## Recent Project Evolution (1990-1993)

1992

- Further Studies of Tren Urbano Phase I
  - Alignment/Station Locations
  - Financial/Economic Studies
  - Intermodal Integration
  - Plan & Profile
- Public Awareness & Support for the System

## Recent Project Evolution (1990-1993)

1993

- Under Tren Urbano Office Direction
  - Further Alignment Refinement & Evaluation
    - Río Piedras subway alignment: to bring rail service closer to the center of the UPR/business district
    - Bayamón & Hato Rey segments also revised
  - Additional Yard & Station Location Studies
  - Revisions to Plan & Profile

## Creation of Tren Urbano Office (1993-94)

- Analysis of Proposed Alignment
- Analysis of Station Location, Design, and Operation
- Provide Urban Policy/Perspective
- Promote socio-economic development, quality of urban life and related public policy.

## Tren Urbano Capacity Characteristics

- 180 passengers/vehicle
- 4 vehicles/train (expandable to 6)
- headway: 2 minutes (30 trains/hour)
- 10,800 passengers/track/hour
- train length: 260 feet (four vehicles)
- capital cost ($25 million/km)
- 140,000 passengers/day in 2010 assuming extensions to Carolina

## Conclusions

- An integrated, coordinated mass transportation system with a rail transit component is a must for SJ Region's social and economic success and the quality of life of its habitants.
- The proposed alignment is an acceptable compromise taking into consideration the technical, social, and political impacts.

## Conclusions

- Technical, environmental, and social aspects which are not clear and need further refinement
  - Natural Resources Impacts
  - Public Parks/Recreational Facilities
  - Displacements
  - Noise, Vibration, Aesthetics
  - Future Development Potential
  - Utility Disruption

## Recommendations

- Strong active participation of the community is essential for proper definition and success of the system.
- Marketing of the immediate and future benefits of Tren Urbano to all levels is critical.

## Recommendations

- Assess role of the Público system and establish realistic performance goals
- Emphasize intermodal/pedestrian accessibility & ease of transfer
- Establish parking policies to discourage auto usage in adjacent areas served by the system
- Fare structure must be carefully evaluated.
- Planning should keep sight of the long range perspective (50 years or more).

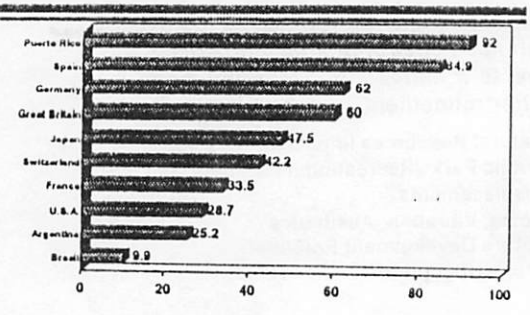
## Acknowledgments


- University of Puerto Rico-Mayagüez
- Department of Transportation and Public Works
- Highway and Transportation Authority

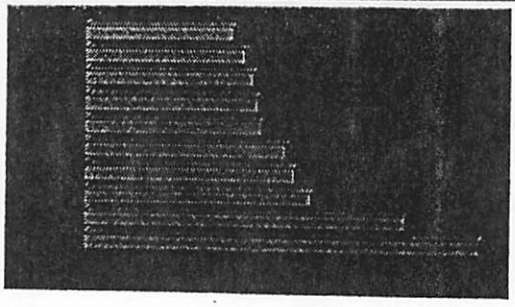

## Conclusions

- Most important alignment selection criteria:
  - Availability of Right of Way
  - Concensus among all political parties
  - Accept by faith that previous alignment studies are still the most cost-effective in a life cycle cost analysis
  - Start by stages
  - Its now or never!

## Vehicles/Kilometer of Highway




## Density in Urbanized Areas (person/acre) without rail transit system (1988-90)



## Major Transportation Studies: Rail Transit for San Juan

- 1964-1967: Wilbur Smith & Associates/Padilla & Associates
- 1979: Consultores Técnicos Asociados/Alan M. Voorhees & Associates
- 1990-1993: Barton-Aschman Associates/Parsons-DeLeuw

## Wilbur Smith & Associates (1967)
Report Highlights

- Planning Horizon:1985
- Population: 1.75 million
- Car ownership: 1 per household
- Four land-use alternatives
  - Sprawl
  - Strong Center Santurce
  - Strong Center Hato Rey
  - Multi-Center
- Product: SJMA Regional Plan

## Wilbur Smith & Associates (1967)
Recommended Plan (transit)

- Two rapid transit routes
  - crossing in Hato Rey to reinforce it as the Regional Core
  - 1/4 area being served
  - 2/3 future employment
  - 1/3 future population
  - multi-center service
- Extensive Bus System, complemented by Públicos

## Wilbur Smith & Associates (1967)
Rapid Transit System

- Routes
  - Old San Juan-Cupey Alto
  - Bayamón-Carolina
- Length: 27.07 miles
- No. Stations: 36
- Avg. station spacing: 0.752 mi (3,970 ft.)

## CTA/ Alan M. Vorhees (1979)
Study Objective

- Identify locally preferred (best) alternative among:
  - Rapid rail system alternatives & different alignment locations
  - Light rail or express bus technologies
  - Low capital alternatives based on TSM (i.e., traffic engineering, land use regulations, etc.)

## CTA/Alan M. Vorhees (1979)
Report Highlights

- Population density and urban structure make San Juan rail system the most justified in the U.S.
- There does not appear to be a reasonable alternative to rapid transit as a central element of the Regional Plan.
- Total capital and operating cost is in the order of $0.10 to $0.13/public transit passenger mile; lowest in the US

## CTA/Alan M. Vorhees (1979)
Report Highlights

- No full system is likely to be built as a single project.
  - Funding limitations require that implementation be conducted in stages.
- Initial alignment recommended (inverted C)
  - Rapid rail technology, feeder service, and TSM projects (busways and priority lanes) for buses

## Barton-Aschman/PDI (1993)
Report Highlights

- Dramatic improvements in the bus or público systems, or in highways by themselves, will not effectively serve the projected 45% increase in traffic volumes by 2010.
- Supports the general alignment of the first phase as defined in 1979.

## Independent Studies
Multisystems (1993)

- Findings
  - No fundamental flaws in Barton-Aschman/PDI studies
- Recommendations
  - New financing strategies
  - Further alignment and station evaluation
  - Developed more detailed mass transportation plan with emphasis on effective coordination and integration

## Decision-making vs. Implementation

- An alternative may be
  - technologically & environmentally feasible
  - economically efficient
  - cost-effective
- but may not be implemented due to
  - high initial investment costs
  - unavailability of financial resources at critical time periods
  - convincing all parties of the definition of benefits not quantifiable in dollar terms

## Impact of Delaying Rail Rapid Transit Implementation

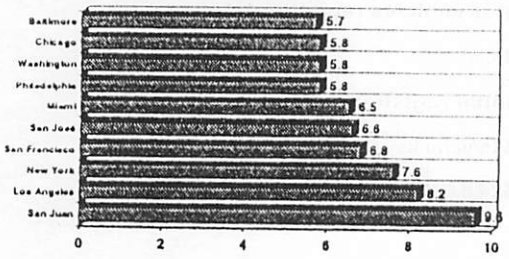
- Full Rail Rapid System: (27 miles; 36 stations)
  - 1967: $231,837,000
  - 1969: $380,640,000
  - 1975: $ 1 billion
- Tren Urbano (LRT)-Phase I (12.1 miles; 18 stations)
  - 1994: $1 billion

## Recent Project Evolution
(1990-1993)

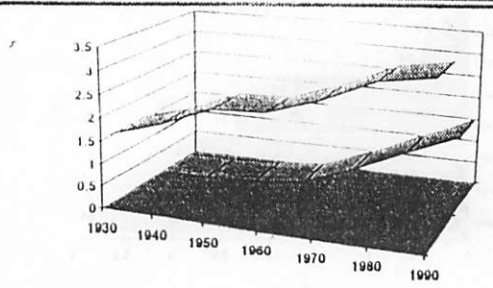
1991

- "Metroliviano" of San Juan: Preliminary Alignment
  - Cost estimates of 20 feasible LRT routes
  - Site visits included
  - Confirms 1979 "Inverted C" alignment
- Cost Estimates – Preliminary Alignment for "Tren Urbano" (PDI)

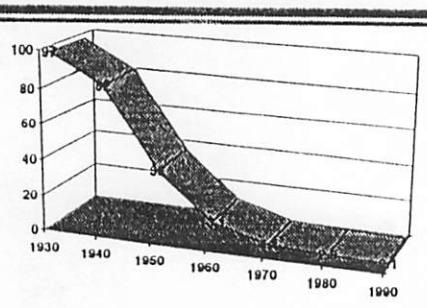
## Density in Urbanized Areas (person/acre) SJ vs. Cities with Rail Transit System (1988-90)



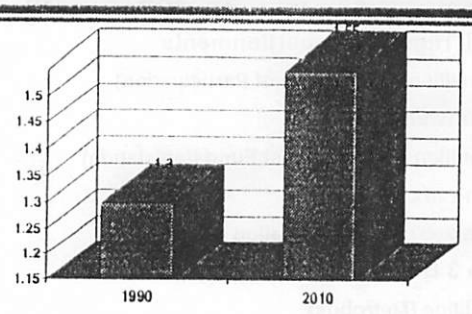

## Relation of Population and Motor Vehicle Registration (1930-1990)



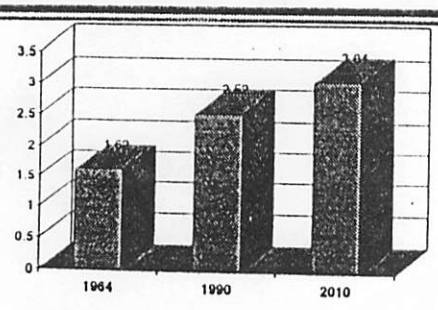

## Persons per Motor Vehicle Registered (1930-1990)



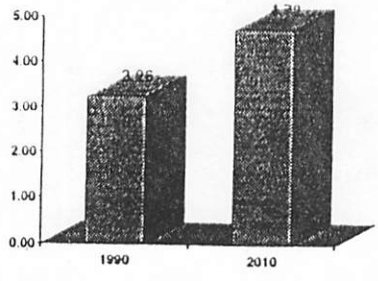

## Regional Population Forecasts (Millions of People)



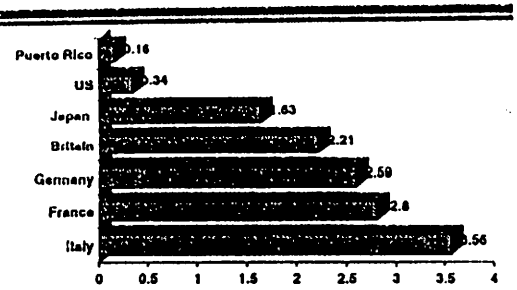

## Growth in Daily Person - Trips/Capita




## Regional Travel Forecast (million person-trips)



## Gasoline Taxes Paid in Selected Countries ($/gallon)




## Motor Vehicle Statistics

- Motor vehicles registered
  - 1,650,000
- Annual registration fees
  - $15/vehicle
  - $24.8 million/year

## Funds-Phase I Critical Assumptions

- Federal Highway Apportionments
  - $300 million (Certificates of Participation)
- Commonwealth
  - $60 million Highway Trust Fund (legislation)
- Gasoline tax
  - 1998 & 2003: 2.5 cents/gallon
- Section 3 Bus Discretionary Funds
  - $32 million (Metrobús)

TABLE 3
CRITERIA USED TO EVALUATE MAJOR TRANSIT INVESTMENTS—FEDERAL TRANSIT ADMINISTRATION

| General Category | Criteria[1] | Measures |
|---|---|---|
| 1. Transportation System Performance | • Highway Congestion | Change in level of service, V/C ratio<br>Change in VMT<br>Change in hours of delay |
| | Parking | Change in number of CBD spaces required |
| | • Transit Service improvements | Population with reduced/increased travel time<br>Passenger miles on reserved right-of-way<br>Percentage of riders who transfer |
| | Ridership | Increase in number of daily riders<br>Increase in person-miles of travel |
| 2. Mobility | Travel time savings | Hours of time saved (work/nonwork) |
| 3. Accessibility | Accessibility (general) | Population within __ feet of transit stop<br>Jobs within __ feet of transit stop |
| | Accessibility (transit dependent) | Population within __ feet of transit stop<br>Services within __ feet of transit stop |
| 4. System Development, Coordination and Integration | Feeder bus system<br>Intermodal linkages | |
| 5. Land Use | Impact on development | Barriers to development<br>Change in accessibility<br>Resulting change in development patterns |
| | Community support | Supportive land use policies |
| | Consequences of development | Environmental, fiscal |
| | Joint development opportunities | Underdeveloped acreage within __ feet of transit stop |
| 6. Freight | Railroad | Impact on freight movements |
| | Trucking | Impact on deliveries |

Note: [1]No specific set of criteria is required by the FTA. This list is typical of studies.

CRITERIA USED TO EVALUATE MAJOR TRANSIT INVESTMENTS—FEDERAL TRANSIT ADMINISTRATION (*Continued*)

| General Category | Criteria | Measures |
|---|---|---|
| 7. Socioeconomic | Economic development | Construction jobs created<br>Operations jobs created<br>Multiplier effects |
| | Displacement and relocation | Number of residents affected<br>Number of jobs affected |
| | Neighborhood impacts | Cumulative impacts |
| | Historic and cultural sites | Identification and review of sites |
| | Parklands | Identification and review of sites |
| 8. Environmental | Air quality | Tons of emissions/day<br>New violations of NAAQS<br>Conformity with SIP |
| | Noise and vibration | Increase in noise levels<br>Violations of noise standards |
| | Ecosystems | |
| | Water | |
| | Visual | |
| 9. Energy | Energy conservation | BTUs for construction and operations<br>Payback period |
| 10. Safety and Security | Auto accidents | Number of accidents prevented |
| | Security | |
| 11. Equity | Who pays? Who benefits? | Farebox recovery ratio<br>Subsidy per trip |
| 12. Costs | Capital costs | Dollars |
| | O&M costs | Dollars/year |
| 12a. Efficiency | Cost-effectiveness | Added cost/new rider<br>Added cost/hour of time savings |
| | Operating efficiency | Change in O&M cost per passenger |
| 13. Financial Arrangements | Local share of capital costs | Percentage of capital cost |
| | Capital finance plan | Soundness |
| | O&M finance plan | Stability and reliability<br>Farebox recovery ratio<br>Subsidy per trip |
| 14. Institutional Factors | Community support | Financial commitments<br>Supporting land use and transportation policies |
| Other | Trade-offs summary | |

TABLE 4
EVALUATION CRITERIA ADAPTED FROM ABRAMS AND DI RENZO (10)

| General Category | | Criteria[1] | Measures[2] |
|---|---|---|---|
| 1. | Transportation System Performance | Capacity | |
| | | • Volume to capacity | V/C ratio[3] |
| | | • Level of service | A - F[3] |
| | | Pedestrian and bicycle use | Counts[3] |
| | | Transit use | |
| | | • Number of passengers | Passengers[3] |
| | | • Passenger miles of travel | PMT[3] |
| | | Auto use | |
| | | • Person miles of travel | PMT[3] |
| | | • Traffic volumes | Volume[3] |
| | | • Vehicle miles of travel | VMT[3] |
| | | Reliability | |
| | | • Freeway incident delay | Vehicle hours[3] |
| | | • Transit schedule adherence | % on time[3] |
| | | Comfort and convenience | |
| | | • Frequency of transit service | Headways[3] |
| | | • Transfers per transit passenger | Number[3] |
| | | • Access/egress time, auto or transit | Time[3] |
| 2. | Mobility and Accessibility | Travel time | |
| | | • Point-to-point travel time | Time[3] |
| | | • Person hours of travel | Time[3] |
| 3. | System Development, Coordination and Integration | – | – |
| 4. | Land Use | – | – |
| 5. | Freight | – | – |
| 6. | Socioeconomic | Displacement | Acres[3] |
| | | | Number of structures[3] |
| | | Economic impacts | |
| | | • Sales | Dollars[3] |
| | | • Employment | Number[3] |
| 7. | Environmental | Noise | Noise level[3] |
| | | Air pollution | Tons of emissions[3] |
| 8. | Energy | Energy consumption | BTUs[3] |
| 9. | Safety | Safety | Accidents/million vehicle miles[3] |
| | | Security | Crimes/million passengers[3] |
| 10. | Equity | Equity | Population within 0.25 miles of bus route[3] |
| | | | Transportation disadvantaged ridership[3] |
| 11. | Costs and Cost-effectiveness | Productivity | |
| | | • Operating cost per passenger trip | $/trip[3] |
| | | • Passenger revenue per vehicle hour | $/vehicle hour[3] |
| | | • Revenue vehicle miles per revenue vehicle | Miles/vehicle[3] |
| | | Costs | |
| | | • Point-to-point transit fares | $[3] |
| | | • Point-to-point out-of-pocket travel costs | $[3] |
| | | O&M costs | $[3] |
| | | Capital costs | $[3] |
| 12. | Financial Arrangements | – | – |
| 13. | Institutional Factors | – | – |
| 14. | Other | – | – |

Note: [1]In original references, the major criteria categories were termed objectives.
[2]Units were not always provided.
[3]Quantitative criteria

## TABLE 2.1
## POPULATION BY MUNICIPIO, 1970 TO 1990

| | Bayamón | Loíza & Canovanas | Carolina | Cataño | Dorado | Guaynabo | Río Grande | San Juan | Toa Alto | Toa Baja | Trujillo Alto | Naranjito | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 156,192 | 39,062 | 107,643 | 26,459 | 17,388 | 67,042 | 22,032 | 463,242 | 18,964 | 46,384 | 30,669 | 19,913 | 1,014,990 |
| 1980 | 196,206 | 52,747 | 165,954 | 26,243 | 25,511 | 80,742 | 34,283 | 434,849 | 31,910 | 78,246 | 51,389 | 23,636 | 1,201,716 |
| 1990 | 220,262 | 66,123 | 177,806 | 34,587 | 30,759 | 92,886 | 45,648 | 437,745 | 44,101 | 89,454 | 61,120 | 27,914 | 1,328,405 |

## TABLE 2.2
## PERCENT OF REGIONAL POPULATION BY MUNICIPIO, 1970 TO 1990

| | Bayamón | Loíza & Canovanas | Carolina | Cataño | Dorado | Guaynabo | Río Grande | San Juan | Toa Alto | Toa Baja | Trujillo Alto | Naranjito | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1970 | 15.39% | 3.85% | 10.61% | 2.61% | 1.71% | 6.61% | 2.17% | 45.64% | 1.87% | 4.57% | 3.02% | 1.96% | 100.0% |
| 1980 | 16.33% | 4.39% | 13.81% | 2.18% | 2.12% | 6.72% | 2.85% | 36.19% | 2.66% | 6.51% | 4.28% | 1.97% | 100.0% |
| 1990 | 16.58% | 4.98% | 13.38% | 2.60% | 2.32% | 6.99% | 3.44% | 32.95% | 3.32% | 6.73% | 4.60% | 2.10% | 100.0% |

Table 2.3
BASE YEAR EMPLOYMENT

| Municipio | Total | Basic | Retail | Service | Government |
|---|---|---|---|---|---|
| Bayamón | 46,931 | 23,431 | 9,202 | 8,841 | 5,457 |
| Canovanas/Loíza | 9,092 | 5,008 | 806 | 1,560 | 1,718 |
| Carolina | 34,710 | 19,029 | 6,044 | 5,980 | 3,657 |
| Cataño | 7,072 | 4,840 | 375 | 939 | 918 |
| Dorado | 6,341 | 3,057 | 417 | 2,296 | 571 |
| Guaynabo | 26,068 | 16,331 | 4,199 | 3,890 | 1,648 |
| Río Grande | 3,784 | 2,393 | 433 | 397 | 561 |
| San Juan | 256,617 | 80,643 | 35,283 | 76,847 | 63,844 |
| Toa Alta | 2,702 | 1,985 | 166 | 134 | 417 |
| Toa Baja | 9,619 | 6,403 | 1,399 | 725 | 1,092 |
| Trujillo Alto | 6,587 | 4,171 | 812 | 1,150 | 454 |
| NARANJITO | 2,939 | 317 | 691 | 529 | 1,402 |
| REVISED TOTAL | 412,462 | 167,608 | 59,827 | 103,288 | 81,739 |

## Table 2.4
## PERCENT OF EMPLOYMENT TYPE BY MUNICIPIO - 1990

| Municipio | Total | Basic | Retail | Service | Government |
|---|---|---|---|---|---|
| Bayamón | 11.4% | 14.0% | 15.4% | 8.6% | 6.7% |
| Canovanas/Loíza | 2.2% | 3.0% | 1.3% | 1.5% | 2.1% |
| Carolina | 8.4% | 11.4% | 10.1% | 5.8% | 4.5% |
| Cataño | 1.7% | 2.9% | .6% | .9% | 1.1% |
| Dorado | 1.5% | 1.8% | .7% | 2.2% | .7% |
| Guaynabo | 6.3% | 9.7% | 7.0% | 3.8% | 2.0% |
| Río Grande | .9% | 1.4% | .7% | .4% | .7% |
| San Juan | 62.2% | 48.1% | 59.0% | 74.4% | 78.1% |
| Toa Alta | .7% | 1.2% | .3% | .1% | .5% |
| Toa Baja | 2.3% | 3.8% | 2.3% | .7% | 1.3% |
| Trujillo Alto | 1.6% | 2.5% | 1.4% | 1.1% | .6% |
| NARANJITO | 0.7% | 0.2% | 1.2% | 0.5% | 1.7% |
| TOTAL | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

## Table 2.5
## POPULATION BY MUNICIPIO: 1990 AND 2010

| Municipio | 1990 Population | Growth | % Growth | 2010 Forecast |
|---|---|---|---|---|
| San Juan | 435,639[1] | 52,361 | 12.0 | 488,000 |
| Bayamón | 217,879[1] | 29,121 | 13.4 | 247,000 |
| Carolina | 177,806 | 23,194 | 13.0 | 201,000 |
| Guaynabo | 92,886 | 35,114 | 37.8 | 128,000 |
| Toa Baja | 89,454 | 8,546 | 9.6 | 98,000 |
| Canóvanas | 36,816 | 13,184 | 35.8 | 50,000 |
| Loíza | 29,307 | 7,693 | 26.2 | 37,000 |
| Trujillo Alto | 61,120 | 12,880 | 21.1 | 74,000 |
| Río Grande | 45,648 | 26,352 | 57.7 | 72,000 |
| Toa Alta | 44,101 | 18,899 | 42.9 | 63,000 |
| Cataño | 34,587 | 13,413 | 38.8 | 48,000 |
| Dorado | 30,759 | 13,241 | 43.1 | 44,000 |
| NARANJITO | 27,914 | 15,471 | 55.4 | 43,385 |
| TOTAL | 1,323,916 | 269,469 | 20.3 | 1,593,385 |

[1] *These figures are less than those in Table 2.1 because institutional populations of 2,106 in San Juan and 2,383 in Bayamón are excluded.*

## Table 2.6
## EXISTING AND PROJECTED EMPLOYMENT BY MUNICIPIO: 1990 and 2010

| Municipio | 1990 Employment | 2010 Employment | | | | |
|---|---|---|---|---|---|---|
| | | Total | Basic | Retail | Service | Government |
| Bayamón | 46,931 | 55,188 | 26,770 | 11,134 | 10,677 | 6,607 |
| Canóvanas/Loíza | 9,092[1/] | 13,977[2/] | 8,166 | 1,148 | 2,220 | 2,443 |
| Carolina | 34,710 | 42,818 | 23,562 | 7,926 | 6,868 | 4,462 |
| Cataño | 7,072 | 10,445 | 7,099 | 563 | 1,407 | 1,376 |
| Dorado | 6,341 | 16,819 | 11,718 | 646 | 3,569 | 886 |
| Guaynabo | 26,068 | 35,417 | 20,930 | 6,249 | 5,787 | 2,451 |
| Río Grande | 3,784 | 7,753 | 5,383 | 736 | 680 | 954 |
| San Juan | 256,617 | 282,187 | 85,780 | 39,335 | 85,887 | 71,185 |
| Toa Alta | 2,702 | 3,553 | 2,447 | 257 | 208 | 641 |
| Toa Baja | 9,619 | 11,938 | 8,130 | 1,655 | 861 | 1,292 |
| Trujillo Alto | 6,587 | 7,885 | 4,724 | 1,062 | 1,503 | 596 |
| NARANJITO | 2,939 | 4,568 | 493 | 1,074 | 823 | 2,179 |
| TOTAL | 412,462 | 492,548 | 205,202 | 71,785 | 120,490 | 95,072 |

1/ *1990 Employment; Loíza 2,256; Canóvanas 6,836.*
2/ *2010 Employment; Loíza 2,490; Canóvanas 11,486.*

Table 2.7
POPULATION AND EMPLOYMENT BY MUNICIPIO: 1990 AND 2010

| | 1990 | | | | 2010 | | | |
|---|---|---|---|---|---|---|---|---|
| Municipio | Population | % of Region | Employment | % of Region | Population | % of Region | Employment | % of Region |
| San Juan | 435,639 | 32.9% | 256,617 | 62.6% | 488,000 | 30.6% | 282,187 | 57.3% |
| Bayamón | 217,879 | 16.5 | 46,931 | 11.4 | 247,000 | 15.9 | 55,188 | 11.2 |
| Carolina | 177,806 | 13.4 | 34,710 | 8.5 | 201,000 | 12.6 | 42,818 | 8.7 |
| Guaynabo | 92,886 | 7.0 | 26,068 | 6.3 | 128,000 | 8.0 | 35,415 | 7.2 |
| Toa Baja | 89,454 | 6.8 | 9,619 | 2.3 | 98,000 | 6.2 | 11,938 | 2.4 |
| Trujillo Alto | 61,120 | 4.6 | 6,587 | 1.6 | 74,000 | 4.6 | 7,885 | 1.6 |
| Rio Grande | 45,648 | 3.4 | 3,784 | 0.9 | 72,000 | 4.5 | 7,753 | 1.6 |
| Toa Alta | 44,101 | 3.3 | 2,702 | 0.7 | 63,000 | 4.0 | 3,553 | 0.7 |
| Canóvanas | 36,816 | 2.8 | 6,836 | 1.7 | 50,000 | 3.1 | 11,486 | 2.3 |
| Cataño | 34,587 | 2.6 | 7,072 | 1.7 | 48,000 | 3.0 | 10,445 | 2.1 |
| Dorado | 30,759 | 2.3 | 6,341 | 1.5 | 44,000 | 2.8 | 16,819 | 3.4 |
| Loiza | 29,307 | 2.2 | 2,256 | 0.6 | 37,000 | 2.3 | 2,490 | 0.5 |
| NARANJITO | 27,914 | 2.1 | 2,939 | 0.7 | 43,385 | 2.7 | 4,568 | 0.9 |
| TOTAL | 1,323,916* | 100.0% | 412,462 | 100.0% | 1,593,385 | 100.0% | 492,545 | 100.0% |

* *Total population excluding 2106 institutional population in San Juan and 2383 institutional population in Bayamón.*

**Table 3.1**
**1990 HIGHWAY LANE-MILES FOR NARANJITO AND THE REGION**

| Functional Class | Naranjito Lane-Miles | % | Regional Lane-Miles[1/] | % |
|---|---|---|---|---|
| Freeways/Expressways | 0 | 0 | 256 | 11.6 |
| Principal Arterials | 35 | 53.0 | 643 | 29.1 |
| Minor Arterials | 31 | 47.0 | 1,064 | 48.2 |
| Collectors | 0 | 0 | 246 | 11.1 |
| TOTAL | 66 | 100.0% | 2,209 | 100.0% |

1/ *Does not include turn lanes at intersections.*

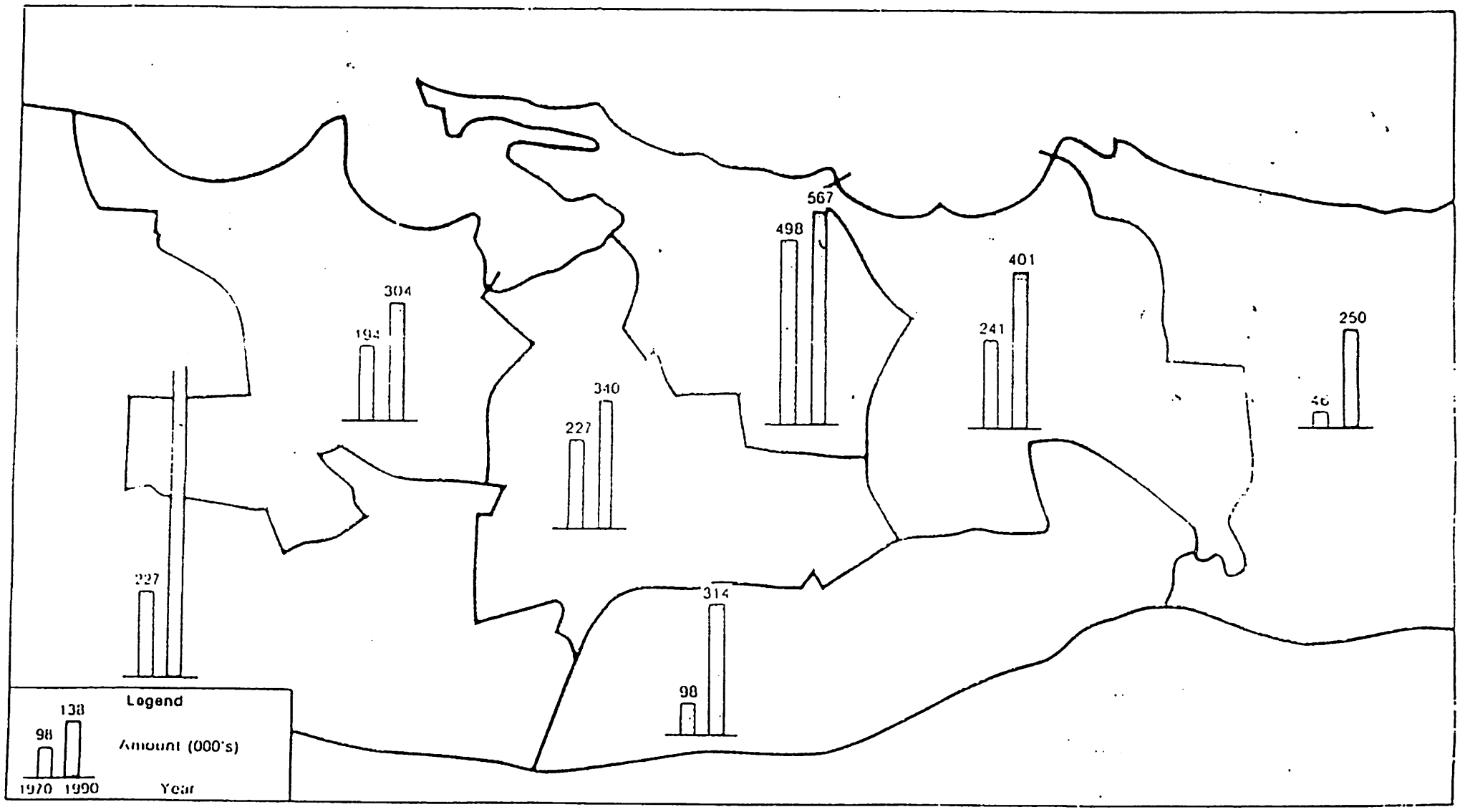



Figure III-8. Trip Productions by Sector

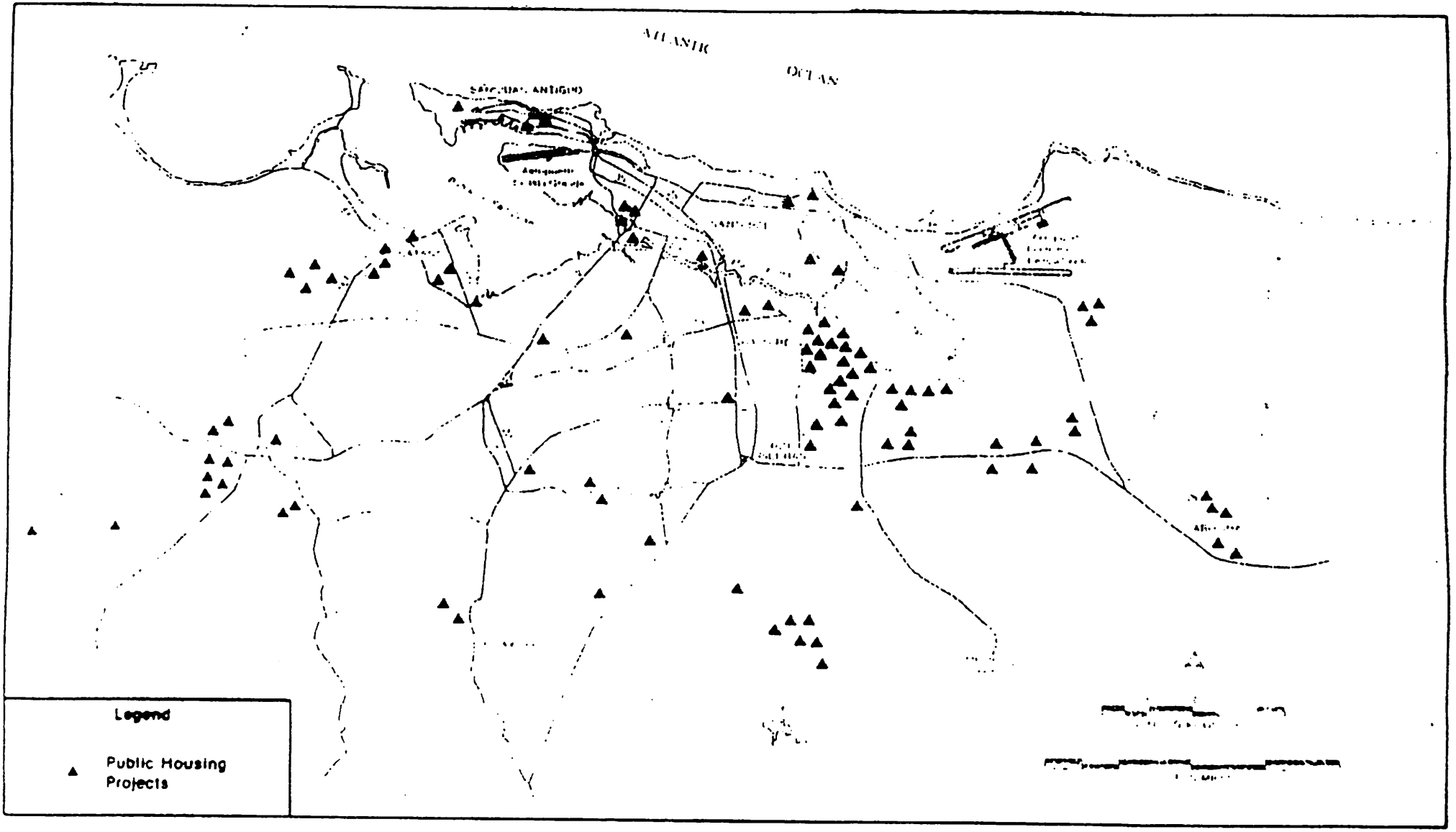



**Figure II-6. Locations of Public Housing Projects**

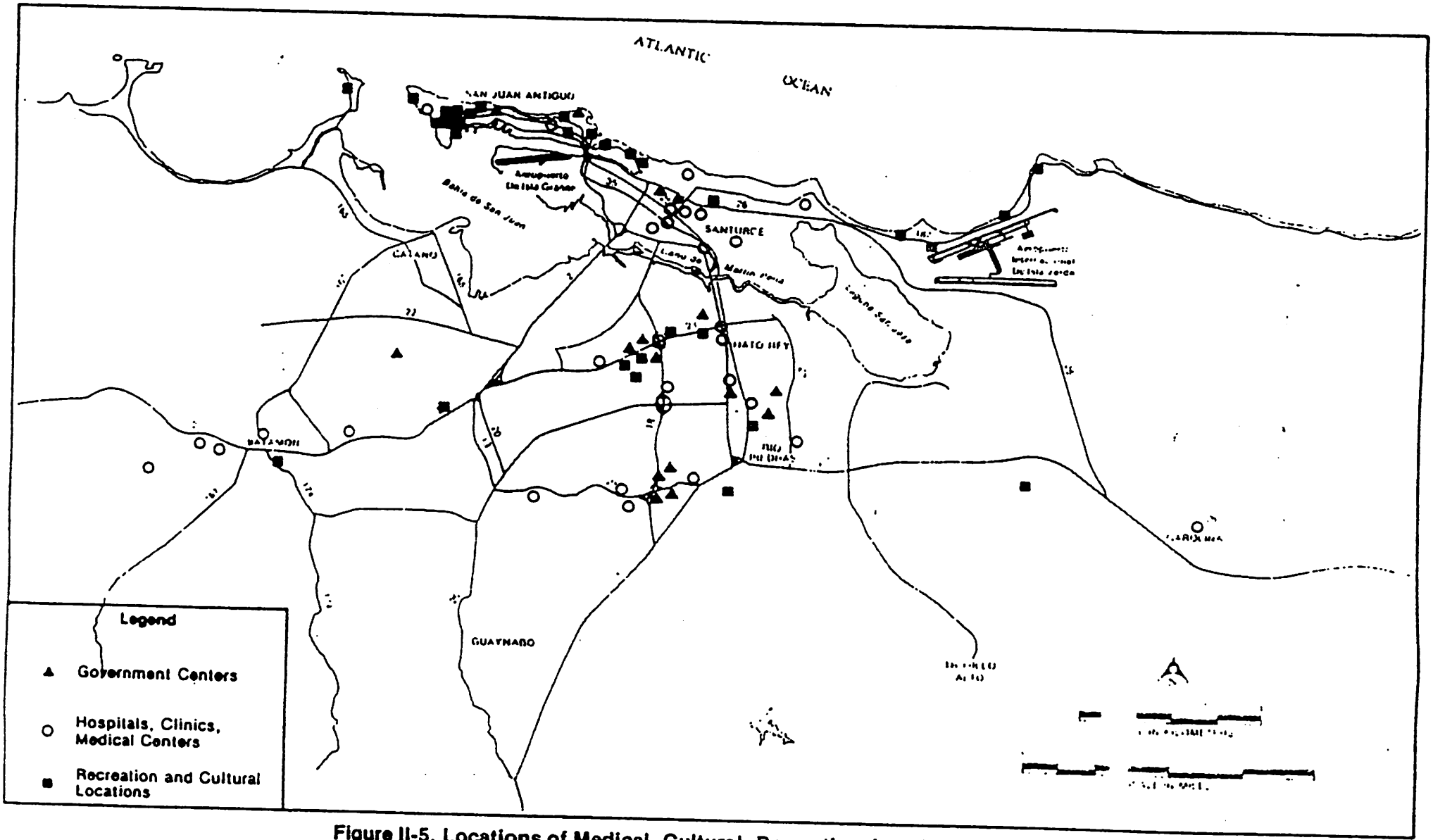



**Figure II-5. Locations of Medical, Cultural, Recreational, and Governmental Centers**


Figure II-4. Business Concentrations

Table II-4. Historical Population and Density

| Area | Population | | Density | |
|---|---|---|---|---|
| | 1960 | 1970 | 1960 | 1970 |
| SMSA | 647,979 | 851,247 | 3,375 | 4,434 |
| Central City | 432,377 | 452,749 | 14,461 | 12,138 |
| Urbanized Area | 542,156 | 820,442 | 9,236 | 8,004 |
| Study Area | N/A | 889,905 | N/A | 4,708 |

Source: U.S. Census Data.

Table II-5. Population and Density in U.S. Urbanized Areas—1970

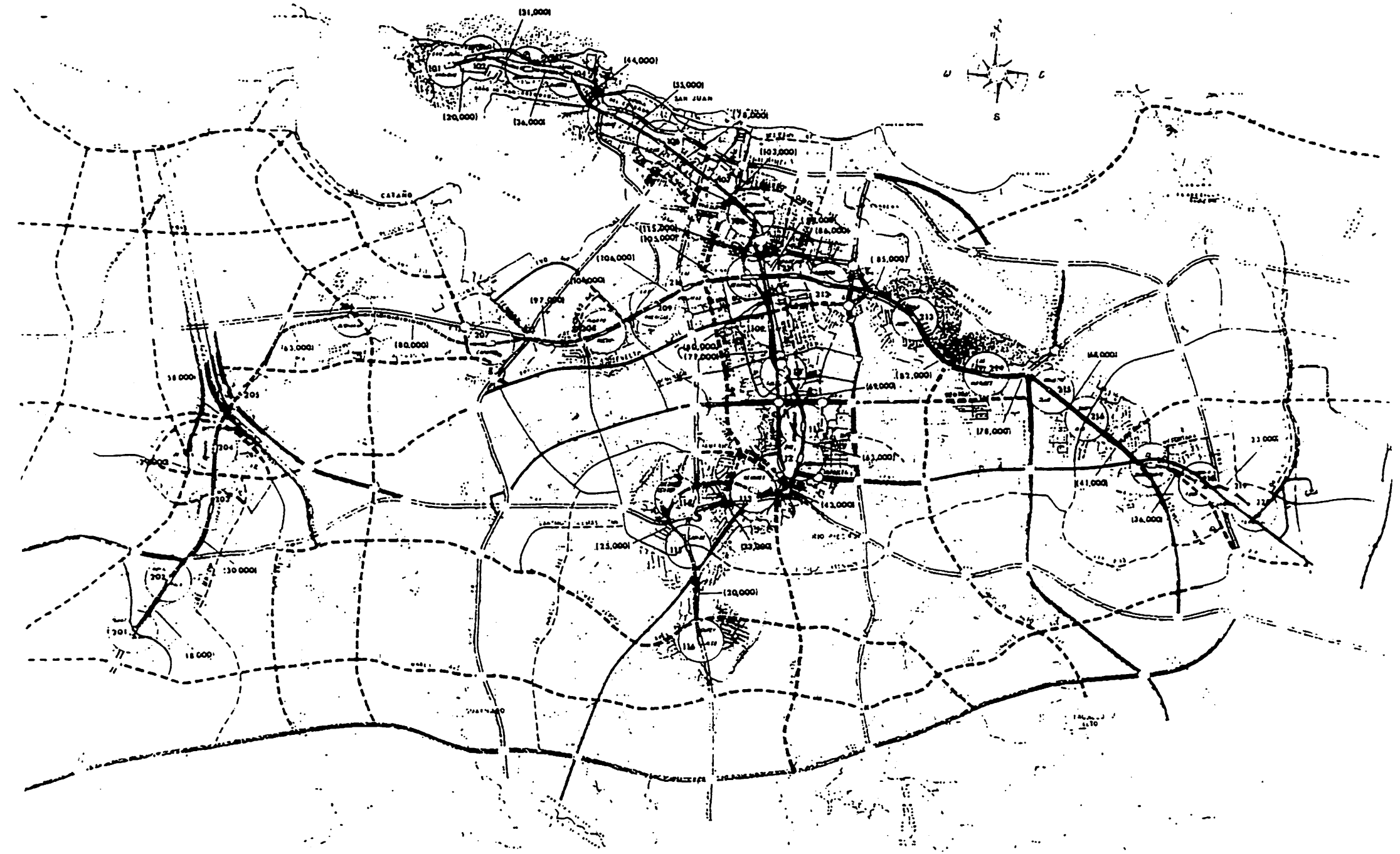
| Urbanized Area | Rank | Population | Density (Persons/Square Mile) | |
|---|---|---|---|---|
| | | | Central City | Urbanized Area |
| New York | 1 | 16,206,841 | 26,343 | 6,683 |
| Los Angeles | 2 | 8,351,266 | 7,364 | 5,313 |
| Philadelphia | 4 | 4,021,066 | 15,164 | 5,349 |
| Washington | 8 | 2,481,489 | 12,321 | 5,018 |
| Baltimore | 14 | 1,579,781 | 11,566 | 5,109 |
| Atlanta | 20 | 1,172,778 | 3,779 | 2,696 |
| Buffalo | 23 | 1,066,594 | 11,206 | 5,085 |
| Phoenix | 27 | 863,357 | 2,348 | 2,228 |
| SAN JUAN | 29 | 820,442 | 12,138 | 8,004 |
| Columbus | 32 | 790,019 | 4,009 | 3,389 |
| Fort Worth | 36 | 676,944 | 1,919 | 1,708 |

Residential construction has stressed multi-unit buildings and closely spaced, single unit housing development. Levels of income and auto ownership lower than in cities in the continental U.S. have forced the San Juan area to retain its high density structure during a period in which continental cities were undergoing a sudden, large-scale decentralization.

Figure II–7 shows 1970 population densities throughout the study area.

Population of Multicenters — Table II–6 shows the population in each of the six major multicenters. Together the centers contain approximately 15 percent of the area population.

Income — According to U.S. Census data, median family income for urban areas of the U.S. in 1969 was about $15,000 (in 1975 dollars), considerably above the median family income in San Juan of $6,750. However, between 1959 and 1969, income in real terms grew significantly faster in Puerto Rico (4.5 percent annually) than on the mainland (2.8 percent). Even so, in 1969, over 40 percent of the families in the SJMA were still below the official poverty line. This constrasts with only 8.5 percent in the U.S.




# RECOMMENDED RAPID TRANSIT SYSTEM

SAN JUAN ( :OPOLITAN AREA TRANSPORTATION STUDY

Table 3.4
Internal Person Trip Productions by Trip Purpose (1990)

| Trip Purpose | Trips | Percent |
|---|---|---|
| Home-Based Work | 602,810 | 18.4% |
| Home-Based Shop | 282,500 | 8.6 |
| Home-Based School | 477,595 | 14.5 |
| Home-Based Other | 1,124,717 | 34.2 |
| Non-Home-Based | 797,284[1/] | 24.3 |
| TOTAL | 3,284,906 | 100.0% |

*Source: Revised 1990 Trip Generation Models.*

1/ *Does not include 54,700 non-home-based internal trips made by non-residents of the region.*

Table 3.5
Average Trip Length by Trip Purpose (1990)[1/]

| Trip Purpose | 12-Municipio Region Average Trip Length (minutes) | 13-Municipio Region Average Trip Length (minutes) |
|---|---|---|
| Home-Based Work | 36.8 | 37.7 |
| Home-Based Shop | 16.3 | 16.8 |
| Home-Based School | 19.3 | 19.4 |
| Home-Based Other | 18.5 | 18.8 |
| Non-Home-Based | 16.8 | 16.7 |
| Internal-External | 29.7[2/] | 29.5 |

1/ *Excludes intrazonal trips.*

2/ *Pertains only to that portion of the trip made within the San Juan Region.*

Table 4.2
1990 and 2010 Internal Person Trips

| | 1990 | | 2010 | |
|---|---|---|---|---|
| Population | 1,323,916 | | 1,593,385 | |
| (Persons per Square Mile) | 3,086 | | 3,714 | |
| Households | 414,009 | | 602,849 | |
| Employment | 412,462 | | 492,549 | |
| Persons Per Household | 3.20 | | 2.64 | |
| Home-Based Work | 602,810 | (18.4%) | 714,225 | (15.0%) |
| Home-Based Shop | 282,500 | ( 8.6%) | 489,406 | (10.2%) |
| Home-Based School | 477,595 | (14.5%) | 493,950 | (10.3%) |
| Home-Based Other | 1,124,717 | (34.2%) | 1,754,763 | (36.7%) |
| Non-Home-Based | 797,284 | (24.3%) | 1,327,810 | (27.8%) |
| Total Person Trips | 3,284,906 | (100.0%) | 4,780,155 | (100.0%) |
| Trips/Person | 2.48 | | 3.0 | |
| HBW/Employee | 1.46 | | 1.45 | |

**Table 4.3**
**Average Trip Length By Trip Purpose (1990 and 2010)[1/]**

| Trip Purposes | 1990 ATL (minutes) | 2010 ATL (minutes) |
|---|---|---|
| Home-Based Work | 37.7 | 37.7 |
| Home-Based Shop | 16.8 | 16.9 |
| Home-Based School | 19.4 | 18.7 |
| Home-Based Other | 18.8 | 19.0 |
| Non-Home-Based | 16.7 | 17.9 |
| Internal-External | 29.5[2/] | 26.3[2/] |

1/ *Excludes Intrazonal trips.*
2/ *Pertains only to that portion of the trip made within the San Juan Region.*

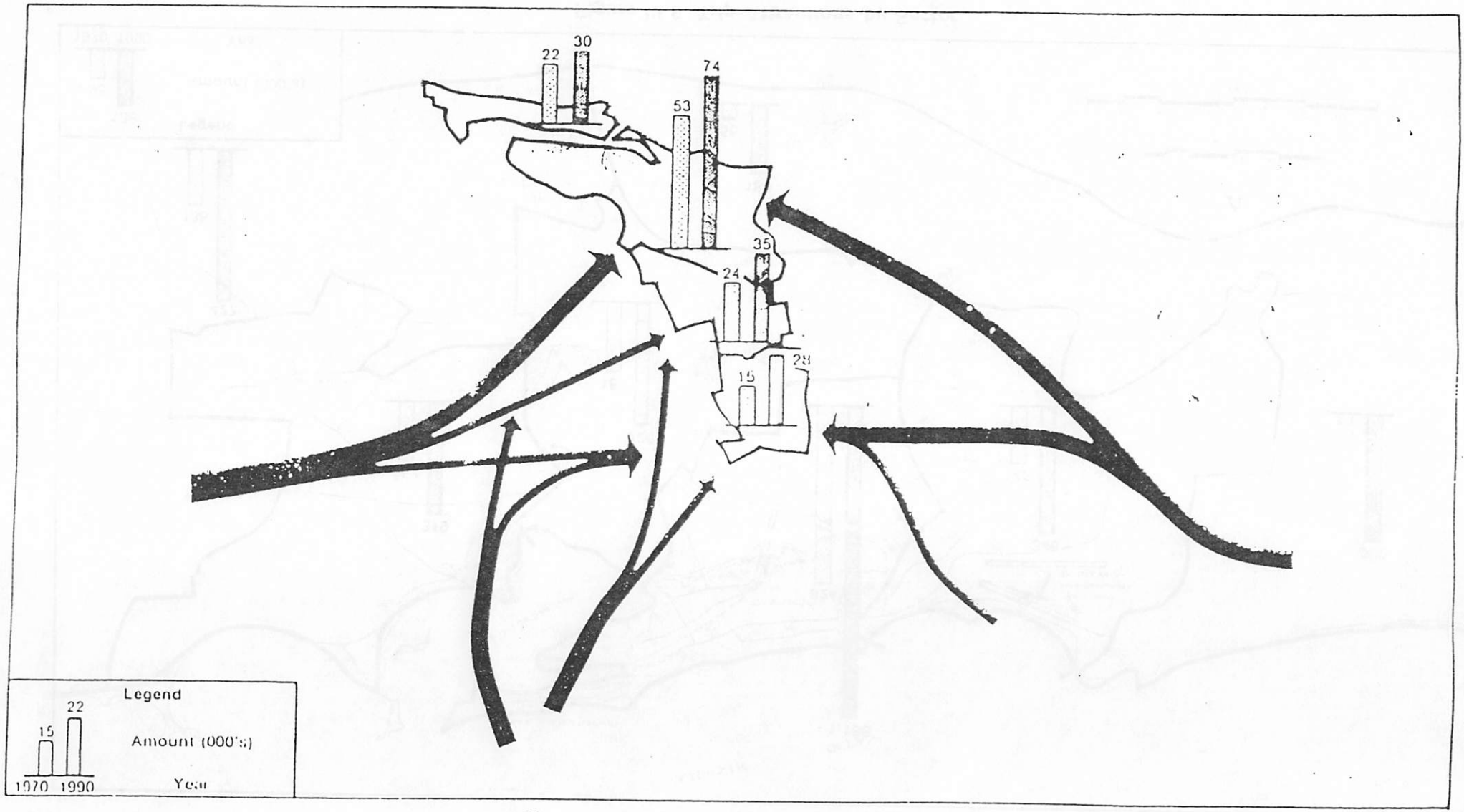



Figure III-10. Employment in the Spine

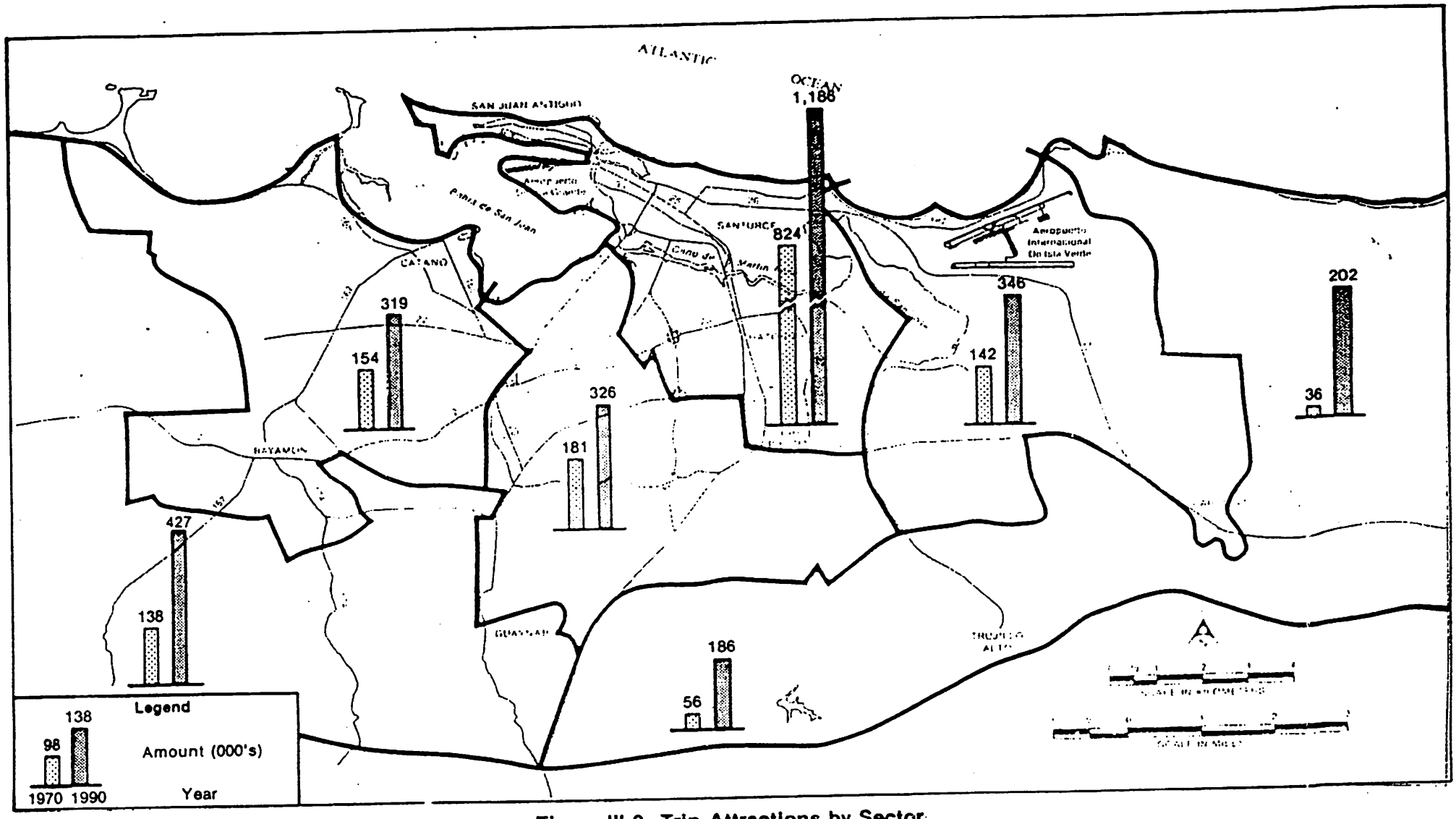
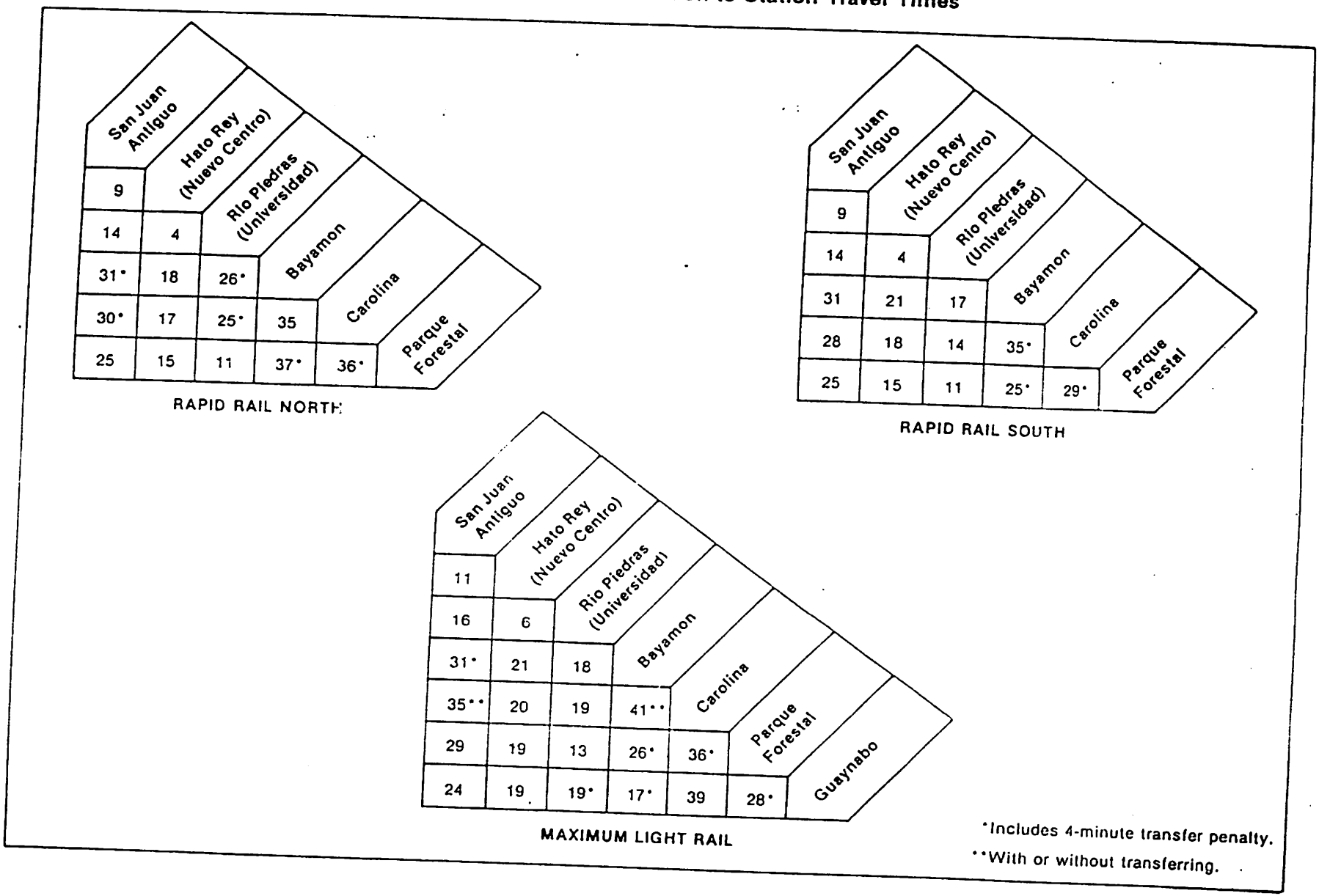



Figure III-9. Trip Attractions by Sector

## Table IV-6. Selected Station-to-Station Travel Times



RAPID RAIL NORTH

| San Juan Antiguo | Hato Rey (Nuevo Centro) | Rio Piedras (Universidad) | Bayamon | Carolina | Parque Forestal |
|---|---|---|---|---|---|
| 9 | | | | | |
| 14 | 4 | | | | |
| 31* | 18 | 26* | | | |
| 30* | 17 | 25* | 35 | | |
| 25 | 15 | 11 | 37* | 36* | |

RAPID RAIL SOUTH

| San Juan Antiguo | Hato Rey (Nuevo Centro) | Rio Piedras (Universidad) | Bayamon | Carolina | Parque Forestal |
|---|---|---|---|---|---|
| 9 | | | | | |
| 14 | 4 | | | | |
| 31 | 21 | 17 | | | |
| 28 | 18 | 14 | 35* | | |
| 25 | 15 | 11 | 25* | 29* | |

MAXIMUM LIGHT RAIL

| San Juan Antiguo | Hato Rey (Nuevo Centro) | Rio Piedras (Universidad) | Bayamon | Carolina | Parque Forestal | Guaynabo |
|---|---|---|---|---|---|---|
| 11 | | | | | | |
| 16 | 6 | | | | | |
| 31* | 21 | 18 | | | | |
| 35** | 20 | 19 | 41** | | | |
| 29 | 19 | 13 | 26* | 36* | | |
| 24 | 19 | 19* | 17* | 39 | 28* | |

*Includes 4-minute transfer penalty.

**With or without transferring.

Figure IV-8. Route Structure for Rapid Rail North

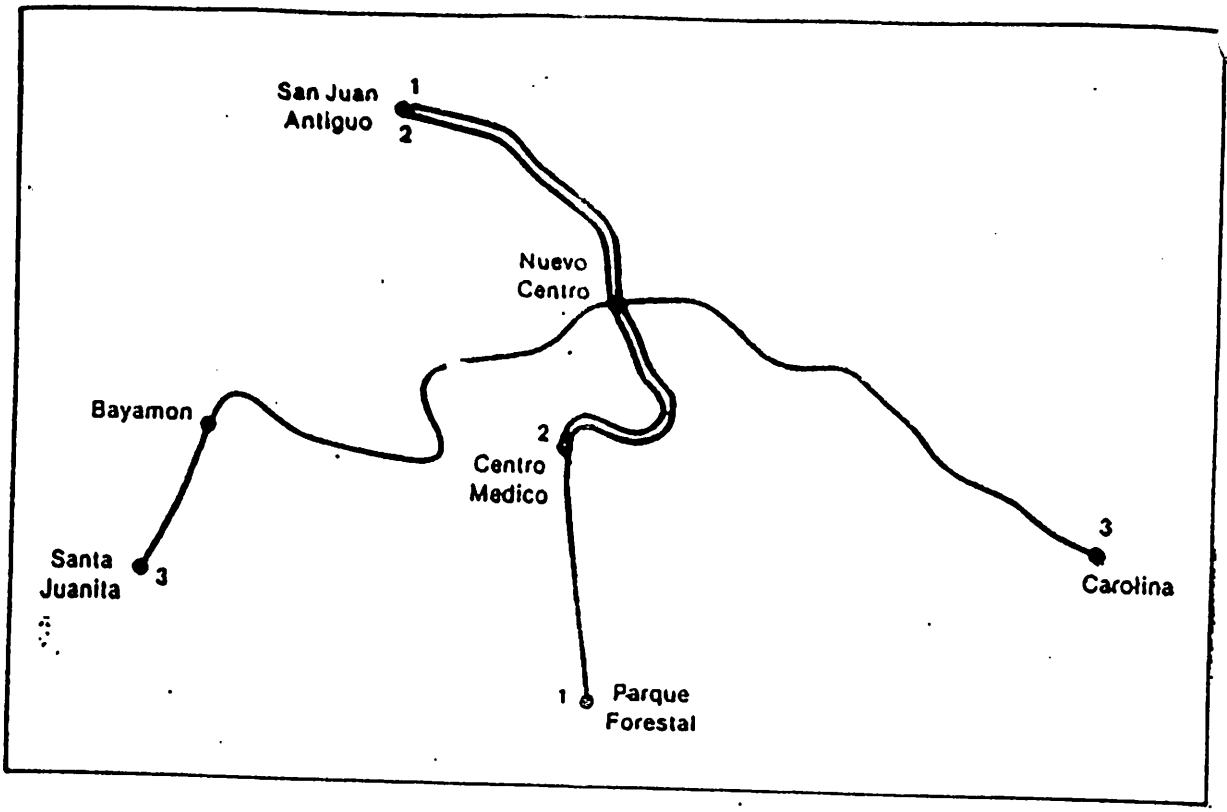



Table IV-7. Operating Plan for RR-N

| | Round Trip Route Miles | Average Speed (mph) | Peak Hour Headway (minutes) | Daily Trains | Daily Cars | Peak Cars In Service |
|---|---|---|---|---|---|---|
| North-South | | | | | | |
| Line 1 | 24.6 | 30 | 10 | 99 | 346 | 20 |
| Line 2 | 17.2 | 30 | 3.1 | 148 | 587 | 44 |
| N-S Total | 41.8 | 30 | 2.4[1] | 247 | 933 | 64 |
| Line 3 | 40.2 | 30 | 4.2 | 183 | 796 | 116 |
| System Total | 82.0 | 30 | — | 430 | 1,729 | 180 |

[1]Effective headway north of Centro Medico Station.

**Figure IV-10. Route Structure for Maximum Light Rail**

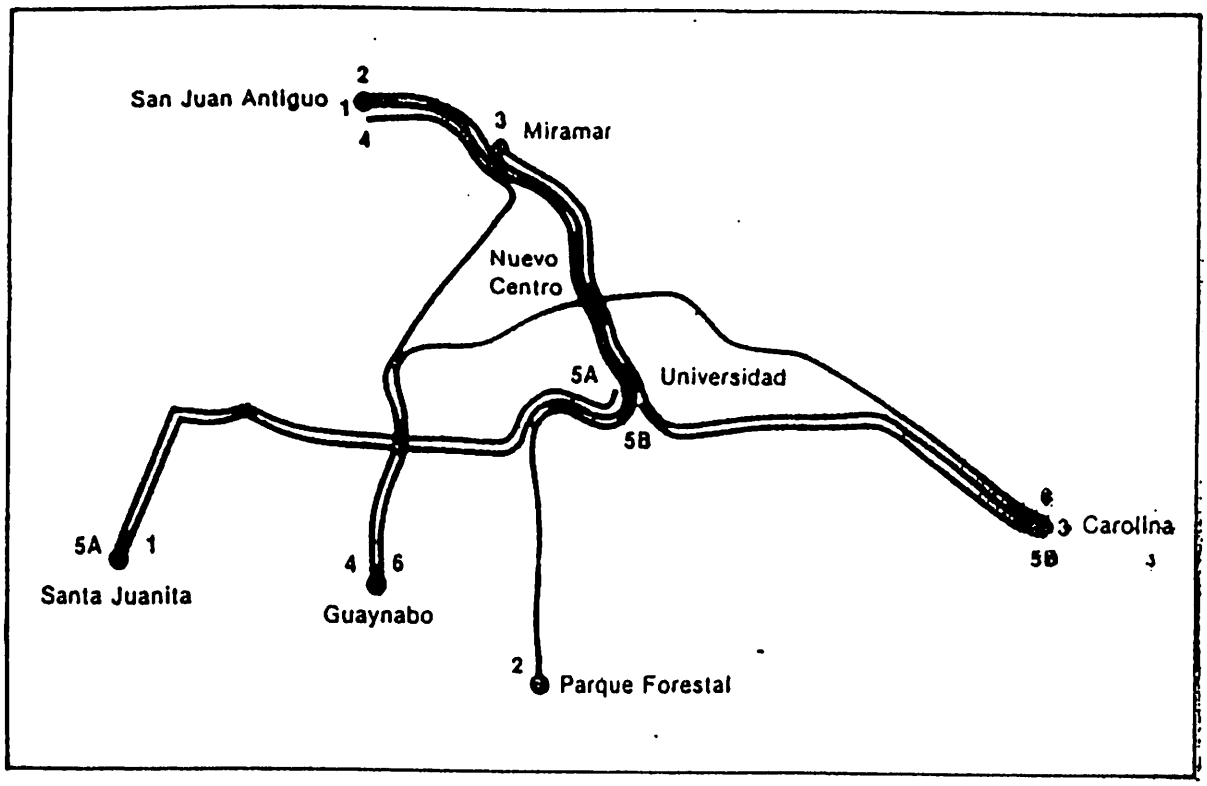



Table IV-9. Operating Plan for LR-M

| | Round Trip Route Miles | Average Speed (mph) | Peak Hour Headway (minutes) | Daily Trains | Daily Cars | Peak Cars In Service |
|---|---|---|---|---|---|---|
| Line 1 | 33.6 | 25 | 6 | 110 | 380 | 54 |
| Line 2 | 24.4 | 25 | 4.3 | 121 | 439 | 54 |
| Line 3 | 24.0 | 23 | 10 | 79 | 271 | 25 |
| Line 4 | 20.0 | 25 | 6.7 | 101 | 187 | 15 |
| Line 5A | 22.4 | 23 | 6 | 90 | 360 | 32 |
| Line 5B | 15.4 | 23 | 6 | 90 | 360 | 30 |
| Line 6 | 30.6 | 24 | 4.6 | 117 | 321 | 50 |
| System Total | 165.4 | — | — | 708 | 2,318 | 260 |

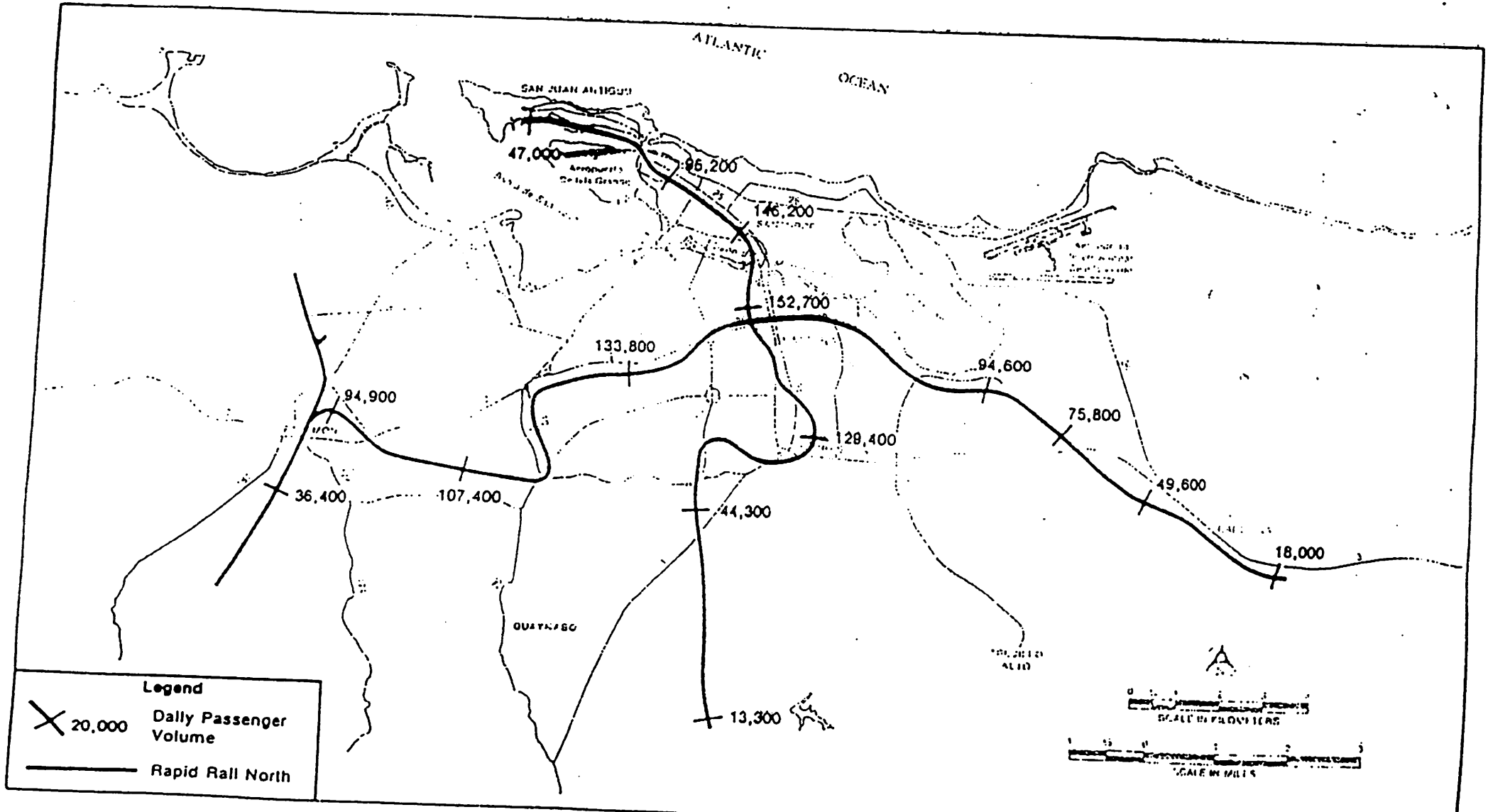



Figure IV-11. Daily Passenger Volu[illegible] in 1990: Rapid Rail North

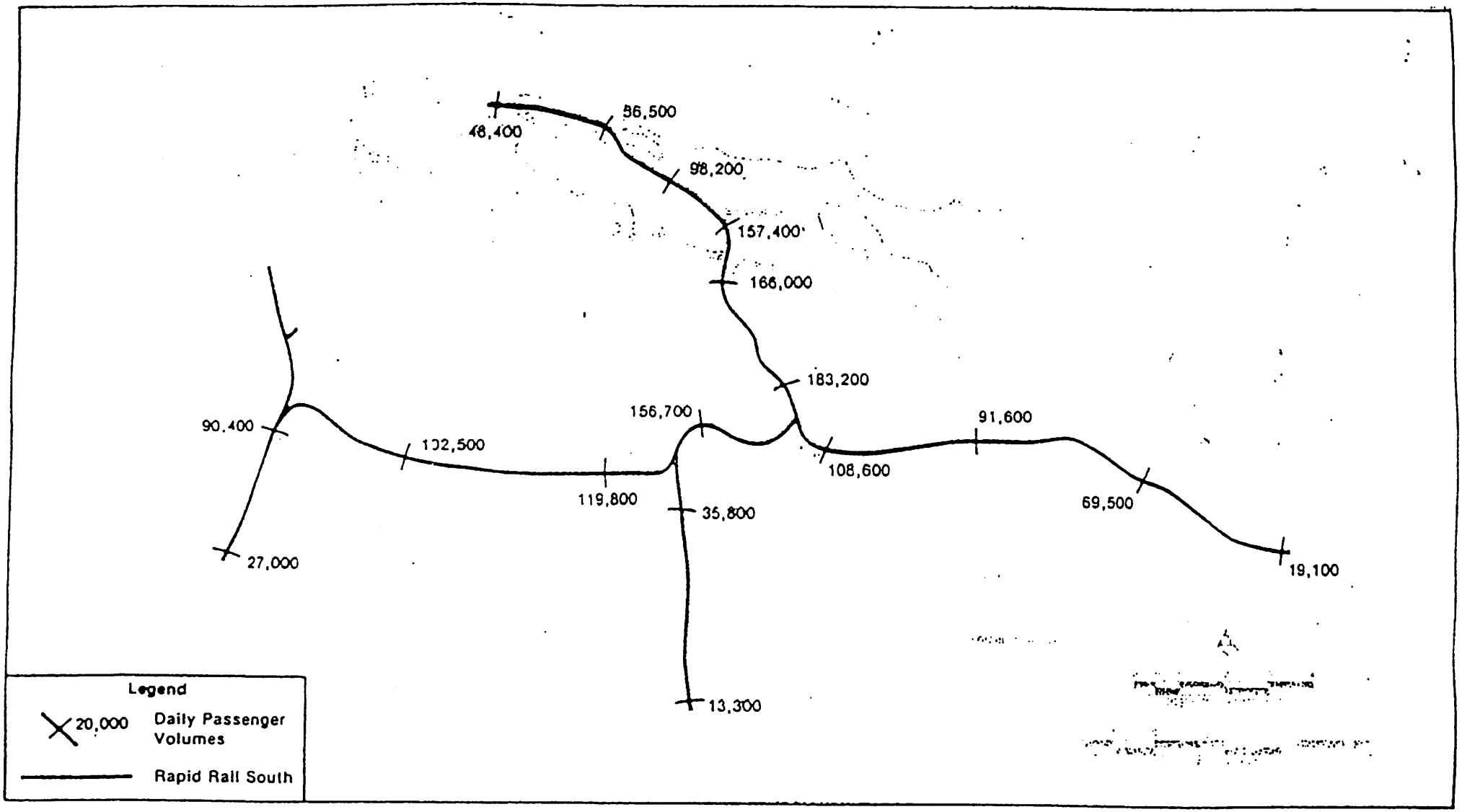



Figure IV-12. Daily Passenger Volumes in 1990: Rapid Rail South

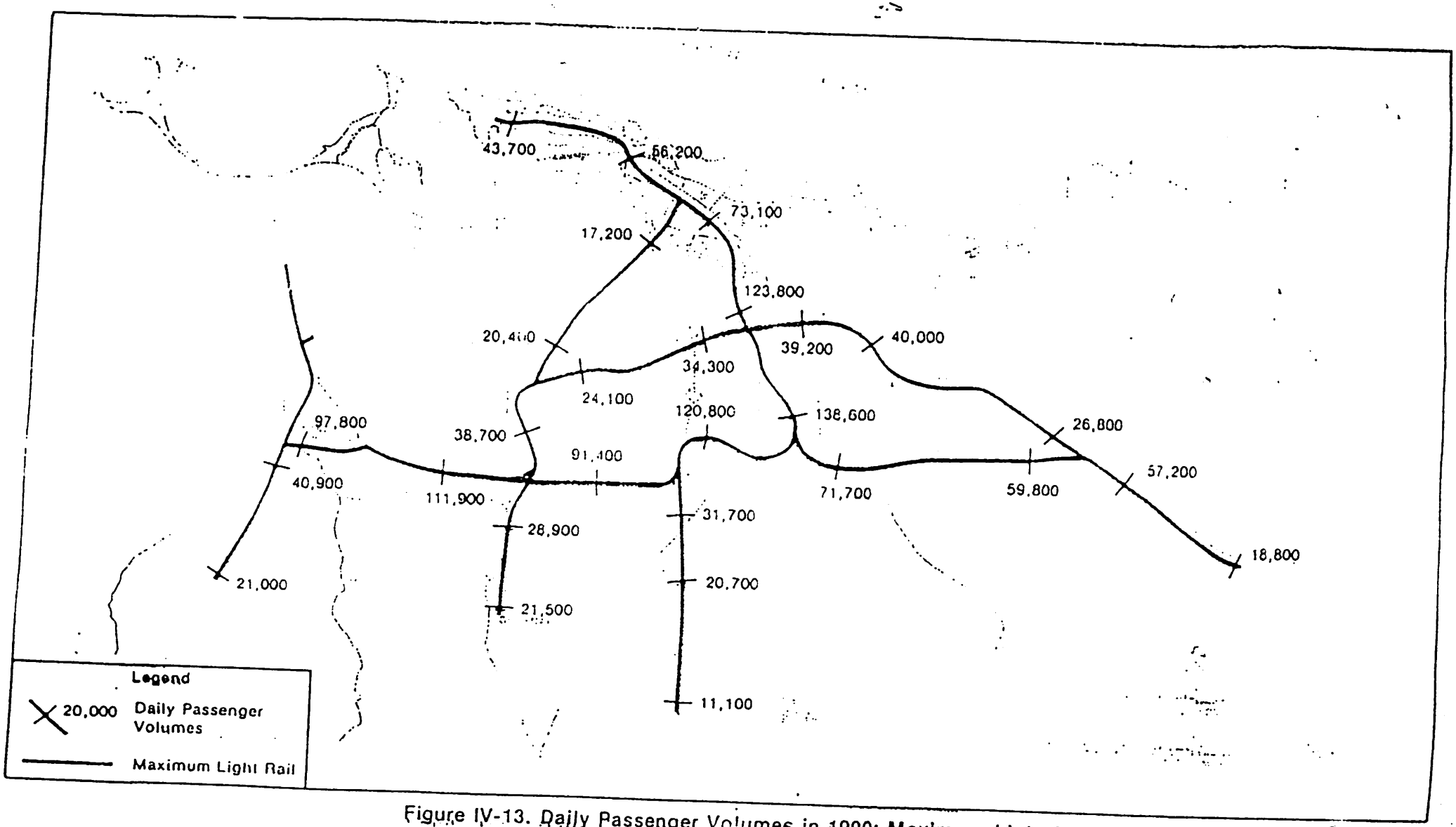



Figure IV-13. Daily Passenger Volumes in 1990: Maximum Light Rail

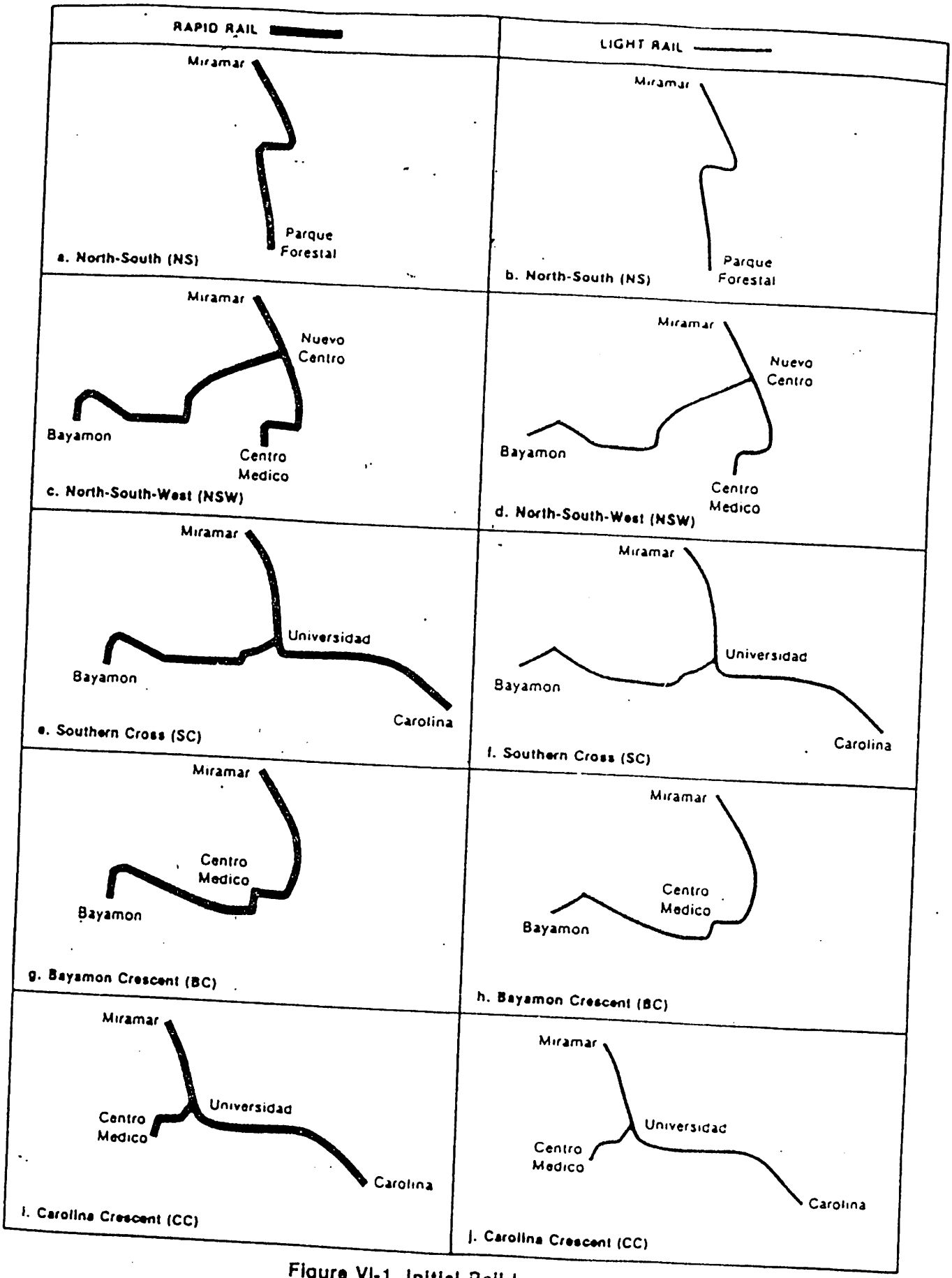
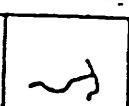
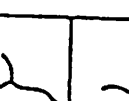
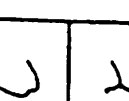
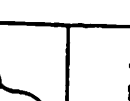
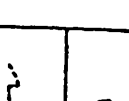



Figure VI-1. Initial Rail Increments

# Table VII-1. Selected Performance Measures

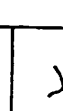
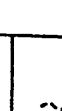
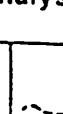
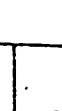
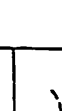
| | Improved Bus | North-South | Bayamon Crescent | Initial Advanced Bus | Poly-Modal System |
|---|---|---|---|---|---|
| DESCRIPTION | | | | | |
| Miles of Grade-Separated Guideway | — | 10.4 | 14.9 | 1.4 | 14.9 |
| Miles of New, Non-Grade-Separated Guideway | — | — | — | 9.9 | 7.2 |
| SYSTEM USAGE | | | | | |
| 1990 Total Daily Public Transit Riders | 291,700 | 379,100 | 399,800 | 356,800 | 399,800 |
| SYSTEM COSTS AND REVENUES | | | | | |
| Total Capital Cost (Includes Vehicles)($M) | 38.0 | 490.4 | 558.4 | 120.6 | 589.5 |
| 1990 Operating and Maintenance Cost ($M) | 57.2 | 59.6 | 65.5 | 66.8 | 65.5 |
| 1990 Total Cost/Passenger ($) | .74 | .78 | .83 | .73 | .84 |
| 1990 Total Cost/Passenger-Mile($) | .11 | .12 | .12 | .10 | .12 |
| 1990 Operating Deficit ($M) | 38.3 | 35.2 | 39.7 | 43.9 | 39.7 |
| QUALITY OF SERVICE | | | | | |
| 1970 Population within 2,000' of Express Lines | 68,778 | 84,959 | 122,878 | 139,842 | 174,594 |
| Overall Service Rating | Low | High | High | Moderate | High |
| ECONOMIC EFFECTS | | | | | |
| Direct Benefits in 1990 ($M) | — | 40.0 | 54.5 | 18.0 | 55 |
| EFFECTS UPON COMMUNITY AND ENVIRONMENT | | | | | |
| Properties Taken | None | 248 | 248 | 39 | 248 |
| Operational Impacts | Negligible | Moderate-Station Traffic | Moderate-Station Traffic | Negligible | Moderate-Station Traffic |
| LEVELS OF ENVIRONMENTAL POLLUTANTS | | | | | |
| Air Quality-Operation Phase | None | Positive | Positive | Positive | Positive |
| Noise/Vibration-Operation Phase | Moderate Adverse | Adverse Near Stations and Tracks | Adverse Near Stations and Tracks | Moderate Adverse | Adverse Near Stations and Tracks |
| PATTERNS OF URBANIZATION AND GROWTH | | | | | |
| Summary Rating | Low | Moderate | High | Low | High |

## Table VI-1. Preliminary Analysis Data (1975 Dollars)

| |  RR-NS |  RR-NSW |  RR-SC |  RR-BC |  RR-CC |  LR-NS |  LR-NSW |  LR-SC |  LR-BC |  LR-CC | Bus IB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Daily Public Transit Trips in 1990 (thousands) | 379.1 | 399.0 | 418.5 | 399.8 | 390.4 | 379.1 | 393.4 | 411.1 | 394.2 | 388.3 | 291.7 |
| Daily Publico Trips in 1990 (thousands) | 168.3 | 160.1 | 150.7 | 159.3 | 167.1 | 168.3 | 161.2 | 151.8 | 160.4 | 167.4 | 181.2 |
| Total Daily Transit Trips in 1990 (thousands) | 547.4 | 559.1 | 569.2 | 559.1 | 557.5 | 547.4 | 554.6 | 562.9 | 554.6 | 555.7 | 472.9 |
| Annual Public Transit Passenger-Miles in 1990 (millions) | 728.6 | 833.7 | 866.0 | 820.4 | 795.4 | 723.1 | 818.8 | 848.3 | 806.6 | 788.9 | 565.7 |
| Initial Capital Costs (millions) | 490.4 | 656.6 | 701.7 | 668.4 | 617.4 | 505.7 | 611.5 | 745.2 | 573.6 | 623.8 | 38.0 |
| O/M Cost in 1990 (millions) | 59.8 | 65.7 | 66.4 | 65.5 | 60.8 | 60.8 | 70.0 | 71.7 | 68.4 | 63.5 | 57.2 |
| Revenues in 1990 (millions) | 24.4 | 25.8 | 26.8 | 25.8 | 25.1 | 24.4 | 25.4 | 26.3 | 26.6 | 26.0 | 18.9 |
| Deficit in 1990 (millions) | 35.2 | 39.9 | 39.6 | 39.7 | 35.7 | 36.4 | 44.6 | 45.4 | 42.8 | 38.5 | 38.3 |
| Total Annual Costs (millions)[1] | 104.8 | 125.1 | 129.6 | 116.5 | 116.8 | 107.3 | 125.6 | 138.5 | 120.7 | 120.1 | 63.6 |

[1] 1990 O/M costs plus capital costs annualized at 7 percent over 40 years.

## Table VI-2. Cost-Effectiveness Measures: Preliminary Analysis

| | |  RR-NS |  RR-NSW |  RR-SC |  RR-BC |  RR-CC |  LR-NS |  LR-NSW |  LR-SC |  LR-BC |  LR-CC | Bus IB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Additional Capital Cost Per Additional 1990 Daily Transit Trip[1] | 6,072 | 7,176 | 6,892 | 6,037 | 6,849 | 6,278 | 7,020 | 7,858 | 6,554 | 7,075 | N/A[3] |
| 2A. | 1990 Deficit Per Annual Public Transit Trip[2] | .32 | .35 | .33 | .34 | .32 | .33 | .38 | .37 | .37 | .34 | .45 |
| 2B. | 1990 Deficit Per Annual Public Transit Passenger-Mile | .048 | .048 | .046 | .048 | .045 | .050 | .053 | .052 | .052 | .048 | .068 |
| 3. | Additional Deficit (Surplus) Per Additional Annual Public Transit Trip[1,2] | (.12) | .052 | .035 | .045 | (.09) | (.099) | .174 | .156 | .118 | (.021) | N/A |
| 4. | Additional Annual Cost Per Additional Annual Transit Trip[1,2] | 1.91 | 2.47 | 2.37 | 2.12 | 2.18 | 2.03 | 2.63 | 2.88 | 2.42 | 2.36 | N/A |
| 5. | Additional Annual Cost Per Additional Annual Public Transit Trip[1,2] | 1.63 | 1.98 | 1.80 | 1.69 | 1.87 | 1.73 | 2.11 | 2.17 | 1.93 | 2.02 | N/A |
| 6. | Additional Annual Cost Per Additional Public Transit Passenger-Mile[1] | .253 | .229 | .219 | .208 | .232 | .278 | .245 | .265 | .237 | .253 | N/A |

[1]Alternative versus IB.

[2]Annualization factor = 289.

[3]N/A — not applicable.

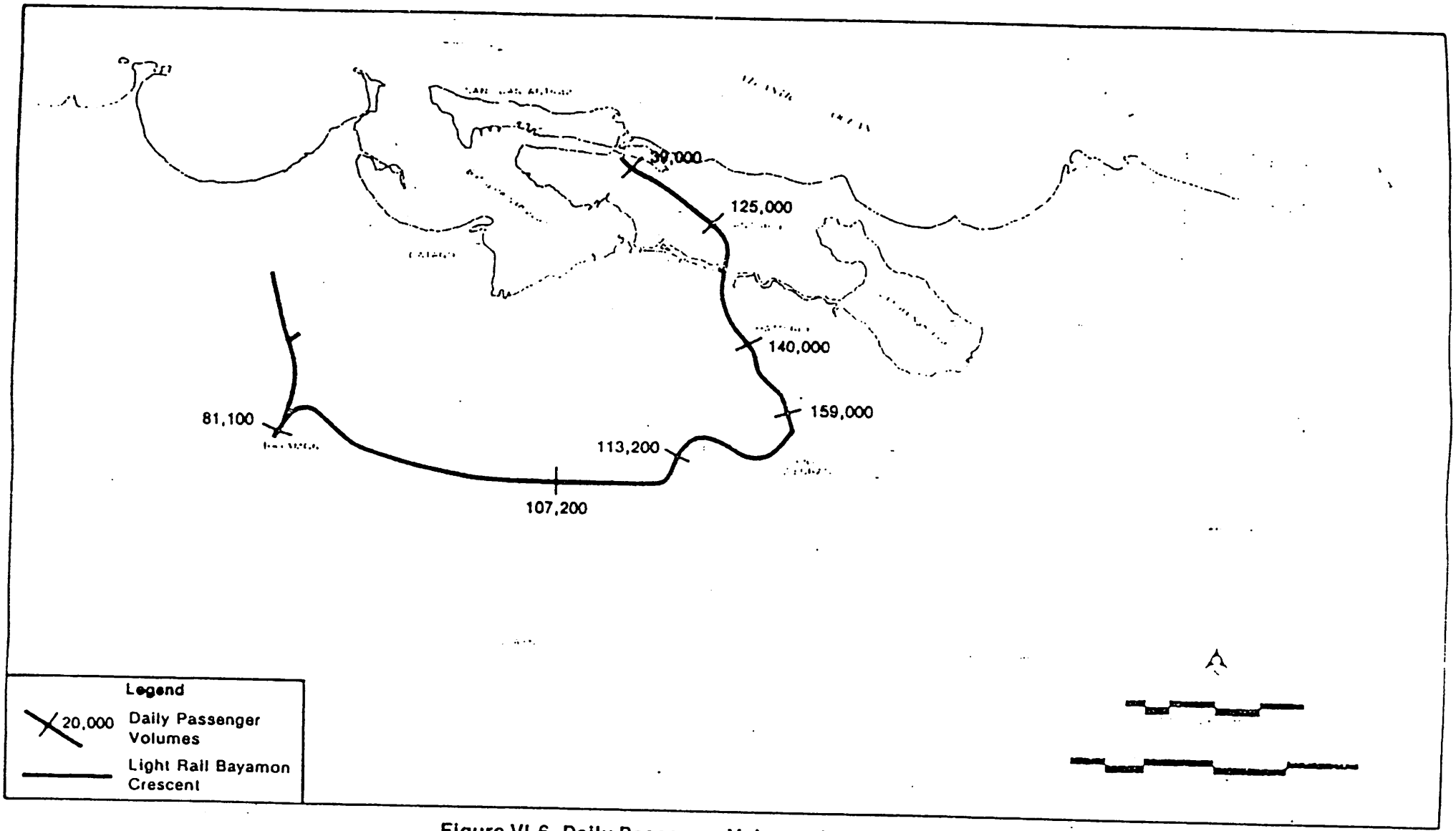



Figure VI-6. Daily Passenger Volumes in 1990: Light Rail-Bayamon Crescent

## Table VI-13. Present Worths and Annual Performance Measures for Discount Rates of 3, 7, and 10 Percent (1975 Dollars)

| | RR-NS | | | LR-NS | | | RR-BC | | | LR-BC | | | IAB | | | IB | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3% | 7% | 10% | 3% | 7% | 10% | 3% | 7% | 10% | 3% | 7% | 10% | 3% | 7% | 10% | 3% | 7% | 10% |
| **TOTAL PRESENT WORTHS (1/1/77)** | | | | | | | | | | | | | | | | | | |
| Total Costs (millions) | 1,362.9 | 726.2 | 518.4 | 1,395.6 | 744.5 | 531.8 | 1,513.1 | 810.4 | 580.5 | 1,578.5 | 837.8 | 597.8 | 1,147.7 | 487.0 | 290.3 | 929.0 | 369.2 | [illegible] |
| • Capital Costs (millions) | 505.0 | 401.0 | 346.0 | 520.5 | 412.7 | 355.9 | 570.3 | 453.0 | 391.0 | 594.0 | 464.5 | 399.9 | 166.2 | 122.5 | 97.1 | 105.7 | 57.1 | [illegible] |
| • Operating Costs (millions) | 857.9 | 325.2 | 172.4 | 875.1 | 331.8 | 175.9 | 942.8 | 357.4 | 189.5 | 984.5 | 373.3 | 197.9 | 961.5 | 364.5 | 193.2 | 823.3 | 312.1 | [illegible] |
| Total Revenue (millions) | 353.2 | 134.5 | 71.6 | 353.2 | 134.5 | 71.6 | 373.5 | 142.2 | 75.7 | 369.2 | 140.5 | 74.8 | 331.5 | 126.2 | 67.2 | 273.6 | 104.4 | [illegible] |
| **1990 PERFORMANCE** | | | | | | | | | | | | | | | | | | |
| Annual Transit Trips (public and private) | 158,200,000 | | | 158,200,000 | | | 161,600,000 | | | 160,300,000 | | | 150,300,000 | | | 136,700,000 | | |
| Annual Public Transit Trips | 109,600,000 | | | 109,600,000 | | | 115,500,000 | | | 113,900,000 | | | 103,100,000 | | | 84,300,000 | | |
| Annual Public Transit Passenger-Miles | 728,600,000 | | | 723,100,000 | | | 820,400,000 | | | 806,600,000 | | | 720,800,000 | | | 565,700,000 | | |
| **1990 PERFORMANCE MEASURES** | | | | | | | | | | | | | | | | | | |
| Annual Capital Costs (millions) | 26.1 | 45.2 | 62.7 | 26.9 | 46.5 | 64.5 | 29.5 | 51.0 | 70.9 | 30.7 | 52.3 | 72.5 | 9.6 | 13.8 | 17.6 | 5.5 | [illegible] | [illegible] |
| • Per Annual Transit Trip (public and private)($) | .16 | .29 | .40 | .17 | .29 | .41 | .18 | .32 | .44 | .19 | .33 | .45 | .06 | .09 | .12 | .04 | [illegible] | [illegible] |
| • Per Annual Public Transit Trip ($) | .24 | .41 | .57 | .25 | .42 | .59 | .26 | .44 | .61 | .27 | .46 | .64 | .09 | .13 | .17 | .06 | [illegible] | [illegible] |
| • Per Annual Public Transit Passenger-Mile ($) | .04 | .06 | .09 | .04 | .06 | .09 | .04 | .06 | .09 | .04 | .06 | .09 | .01 | .02 | .02 | .01 | [illegible] | [illegible] |
| • Per Capita ($)[1] | 17 | 30 | 41 | 18 | 31 | 43 | 19 | 34 | 47 | 20 | 35 | 48 | 6 | 9 | 12 | 4 | [illegible] | [illegible] |

[1]Using 1990 study area population of 1,513,000

## Quality of Transportation Service

Accessibility Indices — Direct access to transit service in a protected or exclusive right-of-way increases its attractiveness to potential users. This section measures the number of people and jobs within 2,000 feet of such ROW's, giving special consideration to low-income, elderly, and female groups. Table VI-16 contains the results.

**Table VI-16. Measures of Accessibility to Major Facilities**

| | RR-NS | | LR-NS | | RR-BC | | LR-BC | | IAB | | IB | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number Within 2,000 Ft. | Percent of Area Total | Number Within 2,000 Ft. | Percent of Area Total | Number Within 2,000 Ft. | Percent of Area Total | Number Within 2,000 Ft. | Percent of Area Total | Number Within 2,000 Ft. | Percent of Area Total | Number Within 2,000 Ft. | Percent of Area Total |
| Population | | | | | | | | | | | | |
| • 1970 | 84,959 | 10 | 84,959 | 10 | 122,878 | 14 | 119,393 | 13 | 139,842 | 16 | 68,778 | 8 |
| • 1990 | 107,299 | 7 | 107,299 | 7 | 167,800 | 11 | 164,075 | 11 | 158,264 | 10 | 74,457 | 5 |
| Employment | | | | | | | | | | | | |
| • 1970 | 81,749 | 28 | 81,749 | 28 | 98,072 | 33 | 95,550 | 32 | 123,147 | 41 | 80,156 | 27 |
| • 1990 | 121,019 | 22 | 121,019 | 22 | 143,258 | 27 | 135,061 | 25 | 210,143 | 39 | 125,909 | 23 |
| Below Poverty Level (1970) | 33,610 | 8 | 33,610 | 8 | 50,314 | 13 | 48,597 | 12 | 62,046 | 16 | 30,691 | 8 |
| 65 Years or Older (1970) | 8,009 | 15 | 8,009 | 15 | 10,441 | 20 | 10,199 | 19 | 12,661 | 24 | 7,371 | 14 |
| Female (1970) | 44,421 | 10 | 44,421 | 10 | 63,965 | 15 | 62,127 | 14 | 73,524 | 17 | 36,261 | 8 |

The BC alignment compares quite favorably to NS in all categories. In both 1970 and 1990, BC directly serves slightly more than 10 percent of the population of the study area. Both alignments serve the Spine, which contains a major proportion of the employment in the study area. The percentage of employment directly served is quite high: about 25 percent for NS and almost 30 percent for BC. The two alignments also serve a substantial number of the transportation disadvantaged, with BC again comparing favorably to NS.

In all categories but population served, IB is equivalent to the NS alignment. Because of its greater coverage, IAB is clearly better than the other five alternatives, but it should be remembered that the level of service in the IAB is lower than that provided by the rail alternatives.

## Ease of Use

All stations on the four rail increments will be designed to allow access to the system for the elderly and handicapped. The four rail systems rank "high" in ease

of use, with the two light rail systems being perhaps slightly inferior in this regard than the two rapid rail alternatives. The IAB system must be ranked "moderate" to "low" because of the difficulty a handicapped or elderly person can experience when attempting to board a bus. IB is ranked "low."

Safety and Reliability

The light rail and rapid rail alternatives will be about equal in safety and reliability because the light rail alignments have almost no non-grade-separated sections of guideway (see Table VI–17). Only on the sections between Nevarez and Centro Medico Stations and between Centro Medico and the 65th Infantry ROW does light rail operate at-grade in non-grade-separated guideways.

**Table VI-17. System Safety**

| |  RR-NS |  LR-NS |  RR-BC |  LR-BC | Bus IAB | Bus IB |
|---|---|---|---|---|---|---|
| Miles of Guideway | 10.36 | 10.14 | 14.85 | 15.05 | 11.31 | 0 |
| • Percent Underground | 25 | 25 | 17 | 17 | 0 | 0 |
| • Percent Aerial | 54 | 40 | 49 | 40 | 13 | 0 |
| • Percent At-Grade, Exclusive, Grade-Separated | 21 | 26 | 34 | 33 | 0 | 0 |
| • Percent At-Grade, Exclusive, Non-Grade-Separated | 0 | 9 | 0 | 10 | 87 | 0 |
| Rating on Guideway Conflicts | High | High | High | High | Moderate | Low |
| Number of Stations | 14 | 17 | 16 | 23 | 13 | 9 |
| • Percent Underground | 29 | 24 | 25 | 17 | 0 | 0 |
| • Percent Aerial | 57 | 41 | 56 | 39 | 0 | 0 |
| • Percent At-Grade, Grade-Separated | 14 | 24 | 19 | 31 | 0 | 0 |
| • Percent At-Grade, Non-Grade-Separated | 0 | 11 | 0 | 13 | 100 | 100 |
| Projected Accidents in 1990 | | | | | | |
| • Total Fatalities | 550.22 | 550.29 | 547.84 | 548.91 | 557.77 | 586.72 |
| - Rail | .17 | .24 | .33 | .47 | — | — |
| - Bus | 5.76 | 5.76 | 5.76 | 5.71 | 7.52 | 6.23 |
| - Auto | 544.29 | 544.29 | 541.75 | 542.73 | 550.25 | 560.49 |
| • Total Injuries | 33,939 | 33,952 | 33,802 | 33,882 | 34,518 | 34,969 |
| - Rail | 19 | 32 | 36 | 64 | — | — |
| - Bus | 768 | 768 | 768 | 761 | 1,003 | 830 |
| - Auto | 33,152 | 33,152 | 32,998 | 33,057 | 33,515 | 34,139 |

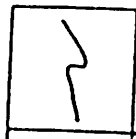
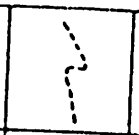
The IAB provides a somewhat lower level of safety and reliability because virtually none of its route mileage is on grade-separated bus facilities.

All five alternatives are safer and more reliable than the Improved Bus, which does not benefit from any new, protected rights-of-way.

## Passenger Comfort

As with safety and reliability levels, significant differences in passenger comfort exist only between the bus and rail systems. Although ride quality and station design standards are a bit lower in light rail alternatives, differences between light and rapid rail alternatives are minimal (see Table VI–18).

**Table VI-18. Measures of Passenger Comfort**

| |  RR-NS |  LR-NS |  RR-BC |  LR-BC | Bus IAB | Bus IB |
|---|---|---|---|---|---|---|
| Number of Transfers Per Trip | .83 | .83 | .89 | .89 | .80 | .74 |
| Rush Hour Loading Standards | | | | | | |
| • Persons Per Rail Car | 200 | 160 | 200 | 160 | N/A[1] | N/A |
| • Persons Per Bus | 70 | 70 | 70 | 70 | 70 | 70 |
| Vehicle Environment | | | | | | |
| • Climate Control | Yes | Yes | Yes | Yes | Yes | Yes |
| • Interior Noise Level [dB(A)] | 72-90 | 77-87 | 72-90 | 77-87 | 72-80 | 72-80 |
| • Noise Level at 50 Feet [dB(A)] | 82-95 | 68-80 | 82-95 | 68-80 | 80-87 | 80-87 |
| Ride Quality | | | | | | |
| • Accel/Decel Rates (mphps) | 3/3 | 3/3 | 3/3 | 3/3 | N/A | N/A |
| • Guideway Mileage Between Stations | .74 | .60 | .93 | .65 | N/A | N/A |
| • Subjective Rating | High | High | High | High | Moderate | Low |
| Station Design | | | | | | |
| • Stations with High Platforms | 14 | 11 | 16 | 13 | 0 | 0 |
| • Stations with Low Platforms | 0 | 6 | 0 | 10 | 13 | 9 |

[1]N/A — Not applicable.

Both IAB and the Improved Bus have significantly lower levels of passenger comfort than any of the rail systems, with IAB being somewhat of an improvement over IB.

## Economic Effects

Economic effects have been calculated using the same methodology as was explained in Chapter IV. Table VI–19 contains the results. RR–BC is clearly the best in this category with a combined travel savings in 1990 of $57 million compared with the North-South at $40 million and the IAB at $16 million.

Indirect Community Benefits — Each of the five initial increments requires some construction, which will generate employment. Since the rail alternatives involve considerably more construction, they will benefit the area more than will IAB (see Table VI–20).

Table VI-19. Economic Benefits (in millions of 1975 dollars)

| | RR-NS | LR-NS | RR-BC | LR-BC | Bus IAB | Bus IB |
|---|---|---|---|---|---|---|
| DIRECT TRANSPORTATION BENEFITS | | | | | | |
| Travel Cost Savings | | | | | | |
| • In 1990 | 18.4 | 18.4 | 21.8 | 20.7 | 10.7 | 0 |
| • Present Worth at 3 percent | 266.4 | 266.4 | 315.6 | 299.7 | 154.9 | 0 |
| • Present Worth at 7 percent | 101.4 | 101.4 | 120.2 | 114.1 | 59.0 | 0 |
| • Present Worth at 10 percent | 54.0 | 54.0 | 63.9 | 60.7 | 31.4 | 0 |
| Travel Time Savings | | | | | | |
| • In 1990 | 21.6 | 21.6 | 32.7 | 32.2 | 5.3 | 0 |
| • Present Worth at 3 percent | 312.7 | 312.7 | 473.4 | 466.2 | 76.7 | 0 |
| • Present Worth at 7 percent | 119.0 | 119.0 | 180.2 | 177.5 | 29.2 | 0 |
| • Present Worth at 10 percent | 63.3 | 63.3 | 95.9 | 94.4 | 15.5 | 0 |
| Combined Travel Savings | | | | | | |
| • In 1990 | 40.0 | 40.0 | 54.5 | 52.9 | 16.0 | 0 |
| • Present Worth at 3 percent | 579.1 | 579.1 | 789.0 | 765.9 | 231.6 | 0 |
| • Present Worth at 7 percent | 220.4 | 220.4 | 300.4 | 291.6 | 88.2 | 0 |
| • Present Worth at 10 percent | 117.3 | 117.3 | 159.8 | 155.1 | 46.9 | 0 |

Table VI-20. Generated Employment During Construction (Man Years)

| | RR-NS | LR-NS | RR-BC | LR-BC | Bus IAB | Bus IB |
|---|---|---|---|---|---|---|
| Non-Supervisory | 13,000 | 13,300 | 14,100 | 14,200 | 1,250 | 0 |
| Supervisory | 1,100 | 1,200 | 1,200 | 1,300 | 210 | 0 |
| Total | 14,100 | 14,500 | 15,300 | 15,500 | 1,460 | 0 |

## Impacts on the Surrounding Community and Environment

Local Impacts of the Initial Increments — Table VI-21 contains a detailed discussion of the local impacts incurred by each alternative. The rail alternatives displace more residences and businesses than IAB.

Regional Impacts on Air Quality, Noise Levels, and Energy Consumption — There are few differences between the rail alternatives themselves but some significant differences do exist between bus and rail (see Tables VI-22 and VI-23).

## Table VI-21. Impacts of the Initial Increments on the Surrounding Community and Environment

| Alternative | Adjacent Land Uses | Displacements | Visual Quality | Disruption |
|---|---|---|---|---|
| RR-NS and LR-NS | Serves all types. | 132 residences, 114 businesses, 1 church, and 1 court will be displaced | **Construction:** Impacts in Santurce and Rio Piedras would occur around staging areas and would be small. The area most affected would stretch from Hato Rey to Rio Piedras along the aerial portion of the alignment. Negligible impacts would be made south of Centro Medico. Gandara Park will be adversely affected<br><br>**Operation:** Slight impacts could be felt along the main aerial section and around stations. | **Construction:** Some disruption would occur around staging areas in Santurce and Rio Piedras. Most disruption will be concentrated along the main section of aerial structure between Hato Rey and Rio Piedras. Negligible disruption should occur south of Centro Medico. Gandara Park will be adversely affected.<br><br>**Operation:** Some disruption due to increased traffic may occur near stations. |
| RR-BC and LR-BC | Serves all types. | Between Miramar and Centro Medico the following displacements will occur: 132 residences, 114 businesses, 1 church, and 1 court. About 25 squatters may be displaced from the segment of ROW between Centro Medico and Las Lomas station. | **Construction:** Underground sections in Santurce and Rio Piedras would cause little impact, except near staging areas. The aerial segment from Hato Rey to Rio Piedras would cause significant visual intrusion. The track section along the 65th Infantry ROW from Centro Medico to PR2 would have negligible impact. Because the rapid rail alignment loops around Bayamon using the 65th Infantry Connector and the Rio Hondo<br>light rail alignment runs on an aerial structure along PR2 through Bayamon and will cause a significant amount of visual intrusion. Gandara Park will be adversely affected.<br><br>**Operation:** Small impacts may be felt along aerial sections and around stations. | **Construction:** Some disruption will occur around staging areas in Santurce and Rio Piedras. Most disruption will be concentrated along the aerial structure between Hato Rey and Rio Piedras. Additional impacts will occur in the light rail alternative due to the aerial segment through Bayamon. Gandara Park will be adversely affected:<br><br>**Operation:** Some disruption due to increased traffic may occur near stations. |
| IA8 | Serves all types. | 39 residences and businesses will be displaced, primarily by the Rio Piedras busway. | **Construction:** Visual intrusion will occur in Rio Piedras because of the construction of the new busway. Some intrusion will arise during the reconstruction of PR3 for the exclusive lanes.<br><br>**Operation:** Slight impacts may be felt near the Rio Piedras busway | **Construction:** Disruption may occur along the Rio Piedras busway and PR3. Minimal amounts of disruption should occur elsewhere.<br><br>**Operation:** Negligible |
| I8 | Serves all types | None | **Construction:** None<br><br>**Operation:** Negligible | **Construction:** None<br><br>**Operation:** Negligible |

## Table VI-22. Impacts on Air Quality, Noise, and Energy Consumption in the Region

| Category | Phase | Initial Rail Alternatives | | Initial Advanced Bus and Improved Bus | |
|---|---|---|---|---|---|
| | | Impacts | Remarks | Impacts | Remarks |
| Air Quality | Construction | Short-term adverse impacts on areas adjacent to construction sites. | Construction activities will generate vehicle emissions, smoke, and fugitive dust. Compared to the impacts of IAB, impacts for rail will affect more area for a longer time to a greater degree. | IAB will have short-term, adverse impacts on areas adjacent to construction sites | The Improved Bus involves no construction, so there will be no impacts. Construction activities for IAB will generate vehicle emissions, smoke, and fugitive dust |
| | Operation | There will be negligible adverse impacts on areas adjacent to rail stations and a positive impact on regional air quality | Pollutants produced in the area should be significantly below the level produced if the Improved Bus is implemented | IAB will have a positive impact, except in specific areas where bus operations increase significantly | Because patronage for IAB will be significantly higher than for the Improved Bus, air quality should be somewhat improved. Buses generate more pollution than do rail vehicles, so the improvement will be greater for the initial rail systems than for IAB. |
| Noise and Vibration | Construction | Short-term adverse impacts on areas adjacent to construction sites. | Potential sources of noise are truck movements, drilling, excavation, compacting, etc. | IAB will have short-term negative impacts on areas adjacent to construction sites | IAB will generate noise to a lesser degree than the rail increments. Maximum impacts will occur along the Rio Piedras busway and the exclusive lanes on PR3. |
| | Operation | Adverse impact on areas directly adjacent to aerial and at-grade tracks. | Principal noise sources are the propulsion system, auxiliary equipment, and wheel/rail interaction. Constant maintenance of wheel and rail surfaces and use of noise barriers can reduce wayside noise levels. The use of tunnels through Santurce and Rio Piedras and the reduction of bus movements along the Spine should cause some reduction in noise levels. | Both IB and IAB will have small adverse impacts on station areas | |
| Energy | Construction | Minimal impact. | The rail alternatives will require more energy for construction than IAB, but careful scheduling and other measures can reduce the amount of energy needed. | IAB will have minimal impact | |
| | Operation | Positive impact. | Regional transportation energy consumption should be somewhat reduced due to the shifting of auto trips to transit | IAB will have a positive impact but it will be smaller than the impact of the rail alternatives | |

Air quality should experience a greater improvement if a rail system is built. Small mobile sources are more difficult to control than are fixed sources like power plants. Significant improvements can be made by switching from gasoline-powered to electrically-powered vehicles.

Noise levels should be higher for the rail during construction but significant improvements may be experienced in those sections of the Spine where vehicles operate underground.

Table VI-23. Pollutants Emitted and Energy Consumed in 1990 on a Daily Basis

| Mode | | RR-NS | LR-NS | RR-BC | LR-BC | Bus IAB | Bus IB |
|---|---|---|---|---|---|---|---|
| | | Pollutants Emitted During Operation (In kilograms) | | | | | |
| Auto | CO | 78,650 | 78,650 | 78,240 | 78,420 | 79,460 | 80,970 |
| | HC | 12,480 | 12,480 | 12,410 | 12,440 | 12,600 | 12,840 |
| | $NO_x$ | 36,210 | 36,210 | 36,020 | 36,100 | 36,580 | 37,270 |
| Bus | CO | 1,910 | 1,910 | 1,910 | 1,900 | 2,500 | 2,070 |
| | HC | 400 | 400 | 400 | 390 | 520 | 430 |
| | $NO_x$ | 2,280 | 2,280 | 2,280 | 2,260 | 2,980 | 2,470 |
| Rail | CO, HC, $NO_x$ | Negligible | Negligible | Negligible | Negligible | — | — |
| Percent Reduction of Total Versus Improved Bus | CO | 3.1 | 3.1 | 3.6 | 3.4 | 1.3 | — |
| | HC | 3.0 | 3.0 | 3.6 | 3.4 | 1.1 | — |
| | $NO_x$ | 3.2 | 3.2 | 3.8 | 3.6 | 0.5 | — |
| | | Energy Consumed During Operation (In Billions of BTU) | | | | | |
| Auto | | 126.11 | 126.11 | 125.46 | 125.74 | 127.41 | 129.83 |
| Bus | | 3.44 | 3.44 | 3.44 | 3.41 | 4.49 | 3.72 |
| Rail | | .82 | .97 | 1.58 | 1.89 | — | — |
| Total | | 130.37 | 130.52 | 130.48 | 131.04 | 131.90 | 133.55 |
| Percent Reduction Versus Improved Bus | | 2.44 | 2.32 | 2.35 | 1.92 | 1.25 | — |

Energy consumption should be reduced by the rail systems and IAB because of the magnitude of the shift of trips from auto to transit for all five alternatives.

## Patterns of Urbanization and Growth

In terms of impact on pa: :s of urbanization and growth, the six systems can be ranked accordingly:

- RR–BC and LR–BC
- RR–NS and LR–NS
- IAB
- Improved Bus