5.3 Environmental Survey

5.3.1 Environmental Preservation in Nicaragua

1) Environmental Management

Environment is managed by MARENA (Ministry of Natural Resources and Environment: see Figure 5.3.1) in Nicaragua. MARENA executes environmental laws and its administration while cooperating with relative organization. And the General Direction of Environmental Quality of MARENA executes the examination concerning the project execution such as Environmental Impact Assessment.

The General Division of Environmental Administration and Technical Control in MTI executes the management of environmental issues concerning the road construction project and prepares environmental technical guidelines, etc.

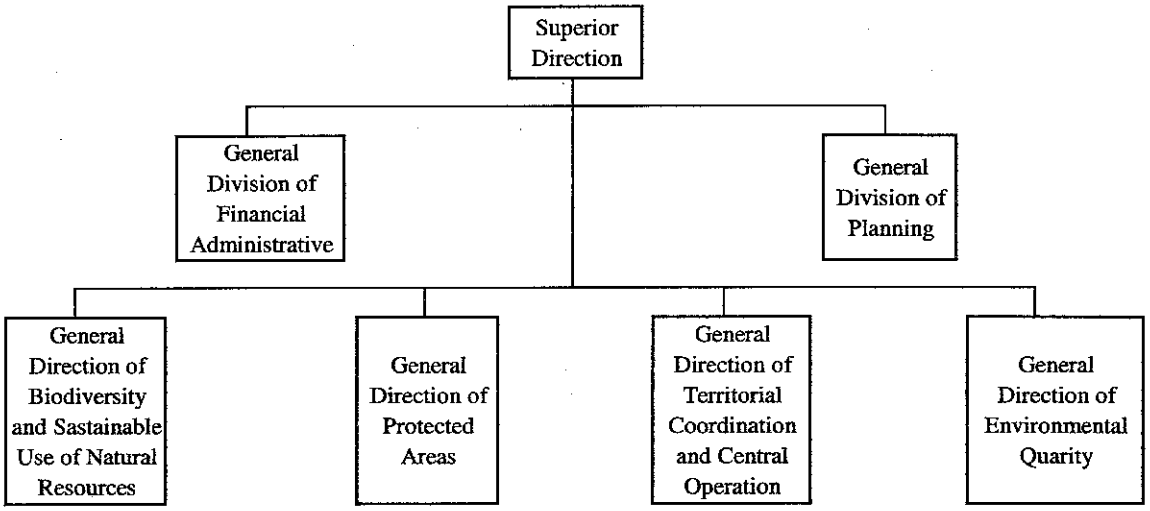


Figure 5.3.1 Organization of MARENA

2) Environmental Laws and Standards

MTI published the "NIC2000" that is based on the road construction standard. Environmental standards along the road construction standards are prescribed in the "NIC2000". The background of the creation of the "NIC2000" is as follows:

A. It aims that road construction in Nicaragua is carried out on the basis of Law NO.217 and those detailed regulations, and other environment related regulations extant.

B. Basic environmental standards are provided for the proper execution of the road

construction work by supervisors, environmental administrators and contractors.

Above law NO.217 (General law of environment and natural recourse) is the Environment Basic Law enacted in 1996, and this is the base of the entire environmental legislation. The objectives of law NO.217 are as follows:

1. To regulate, adjust and prevent every cause and action that cause harm to the environment and the eco-system;
2. To establish the method, form and time of rational development of natural resources considering social equity, society justice and cultural diversity, whilst furthermore respecting the rights of the Autonomous Regions of the Atlantic Coast and local authorities.
3. To suitably development the country properly through the country development plan which recognizes the protection of the environment and the natural resources as a base for the development of various human activities.
4. To establish a national system about the natural conservation area for protection of biodiversity and other resources.
5. To enforce the legitimate utilization and management of catchment areas and water resources and to ensure their durability.
6. To encourage and aid environment education so that society may be in the harmony with the nature.
7. To create a healthy environment so as to contribute to the health and the prevention of illness of Nicaraguan people.
8. To motivate and support the various activities and plans needed to implement the law;.
9. And others, the thing contained in this law.

Environmental standards and acts related to road construction, including Law No.217, are shown in Table 5.3.1.

The intended projects for environment impact assessment shown in the above table (NO.6) are covered in the list overleaf (a through m). Reconstruction works of existing roads, such as the subject of this project are not covered. However, regardless of the size of the project, the permission of MANENA should be necessary all projects. A private firm applies an application for the permission in case of a private project, and related government agencies carry it out in case of a public project.

Table 5.3.1 List of Environmental Standards and Act about the Road Construction

No	TITLE	No.and Decree Date	No. And date of LA GACETA
1	The legal documents and the trade of the project (DLC)	-	-
2	General law of environment and natural recourse (MARENA)	Law No 217 (27-03-96)	105 (6-6-96)
3	Regulation of the general law of environment (MARENA)	9-96 (25-7-96)	163 (29-8-96)
4	Permit regulation and evaluation of the environment impact (MARENA)	45-94 (28-1094)	203 (Octuber,94)
5	Law of administrative contract of the state, decentralize entity and municipal	809-81 (28-08-81)	202-81 (7-9-81)
6	General reglament of the law of administrative contract of the central goverment	60-91 (6-11-91)	
7	Sanitary disposition (MINSA)	394 (30-09-88)	200 (21-10-88)
8	Reglament of sanitary inspection (MINSA)	432 (10-04-89)	71 (17-04-89)
9	Norms and ministerial resolution about the basic disposition of hygiene and security in the places of work (MITRAB)	1-90 (21-04-90)	165 (01-09-93)
10	Civil code of the Republic of Nicaragua	2 edicion, 1997	
11	Centroamericano agreement of the roads circulation	8-59 (11-3-59)	226 a 32 7 a 14 (October 59)
12	Ministerial resolution (MCT) fine for the violation of the decree 01-96	01-96 (25-1-96)	-
13	Ministerial resolution (MCT) about increas in weight car	17-95 (28-3-95)	-

An evaluation process for a project is shown in the figure 5.3.2.

According to the Law of Permit Regulation and Evaluation of the Environment Impact, Article 5, investigations about the impact on the environment and the presentation of the document are necessary for the acquisition of the permission of the following projects and activities:

a) The prospecting and the mining of gold, zinc, copper, iron, silver, hydrocarbon and other subterranean heat resources.
b) For other minerals, the prospecting and the mining when the lode exists in a fragile biological area or one protected by the law.
c) Intensive or semi-intensive shrimp farms, and intensive or semi-intensive farms of other marine life.
d) The change of use of land in forestry areas, the change of the forest facilities plan of an area grater than 5,000 ha, forestry use of 35% and more of the inclination areas, and the construction of all-weather types of forest road.
e) Energy production plants, of every kind, above 5MW and power cables of 69KW or more.
f) Ports, airports, and airports for agricultural chemicals sprinkling, mineral, hydrocarbon and terminals of source products.
g) Railways and new trunk roads.
h) Laying of oil pipe lines, gas pipe lines and mineral pipe lines.

i) The construction of large drainage systems, water purification plants, sewage systems, sewage pipes and dams (including small dams).

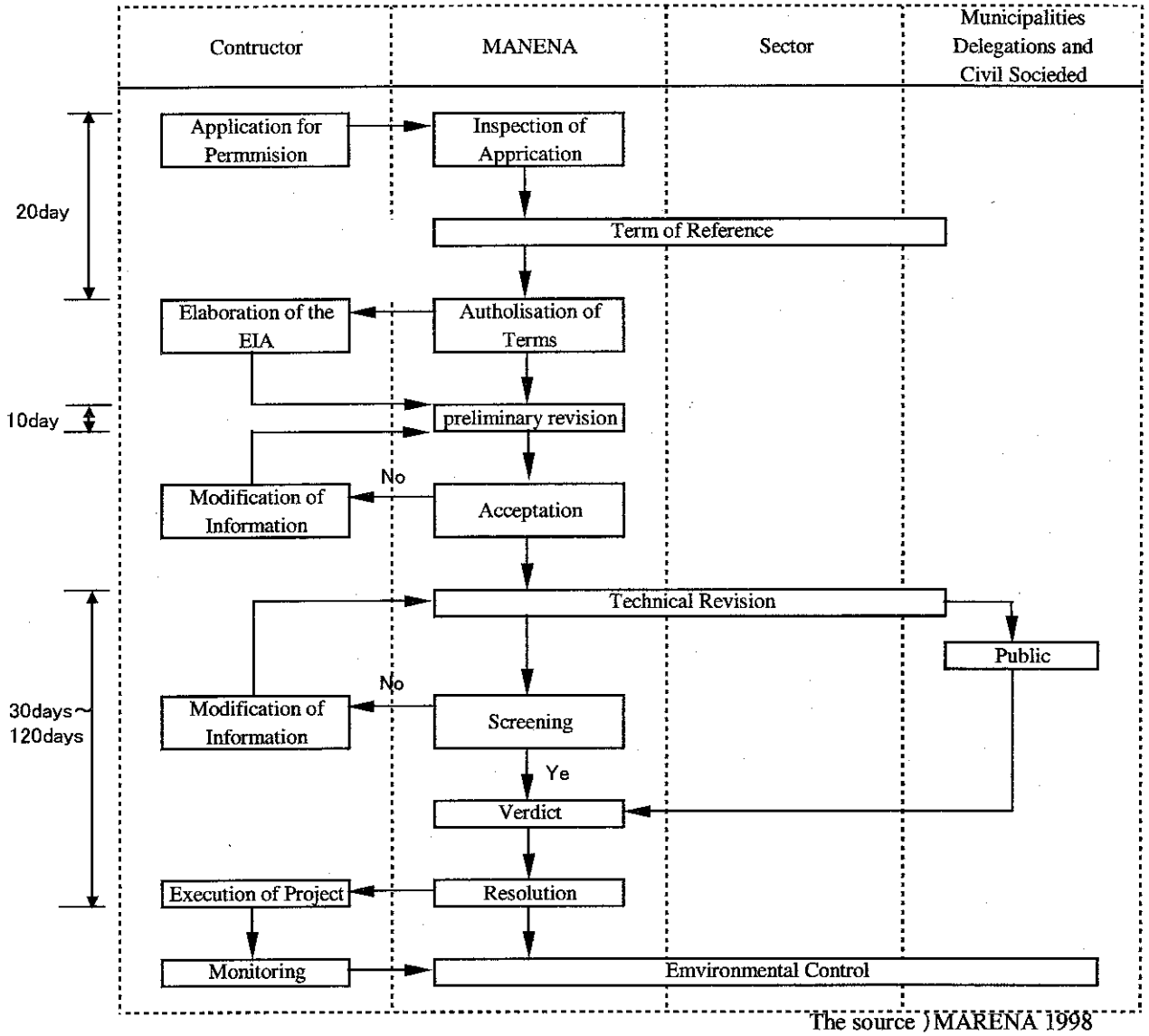
j) Dredging construction and change of flow channel of surface running water.

k) The management and reclamation of an incinerator for industry, and incinerators for chemical material, poisonous and other materials.

l) Reclamation, compound facilities for sightseeing, building, and sport facilities in fragile biological areas or those protected by the law.

m) The construction of fishing compound facilities or plants, large slaughterhouses, food and drink factories, sugar manufacture factories and alcoholic distillation plants, fibre and sewing factories, tanneries, agricultural chemical factories, paint and lacquer solvent factories, petroleum refineries, ironworks, metallurgy factories, chromium factories, chemical and petro-chemcial factories, cement works and battery manufacturing industry.

Environment guidelines on quarries etc are currently being considered by MARENA.



Sector : The section which influences a project

Figure 5.3.2 Process of Environment Evaluation

5.3.2 Condition of Natural Environment and Society Environment

1) Conservation of Natural Environment

a) Conservation of Forest

The disappearance of the rain forests is one of the big environmental problems in Nicaragua. Therefore a regulation about the forest conservation is reinforced in Nicaragua by the Forest Law (NO.45-93, official gazette NO.197, October 19, 1993). This rule is applicable to all the forests. Developments and uses controlled to prevent the disappearance of the forests. Moreover, because the forest resources of any country need sustainable and rational utilization, it aims at the protection of the biodiversity as well. Although the use of the forests is regulated and the owner of the land is recognized as the owner of the forests under the Forest Law, permission for the use of the forests is issued by INAFOR (Forest Institute, previously a subordinate organization of MARENA until three years ago). When tree-felling is proposed, each felled tree must be replaced by four new plantings. Costs for these must be included in projects budget. Locations for newly planted trees are directed by MARENA or INAFOR.

b) Game Preservation

The Hunting Law (statute NO.206:1956) is the primary legislation aimed at protecting wild life. This law regulates hunting areas, hunting methods, etc. Areas and times for hunting are regulated by statute NO.2 of IRENA to protect breeding and generally conserve wild life. The capture of specific species is prohibited.

c) The conservation of the precious fauna and flora (Figure 5.3.3)

A "Red data book" is published, based on the Washington Treaty, with the aim of conserving precious fauna and flora as specified in Nicaragua. These are into the following eight categories (Including the Historical Monument, etc), and government regulates development in designated areas. Moreover, eight wetlands are registered in Ar-Rantha treaty (an international treaty, and environmental conservation plan currently being drafted). And, the execution of the environmental impact assessment is required in accordance with "the regulation of conservation area" when a development act is done in the area where it registers for these eight categories. The eight categories are:

- National Park (Figure 5.3.4)
- Biological Reserve
- National Monument
- Historical Monument
- Wild life Reserve

- Genetic Resource Reserve
- Natural Reserve
- Biodiversity Reserve

d) Conservation of Soil

The soil protection of all the land is declared to be for public benefit and the good of society law (Statute 1308). This law intends to prevent soil protection and erosion. Geography and changes to soil are regulated within law 217 to preserve it with respect for an eco-system balance, and to prevent the erosion of the soil. Where, 35% and more of the land is covered with flora, landowners and land-users are confined to arable uses.

e) Conservation of Water

One of the big environmental problems in Nicaragua is the pollution of the water. Therefore cutting down of trees nearby the river and valley which spring water follows into, the lake, natural dam and branching bay regardless of the water supply to the inhabitant, the irrigation activities, the generation of electricity use, etc is prohibited by Law (statute No.235: 1974). This promotes the rational use of the forests in Nicaragua.

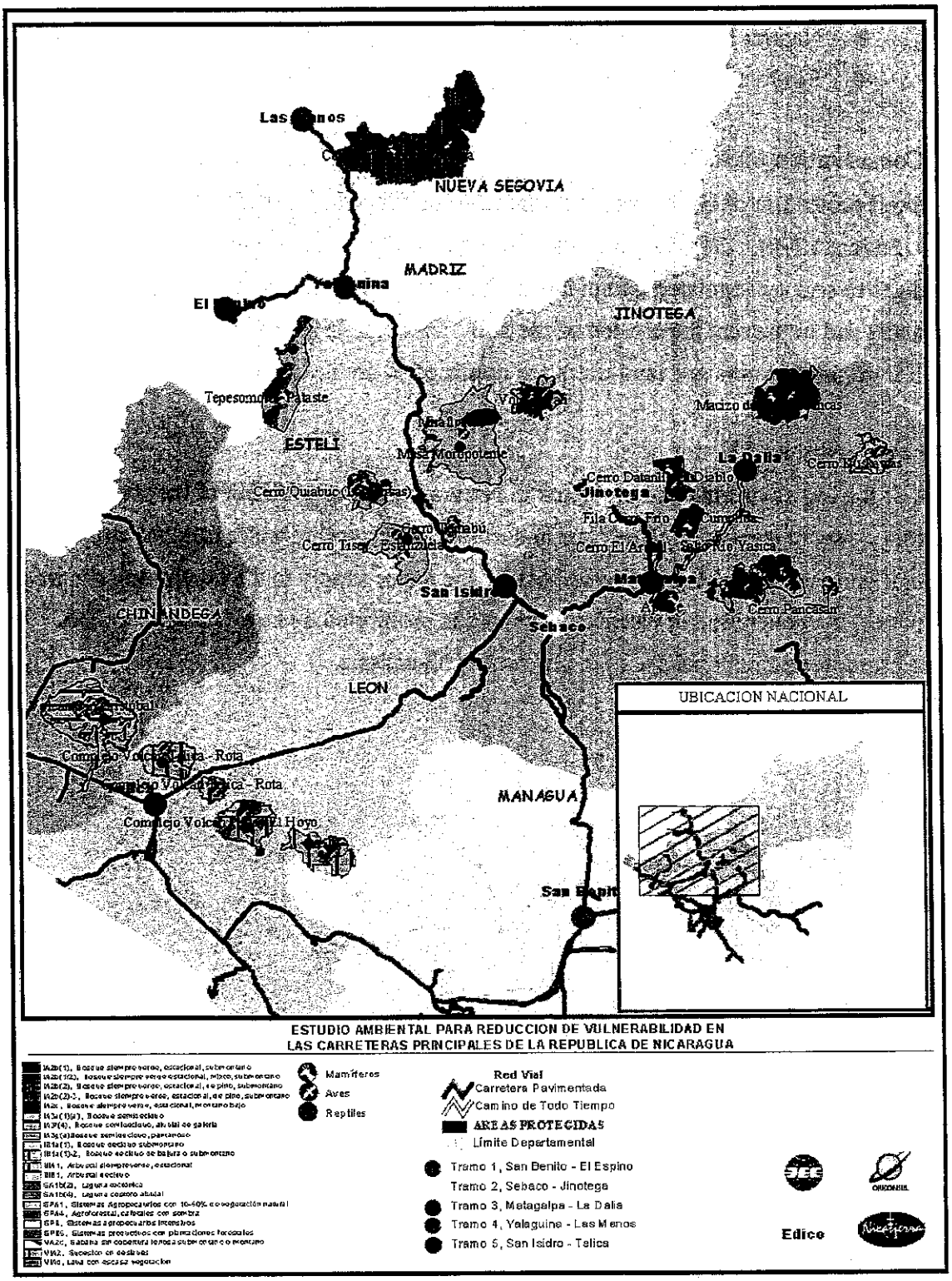


Figure 5.3.3 Conservation of Precious Fauna and Flora

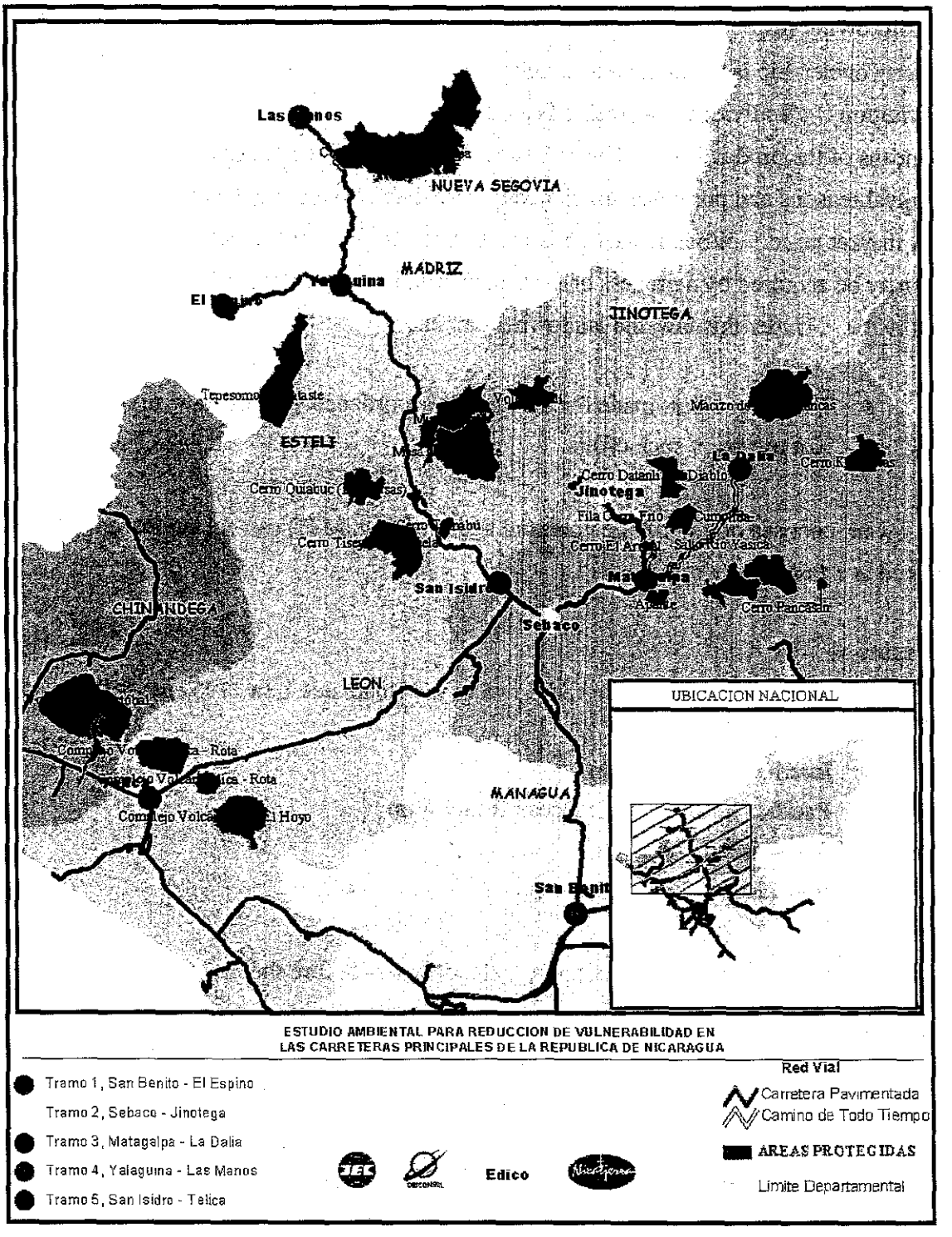


Figure 5.3.4 National Park Map

2) Condition of the Social Environment

a) Land ownership

Property ownership is recognized as a right in Nicaragua. According to Clause 44 of the constitution : "Individual ownership is assured for the real estate and the property and for the means of the production." Under Law, a limit and duty of use are assigned to ownership for social reasons and public-sector projects. Real estate can only be acquired by the state at a fair market price. When landowner's independent rights conflict with the national interest, land may be acquired by a process of land expropriation laid down in Clause 44 and Statute 229 (1976). Under this law, the landowner can choose :

- To accept offers made for the land in accordance with the law; or
- Not to accept such offers..

If an owner chooses option b), the potential acquirer (e.g. MTI) can declare expropriation of the land at a fair market price.

b) Rights of Way

The rights of way in Nicaragua are laid down in the Road side Law (1952) as follows.

- International road: 40m
- Pacific Ocean-Atlantic Ocean Road: 40m
- Trunk Road: 20m
- Rural Road: 20m

However, This legislation does not apply to landowners before the law enactment. Moreover, in cases where the right of way is not registered, and where cities may recognize individual registration in a right of way, the law is not enforced.

c) Water Right/Fisheries Right/Common Right

Water rights are not fully established in Nicaragua. Fishery rights (commercial fishing) in the Pacific Ocean, the Atlantic Ocean, lakes and two rivers (the TISMA River and the SAN JUAN River) are established. Common rights are not held under law, because forests tend to the private land. Where forests are specified in a nature conservation area, uses are regulated permission of MARENA.

d) Conservation of Indigenous People (Figure 5.3.5)

Three areas are specified as conservation areas for the indigenous people of the Atlantic coast.

Other spatial designation of these conservation areas is not made because residences of the indigenous people overlap the area of others. There is no regulation of development in these areas.

e) Historical Place/Cultural Asset (Figure 5.3.6)

Conservation of historical places, cultural assets, national monuments, historical monuments, and protection areas are designated by Government. Other historical monuments (including the World Heritage sites such as historical urban structure in Leon) are protected by the cultural institute under the organization of the Ministry of Education, Culture and Sport.

f) Solid Waste

Solid waste is one of the environmental problems in Nicaragua, and is dealt with under the third chapter of the Law No.217 the inside "Non-hazardous solid waste" as follows:

> *The 129th clause*
> Each local government collects and disposes of non-hazardous solid waste in accordance with the standard by Ministry of Natural Resources and Environment and the Ministry of Health, in order to protect environment and health.
>
> *The 130th clause*
> The government encourages and aids the development of recycling of industrial waste and household waste through the sanitary and technical methods, agreed with related organizations.

MARENA guides the specification of the kind of the waste and the decision of the disposal site in the stage of the EIA. MTI has already secured some disposal sites. Therefore, the disposal site can be specified if a project and waste can be specified. MTI re-crushes removed asphalt, and this is re-used as base course for roads etc.

g) Noise/Vibration/Air Pollution

Environmental standards on noise, vibration, air pollution (excluding the exhaust gas regulation) are not established in Nicaragua. Environmental standards for construction projects, roads under construction, use of plant etc, are prescribed in NIC2000.

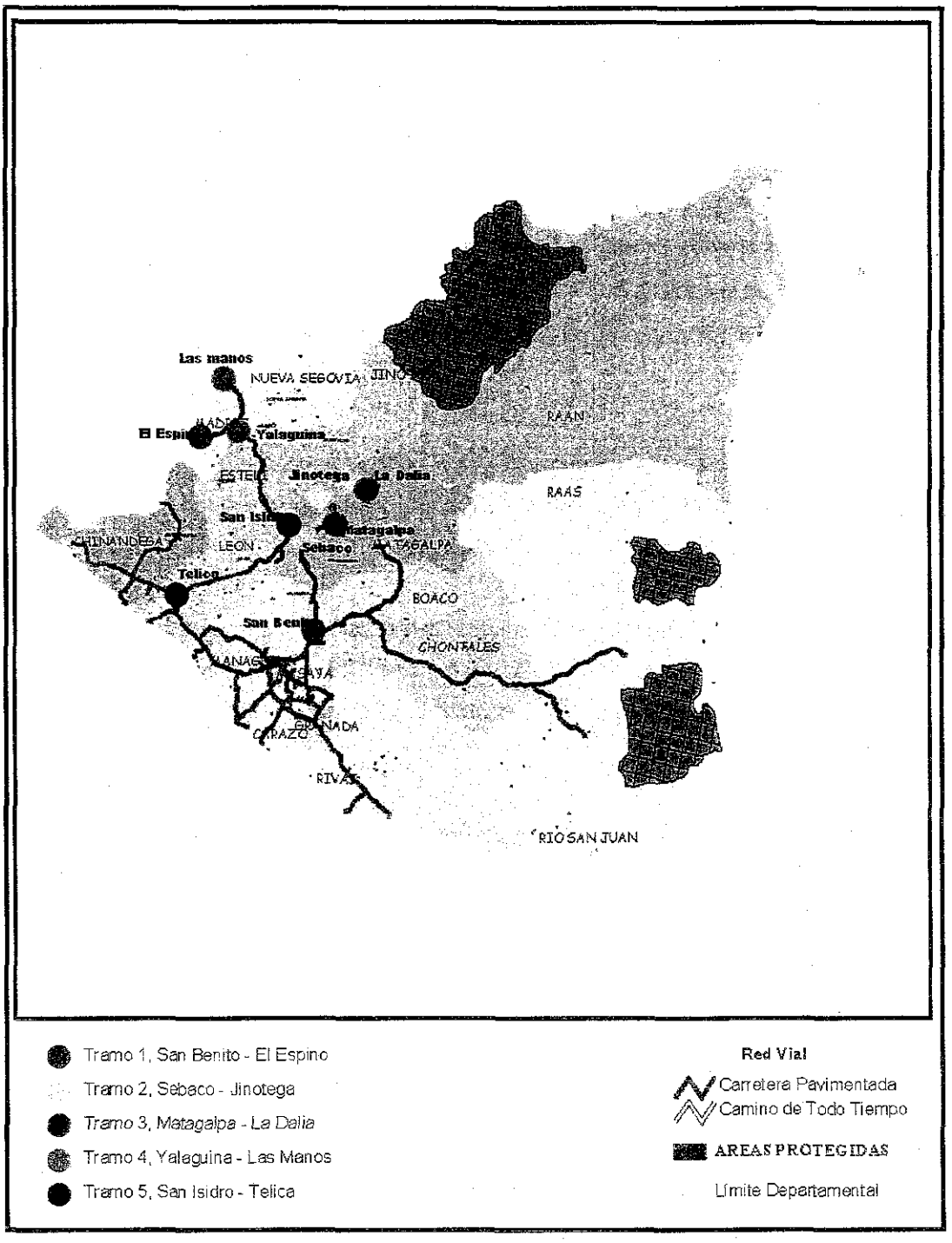


Figure 5.3.5 Conservation of Indigenous People

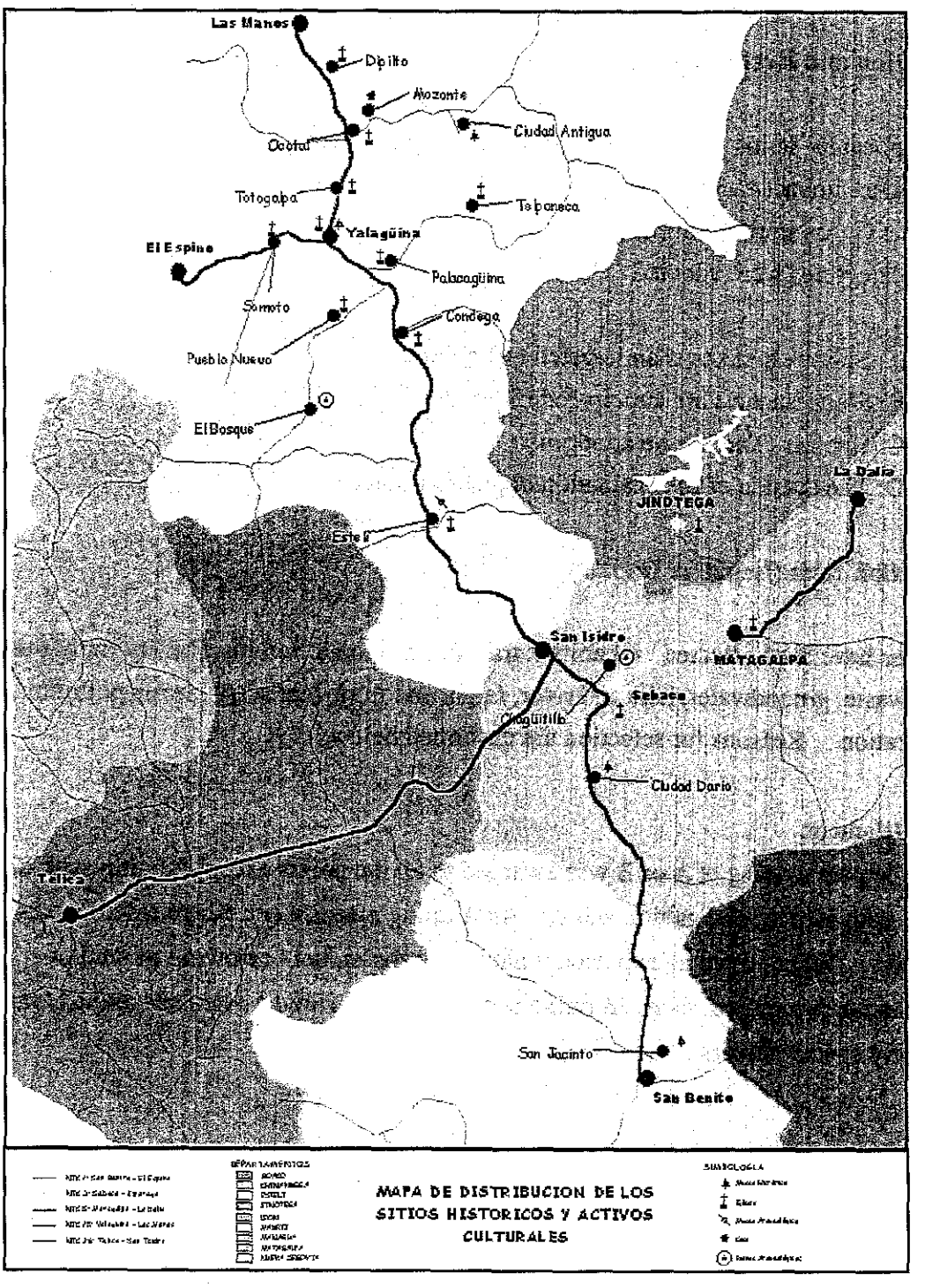


Figure 5.3.6 Historical Place/Cultural Asset

5.3.3 Environmental Impact Factors

1) Selection and Evaluation Method

The applicable items of the environment impact evaluation were selected from the environment impact factor by reference to project contents, field investigations and existing references. An impact rating for each project point is shown in the Table 5.3.2. Four scoring categories were adopted :

A: Serious impacts is anticipated (10 points)
B: Some impacts are anticipated (5 points)
C: Unclear (There is no adoption)
D: The outside of the evaluation object (0 point)

2) Selection Item (Negative Impact)

Ten items have been selected : inhabitant transfer, economic activity, facility for life and traffic, waste, groundwater, lake and river, fauna and flora, landscape, water pollution, noise and vibration. Reasons for selection are described below.

a) Resettlement

For this impact a rating of A or B was awarded to all the points except for sites with bridges, barriers with gabion, and gabion walls. An A rating means a site where resettlement is expected. Where there no expected inhabitant transfer, but borrowing of land or expropriation is required, then a B rating is applicable. Three A rated site and a D rated point have special factors :

A rating
No.27: A hotel (complete schedule is after two years) during the construction is on the slope. Therefore, countermeasures that contain excavation of the existing slope should be avoided.
No.31: Three private houses exist on the mountain slope side. Countermeasure such as re-cutting and prevention net should be avoided. There is a property on the valley side of the road. Countermeasures should avoid the need to relocate residents of the property.
No.36: The transfer of the private houses of both riverbanks would be necessary by the current position depending on the scale of the proposed dam. Therefore, the position of construction should be moved to a point where influence on the private house is avoided.
D* rating
No.1: One private house exists but is illegally occupied.

b) Economic Activity

Where facilities that generate income exist, impacts at the target point are evaluated.

A rating

No.3: There is water for one year in the river, and a target river is being used as service water and drainage to rice fields in the locality. Therefore, measures should avoid obstructing flow to the down stream by the stopping-up the river etc.

No.27: A hotel (complete schedule is after two years) during the construction is on the slope. Therefore, countermeasures that contain excavation of the existing slope should be avoided.

No.31: Three private houses are on the mountain slope side, along with arable land on the slopes. A flower stand has been opened by one house of that along the road. Therefore, countermeasures that contain excavation of the existing slope should be avoided.

No.33: There is arable land under the valley slope side. Countermeasure that influence on arable land should be avoided

No.36: A brick-kiln made by the joint capital investment of the community would be affected by the position of construction and the scale of the dam. Therefore, the position of construction should be at a point where an influence on the kiln is avoided.

B rating

No.34: Because a restaurant exists in the opposite side of the target point, construction is expected to influence the number of visitors in the lane.

c) Facility for Life and Traffic

As for the traffic and life facilities, all the target roads carry bus and other public service vehicles. Therefore, all B's were rated in consideration of the influence by the lane regulation under construction. But, only No16 was rated B*.

B* rating

No.16: The well that exists in the opposite side of the target point is being used as a drinking water of 25 local houses. The installation of a fence etc should be considered during construction because the well water is used by women for washing themselves.

d) Waste

Construction waste occurs in all the points along with the construction of the target facilities. It must deal with these in accordance with the law No.217 that was above mentioned, and the guidance of MARENA.

e) Groundwater

There are wells close to the points where counter measures are proposed at these sites. Generally, non-confined water (free water) is being used from all wells of around 5-6m depth and it is expected to react to changes in the slight geographical features sensitively. Therefore, countermeasures that cover slopes with structures, such as shotcrete, should be avoided. Permeation catchment pits should be considered when a slope is covered by a structure.

Where wells are near bridge points, they should not influence groundwater because foundations of bank protection are shallow with sufficient catchment area.

f) Lake and River

As for lake and river, 3 points where dams were planned was selected as the B rating. The rivers at these 3 points are used for washing and cleaning dishes. Therefore, structures that do not affect the river condition must be adopted because a change in river condition by the construction of a dam would be expected.

g) Fauna and Flora

There are many precious fauna and flora, and conservation areas such as national parks near to the target roads as shown below. Therefore, when a target point exists in these areas, it has the potential to impact on precious fauna and flora.

- Cerro Tomabu area (No.4: A)

The down stream side is specified by a conservation area. Gabion of prevention of scouring of the bridge foundation is planned. Therefore, construction must avoid decreasing of water supply to the fauna.

- Cerro El Arenal area (No.28: B, No.29: B)

Replanting of vegetation should be included in countermeasures here, although both No28 and 29 have suffered from slope collapse and there is no existing vegetation. Because the replanting of vegetation is being taken into consideration, the present proposal is for countermeasures at site No28 is in keeping with the environment. However, proposals for shotcrete at Site 29 should be altered to be consistent with re-planting of vegetation.

- Cordillera Dipilto y Jalapa area (No.36: A, No.37: A, No.38: B, No.39: B)

Dams are planned at both sites No36 and 37. Because much tree-felling is necessary for the construction of dam, construction should be sited at points where felling is minimized, as much as possible. Countermeasure for replacement of vegetation should be implemented.

Replanting of vegetation should be included although No38 and 39 also suffer from slope collapse and vegetation is not visible currently.

h) Landscape

The target point inside the conservation area except for the foundation countermeasure point (No4) of the bridge and No16 are selected as points to give careful consideration to the landscape. The construction of artificial structures in concrete, able to be viewed from roadside, should be avoided. Countermeasures that complement the surrounding environment should be selected in the conservation area. When an artificial structure is unavoidably adopted, structures should be covered with vegetation.
It is necessary with No16 to leave existing vegetation because the opposite side of the countermeasure point is a location for woman's washing area.

i) Water Pollution

B is rated all points because there will be an occurrence of polluted water along with the prevention of scouring for bridge foundation and protection construction of the slope. Though this is not used for drinking, fishing by local residents, and washing is carried out in rivers around all the target projects. Therefore, construction should be carried out in the summer (December – April) when water levels are low. If it is carried out in winter (May - November), measures should be put in place to manage water pollution by the facilities such as filtration and precipitation.

j) Noise and Vibration

Where schools and hospitals exist close to target points, it is considered that these facilities need quietness, and a B rating was awarded. Construction must include installation of soundproof facilities or use low noise machinery in these points.

3) Non-selection item

Thirteen items were not evaluated: severance, historical place/cultural asset, right of water/right of common/fishery right, health/hygiene, a disaster (risk), geography/geology, soil erosion, the coast/sea area, the weather, air pollution, soil pollution, ground subsidence, foul smells, for the following reasons:

a) Severance

The purposes of the target project are slop protection and prevention of scouring of the bridge

substructure. Therefore, the facilities or structures that cause the area severance are not proposed.

b) Historical Place/Cultural Asset

Historical places and cultural assets do not exist at points where the project has an influence.

c) Water Right/Fishery Right/Common Right

There are no such rights at any of the target sites.

d) Health/Hygiene

Facilities or structures that makes health and hygiene conditions worse not proposed

e) Disaster (Risk)

The target project aims at the prevention of the disaster. The activities and facilities that induce a new disaster are not proposed.

f) Geography/Geology

Precious geography and geology do not exist in the target area. And, because the alteration of the geography carried out is slight, there is no impact geography and geology.

g) Soil erosion

The target projects reduce soil erosion.

h) Coast/Sea area

The coast and sea area do not near the target sites.

i) Weather

There are no direct weather impacts.

j) Air pollution

Though there will be discharges of exhaust gases by construction vehicles, it is very short-term, and has a negligible affect on the atmosphere. Projects are measures against disasters, and increases in traffic are not envisaged. Therefore long-term effects on the atmosphere are also negligible.

k) Soil pollution

There are no points that have a ground-history that heavy metals and so on were handled.

Activities and facilities that pollute soil during construction and after completion will be avoided.

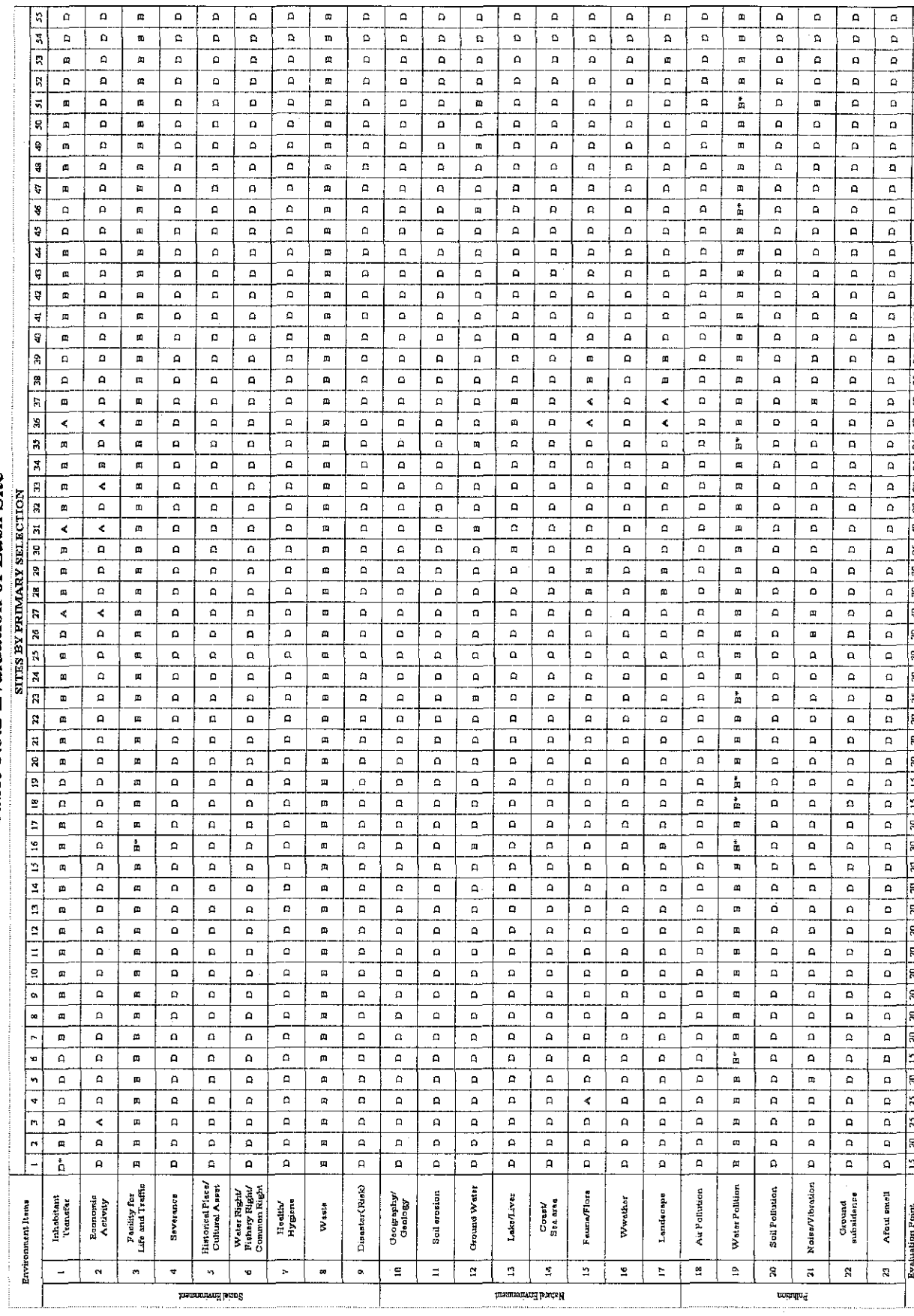
l) Ground subsidence

The target projects do not contain measures that have a soft ground layer and pumping of subterranean water that causes ground subsidence.

m) Foul smell

The activities and facilities proposed will not produce foul smells during construction or after project completion

Table 5.3.2 Evaluation of Each Site



5.4 Traffic Demand Forecast

5.4.1 Traffic Volume of Present Situation

1) Objectives

Traffic surveys were carried on the objective roads, for the purpose of developing a traffic model which could be used to assess the impacts of natural disasters on these roads. The objectives of the surveys were to gather data on both the scale, and patterns of movement, of traffic. Survey data were analysed to determine existing traffic volumes and composition on the objective roads, and could be used in conjunction with the economic forecasts to provide traffic forecasts.

2) Survey Methodology

Two types of survey were carried out :

- Direct classified counts; and
- *Origin-Destination interviews.*

Both types of survey were undertaken at 9 locations, set out in Table 5.4.1. Traffic counts were carried out over a 12-hour day (06.00 to 18.00) at all 9 locations, and 24 hour counts undertaken at surveys sites 2 and 6. The target interview rate was set at 30% to 50% of all traffic.

Table 5.4.1 Traffic Survey Locations and Dates

Location Number	Road	Location	Dates
1	NIC 24	La Grecia No. 2, km 103.5	11 and 12 June 2002
2	NIC 26,	Telica	11 and 12 June 2002
3.1	NIC 1	Yalaguia, km 207.15	11 and 12 June 2002
3.2	NIC 15	Yalaguia, km 207.2	11 and 12 June 2002
4	NIC 26	San Isidro, 800m from junction with NIC 1	11 and 12 June 2002
5	NIC 1	Santa Cruz, km 138.5	11 and 12 June 2002
6	NIC 1	Sebaco, km 99.1	11 and 12 June 2002
7	NIC 3	Comarca de Chaguitillo, km 107.1	11 and 12 June 2002
8	NIC 1	San Benito, 250m north of junction with NIC	11 and 12 June 2002

The classified counts were taken at 15 minute intervals. Ten vehicle types were recorded: car, pick-up, minibus, bus, light goods, medium goods, heavy goods, tractor, motorcycle, and bicycle. The survey form is reproduced in Appendix-4.

Goods vehicles were classified as follows:

- Light Goods or Small Trucks, include the different types of the Cx (C2 and C3) with a capacity of 8, 10 and 12 tons.
- Medium Goods or Big trucks, includes the type Cx (C4), with a capacity up to 14 ton.
- Heavy Goods or Articulated trucks, includes the types Tx-Sx (T2-S1, T2-S2, T2-S3, T3-S1,T3-S2,T3-S3) and all the types Cx-Rx (C2-R2, C3-R2,C3-R3), with a capacity up to 22 tons

The origin-destination surveys recorded : vehicle type (as above); journey purpose, origin, destination, number of passengers, frequency of journey, type of cargo, weight of cargo. Pre-coded responses were provided to the field surveyors as shown in Table 5.4.2

Table 5.4.2 Response codes in Origin-Destination Survey

Code	*Vehicle Type*	*Journey Purpose*	*Frequency*	*Cargo*
1	Private Car	Work, business	5-7 times per week	Oil, petroleum
2	Minibus	Education	3-4 times per week	Cotton
3	Autobus	Shopping	1-2 times per week	Rice
4	Light Goods	Tourism	0-1times per week	Sugar
5	Medium Goods	Sport, social		Bananas
6	Heavy Goods	Other		Coffee
7	Motorcycle			Cement
8	Bicycle			Construction materials
9	Tractor			Livestock
10	Pick-up			Grain
11	Others			Wood
12				Metals
13				Chemicals
14				Sesame seed
15				Tobacco
16				Beef products
17				Passengers only
18				Other food products
19				Other non-food products
20				Empty

Vehicle origins and destinations were recorded by field surveyors and re-coded after the fieldwork. Nicaragua was split into 45 traffic zones and codes allocated as set out in Table 5.4.3.

Table 5.4.3 Origin and Destination to Zone Coding

Zone No.	Department	Town/City
1	Nueva Segovia	Santa Maria, Ocotal, Macuelizo, Ococona, Diplito
2	Nueva Segovia	Mozonte, San Fernando, Santa Clara, Jalapa, Murra, Ciudad Sandino, Susucayan, Ciudad Antigua
3	Nueva Segovia	Las Manos
	Honduras	Honduras via Los Manos
4	Madriz	Yalagüina, San Lucas, Las Sabanas, San José del Guaspan
	Esteli	Los Llanos,
5	Madriz	El Espino
	Honduras	Honduras via El Espino
6	Nueva Segovia	Quilali
7	Jinotega	Wiwili, Wamblan, Plan de Grama, Ayapal
8	R.A.A.N	All towns
9	R.A.A.S	El Gallo, Siawas, Chicago, La Cruz del Rio Grande, Casa de Alto, San Pedro del Norte, Copalar, Wasayama, Rio Blanco
10	Jinotega	San Jose del Bocay, El Cua,
11	Matagalpa	Matagalpa Carretaera Yaoska, Rancho Grande, San Antoniio de Kyskawas, El Tuma, La Dalia, San Ramon, Santa Rita
12	Madriz	Palacagüina, Telpaneca, Quinbuto, San Juan del Rio Coco
13	Jinotega	Jinotega, Mancotal, San Pedro de Buculmay, Asturias,
14	Jinotega	Las Praderas, La Concordia, San Rafael, del Norte, San Sebastian de Yali, La Rica
15	Esteli	Condega
16	Esteli	Esteli, La Sirena
17	Esteli	La Trinidad , Santa Cruz, San Nicolas
18	Esteli	El Regadito, San Juan de Limay, el Bosque, Pueblo Nuevo
	Chinandega	Cinco Pinos, San Francisco del Norte
19	Honduras	via Guasaule
	Chinandega	Guasaule, Somotillo, Santo Tomas del Norte, Palo Grande, San Pedro del Norte
20	Chinandega	Villanueva
21	Chinandega	Monte Rosa, Aposentillo, Jiquilillo, El Congo, Potosi, Punta Nata, Puerto Morazan, Tonalá
22	Chinandega	Chinandega, El Realejo, La Grecia, Corinto, Paso Caballos, Chichigalpa, Posoltega
23	Matagalpa	Sebaco, Chiquilillo, San Isidro
24	Leon	Achuapa, Rio Grande, El Sauce
25	Leon	Santa Rosa del Peñon, El Jicarol
26	Leon	Malpaisillo Mina El Limon, La Reynaga
27	Leon	Leon, Telica, Quezalguagüe, Ponelova, Las Peñitas
28	Leon	Izapa, La Paz Centro, Puerto Monotombo, El Tamarindo, El Transito, El Velero, Puerto Sandino, Salinas Grandes, Nagarote, Soledad, San Lorenzo
29	Managua	Managua, Mateare, Los Brasile, Los Cedros, Villa Carlos Foncersa, San Bartolo, San Cavetano, Santo Domingo, Aeroporto, Montelimar, Masachapa, Pochomil, San Rafeal del Sur, San Marco, Esquipulas, Saban Grande
30	Masaya	All towns
31	Carazo	All towns
32	Granada	Granada, El Paso de Paneloya, Diria, Ditomo
Zone No.	**Department**	**Town/City**
33	Granada	Nandaime, La Conquista
	Rivas	All towns
34	Costa Rica	Costa Rica
35	Managua	Tipitapa, Zona Franca, Zambrano, Granada, San Juan

Zone No.	Department	Town/City
36	Managua	San Francisco Libre
37	Managua	Las Maderas, San Jacinto
38	Managua	San Benito, Las Banderas
39	Matagalpa	Ciudad Dario, Las Calabazas, Terrabona, Puertas Vieias
40	Boaco	All towns
	Granada	Malacatoya
41	Matagalpa	San Dionisio, Esquipulas
42	Matagalpa	Muy Muy, Matiguas, Santa Elsa, Rio Blanco
43	Chontales	All towns
44	Rio San Juan	All towns
45	R.A.A.S.	El Rama, Zelaya Central, Bluefields, Nueva Guinea, Muelle do los Bueves, Buena Vista, Atlanta, San Miguel, Rio Plata, Talolinga, El Cascal, Verdun, Providencia, Nuevo Leon, San Martin

During the execution of the field work, there were some interruptions on the Origin-Destination interviews because of difficulties with police support and weather conditions. For a period on June 11th there was no police support on the Station 01(Departure Chinandega – El Guasaule district "La Grecia No. 2") and there was also late arrival of the police to the others stations located on the Rout NIC-1. This was compensated by a higher effort of the interviewers to obtain the required information for the traffic survey.

Table 5.4.4 lists the interview sample rates for each vehicle category

Table 5.4.4 Interview Rates

Vehicle Type	*Interviews*	*Sample Rate (%)*
Car	1102	47.2
Pick-up	2957	59.5
Mini-bus	198	43.2
Bus	782	60.3
Small Truck	1408	82.8
Medium Truck	779	78.8
Heavy Truck	330	51.8
Motorcycle	363	56.8
Bicycle	274	27.9
Tractor	59	57.8
Taxi	132	44.0
Other	136	59.1
Total	8520	58.2

In every other vehicle category, over 40% of traffic was interviewed, with a total sample rate of well over 50%. This is considered very satisfactory in statistical terms.

3) Aggregate Traffic Count Results

Table 5.4.5 lists the average traffic counts for each site, by vehicle type over the two 12 hour periods. These are shown graphically in Figure 5.4.1.

Table 5.4.5 Aggregate Traffic Counts, June 2002, 06.00 to 18.00 hours

Site	*1*	*2*	*31*	*32*	*4*	*5*	*6*	*7*	*8*
Car	141	160	212	149	87	375	402	280	533
Pick-up	317	300	335	309	288	788	763	711	1160
Minibus	121	36	8	14	19	76	91	47	48
Bus	165	98	83	76	62	168	203	197	248
Light Goods	133	63	105	103	120	173	398	305	303
Medium Goods	158	85	122	38	18	137	137	128	168
Heavy Goods	259	35	66	2	14	67	39	40	118
Motorcycle	99	46	69	100	39	90	85	77	37
Bicycle	266	118	98	90	69	73	141	65	66
Tractor	26	11	1	0	8	8	44	1	5
Taxi	115	5	12	15	10	17	70	33	26
Other	1	1	30	1	0	3	57	135	5
Total	1798	955	1138	894	732	1972	2426	2016	2714

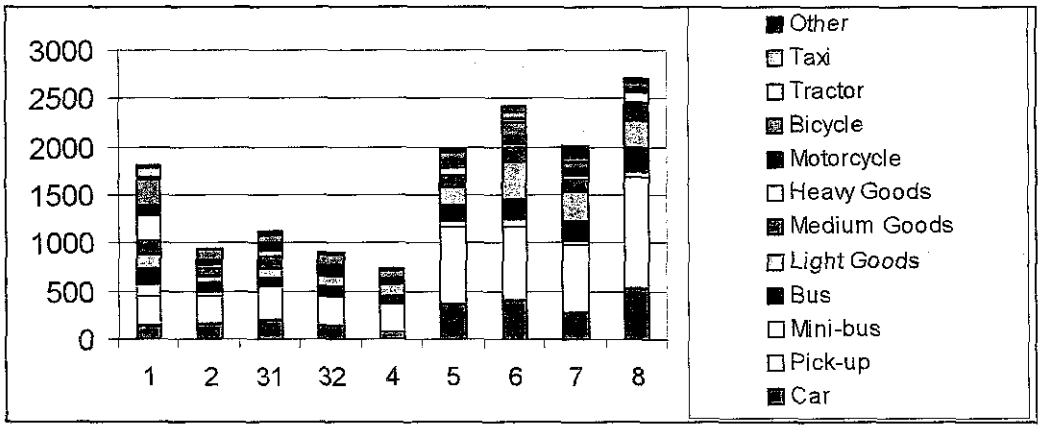


Figure 5.4.1 Aggregate Traffic Counts at Sites, June 2002, 06.00 to 18.00 hours

Figure 5.4.2 shows the hourly profiles over the 12 hour day for each site. Sites 1, 2, 31, 32, 4 and 7 all display relatively flat profiles over the day. However the sites on NIC 1 tend to have greater variation. Site 5 (Santa Cruz, NIC 1) shows a strong peak in the evening between 16.00 and 17.00 hours. Site 6 (Sebaco, NIC 1) shows a peak in the morning (06.00 to 07.00), and at Site 8 (San Benito, NIC 1) much higher volumes were observed after 12.00 than in the previous six hours.

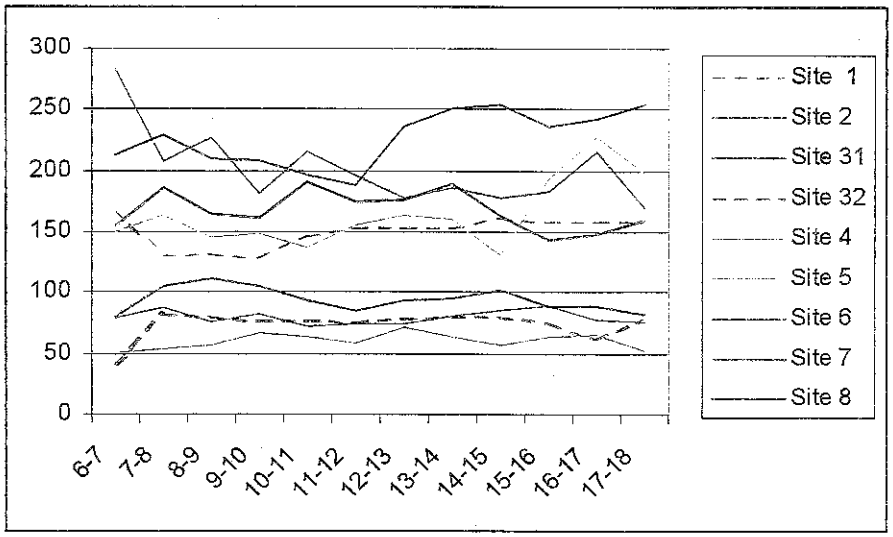


Figure 5.4.2 Hourly Total Traffic Variations, 06.00 to 18.00 hours, all Sites

Figure 5.4.3 shows the hourly profile of observed traffic at the two sites where 24 counts were undertaken. The peak hour at Site 2 (Telica, NIC 26) was found to be 15.00 to 16.00 hours, when 7.1% of the 24-hour traffic was observed. The peak hour at Site 6 (Sebaco, NIC 1) was 06.00 to 07.00 hours when 8.3% of the 24-hour traffic was observed. At Site 2, 76.5% of the 24-hour traffic was observed during the 12 hour day, whereas at Site 6 it was lower, at 70.7%.

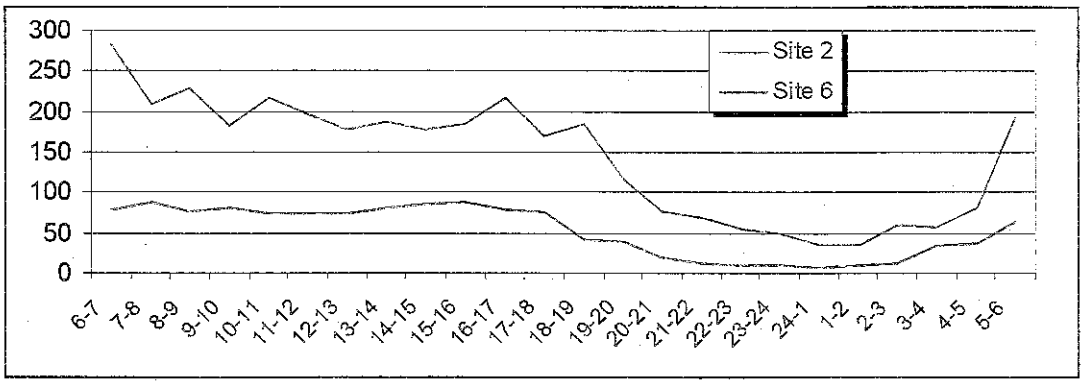


Figure 5.4.3 Hourly Total Traffic Variations, 24 Hours, Sites 2 and 6

Data for converting 12-hour counts to 24-hour counts is available for 20 main roads in Nicaragua for the year 2001, as shown in Figure 5.4.4. The data from the surveyed sites 2 and 6 are also included. The data from Site 2 is seen to be very close to the observed average, and this latter value has been adopted. The resultant proportion of daily traffic occurring in the 12-hour period is 0.762, and the conversion factor from 12-hours to 24-hours is 1.31.

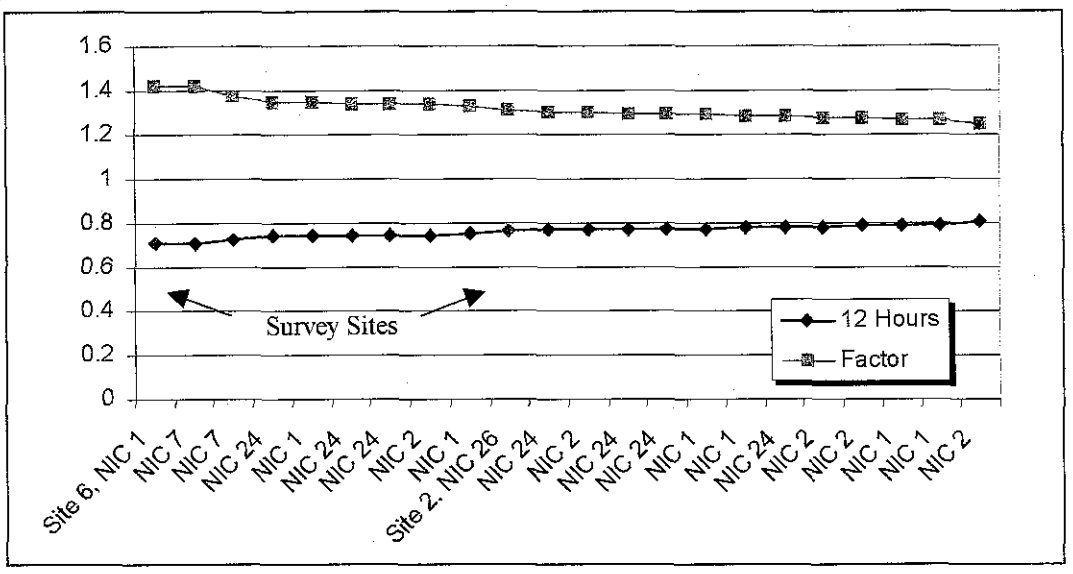


Figure 5.4.4 Observed Relationships between 12-hour and 24-hour Counts

Lavial SA prepared factors to enable average daily traffic to be calculated. These are set out in Table 5.4.6. The factor for converting June traffic to an average month is 1.2

Table 5.4.6 Daily to Weekly Adjustment Factors

Day	*Factor*
Tuesday (11 June 2000)	1.15
Wednesday (12 June 2002)	1.04

The application of the above results in a total factor of for use in converting the observed 12-hour flows to Annual Average Daily Traffic (AADT) volumes, summarized in Table 5.4.7. The resultant AADT's are shown in Table 5.4.8.

Table 5.4.7 AADT Conversion Factors

Conversion	Factor
12-hour to 24-hour	1.31
Tuesday/Wednesday to average weekday	1.0943
June to Average Month	1.05
12-hour to AADT	1.51

AADT's constructed from the surveyed counts have been compared with historic data from MTI for these sites. The estimated AADT's for motorized traffic (excluding bicycles and tractors) are shown in Figure 5.4.5. for the years 1997 to 2002. In aggregate at the nine sites, traffic has grown by an average of 10.4% per year over the 5-year period.

Table 5.4.8 Annual Average Daily Traffic Volumes, Surveyed Sites

Site	*1*	*2*	*31*	*32*	*4*	*5*	*6*	*7*	*8*
Car	236	262	349	246	143	618	661	459	879
Pick-up	523	497	552	509	474	1307	1244	1183	1913
Minibus	205	59	13	23	30	125	152	77	79
Bus	277	162	136	125	107	277	333	324	409
Light Goods	224	103	175	173	198	284	647	501	481
Medium Goods	263	140	200	62	29	225	228	213	276
Heavy Goods	429	57	108	3	21	109	67	65	194
Motorcycle	166	76	113	165	64	148	141	126	62
Bicycle	441	193	163	148	115	120	233	104	109
Tractor	42	18	2	0	12	13	75	1	9
Taxi	190	8	19	24	17	29	116	54	42
Other	1	1	49	1	0	5	96	222	8
Total	2998	1576	1880	1479	1211	3261	3993	3327	4460

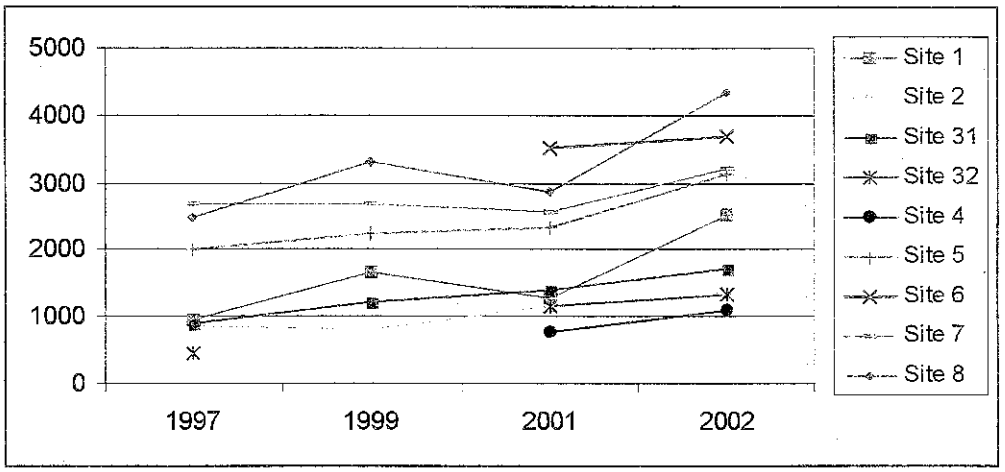


Figure 5.4.5 Motorised Traffic Growth at Surveyed Sites

4) Aggregate Interview Results

Table 5.4.9 lists the number of completed interviews carried out at each site.

Table 5.4.9 Total Valid Interviews by Site

Site	Interviews	Site	Interviews
1	535	5	934
2	1347	6	1233
31	635	7	882
32	897	8	1604
4	453	Total	2520

Table 5.4.10 lists average observed occupancies by vehicle type

Table 5.4.10 Average Observed Vehicle Occupancies

Site	Vehicle Occupancy (including driver)
Car	3.0
Pick-up	2.7
Minibus	9.7
Bus	32.1
Light Goods	2.8
Medium Goods	2.8
Heavy Goods	2.3
Motorcycle	1.4
Bicycle	1.3
Tractor	2.6
Taxi	2.9
Other	2.8

Figure 5.4.6 shows the distribution of cargo weights by type of truck. Table 5.4.11 lists the average loads carried by each type of truck. On average laden trucks were observed to carry 7.8 tonnes. Taking into account unladen trucks the average drops to 4.8 tonnes. Almost half of light trucks were observed to running unladen, or with passengers only. This reflects the fact that most of these are operating loaded in one direction only. However, efficiencies for medium trucks are higher, and for heavy trucks highest, with only 23.3% operating unladen. Thus as vehicle operating costs rise there is a greater incentive to attract return loads.

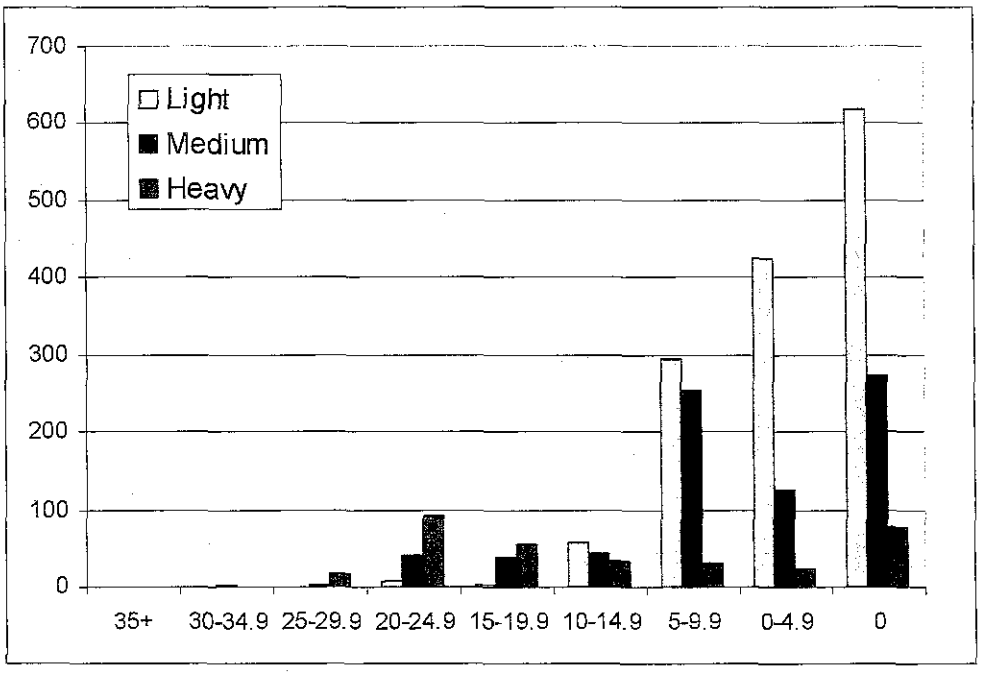


Figure 5.4.6 Distribution of Observed Loads Carried by each Truck Type

Table 5.4.11 Average Loads by Truck Type

Truck	Average load (Laden Trucks) Tonnes	% Trucks unladen	Average load (All Trucks) Tonnes
Light	4.9	43.9	2.8
Medium	8.5	35.0	5.5
Heavy	15.3	23.3	11.7
All Trucks	7.8	38.5	4.8

Types of cargo carried by trucks are listed in Table 5.4.12.

Table 5.4.12 Cargos carried by Truck Type Surveyed

Type of Cargo	% of trucks	% Light	% Medium	% Heavy
Other non-food	24.4	23.8	26.8	21.7
Other Food	21.5	28.4	12.7	15.0
Construction	11.4	10.7	15.7	4.7
Chemicals	8.1	7.7	7.7	10.7
Rice	6.0	7.1	4.2	5.9
Grain	5.0	4.1	6.6	5.1
Cement	3.9	2.6	3.9	9.1
Wood	3.7	2.8	3.0	8.7
Oil, Petroleum	3.1	1.9	5.5	3.6
Livestock	2.9	3.6	2.4	1.6
Metals	2.3	1.3	3.5	3.2
Sugar	2.1	1.0	4.2	2.0
Bananas	1.6	1.5	0.9	3.6
Beef Products	1.3	1.6	1.1	0.4
Coffee	1.0	0.8	0.9	2.4
Tobacco	0.6	0.5	0.4	1.6
Cotton	0.6	0.4	1.1	0.4
Sesame Seed	0.2	0.2	0.0	0.4
Total	100.0	100.0	100.0	100.0

The most common cargo carried is non-food other than listed above. It includes manufactured goods. Non-food products, other than rice, grain, sugar, bananas, beef, and sesame seed, includes dairy products and other processed food. Construction equipment and materials account for over 10% of goods traffic. Taken with cement this category accounts for 15.3% of all goods vehicles.

The weight limit for a 2-axle truck is 13.5 tonnes. Only 1.1% of trucks were recorded as overweight. The weight limit for a 3 axle truck is 23 tonnes. 1.2% of these vehicles were found to be overloaded. No heavy goods vehicles were recorded as overweight.

Table 5.4.13 lists the main origins and destination recorded during the surveys. Managua was the most frequently (16.4%) recorded. Towns on the objective roads, such as Esteli, Sebaco, Ocotal, Somoto, Matagalpa, Chinandega, San Isidro, Cuidad Dario, Jintotega and La Trinidad accounted for a further 49.4% of origins and destinations.

Table 5.4.13 Frequency Distribution of Origins and Destinations

Origin/Destination	Interviews	%
Managua	2793	16.4
Esteli	1898	11.1
Sebaco	1079	6.3
Ocotal	998	5.9
Somoto	944	5.5
Leon	940	5.5
Matagalpa	544	3.2
Chinandega	517	3.0
San Isidro	435	2.6
Cuidad Dario	386	2.3
Jinotega	385	2.3
La Trinidad	283	1.7
Honduras	250	1.5
Yalaguina	233	1.4
El Sauce	144	0.8
El Guasaule	142	0.8
La Grecia	130	0.8
Tipitapa	114	0.7
Telica	109	0.6
Mina El Limon	108	0.6
Masaya	105	0.6
Costa Rica	103	0.6
Santa Cruz	102	0.6
Corinto	100	0.6
Other	4196	24.6

Figure 5.4.7 shows the distribution of journey purposes by site. At every site, interviewed vehicles were dominated by trips to, from and in the course of work. On average, 83% of all trips interviewed gave work as their journey purpose. At Site 1 this figure rose to 92%. Personal business, including shopping, accounted for 7% of respondents.

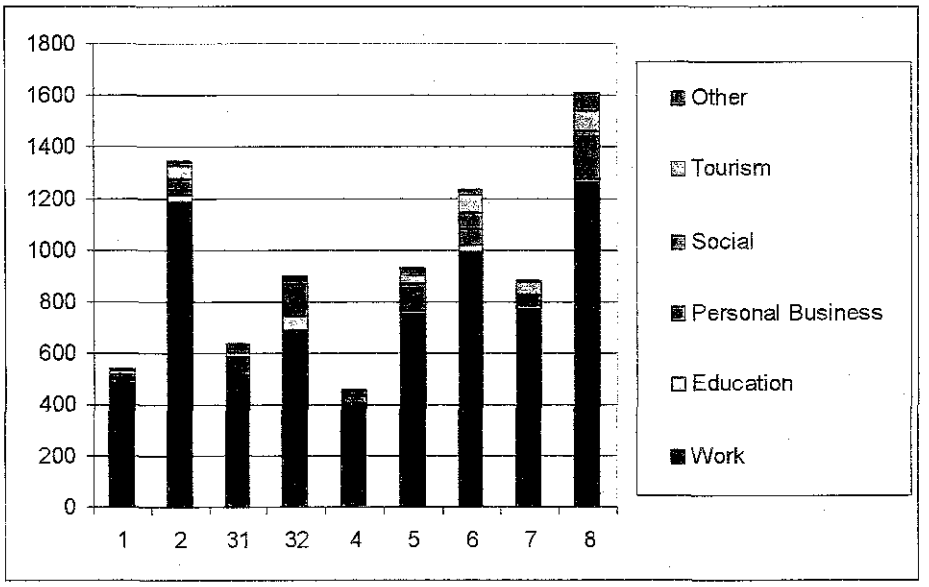


Figure 5.4.7 Number of Interviews at Each Site by Journey Purpose

5.4.2 Relative Data for Traffic Demand Forecast

1) Vehicle Operation Costs

Parameters for vehicle operating costs were taken from the National Transport Plan, 2001. Fuel and lubricant costs were updated to 2002 values. Vehicle occupancies were taken from the 2002 surveys, as they more accurately reflect conditions on the objective roads than national average. Passenger time values were not included in vehicle operating costs (per 1000 km), but calculated separately and converted to costs per vehicle-hour. In this way, the traffic model output can be used to directly estimate passenger time savings and hence costs.

The compositions of vehicle operating costs by vehicle type are shown in Figure 5.4.8. The fuel component of cost tends to be much higher in Nicaragua than many other countries due the cost of gasoline (Cordoba 29.99, US$ 2.13 per litre), and the cost of diesel (Cordoba 23.0, US $ 1.64 per litre) observed in June 2002.

Vehicle operating costs per 1000 km, and passenger costs per hour are summarised in Table 5.4.14.

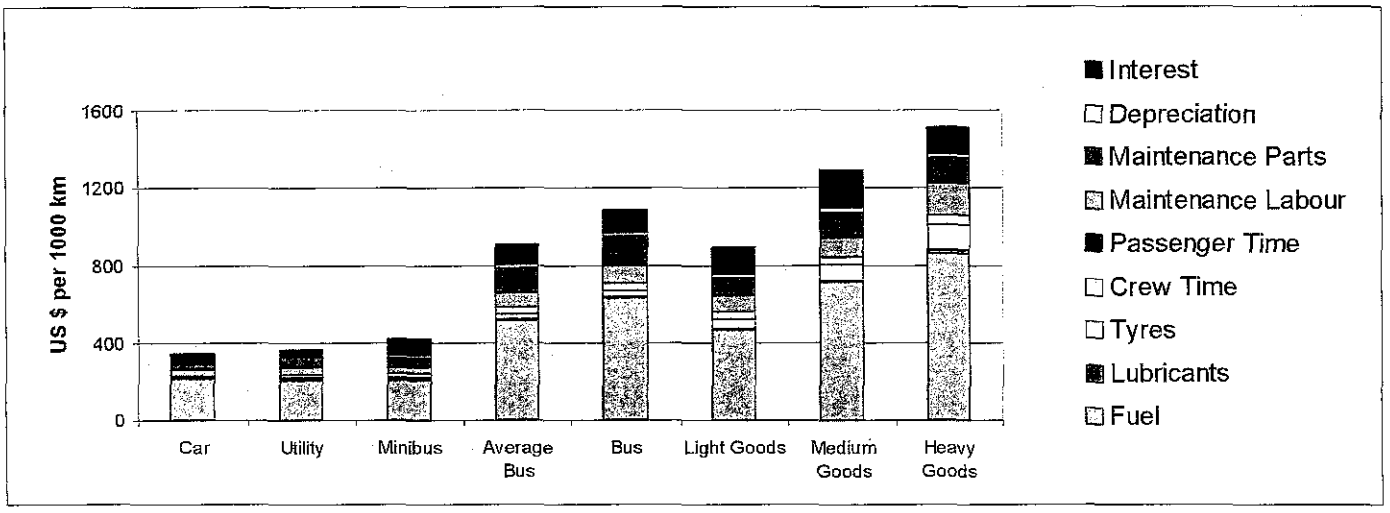


Figure 5.4.8 Vehicle Operating Costs, Nicaragua 2002, US $ per 1000 km

Table 5.4.14 Vehicle Operating Costs and Passenger Costs, Nicaragua 2002

Vehicle type	*Operating Cost per 1000 km, US $*	*Passenger Costs per vehicle hour*
Car	341.9	2.84
Utility	365.6	1.09
Minibus	421.0	5.31
Average Bus	909.8	14.90
Bus	1082.6	18.35
Light Goods	891.9	1.04
Medium Goods	1289.8	1.04
Heavy Goods	1509.8	0.75

2) Traffic Growth Factors

For this study two forecast years have been established : 2010 and 2020 in Table 5.4.15

Table 5.4.15 Traffic Growth Factors to 2010 and 2020

	Growth 2002 to 2010	Growth 2002 to 2020	Functional Description
Cars	1.57	2.74	Population growth x vehicle ownership growth
Pick-ups	1.57	2.74	GDP growth x vehicle ownership growth
Buses	1.29	1.78	Population
Goods (Agriculture)	1.68	2.87	Agriculture Sector Growth
Goods (Other Primary)	1.19	1.60	Other Primary sector growth
Goods (Industry)	1.66	2.79	Industrial sector growth
Goods (Construction)	1.65	2.91	Construction sector growth
Goods (Vacant, other)	1.62	2.70	Average economic growth

Growth in traffic will be very dependant on economic growth. The GDP forecasts are relatively optimistic, predicting a sustained growth in the economy of around 5% over a 20-year period. In order to assess the effects of a lower out-turn growth, a sensitivity test has been developed. In this test, it is assumed that economy grows at 60% of the forecast rates in Table 5.2.1, across all sectors equally. When this reduced growth is converted in to the traffic growth factors, the values in Table 5.4.16 result.

Table 5.4.16 Traffic Growth Factors (Sensitivity Test)

	Growth 2002 to 2010	Growth 2002 to 2020
Cars	1.31	1.83
Pick-ups	1.21	1.48
Buses	1.29	1.78
Goods (Agriculture)	1.21	1.48
Goods (Other Primary)	1.07	1.19
Goods (Industry)	1.20	1.45
Goods (Construction)	1.20	1.48
Goods (Vacant, other)	1.12	1.38

3) Values of Time and Cost

Values of time are expected to rise in line with average GDP per head. The factors to be applied to passenger costs per vehicle hour (Table 5.4.14) are set out in Table 5.4.17. In the Sensitivity test, values of time are forecasted to fall, owing to a decrease in GDP per head, because population is forecast to rise at a higher rate than GDP. Values of cost are held constant at 2002 prices, in US Dollars.

Table 5.4.17 Growth Factors applied to Value of Time, at 2002 US$ values

	2002 to 2010	2002 to 2020
Base Case	1.239	0.924
Sensitivity Test	2.678	0.811

4) Evaluation Parameters

The costs resulting from a disaster on the objective roads are calculated using the gross vehicle-kilometre and vehicle-hour changes for each mode of vehicle, output from the JICASTRADA Traffic Model.

Vehicle-kilometres and vehicle-hours are converted into monetary units using the values of time and cost taken from Tables 5.4.14 and 5.4.17. Other evaluation parameters are listed in Table 5.4.18.

Table 5.4.18 Evaluation Parameters

Parameter	*Value*
Base year for evaluation	2002
Price Base	2002, constant prices
Evaluation period	21 years
Road Maintenance Cost, per km, per year	$,1313
Conversion Factor, construction cost to total capital cost (less than $50,000)	1.92
Conversion Factor, construction cost to total capital cost (more than $50,000)	2.05
Capital Cost Expenditure profile (Permanent Works)	100% in 2003
Capital Cost Expenditure profile (Temporary Works)	100% in 2003, repeated every 3 years
Maintenance costs (Permanent Works)	5% of total capital cost annually
Maintenance costs (Temporary Works)	Zero
Discount Rate	10%

5.4.3 Traffic Demand Forecast

1) General Methodology

The overall demand for traffic movement has been formulated using a combination of data from the traffic surveys and economic growth projection for Nicaragua. The way in which traffic routes on the highway network is forecast using the traffic assignment model JICASTRADA[1].

The key modules in JICASTRADA used in this study were :

Network Editor : to build, modify and test highway networks
OD Matrix Manipulator : to construct traffic demand matrices
Incremental Assignment : to assign traffic to the network
Highway Reporter : to view traffic volumes and network statistics

2) Highway Network

The base year (2002) highway comprises 83 nodes and 113 links and is shown as Figure 5.4.9. Objective roads are shown as red.

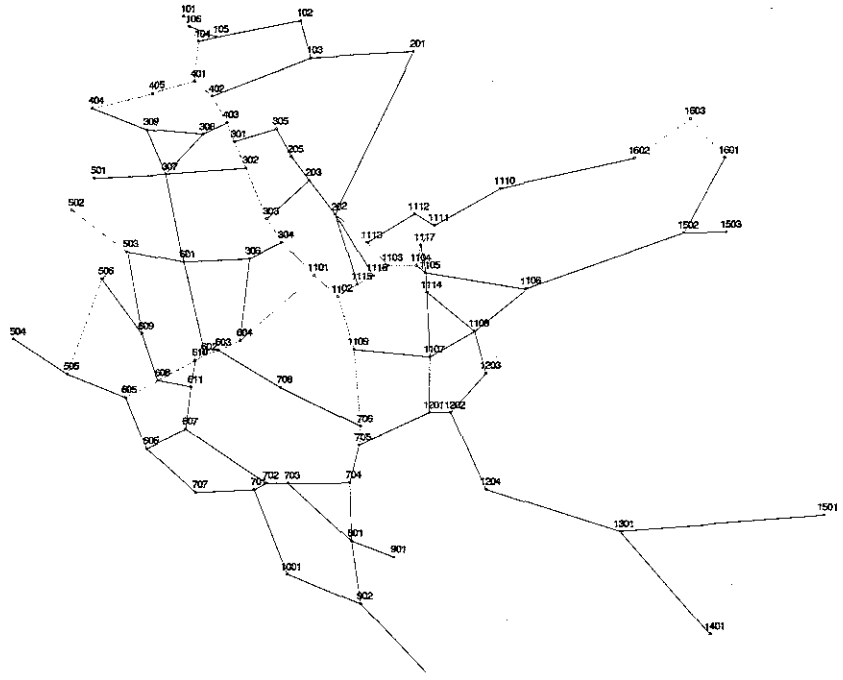


Figure 5.4.9 Base Year Highway Network

(1) JICASTRADA Version 2, International Cooperation Data Service Co., Ltd, JICA, 1997 - 2000

Figure 5.4.10 shows the major roads on the highway network along with place names.

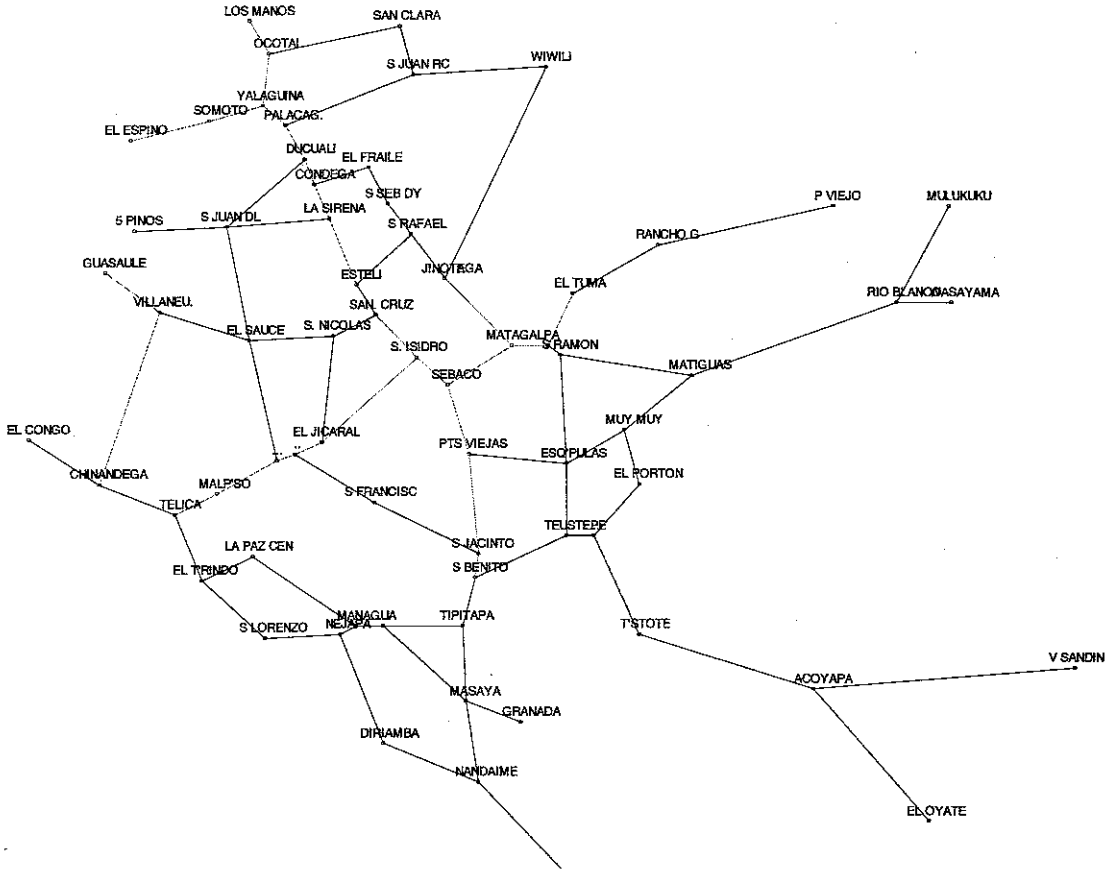


Figure 5.4.10 Base Year Network, Major Roads

All links were coded as to length, maximum velocity, capacity and volume-delay function. QV type 1 was used in each case. There is currently little congestion on the objective roads. Six traffic modes were specified : car(1), utilities/pick-ups(2), buses(3), light goods(4), medium goods(5), and heavy goods(6). Traffic zones (1 to 45) are connected to the network at the nodes listed in Table 5.4.20.

3) Base year matrices

Base year (2002) matrices were constructed from the origin-destination interviews, factored to the traffic counts recorded in June 2002. For modes 1 through 3 the following procedure was adopted. All interviews were entered by site into nine separate matrices. For each mode and each site the matrix was factored to the site count for that mode of traffic. Sites were combined for each mode and double (or treble) counted trips removed. For modes 4 through 6, interview data were entered for each mode into five separate matrices representing :

Table 5.4.20 Zone Connectors

Zone	Name	Node Connector
1	Ocotal	104
2	San Fernando	102
3	Honduras via Los Manos	101
4	Yalagüina	405
5	Honduras via El Espino	404
6	Quilali	103
7	Wiwili	201
8	R.A.A.N.	1601
9	La Cruz del Rio Grande	1503
10	La Dalia	1108
11	Matagalpa	1103
12	Telpaneca	402
13	Jinotega	202
14	La Concordia	203
15	Condega	301
16	Esteli	303
17	La Trinidad	304
18	San Juan de Limay	307
19	Honduras via Guasaule	502
20	Villanueva	503
21	Tonalá	504
22	Chinandega	505
23	Sebaco	1102
24	El Sauce	601
25	El Jicarol	604
26	Malpaisillo	608
27	Leon	605
28	La Paz Centro	606
29	Managua	701
30	Masaya	801
31	Carazo	1001
32	Granada	901
33	Rivas	902
34	Costa Rica	1701
35	Tipitapa	704
36	San Francisco Libre	708
37	San Jacinto	706
38	San Benito	705
39	Ciudad Dario	1109
40	Boaco	1202
41	Esquipulas	1107
42	Muy Muy	1106
43	Chontales	1301
44	Rio San Juan	1401
45	Bluefields	1501

construction(1), industry(2), other primary(3), vacant/other(4), and agriculture(5). Because the matrices of interview data were small for each commodity type they were combined by mode and calibrated against the traffic counts at the nine sites.

4) Base Year Traffic Estimates

The base year validation is shown in Table 5.4.21. Note that the model is not valid away from the objective roads.

Table 5.4.21 Base Year Validation, 12 hour Vehicle flows, June 2002

Site		*Car/Taxi*	*Utilities*	*Buses*	*Light Goods*	*Medium Goods*	*Heavy Goods*	*Total*
1	Observed	255	317	286	133	158	259	1408
	Synthesised	257	325	282	123	89	179	1255
2	Observed	164	300	134	63	85	35	780
	Synthesised	170	308	126	126	79	38	847
31	Observed	224	335	91	105	122	66	942
	Synthesised	209	360	112	104	119	64	968
32	Observed	164	309	89	103	38	2	704
	Synthesised	165	328	97	100	46	27	763
4	Observed	97	288	81	120	18	14	617
	Synthesised	112	284	90	131	62	35	714
5	Observed	392	788	241	173	137	67	1796
	Synthesised	389	706	228	222	157	90	1792
6	Observed	472	763	294	398	137	39	2101
	Synthesised	550	936	266	366	131	110	2359
7	Observed	394	711	212	305	128	40	1789
	Synthesised	381	678	229	251	118	49	1706
8	Observed	559	1160	295	303	168	118	2602
	Synthesised	515	1193	261	326	142	111	2548
Total	Observed	2719	4970	1722	1700	989	637	12736
	Synthesised	2748	5118	1691	1749	943	703	12952

The base year 12 hour matrices were factored to AADT volumes in accordance with the data set out in Chapter 10. For information, these matrices were assigned to the network, and the resultant traffic estimates are shown in Figure 5.4.11. Network data for 2002 are set out in Table 5.4.22. Full matrices are shown in the Appendix-4.

Figure 5.4.11 2002 Estimated AADT Flows

Table 5.4.22 Base Year (2002) Network Statistics, Estimated AADT

Mode	*Vehicle Hours*	*Vehicle kms*	*Average Speed (km/hr)*	*Total Trips*	*Average Trip Length (km)*
Car (1)	4069	253954	62.4	2367	107.3
Utlilities (2)	7111	443443	62.4	4409	100.6
Buses (3)	2614	157487	60.2	1419	111.0
Light Goods (4)	3099	191994	62.0	1515	126.7
Medium Goods (5)	1731	107714	62.2	726	148.4
Heavy Goods (6)	1479	88568	59.9	546	162.2
Total	20103	1243160	61.8	10982	113.2

5) Forecast Year Traffic

Forecast traffic demand matrices have been prepared for three years : 2003, 2010 and 2020, using the factors derived in Section 5.4.2. In the traffic surveys, no interviews were carried out on NIC 5 and so trips were added to the validation matrices between Zone 10 (La Dalia) and Zone 11 (Matagalpa) to match traffic counts taken by MTI in 2001. The trip totals in each forecast matrix are summarised in Table 5.4.23.

Table 5.4.23 Forecast Year AADT Totals by Mode

Vehicles/ Year	2003	2010	2020
Cars	2493	3711	6521
Pick-ups	5006	7351	12811
Buses	1523	1939	2654
Light Goods	1533	2481	4136
Medium Goods	889	1432	2412
Heavy Goods	581	669	1539
Total	12028	17613	30073

Figures 5.4.12, 5.4.13 and 5.4.14 show traffic assignments for the three forecast years. Network statistics are shown in Table 5.4.24.

Figure 5.4.12 Traffic Forecast, 2003, AADT

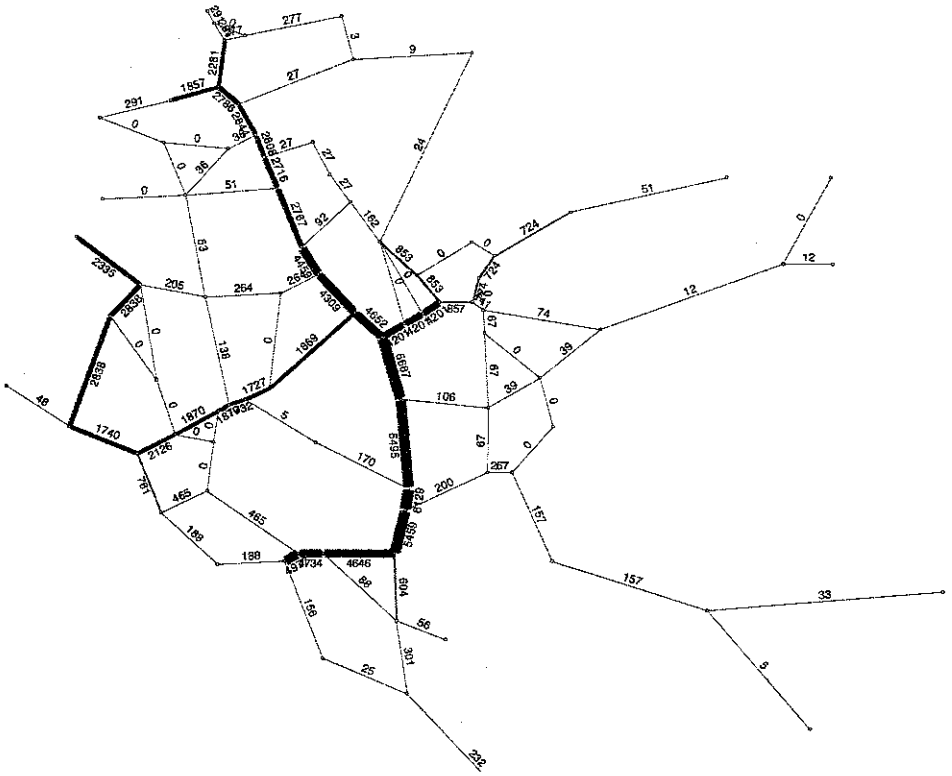


Figure 5.4.13 Forecast Traffic, 2010, AADT

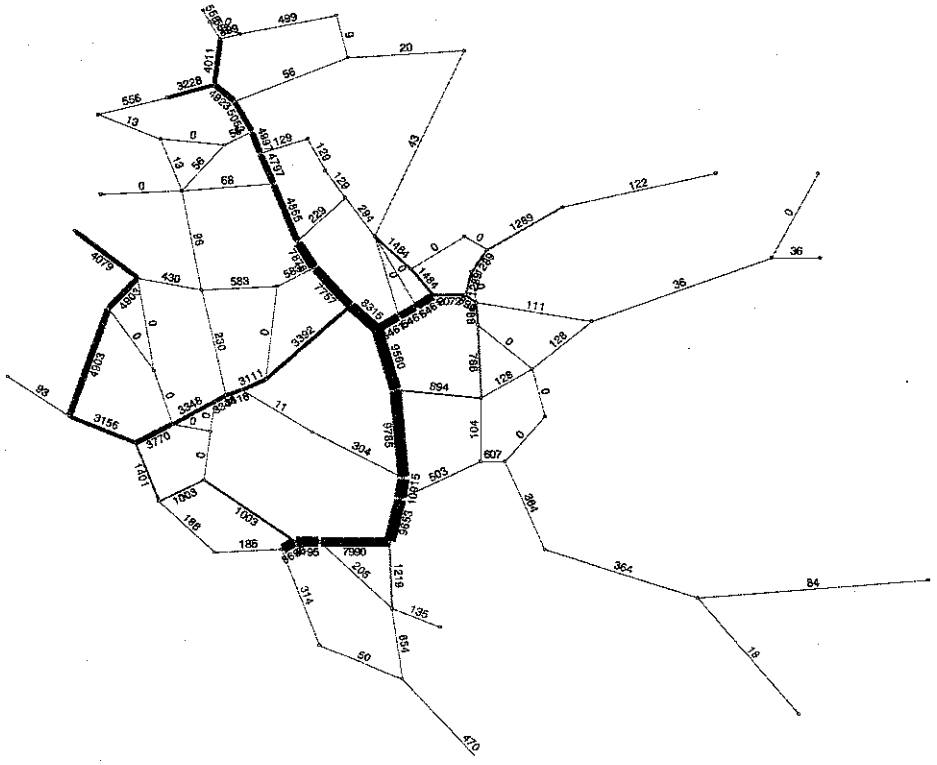


Figure 5.4.14 Forecast Traffic, 2020, AADDT

Table 5.4.24 Network Statistics for Forecast Year Traffic

Mode	2003		2010		2020	
	Vehicle Hours	Vehicle Km	Vehicle Hours	Vehicle Km	Vehicle Hours	Vehicle Km
Cars	4299	268075	6167	391813	11365	713975
Pick-ups	7586	472217	10991	691648	19747	1230257
Buses	2686	161758	3136	199148	4340	271850
Light Goods	3133	193383	4938	309370	9042	560748
Medium Goods	2121	131812	3105	199683	6042	379385
Heavy Goods	1560	93606	1684	107094	4146	260251
Total	21387	1320851	30021	1898756	54682	3416466

5.4.4 Evaluation of Traffic Forecasts

1) General Methodology

The traffic benefits that would result from disaster prevention measures are evaluated by calculating the dis-benefits to traffic of a disaster occurring. It is assumed that at each site a disaster would result in the closure of that particular link in the network and the need for traffic to re-route. When traffic re-routes to avoid the closed link it potentially incurs two types of dis-benefit:

- increased vehicle operating costs due to additional distance; and
- increased passenger time costs.

These two parameters are evaluated by the JICASTRADA model in aggregate over the network for each vehicle mode, in the form of vehicle-kilometres and vehicle-hours. These are converted to monetary costs using the parameters set out in Table 5.4.14. These are then expressed as the benefits of undertaking disaster prevention measures.

The costs of disaster prevention measures are expressed in terms of the capital cost of works (assumed to be incurred in 2003) and the continued maintenance cost of the link. The costs of temporary prevention measures are assumed to recur every three years. Permanent measures incur a single capital cost, but annual maintenance costs thereafter.

The benefit flow is not guaranteed to occur, because disaster may not strike, even if no preventative measures are taken. There is a probability that disaster will occur, which is used to affect the benefit stream. Preliminary engineering inspections of the sites have resulted in two parameters used to affect the benefit stream. These are:

- A maximum life of the road, if no preventative measures are taken. This varies from 1 year to 20 years, and reflects the risk of disaster occurring. Benefits only accrue

after the life time has ended;

- An indicator of the stability of the slope or bridge foundation which varies from 70 to 100. This score is used to factor down the benefits, which then accrue each year after disaster prevention works have been implemented.

An example calculation sheet for evaluating costs and benefits is shown as Figure 5.4.15.

Figure 5.4.15 Example Cost/Benefit Calculation Sheet

Average B/C	16.4	Cost-Benefit Analysis											
													Base Case
Site No	39		A-Node	106	B-Node	105					Maintenance Cost per km		
Site Name	NIC 15, 13.6		Link Length (km)			9					1340		
Type of Disaster	Debris Flow		Permanent/Temporary (P/T)		T						By Risk	B/C	
Discount Rate (%)	10		Discount Period		21								
Risk : Without Prevention Measures Road will fail in						years					By Score	B/C 16.45	
Score	70		Benefit Factor	70									
	2003		2010		2020								
Mode	Base	Disaster	Base	Disaster	Base	Disaster							
1	268075	268863	391813	392629	713975	715475					AADT	Cars	
2	472217	472951	691648	692847	1230257	1232213					Vehicle	Pick-ups	
3	161758	161914	199148	199328	271850	272054	<---				Kilometres	Buses	
4	193383	193522	309370	309600	560748	561418					input from	L Goods	
5	131812	132436	199683	200627	379385	381125					JICASTRADA	M Goods	
6	93606	94038	107094	107604	260251	261354					Traffic Model	H Goods	
Veh. Op Cost			Benefits, US $, per year										
1000 km		2003		2010		2020					Capital Cost		
341.9	588	73379	816	101831		187190					$		
365.6	734	97948	1199	159999		261016					119169		
909.8	156	51804	180	59774		67744							
891.9	139	45251	230	74875		218114							
1289.8	624	293765	944	444413		619152							
1509.8	432	238065	510	281049		607838							
Total		800211		1121942		2161054							
1	4299	4326	6167	6200	11365	11432					AADT	Cars	
2	7586	7612	10991	11023	19747	19813					Vehicle	Pick-ups	
3	2686	2693	3136	3143	4340	4350	<---				Hours	Buses	
4	3133	3133	4938	4933	9042	9043					input from	L Goods	
5	2121	2142	3105	3136	6042	6090					JICASTRADA	M Goods	
6	1560	1580	1684	1707	4146	4194					Traffic Model	H Goods	
Passenger			Benefits, US $, per year										
VOT, 2002		2003		2010		2020							
2.84	27	28744	33	42383		185993							
1.09	26	10623	32	15774		70319							
14.9	7	39097	7	47168		145643							
1.04	0	0	-5	-2352		1017							
1.04	21	8187	31	14580		48795							
0.75	20	5623	23	7801		35189							
Total		92274		125355		486956							
Value of Time	Base	1.027		1.239		2.678							
Factors	Sensitivity	0.97		0.924		0.811							

Year	Capital Cost US$	Maintenance Cost (US$)	Total Cost (US $)	Total Discounted Cost	Veh Km Benefits	Veh Hour Benefits	Risk Prof	Total Benefits	Discounted Benefits By Risk	Total Benefits	Discounted Benefits By Score
2002											
2003	119169		119169	107252	800211	92274	0	0	0	0	0
2004	0	12060	12060	9768	846173	97000	0	0	0	660221	534779
2005	0	12060	12060	8792	892134	101726	0	0	0	695702	507167
2006	119169	12060	131229	86099	938096	106452	0	0	0	731183	479729
2007	0	12060	12060	7121	984058	111178	0	0	0	766665	452708
2008	0	12060	12060	6409	1030019	115903	0	0	0	802146	426293
2009	119169	12060	131229	62766	1075981	120629	0	0	0	837627	400634
2010	0	12060	12060	5191	1121942	125355	0	0	0	873108	375844
2011	0	12060	12060	4672	1225854	161515	0	0	0	971158	376247
2012	119169	12060	131229	45757	1329765	197675	0	0	0	1069208	372810
2013	0	12060	12060	3784	1433676	233835	0	0	0	1167258	366298
2014	0	12060	12060	3406	1537587	269995	0	0	0	1265308	357360
2015	119169	12060	131229	33357	1641498	306156	0	0	0	1363358	346547
2016	0	12060	12060	2759	1745410	342316	0	0	0	1461408	334323
2017	0	12060	12060	2483	1849321	378476	0	0	0	1559458	321078
2018	119169	12060	131229	24317	1953232	414636	0	0	0	1657508	307139
2019	0	12060	12060	2011	2057143	450796	0	0	0	1755557	292778
2020	0	12060	12060	1810	2161054	486956	0	0	0	1853607	278217
2021	119169	12060	131229	17727	2161054	486956	0	0	0	1853607	250395
2022	0	12060	12060	1466	2161054	486956	0	0	0	1853607	225355
2023	0	12060	12060	1320	2161054	486956	0	0	0	1853607	202820
Total	834,183	241,196	1075379	438,268				0	0	25,051,302	7,208,522

2) Simulation of Disaster Sites in Traffic Model

Figure 5.4.16 shows the locations of 55 potential disaster sites in the traffic model network. These are located on the model links listed in Table 5.4.25.

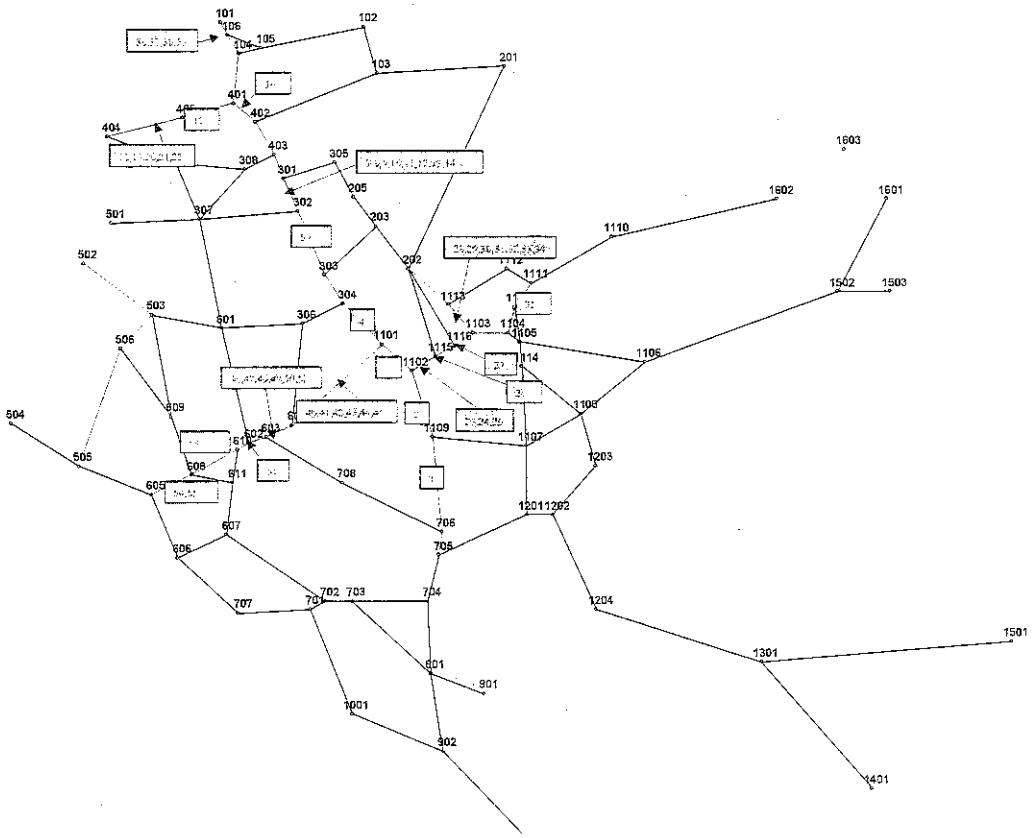


Figure 5.4.16 Disaster Sites

Table 5.4.25 Potential Disaster Links in Traffic Model

Link	A-Node	B-Node	Sites	Link	A-Node	B-Node	Sites
1	101	104	36,37,38,39	40	602	603	51
6	405	401	17	41	602	610	53,55
7	405	404	18,18,20,21	42	605	608	52
8	401	402	16	55	1102	1109	2
14	301	302	7,8,9,10,11,12,13,14,15	57	1109	706	1
22	302	303	5,6	82	1117	1111	35
32	304	1101	4	83	1115	1116	26
33	1101	1102	3	90	1102	1115	23,24,25
37	1101	604	40,41,42,43,44,45	91	1116	1103	27
38	603	604	46,47,48,49,50,54	94	1113	1103	28,29,30,31,32,33,34

Disaster sites were evaluated by removing the relevant link identified in Table 5.4.25 and performing a traffic assignment. Figure 5.4.17 shows an example for Sites 28 through 34, located on Link 94, the road between Matagalpa and Jinotega. A disaster in 2010 is forecast to result in the traffic flows shown below.

Figure 5.4.17 Forecast AADT Volumes, 2010, No Link 94

Network statistics for each vehicle type were extracted from JICASTRADA for the years 2003, 2010 and 2020 and input into the evaluation sheet. Data for intermediate years were estimated by linear interpolation. Benefits for years after 2002 were held constant at 2002 values. Benefit to cost ratios for each site were calculated and are shown in Table 5.4.26 and Figure 5.4.18.

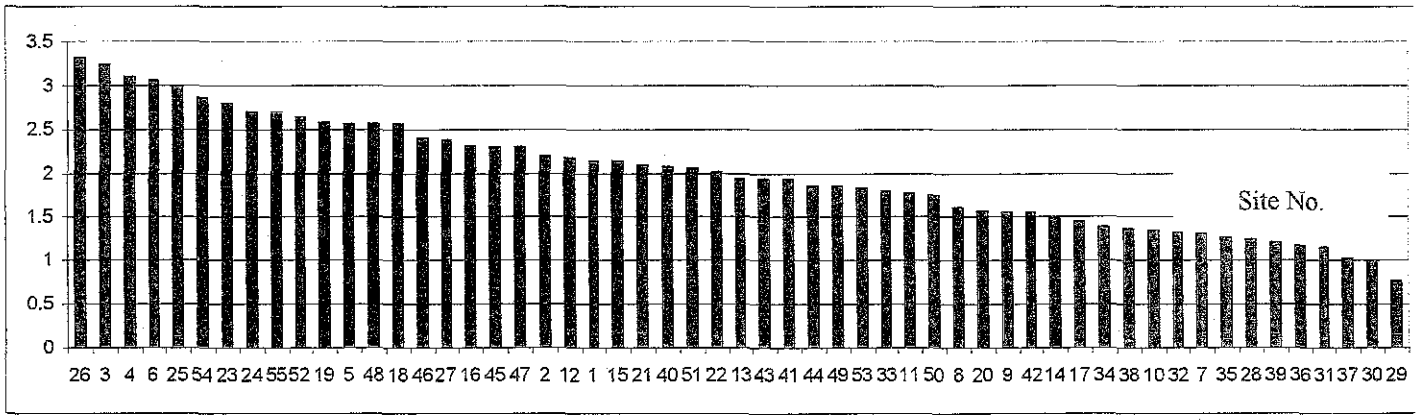


Figure 5.4.18 Cost/Benefit Ratios of Disaster Sites (Log-scale)

Table 5.4.26 Benefit to Cost Ratio by Disaster Site

Site	Benefit to Cost Ratio
1	137
2	153
3	1720
4	1240
5	365
6	1155
7	20
8	41
9	36
10	22
11	59
12	146
13	85
14	31
15	134
16	202
17	28
18	353
19	374
20	37
21	121
22	103
23	613
24	500
25	1001
26	2083
27	238
28	18
29	6
30	10
31	14
32	21
33	62
34	25
35	18
36	14
37	11
38	23
39	16
40	115
41	85
42	35
43	85
44	71
45	200
46	245
47	197
48	361
49	70
50	55
51	112
52	436
53	69
54	730
55	488

It has not been possible to carry out all the sensitivity tests with lower levels of traffic. Table 5.4.27 shows the comparison of benefit to cost ratio for eight sites for the Base case and Sensitivity Test levels of traffic. The benefit to cost ratios remains relatively high, even under lower-growth assumptions regarding traffic.

Table 5.4.27 Sensitivity Tests on Benefit to Cost Ratio

Site Number	*Benefit to Cost Ratio*	
	Base Case	*Sensitivity*
2	153	111
17	28	20
23	613	463
24	500	378
25	1001	757
36	14	10
37	11	7
38	23	16

3) Incorporation of Risk

Whilst the benefits reported in former section 2) are useful in preparing priorities for investment, they cannot be considered as *absolute* values. This is because, at this stage, the element of risk has not been considered. The benefits above all assume that without countermeasures, a disaster would strike in by the end of the year 2003. This is extremely unlikely, and furthermore the risk element varies from site to site. This factor will be incorporated in the next stage of work.