San Jorge (No. 40) drainage.
42. CAÑON SAN BERNARDO (MIRAFLORES). (23°22' N lat. 109°47' W long.) Location is for Miraflores about 1.5 miles (2.5 km) west of Highway 1 on the southern end of the loop road from Santiago. We had a very reliable report of a permanent stream from someone who collected aquatic insects here. We spent much of a day following every road and cowpath out of Miraflores and asked locals several times for directions. We could not find this stream and must have made some fundamental direction error. Seemingly all we had to do to find Cañon San Bernardo was to drive west from Miraflores to or past Boca de la Sierra (on all maps except AAA). Nelson (1966: 45) described Miraflores as a small village "at an elevation of about 400 feet on the west side of the San Jose River, just above its junction with the Arroyo San Bernardo, a small stream coming down a rocky wash from a canyon on the east face of the Victoria

Mountains." Follett (1960: 215, 225) lists fresh water fish records, including the trout *Oncorhynchus mykiss*, from Boca de la Sierra.

43. TODOS SANTOS. (23°26' N lat. 110°13' W long.) Todos Santos is north of Cabo San Lucas and southwest of La Paz on Highway 19. Underground water flow from the west slope of the Sierra Laguna emerges as a huge spring 3 miles (5 km) from the Pacific coast and is used to irrigate a valley of sugar cane. The springs were once higher up the valley but went dry, then reappeared lower down. In the cape district, this is the only stream that flows permanently to the sea on the Pacific coast (Nelson, 1966: 44, 78, 82).
44. RIO SAN JOSE. (23°04' N lat. 109°41' W long.) Coordinates are for San Jose del Cabo at Highway 1 on the Gulf of Mexico near the bottom of the peninsula. The river channel from its origin in the mountains in Cañon San Bernardo flows east past Miraflores then south to the sea at San Jose del Cabo. There is a large amount of permanent water that surfaces here and flows to the sea. This is the largest and most important stream in the cape district (Nelson, 1966: 79, 82). See also the text for stream No. 42. Fresh water fish records are listed for San Jose del Cabo (Follett, 1960: 220, 221, 227). We had very little time to spend in the cape region and considerable time should be allotted to explore the whole area south of La Paz.
45. ARROYO DE SANTA CRUZ. (SIERRA DE LAS CACAHILAS). This represents a fresh water fish record south of La Paz (Follett, 1960: 221). No coordinates are given. We cannot locate this.
46. ARROYO SANTA ROSA. (23°05 N lat. 109°42' W long.) Location is for Santa Rosa (on all maps) on Highway 1 just north of San Jose del Cabo. Stream is tributary to Rio San Jose. Water is permanent high up within the canyon (Nelson, 1966:82). South of Santa Rosa, a dirt road goes from Highway 1 (Topo map only) west for 6-10 miles (10-16.6 km) where it crosses what we assume to be the arroyo near Las Paritas. The arroyo is not named on the Topo map.
47. ARROYO SAN LAZARO. (23°11' N lat. 109°42' W long.) Coordinates are for Santa Anita (on all maps) north of Santa Rosa and San Jose del Cabo at Highway 1. This is tributary to Rio San Jose and during the dry season permanent water should be found only in the canyon (Nelson, 1966: 82). The arroyo drains east from the mountains and crosses Highway 1 below Santa Anita. There are no marked roads into the canyon. The arroyo is named on the Topo map; it appears unnamed on the AAA and Clark maps crossing Highway 1. A trail about 8 km long appears on the Topo atlas from San Jose el Viejo into the canyon. This village is on Highway 1 about 7-8 km north of San Jose del Cabo.
48. CADUANO. (23°20' N lat. 109°47' W long.) Coordinates are for Caduano (on all maps) just west of Highway 1 south of Miraflores. Nelson (1966: 82) refers to Arroyo Caduano as having permanent water in the canyon. On the Topo map, the name San Pedro y San Pablo is shown for the major canyon above (west) Caduano. The arroyo crosses Highway 1 at the turnoff to Caduano. Roads or trails into the area are shown only on the large scale Topo atlas. The canyon mouth is about 5 miles (8.3 km) from Caduano to El Salto. The Topo map shows 3 other prominent arroyos between Caduano and Santa Anita. One that

is named A. Verde on the large scale Topo atlas joins San Pedro y San Pablo near Caduano. The middle one is called La Palma and the southern one is named San Miguelito (large scale Topo atlas only) and originates west of Cajon and El Cardonal. A dirt road leads from Santa Anita to El Cardonal. San Miguelito may perhaps be San Miguel Arroyo mentioned by (Nelson, 1966: 82). It is supposed to have permanent water in the canyons.

49. EL SAUZ. (approx. 23°29' N lat. 109°57' W long.) Nelson and Goldman camped in a canyon with a small stream of clear cold water at an elevation of about 4600 feet (1462 m). This would be about 26 miles in a generally northwest direction from Miraflores. El Sauz is the name of an abandoned milk ranch (Nelson, 1966: 46, 83). This, supposedly is the southern most tributary of the Santiago (Arroyo San Jorge) from the Sierra de la Laguna. We estimate this location to be La Primer Aqua Arroyo (Topo map) and the coordinates are given for the 1500 m elevation.
50. LA CHUPAROSA. (Approx. 23°31' N lat. 109°54' W long.) Nelson and Goldman crossed a small stream coming from a side gulch, 8 miles (13.3 km) north of El Sauz at an altitude of about 5000 feet (1524 m). Plate 19, Fig. 1 is a photo of their camp in an oak forest here (Nelson, 1966: 46, 82). The coordinates above are given for the 1500 m elevation of the unnamed arroyo just north of La Primer Aqua, and may not be correct.
51. ARROYO DE SAN ANTONIO. (23°32' N lat. 109°56' W long.) The trail followed by Nelson and Goldman out of Miraflores is shown on the Clark map. This trail crossed an old camping place called San Antonio, also shown on the Clark map but not on any of the others. A small stream exists at San Antonio and flows easterly down to Santiago and the gulf (Nelson, 1966: 46, 82). We thought this might be the arroyo called San Dionisio on the Topo map, but Canada San Antonio is shown at the above coordinates on the large scale Topo atlas, and this is a tributary to San Dionsio. A trail is shown (Topo map) going from La Cueva at Highway 1 to El Chinal at the 400 m elevation in the canyon. We did not see any flowing water at Santiago, so unless we missed the stream, it probably flows only higher up or possibly is diverted for irrigation. We were not able to evaluate this area thoroughly.
52. LA LAGUNA. (23°33' N lat. 109°56' W long.) La Laguna (Clark map) is an old ranch (ruins) at about 5,500 feet (1676 m) and just north of San Antonio. This also lies on the trail described by Nelson. Nelson described this place as an open, flat-bottomed valley, about a mile long. Several small brooklets unite at the upper end and flow down the middle of the valley (Nelson, 1966: 47, 64, 82). The large scale Topo atlas shows La Laguna at the above coordinates. Rick Westcott reported streams at La Laguna and a stream in Canyon de la Zorra (23°31' N lat. 109°56' W long. large scale Topo atlas). He also saw a stream 3 km east of La Burrera (Clark map). La Burrera may be Santa Gertrudis (23°32' N lat. 110°04' W long.) or close to it.
53. SIERRA DE LA LAGUNA. Unknown streams. (Approx. 23°39' N lat. 109°58' W long.) Nelson described a couple of streams in a remote area down the north end of the mountain range. His description suggests a primitive trail fit solely for

mountain goats (Nelson, 1966: 47, 82). He mentions a mining camp called El Valle and if this is the same as or close to Valle Perdido (Clark map), then these streams are probably 12-15 trail miles south and probably east of Valle Perdido. We have arbitrarily placed our location at the 1000 m line near the head of Arroyo Santo Domingo (Topo map). On the large scale Topo atlas the names El Aguado (La Choya) appear instead of Santo Domingo.

54. EL TRIUNFO. (23°48' N lat. 110°08' W long.) H.P. Brown has an aquatic beetle *Helichus* collected from here, but that genus does not necessarily indicate a permanent flow of water. More information is needed in this area.
55. SAN BARTOLO. (23°44' N lat. 109°50' W long.) San Bartolo is on Highway 1 about 10 miles (16.6 km) from Bahia las Palmas on the Gulf of California. A spring arises from the arroyo and flows for about 4 miles (6.6 km). The water flow in 1905 was about 5 cubic feet per second (Nelson, 1966: 82). We did not see any stream while driving past and had no knowledge of any spring.
56. RIO GUADALUPE. (RIO SAN MIGUEL). (32°06' N lat. 116°50' W long.) This stream north of Ensenada and El Sauzal drains a large area west of the Sierra Juarez and has permanent water in parts of its course (Nelson, 1966: 78). More information is needed as to specific location. A fresh water fish record is listed for Arroyo San Miguel about one-half mile above the mouth and Arroyo Guadalupe (=Arroyo San Miguel) (Follett, 1960:217). These streams join above the mission San Miguel, the Rio Guadalupe flowing into Rio San Miguel from the south. Rio San Miguel is shown as Cañon Aqua Escondida on the Topo.
57. OJOS NEGROS. (31°53' N lat. 116°16' W long.) There are some large springs here which flow north toward Arroyo Guadalupe (Nelson, 1966: 75). Nelson's description of this habitat sounds more like a swamp than running water.
58. LA HUERTA. (31°56' N lat. 116°08' W long.) East of Ensenada and Ojos Negros and north of Highway 3 near Sangre de Cristo or El Gato (AAA map). "Here a small stream flows through the lower end of a canyon in the foothills of the Sierra Juarez." (Nelson, 1966: 15). Elevation is 2800' (853 m).
59. EL RAYO. (31°59' N lat. 115°58' W long.) A dirt road south of La Huerta goes east for about 8 miles (13.3 km) to El Rayo. This name is on all maps but the Topo map does not show this road. Just beyond El Rayo is a sawmill (AAA and McMahan maps) and Nelson (1966: 16) described..."Abandoned sawmill on a small stream in a pretty little valley."
60. SANGRE DE CRISTO. (31°52' N lat. 116°09' W long.) Nelson and Goldman camped at about 4200' (1280 m) above the village of Sange de Cristo (not shown on AAA map but is above (northwest) El Gato on Highway 3 southeast of Ensenada. Their camp was by a little stream in the lower end of a small canyon (Nelson, 1966: 16). The stream could be permanent. Nelson described this area as the southeastern border of the San Rafael Valley. This name does not appear on maps and should not be confused with Arroyo San Rafael south of Colonet.
61. CERRO COLORADO. (31°48' N lat. 116°01' W long.) A small spring and marshy meadow are near the base of a hill called Cerro Colorado (not on Topo map). The village Cerro Colorado appears on all other maps. We have plotted this from the description in Nelson (1966: 16). The coordinates above are for the

1150 m contour about 1.5 miles (2.5 km) due east of Highway 3 and almost 5 miles (8.3 km) southeast of El Gato or about 9 miles (15 kin) southeast of Sangre de Cristo. This arroyo flows northwest toward El Gato and Sangre de Cristo. Nelson's reference to this spring being at the head of the drainage flowing into San Rafael Valley should not be confused with the valley of that same name farther south. We became confused and had to recheck his journal and the trail on his map several times. This may be an old or local name that no longer appears on maps.

62. CANON DE GUADALUPE. (32°09' N lat. 115°47' W long.) The name and road to it are shown on all maps at the east base of the Sierra Juarez. The drainage here, like No. 11, El Tajo (Aqua Grande), is to Laguna Salada. Arroyo Carrizo (Clark and McMahan maps) is about half way between El Tajo and Guadalupe and has similar drainage. We have no information on either stream except that Guadalupe supposedly has a permanent flow somewhere in the canyon (Nelson, 1966: 79).

63. EL PALOMAR. (31°56' N lat. 115°45' W long.) Coordinates are for the 750 m contour and the name El Palomar on the Topo map and the Clark map. Drainage is east out of a canyon in the Sierra Juarez and then northeast to Laguna Salada. Information is lacking except that permanent water exists somewhere in the canyon (Nelson, 1966: 79). There are no roads into here on the Topo map, but the road (AAA, Clark and McMahan maps) for Pozio Cenzio near the bottom of Laguna Salada to La Palmita has a west branch that may go near/into Palomar. The maps are somewhat contradictory. Cañon Santa Isabel is the next canyon south of Palomar and a road from El Rayo to the headwaters of this canyon, at the village of Santa Isabel Viejo, is on all maps except AAA. There is no information on this stream. It would be unwise to travel into this area without good local information and the large scale Topo atlas.

64. EL TULE (CANADA JAQUEREL). (31°35' N lat. 115°26' W long.) We cannot locate El Tule accurately on our maps. A small stream and village, El Tule is at coordinates 31°53' N lat. and 115°58' W long., but it flows west and cannot be the one here described. The coordinates above are given for Canada (Arroyo) Jaquerel, which is the location of El Tule on the map of Nelson (1966). A surface stream with clear water runs for several miles down the east side of the Sierra Las Tinajas with flow originating from the southeast base of the Sierra Juarez. This is one of the largest and most permanent streams in the east part of this mountain range. El Tule originates and flows through where the two ranges join (Nelson, 1966: 55, 68, 79). Nelson's Plate 24, Fig 1 shows a photo of water flowing down the canyon. Water is apparently scarce along the Sierra Juarez summit with water being less plentiful on the higher parts of the east slope than the west. It occurs farther down the canyons closer to the desert (Nelson, 1966: 55). This is an important point to remember when trying to find a trail or road into the canyons.

65. CAÑADA ARROYO GRANDE. (31°29' N lat. 115°22' W long). Coordinates are given for the word Canada in Canada Arroyo Grande on the Topo map. This stream is south of El Tule (Jaquerel) and is the larger of the two. Water

flow, after heavy rains, may reach the Laguna Salada basin, but..." permanent water flows for 10 miles in the canyon bottom but sinks well above the open desert (Nelson, 1966: 79). Most of what could be said to describe this stream is the same as that for El Tule. The AAA and Topo maps do not show any roads into this stream. The Clark and McMahan maps do, but they differ. The Topo map shows a route from Highway 3 to the village of Arroyo Grande which is higher up in the canyon. The first half of this is a dirt road and the last half trail. If, like El Tule, most of the permanent water is in the canyon bottom, then the approach should be made up the mouth of the canyon. Reliable directions from locals familiar with the area would probably save hours of searching.

66. SAN MATIAS SPRING. (31°17' N lat. 115°31' W long.) The exact location of the spring and the road to it can be seen on the Topo map at 1250 m. It is about 3 miles (5 km) up a dry wash south of San Matias Pass on Highway 3, just before entering the narrow part of the pass while traveling east. The spring produces a small trickling stream which runs down the canyon a short distance (Nelson, 1966: 17). The road to the pass is about a mile (1. 6 km) east of Francisco R. Serrano (Topo map), or E. Serrano (Clark map) or Servicio and Ejido San Matias (AAA map). We assume the spring to still be a permanent flow, but nothing else is known of lotic conditions.
67. CANADA LA PROVIDENCIA. (31°05' N lat. 115°22' W long.) Coordinates are for the mouth of the canyon about 6 miles (10 km) due west of Santa Clara (on all maps), and 8 miles (13.3 km) east of the observatory atop the Sierra San Pedro Martir. The name of the stream appears on the Clark and Topo maps only. A small crystal clear stream was flowing at the mouth of the canyon at an elevation of 2000 ft. (609 m) on June 19, 1905. By June 27, the water was much farther up the canyon and may be a mile (1.6 km) above the canyon mouth by midsummer (Nelson, 1966: 17, 19). A photo of the stream and the huge boulders at the canyon mouth appears on Plate 5, Fig. 1 of Nelson's paper. The Topo map shows a road going to Laguna La Salada and Santa Clara from San Felipe on the Gulf of California. A side road leads south along the front of the canyons to Algodoon beyond to Aqua Caliente. The AAA, Clark and McMahan maps all show this road, but they also show one going farther west toward the mountains from Santa Clara and one from Santa Clara north to Highway 3.
68. ESPERANZA CANYON. (Approx. 31°13' N lat. 115°27' W long.) Our coordinates are for the 500 m contour immediately west of the number 5 and words Valle Santa Clara on the 1:250,000 Topo map, immediately above the junction of two tributaries. We think this is the lower part of Esperanza Canyon but cannot be positive since there is no name. That name appears on the Clark map and Canada La Esperanza appears at 31°08' N lat. and 115°27' W long., on the large scale Topo atlas, but it does not indicate any water flow. It is in the approximate location (10 miles = 16.6 km), south of San Matias pass described by Nelson (1966: 56). It is one of several important canyons that drain the steep east slope of the Sierra San Pedro Martir and has water permanently flowing somewhere in the canyon. The description of water flow in No. 67, Canada La Providencia applies to this stream (Nelson 1966: 19, 56, 79). The AAA, Clark

and McMahan maps show a road from San Matias Pass south along, and perhaps near, the mouths of most of the major canyons draining onto the bajada below.

69. ARROYO DIABLO. (31°04' N lat. 115°25' W long.) Coordinates are for Canada El Diablo about half way between Canada El Copel 2 miles (3.2 km) to the north and Canada La Providencia about 3 miles (5 km) south. The headwaters of this stream flow north for a distance, then turn to the east as described (Nelson 1966: 56, 78, 79). The stream is not named on any of our maps except the large scale Topo atlas, but is supposed to have a permanent flow in the canyon. It is one of the more important water bearing courses on the east side of the peninsula and has the wildest and most rugged canyon in this part of the range (Nelson 1966: 78, 79). This stream has its headwaters near Picacho El Diablo 2 km due east of the observatory in San Pedro Martir National Park. Information on access into the canyon is needed.
70. AQUA CALIENTE. (30°39' N lat. 115°10' W long.) Coordinates are for Arroyo Aqua Caliente village, at or near the end of the road south of Algodoon (on all maps) and Arroyo Huatamote (called Caliente on the Clark map). This joins Paral from the south and La Gringa to the north and then joins Huatamote flowing to the gulf. There may be permanent water in the canyon but we are listing it as questionable (Nelson 1966: 57, 79).
71. ARROYO PARRAL. (30°3W N lat. 115°04' W long.) Location given is that part of the stream channel with the word Parral on the Topo map. Parral flows north from its headwaters near El Parral, joins Aqua Caliente at Linda Vista (AAA) and flows east into Arroyo Huatamote at 30°46' N lat. and 115°04' W long., and flows to the gulf. On the AAA, Clark and McMahan maps, Parral is unnamed, but is the long north flowing stream south of Algodones. The AAA map shows a road into Aqua Caliente at Linda Vista. There are some roads and trails into Canyon Parral, but large scale maps and good information are necessary before entering this area. This is a major stream in this part of the peninsula and there is supposed to be fresh water in the canyon (Nelson 1966: 57, 79). Statements in Nelson's journal suggest they did not go this far south, but went to San Felipe from La Providencia canyon.
72. ARROYO MATOMI. (30°29' N lat. 114°58' W long.) Coordinates are for the word Matomi on the Topo map. The village Matomi is upstream near the headwaters. This stream is shown and clearly marked on the AAA, Clark and McMahan maps as flowing into the gulf at Punta San Fermin (not on Topo map, but above San Juan de los Lagos). The Clark and McMahan maps show a road into the canyon from the coast. Again, the large scale Topo atlas seems necessary for travel in this area. Matomi is a more important drainage canyon than either Parral or Aqua Caliente (Nelson 1966: 57).
73. ARROYO DE SANTA MARIA. (29°43' N lat. 114°31' W long.) Santa Maria Canyon is located about half way between Highway 1 and Bahia San Luis Gonzaga on the gulf. The stream is identified on the Topo map and the above coordinates are for the 500 m elevation contour. The stream is shown, but not named on the AAA, Clark and McMahan maps. The only information available is that there is a small stream in the upper part of the canyon (Nelson 1966: 58,

82). The same may be true for two others, Arroyos El Tule and San Francisquito, which are in this area (Nelson 1966: 58, 82). We cannot locate El Tule, but San Francisquito flowing from the south joins Arroyo de Santa Maria. The Clark and McMahan maps indicate a road from Catavina and Santa Inez (see stream No. 27) to the ruins of the old mission located in or near Arroyo de Santa Maria. The road/trail on the large scale Topo atlas suggests it would not be wise to enter this area without 4-wheel drive and good directions. There is permanent water at the mission site (Grismer and McGuire 1993) and Grismer recently told the senior author that you can't get here except on horse or foot. It is a one and a half days hike up the canyon from the gulf approach. In this same general area, Nelson (1966: 26) found a small, strongly mineralized stream flowing east through a series of rock bottom pools in a broad canyon. There seems to be no way to locate this by following Nelson's journal. It is supposed to be southeast of Jaraguay and is probably tributary to San Francisquito wash (Clark Map). We assume San Francisquito to be Arroyo Las Arrastras on the Topo map. Two tributaries (unnamed), above La Turquesa, and southeast of Jaraguay could be this unknown stream. Since it was flowing in September, we have called it permanent.

74. EL PIÑON. (Approx. 31°7' N lat. 115°34' W long.) An old indian village, called El Piñon, at 5300 feet (1615 m) in the foothills of the Sierra San Pedro Martir, had a small stream (Nelson 1966: 20). We cannot locate this, but think it likely that Nelson and Goldman crossed El Huico (see No. 21) or El Pleito canyons at this elevation (see Topo map). One day later, July 11, 1905, Nelson reached a small swift stream at 4800 feet (1462 m) which he thought to be the headwaters of the Arroyo de San Rafael (Nelson 1966: 20). If so, this location would be upstream from No. 20 at Mike's Sky Rancho.
75. VALLECITOS. (Approx. 31°0' N lat. 115°27' W long.) Vallecitos is marked only on the Clark map and we have arbitrarily marked the 2400 m contour south of the observatory in Sierra San Pedro Martir National Park. Several streams from 7200 feet (2194 m) to 8000 feet (2438 m) have been reported (Nelson 1966: 20, 21). Photos of this area are also given in Nelson's Plate 6, Figs. 1 & 2. Those interested in this area should refer to Nelson's description on these pages.
76. ARROYO SAN ANTONIO. (30°49' N lat. 115°38' W long.) Location is for San Antonio at 2000 feet (610 m). Arroyo La Grulla is another name for this stream (Nelson 1966: 80) and photos of La Grulla meadows appear on Plate 7, Figs. 1 & 2. A small stream called La Grulla (30°53' N lat. 115°29' W long. on the large scale Topo atlas) flows out of the main meadow at 7000 feet (2133 m) down to Arroyo San Antonio and is supposed to be the extreme head of the Rio Santo Domingo (Nelson 1966: 21). Arroyo San Antonio is shown on the Topo and Clark maps and seems to be the most important tributary to the Rio Santo Domingo. San Antonio at 610 m is shown on all but the AAA map. It's approximate location on the AAA map would be on the trail south of Santa Cruz. There are other unmarked tributaries which seem less important and Valladares Creek may not have water all year (Nelson 1966: 80). Valladares (on all maps) is the location of an old placer gold mine, suggesting the availability of

water at times. The stream at San Antonio was 30-45 feet (9.1-13.7 m) wide and less than a foot (0.3 m) deep on July 28, 1905 and native trout were collected (Nelson: 1966: 22). There may be a road and/or trail into here from Valladares, but the maps are contradictory. The large scale Topo atlas shows a road from Valladares east to Santa Cruz and a trail about 5 miles south to San Antonio.

77. RANCHO SANTO TOMAS. (30 45' N lat. 115°28' W long.) Coordinates are for the junction of two southern tributaries of the Arroyo San Antonio at an elevation of about 6000 feet (1826 m). One is Campo del Oso and the other is unnamed. The headwaters of both are near Santa Rosa (Clark and Topo maps). There is a stream at Rancho Santo Tomas as well as at the old San Pedro Martir Mission site (Clark map), a few miles below the ranch (Nelson 1966: 22). An old trail was followed by Nelson and Goldman from Santa Rosa down the canyon to here and then down to San Antonio.
78. SANTA ROSA CANYON. (30°47' N lat. 115°20' W long.) Coordinates are for Santa Rosa, but the canyon is on an old trail east of here and drains to the gulf. Permanent water is supposed to occur near the mouth of the canyon (Nelson 1966: 22). We assume this is the unmarked arroyo just north of Arroyo Huatamote (Topo map) and is called Canada Barroso on the large scale Topo atlas. Nelson (1966: 56, 79) described a Santa Rosa canyon as being one of four major canyons to drain the east slope of the northern part of the Sierra San Pedro Martir. His location of that canyon, about 8 miles (13.3 km) south of La Providencia seems too far north to be this one east of Santa Rosa. There is an unnamed stream canyon (large scale Topo atlas) but it is about 10 miles north of Canada Barroso.
79. CANON DE NUEVA YORK. (30°43' N lat. 115°42' W long.) Coordinates are for Nueva York, which is shown on all maps, but called El Sauzalito on the AAA map. A road from Highway 1 about 2 miles (3.3 km) north of San Quintin goes northeast into the canyon at Nueva York. A small stream at 800 feet (244 m) was flowing on August 1, 1905 at the upper end of the canyon (Nelson 1966: 22). We assume that elevation figure to be incorrect since Nueva York and the upper canyon reaches are above 1640 feet (500 m) on the Topo map. The large scale Topo atlas shows another road that goes into the 200 m elevation part of the canyon but it originates at San Quintin.
80. SAN FERNANDO RIVER. (29°58' N lat. 115°12' W long.) Coordinates are for El Progresso and San Fernando at Highway 1 between El Rosario and Catavina. San Fernando, but not El Progresso, is omitted from the Topo map. Some permanent springs, used for irrigation, were reported by Nelson (1966: 24, 76), but the rest of the stream bed is dry throughout most of the course except during floods. Grismer and McGuire (1993) say that moving water is above ground year round at Mission San Fernando Velicita.
81. ARROYO SAN ANDRES. (28°43' N lat. 114°15' W long.) Location is San Andres (not on AAA map) on Arroyo San Andres near the Pacific coast, west of Highway 1, south of Punta Prieta and north of Rosarito. Water flows a short distance in the channel within a few miles of the coast (Nelson 1966: 81).

82. ROSARITO ARROYO. (28°38' N lat. 114°01' W long.) Water is supposed to flow a short distance in the lower part of the channel near the coast (Nelson 1966: 81), but another statement suggests there is no flowing water here except during rains (Nelson 1966: 30).

83. SAN JAVIER WASH. (28°31' N lat. 114°02' W long.) Coordinates are for Highway 1 south of Rosarito, where an arroyo crosses the road and enters the Pacific ocean above El Tomatal and Miller's Landing (AAA, Clark and McMahan maps). This is near Chula Vista on the Topo map. Nelson (1966: 30) reported a series of water holes and a clear stream flowing in late September. Water flowed about a mile (1.6 km) before going underground. It is difficult to determine the location of this stream, but it's probably a few miles east of the sea. This San Javier location should not be confused with that of No. 39.

84. SANTA GERTRUDIS. (28°03' N lat. 113°05' W long.) Location is for Mission Santa Gertrudis east of El Arco, which is east of Highway 1 southeast of Guerrero Negro. Nelson (1966: 81) reported a small stream irrigating small patches of land. The original water system is now in terrible shape with a few small pools heavily polluted by livestock (Grismer and McGuire 1993).

85. TINAJA DE SANTA CLARA. (27°08' N lat. 113°37 W long.) Goldman (see Nelson 1966: 34) found a large tank of good water in a small canyon on the west side of the Santa Clara Mountains. The photo, p. 94, Plate 24, Fig. 2 indicates that this is clearly a huge tank (tinaja) of water in a canyon and not a flowing stream. It is over 50 miles from San Ignacio near the Pacific Ocean northeast of the coastal town of La Bocana. The mountain range is shaded but unnamed on the AAA map. The mountain range is indicated on the Clark, McMahan and Topo maps. The large scale Topo atlas shows roads from La Bocana and Punta Abreojos on the Pacific Ocean into Santa Clara. We list this since it demonstrates a good water source in what appears to be one of the remotest parts of Baja. Our coordinates above are based on the stream name Santa Clara on the large scale Topo atlas. This tank was visited more often in the past by those working placer mines in the mountains northwest of here. It seems likely that locals in coastal towns might provide good directions.

86. ARROYO SAN LUIS. (27°19' N lat. 112°39' W long.) Water apparently comes to the surface at a few places near a place called La Cueva at 750 feet (229 m) elevation in the San Ignacio Arroyo about 21 miles (35 km) east of San Ignacio. The above coordinates are for La Cueva (large scale Topo atlas only), about 5 miles west of Santa Lucia. The only information available does not suggest a flowing stream (Nelson 1966: 34). A road about 5 miles long goes into here south from Highway 1 at Lic. Alfredo V. Bonfil, 13.7 miles east of San Ignacio.

87. ARROYO SANTA AGUEDA. (27°15' N lat. 112°21' W long.) Coordinates are given for Santa Agueda in Arroyo Santa Agueda about 10 miles (16.6 km) southeast of Santa Rosalia on the Gulf of California. There must have been some permanent flow here in 1905, since water was piped into Santa Rosalia from this important drainage (Nelson 1966: 79, 82). We looked for streams closer to Santa Rosalia without success but did not know of this locality. There may be two roads (Clark map) into here from Highway 1, but the other maps

show one. The Arroyo Santa Agueda on the AAA map must be in the wrong location, being too far south and below the road to Santa Agueda. The road into the arroyo goes west from Highway 1, 5.2 miles south of Santa Rosa (large scale Topo atlas).

88. ARROYO SAN JOSE. (27°04' N lat. 112°14' W long.) Location given is for San Jose Magdalena (AAA and Topo map) or this may be called Baca de Magdalena (Clark, large scale Topo atlas and McMahan maps). This is a major drainage course on the east side of the peninsula, but there is no information as to water flow in the canyon. A large system of ponds occurs here in a wide rocky arroyo (Grismer and McGuire 1993). All maps show a road from Highway 115 miles south of Santa Rosalia going into the arroyo at San Jose Magdalena.
89. ARROYO SAN GREGORIO. (26°21' N lat. 112°10' W long.) Location is for Paso Hondo (all maps except AAA) in Arroyo San Gregorio which is called Guajademi on the large scale Topo atlas. The arroyo is named on the AAA map. The lower parts of this stream and Arroyo La Purisma (see stream No. 36) join and flow into the Pacific Ocean at Punta San Juanico. A north-south trending road connects Arroyo San Gregorio with San Isidro and Purisma. Purisma Vieja (Clark, large scale Topo atlas and McMahan maps) is at the junction of the road and the arroyo. There are springs here used for irrigation. Water rises in the arroyo about 3 miles (5 km) upstream above Paso Hondo producing a small flowing stream (Nelson 1966: 37, 81). This was the rainy season and we are not listing the stream as permanent without more information. It does seem likely that flow is permanent in some parts of the canyon. Grismer and McGuire (1993) described the oasis at Los Burros (26°10' N lat. 112°14' W long. large scale Topo atlas), which is in the arroyo, as having a permanent system of extensive ponds. La Ballena occurs about 35 km north of here at 26°23' N lat. 112°36' W long. and this oasis described by Grismer and McGuire (1993) has an extensive system of water in an open, wide, rocky stream bed.
90. ARROYO SAN VENANCIO. (25°52' N lat. 111°53' W long.) Location is San Venancio (Topo map) near the junction of Arroyo San Venancio and probably Santa Rosalia which is the name given on the AAA map. There is supposed to be permanent surface water somewhere in the arroyo (Nelson 1966: 78,81). Our listing is based solely on that reference. There is a dirt road about 14 or 15 miles long into here from Fransisco Villa near La Poza Grande.
91. ARROYO SANTO DOMINGO. (25°29' N lat. 111°55' W long.) Coordinates are for the village of the same name about 19 miles (31 km) north of Villa Insurgentes. This is shown on all maps. Arroyo San Javier and El Canelo join about 4 miles (6.6 km) upstream to form Arroyo Santo Domingo. This is a major drainage on the west side of the peninsula and is supposed to have a permanent flow of water somewhere. The Clark and McMahan maps have Arroyo San Javier marked as Santo Domingo. The AAA map calls Arroyo Santo Domingo what the Topo map refers to as El Canelo. The Topo map shows a dirt road originating about 5 miles (8.3 km) north of Santo Domingo and going some distance into El Canelo Arroyo. The large scale Topo atlas shows several roads into this area.

92. ARROYO SOLEDAD. (25°09' N lat. 111°43' W long.) Arroyo Soledad (AAA map) drains a very large area and flows to the Pacific Ocean crossing Highway 1 about halfway between Villa Insurgentes and Ciudad Constitution. Both topo maps call this drainage Las Bramones. We have virtually no information as to the presence of flowing water east of Highway 1 from Villa Insugences to south of Santa Rita. The mission at San Luis Gonzaga (24°55' N lat. 111°18' W long.) is located on an important northwest flowing tributary, the Arroyo San Luis. A small stream, used for irrigation was reported at the mission (Nelson 1966: 81). Nelson (1966: 81) listed several other streams in this general area for which there is no specific information, but may have flowing water in parts of their courses. El Quepo (25°15' N lat. 111°24' W long.) is about 20 miles (33.3 km) due east of the Highway 1 coordinates. There is a road (Topo map) from Ciudad (Villa) Constitution into several villages all along the arroyo to the headwaters. Arroyos Jesus Maria (25°20' N lat. 111°26' W long.) and Aquajitos (25°24' N lat. 111°28' W long.) are not on any map except the large scale Topo atlas and they are north of El Quepo. They are tributary to Arroyo Huatamote (Topo map). Huatamote turns northwest to cross Highway 1 about 10 miles (16.6 km) east of Villa Insurgentes to eventually join Arroyo Santo Domingo. The AAA map calls this stream Arroyo Santa Cruz.

    There are dirt roads and trails into these streams and the villages along them, but a large scale topo map is needed. The presence of a large federal water project along the highway east of Villa Insurgentes suggest that a huge aquifer is being tapped for irrigation to the farms in this area. We do not know what effect this would have on flowing streams. Good local information seems necessary to properly explore this area. Much of the topography seems to require a 4-wheel drive vehicle.

    Nelson (1966: 81) also lists Arroyos San Vicente, San Gregoria, and La Junta. Canada San Vicente (24°36 N lat. 110°56' W long.) and Canada San Gregoria (24°34' N lat. 110°59' W long.) are on the large scale Topo atlas. These are tributary to Las Pocitas which becomes El Colorado at Highway 1, 1.3 miles north of Penjamo and 1.3 miles south of Las Pocitas and about 19 miles (31.6 km) south of Santa Rita. Arroyo La Junta is another name for this stream No. 94, Arroyo de la Colorado (Nelson 1966: 41).

93. EL SAUZ. (24°32' N lat. 111°30' W long.) Coordinates are for El Médano (on all maps) about 4 miles (6.6 km) southeast of Santa Rita on Highway 1 south of Ciudad Constitucion. El Sauz (= El Sauce on McMahan map) is just east of El Médano, on or near Arroyo La Presa (Topo map) or called Arroyo de la Pasion on the Clark map. This was a small cattle ranch in 1905 and a small clear stream was reported flowing a short distance (Nelson 1922: 41). This should not be confused with another El Sauz at latitude 23° above Miraflores. Also, our location above for El Sauz may be wrong. Nelson may have been referring to El Sauz de San Hilario in Arroyo San Hilario mentioned below in No. 95. Grismer and McGuire (1993) refer to this area as La Presa Region consisting of at least

three separate drainages with many canyons and oases of considerable diversity. They should be contacted as to the exact location and nature of streams here as we cannot locate their sites on our maps.

94. ARROYO DE LA COLORADO. (24°22' N lat. 111°08' W long.) Coordinates are for Las Pocitas (on all maps) where Arroyo de la Colorado crosses Highway 1 and flows southwest toward Santa Fe (Poza de Venazio on AAA map) and the Pacific Ocean. Water was reported flowing in the stream at a cattle ranch at 75 feet (22.8 m) elevation, called Aqua Colorado (Nelson 1966: 41). The old trail followed by Nelson and Goldman went south from El Médano to approximately Santa Fe then up to Las Pocitas on Highway 1. We estimate that the Aqua Colorado Ranch was on the arroyo somewhere between these last two points. Based on the location of the following stream at San Hilario, the ranch mentioned above must be close to or at Las Pocitas.
95. ARROYO SAN HILARIO. (24°22' N lat. 110 58' W long.) Coordinates are for San Hilario village (Clark and McMahan maps, but called El Sauce de San Hilario on the Topo atlas) on Arroyo San Hilario east of Highway 1 at El Cien (AAA, Clark and Topo maps). The large scale Topo atlas shows that El Sauz de San Hilario is a mile upstream from San Hilario. The Topo map shows another San Hilario downstream, west of Highway 1, but that cannot be correct. A small stream, used for irrigation, was reported for this local (Nelson 1966: 42).
96. ARROYO GUADALUPE. (24°21' N lat. 110 54' W long.) Arroyo Guadalupe crosses Highway 1 about 3 miles (5 km) south of El Cien (not on McMahan map). The above coordinates are for the village Guadalupe de la Herradura (Topo map) about 5 miles (8.3 km) east of Highway 1 on a dirt road that originates 2.2 miles (3.5 km) south of El Cien. A small stream was seen flowing over a rocky bed in the arroyo in December, 1905 (Nelson 1966: 42). Nelson must have been on a northern tributary to the main arroyo or close to where they join about 3 miles (5 km) east of Herradura. The road described above goes for 20 miles (16.6 km) or more beyond Herradura.

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Richard K. Allen (Dick) died in 1992 before this project could be completed. I dedicate this paper to his memory. I will miss the many nights we camped out in the field, drank beer and argued biogeography and many other subjects.

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{Solicitation for contributions: Please send in your contributions for this column to Cathy Pringle, Institute of Ecology, 308 Biological Sciences, University of Georgia, Athens, GA 30602, Pringle@zookeeper.zoo.uga.edu}

- **INFORMATION FROM THE NABS CONSERVATION AND ENVIRONMENTAL ISSUES COMMITTEE**

Now that the the Conservation and Environmental Issues Committee is a standing committee we are required to have a group of permanent core members. Past NABS Presidents Art Benke and Colbert Cushing, along with Charles Dewberry, Jane Marks, and Morgan McClure have agreed to act as members of the core committee.

The committee is co-chaired by Cathy Pringle and Nick Aumen and has 38 members (including the co-chairs and the core committee above): David Allan, Lisa Barnese, Isabel Braga, Sue Bruenderman, Betsy Colburn, Ross Coleman, Dave Courtemanch, Alan Covich, Thomas Cuffney, Bob DiStefano, Tom Dudley, Alex Flecker, Sharon Gross, Marty Gross, Marty Gurtz, Nina Hemphill, Bob Hughes, Sherri Johnson, Judy Meyer, Barbara Peckarsky, Bob Piorkowski, Charles Rabeni, Seth Reice, David Rosenberg, Jordan Rosenfeld, Andy Sheldon, Jack Stanford, Cathy Tate, Eleanor Trotter, Caryn Vaughn, and Chris Yoder.

- **NEW PUBLICATIONS ON RIVER CONSERVATION AVAILABLE FROM NON-GOVERNMENTAL ORGANIZATIONS:**

TATSHENSHINI **WILD:** *Tatshenshini River Wild* ISBN 1-56579-041-3

PACIFIC RIVERS COUNCIL:

(a) *Healing the Watershed* 1993, $25 paperback order through Pacific Rivers Council, P. **0.** Box 309, Eugene, OR 97440
(b) *Decline of Coho Salmon* - available for free through Pacific Rivers Council
(c) *Entering the Watershed* by Doppelt, *et al.* 1993, paperback (ISBN 155963-275-5)

ENVIRONMENTAL DEFENSE FUND:

The Big Kill: Declining Biodiversity in America's Lakes and Rivers, 1994, edited by David S. Wilcove and Michael **J.** Bean, copies of this paperback are available for $20 postpaid from the Environmental Defense Fund, 1875 Connecticut Avenue, NW, Washington DC 20009. (excellent reference book with input and review by David Allan)

NATIONAL AUDUBON SOCIETY:

Valuing wetlands: The cost of destroying America's Wetlands, 32 pages; Available through Audubon Society National Office, 666 Pennsylvania Avenue, S.E., Washington DC 20003; $2 mailing fee.

- **WATER QUALITY PROBLEMS IN CENTRAL AND EASTERN EUROPE**

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The stimulus for this note about water quality problems in Central Europe was a recent international workshop jointly sponsored by the U.S. and Polish National Academies of Sciences "Preservation of Natural Diversity in Transboundary Protected Areas: Research and Management Options," held in Bieszczady and Tatry National Parks, Poland, May 1994.

As is the case for many European countries 'in transition,' intensive economic development/industrialization over the past forty years during the Soviet Era resulted in the degradation of aquatic systems at a level of magnitude greater than what much of the western world has experienced. Centrally-planned economies were characterized by energy-intensive production, with dependence on high sulfur coal and low quality lignite. These resources were heavily subsidized by the central government, with a lack of economic and legal incentives to preserve the environment (Bochniarz 1993). Such factors contributed to massive wastes of energy and natural resources, particularly by industry. While the sweeping reforms of 1989 brought an end to the centrally-planned economies, the legacy of the past remains.

The magnitude of regional environmental pollution in Central and Eastern Europe challenges conservation and management strategies that have developed in the West. Statistics on air pollution in Central and Eastern Europe are alarming.. For instance, the yield of air particulates in the region is 60 times higher than in Western Europe per $1000 of GNP production. Gaseous emissions of SO_2 and NO are, respectively, 30 and 8 times higher than in Western Europe (Polish Statistical office 1992 and United Nations 1992 Annotated Statistics).

A dramatic example of the devastating consequences of regional pollution on public health and the development potential of a specific country is widespread radioactive contamination in the Republic of Belarus. After the Chernobyl accident, Belarus became an area of ecological disaster. Programs for human resettlement, along with the cessation of agricultural production have been implemented in areas where irradiation doses exceed given levels. Radiation effects on human health have been aggravated by the fact that in some regions of the Republic, areas of radioactive pollution coincide with regions of high chemical pollution from industrial and other sources. The country is critically short of medicines and medical equipment. Inhabitants of the most contaminated areas have a special status which is meant to partly compensate for the effect of radiation on health through pensions, special

medical treatment, preferential taxation, compensation payments, etc. One quarter of the state budget of the Republic of Belarus goes toward mitigating the effects of the Chernobyl tragedy, underlining the financial constraints that the country faces in addressing other environmental problems.

'Poland's Vistula River is a compelling example of the severe regional degradation of aquatic ecosystems in European countries 'in transition.' The Vistula is the largest river in Poland and the second largest river emptying into the Baltic Sea. It plays an essential role for human populations, with most large towns including the previous capital (Krakow) and the present one (Warsaw) located along the river. The river serves as a source of drinking and industrial water for most of the towns and industry located along it, and it also receives their sewage. While the Vistula is in fact the largest source of water in Poland, it is polluted almost from its source in the Carpathian Mountains by heavy industry (i.e. runoff from coal and sulphur mines, forges, nitrogen fertilizer plants, etc.; Kajak 1992). Most of the upper reach of the river is acidified (Wrobel 1989), caused by acid rain originating from areas of heavy industry in Germany, Czechoslovakia and Poland. Pesticides and heavy metals are high and they are often concentraterd to dangerous levels along the food chain (Kajak 1992).

Water quality and quantity problems throughout Central and Eastern Europe pose a serious and immediate threat to human health and economic development. High quality drinking water in Poland has dropped from 32% to less than 5% during the last twenty years. Postel (1992) reports that over half of Poland's river water is too contaminated even for industrial use. According to recent data from the Polish Inspectorate for Environmental Protection (Srodowiska 1992), 82% of Polish Rivers are not suitable for industrial use. Waters suitable for industrial purposes comprise only 14.5% and those suitable for agricultural use, a mere 3.3%. Pollution in surface waters is increasing due to contamination of surface waters by industry and municipal sewage discharges as well as by agricultural sources. Water shortages also limit economic activity within Poland. Drainage projects have led to lowered groundwater tables and excessive drying of considerable areas of land and increasing needs for water have led to further stresses on water supply. The area of excessively dried land in Poland amounts to ~ 4 million hectares. Increased drying of the central region of Poland is also associated with high degrees of deforestation - particularly in those area where forest cover is below 15% (Ryszkowski 1990).

With the restucturing of the Soviet Union, many countries in Central and Eastern Europe are moving toward a market economy. The dominant processes in this transitional period are economic openness, privatization and restructuring. Despite many positive aspects, there is a valid concern that these processes may bring about negative effects for the natural environment. That is, in the rush to achieve privatization, Central and Eastern European countries might encourage unsustainable development.

Central and Eastern European countries are already experiencing adverse impacts of trade liberalization (Bochniarz 1993). With 'free trade' came a flood of hazardous waste into the region (Valette and Spauling 1990). According to a recent report by Greenpeace International, since 1989, twenty-two million tons of toxic waste have crossed the open borders, from countries including West Germany, Austria and Sweden (Bernstorff and Puckett 1990). Also, the initial result of foreign investment and privatization in Central and Eastern Europe is not encouraging. Not only is foreign investment less than the needs of the countries, but environmentally unsound investments are often being made (Bochniarz 1993). Some Western investors are taking advantage of the difficulty in enforcing environmental regulations and/or the lack of environmental regulations by importing products and 'dirty' technologies that are considered unacceptable in their home countries (Kruszewska 1993).

The questions arise: How can the transitional period in Central and Eastern Europe be used as an opportunity to carry out sustainable restructuring in an environmentally healthy manner (National Foundation for Environmental Protection of Poland 1993)? How can Central and Eastern European countries in transition benefit from western conservation strategies?

It has been noted that water quality problems in Poland resemble those that were familiar to the U.S. over two decades ago before the U.S. undertook massive water cleanup and sewage treatment programs (e.g. Hillbricht-Ilkowska 1990, Cooper 1990, Gromiec 1990). Also, as in the U.S., Poland is now discovering that it has to address serious groundwater contamination problems in addition to its present surface water problems. While some technologies for improved water treatment methods, advanced treatment processes, systems of water recovery and reuse (Gromiec 1990) can be imported from the West, there is also a need for new improved technologies in chemical methods for analysis and removal of water pollutants.

As in the U.S. and Britain, collaboration between scientists and nongovernment organizations involved in conservation and management issues could be a powerful force in the development of environmental reforms in Central and Eastern Europe. However, while scientists in Central and Eastern Europe are well aware of the serious magnitude of the problems that face aquatic systems in their country, not only must the economic resources be developed to implement necessary changes, but strong internal public support must be developed to advocate environmental remediation and environmentally sound legislation. Society's participation in the process of decision-making constitutes a challenge for nationals of countries who, for half a century, had no experience with such forms of governance and state functioning (National Foundation for Environmental Protection of Poland 1993).

Interestingly, the scientific disciplines of botany, ornithology and hydrology, which are historically very strong in Poland, have emerged as strong voices for the conservation of riverine systems in that country. These disciplines were instrumental in the publication of a recent volume on environmental conservation and restoration

in the lowland river valleys of Poland (Tomialojcia 1993). Many of the contributed papers stress the importance of life support properties of water from ornithological and botanical perspectives - including the significance of natural river fragments for waterfowl migrations and breeding and the importance of riparian zones at both an ecosystem level and for the population dynamics of specific plant species. Several papers in this volume point out the negative environmental repurcussions for large hydroprojects such as the proposed East-West waterway in Poland which would tie the German Rivers through the Oder, Warta, Notec, lower Vistula and Bug, with the Belorussian rivers of Muchaviec, Pripiet and Dniepr. The economic crises that many Central and European countries 'in transition' face places them in a vulnerable position. As an alternative to such environmentally disastrous mega-hydroprojects, Polish scientists recommend two types of hydrotechnical activity: construction of thousands of small reservoirs in tributaries or in upper courses of large rivers (for drinking water) and purification of heavily polluted water.

General recommendations for aquatic management strategies in Poland were generated at a joint Polish - U.S. workshop on ecological risks held in Poland in 1987 and 1988 in Poland and Washington DC, respectively. These recommendations include: (1) exploration of river basin management units for water quality regulation. Possible models in the U.S. for institutional arrangements were suggested (e.g. The Tennessee Valley Authority). It was also recommended that emphasis should be given to discharges from nonpoint sources of nutrients, using wetlands as pretreatment units and riparian strips as buffer zones; (2) Evaluation of legislatively based regulations on potable water and pricing policies with a focus on water conservation and water quality management; (3) Development of an infrastructure to support appropriate technologies for remediation and control of water quality; (4) encouragement of consumer products that reduce environmental loadings (e.g. biodegradable pesticides, low phosphate detergents, etc.); (5) Development of cooperative training programs between Poland and the U.S. (university level: graduate, post-graduate and faculty) that integrate environmental engineering and ecological risk assessment; (6) Development of programs for monitoring nitrates and other toxic substances in groundwater including the detection and measurement of organic substances through the use of advanced analytical techniques. (Contamination of potable water by halogenated solvents and pesticides is a major class of emerging environmental problems in Poland); and (7) Expansion of the current lake-monitoring program in Poland to include toxic chemicals. It is clear that, without the participation and financial help of European and non-European industrialized states, follow-up on many of these recommendations will be difficult.

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