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HARD CHOICES

A Report on the Increasing Gap Between America's Infrastructure Needs and Our Ability To Pay for Them

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Appendix 15. NEW YORK

A CASE STUDY

PREPARED FOR THE USE OF THE

SUBCOMMITTEE ON ECONOMIC GOALS AND INTERGOVERNMENTAL POLICY

OF THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

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Preface

Infrastructure problems are widespread. They do not respect regional or state boundaries. To secure a better data base concerning national and state infrastructure conditions and to develop threshold estimates of national and state infrastructure conditions, the Joint Economic Committee of the Congress requested that the University of Colorado's Graduate School of Public Affairs direct a twenty-three state infrastructure study. Simultaneously, the JEC appointed a National Infrastructure Advisory Committee to monitor study progress, review study findings and help develop policy recommendations to the Congress.

In almost all cases, the studies were prepared by principal analysts from a university or college within the state, following a design developed by the University of Colorado. Close collaboration was required and was received from the Governor's staff and relevant state agencies.

Because of fiscal constraints each participating university or college agreed to forego normal overhead and each researcher agreed to contribute considerable time to the analysis. Both are to be commended for their commitment to a unique and important national effort for the Congress of the United States.

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California	Fred Collignon University of California at Berkeley
Colorado	James Ohi University of Colorado at Denver
Florida	Earl Starnes Neil Sipe University of Florida
Indiana	Salmon Shah Morton Marcus Indiana University
Kentucky	Phillip W. Roeder Dennis B. Murphy University of Kentucky
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INFRASTRUCTURE NEEDS ANALYSIS FOR NEW YORK STATE

by

Rae Zimmerman
Associate Professor
Graduate School of Public Administration
New York University

November 7, 1983

C O N T E N T S

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SUMMARY REPORT

Introduction[1]

Now that the nation's existing infrastructure problems have been recognized, estimates have to be developed for the magnitude of these needs and the ability of existing financial resources to meet them. Infrastructure improvements for New York State are estimated here in the areas of water supply, wastewater treatment, and transportation as part of a multi-state study of nationwide infrastructure needs. Estimates of the cost of infrastructure rehabilitation for public systems, excluding system expansions, are based upon existing data on the current inventory, its condition relative to currently accepted levels of performance, and unit costs of rehabilitation. A more comprehensive assessment of needs based upon demand, technology and service preferences and tolerance limits is currently precluded by limitations and uncertainties in existing data.[2]

Table S. 1 summarizes the estimates of needs and the near-term financial shortfall. Table S. 2 gives selected indicators of inventory characteristics and condition in the infrastructure categories covered. Table S.3 gives very general needs and shortfall estimates for the entire 1983-2000 period.

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1. Note: For detailed references and citations, see the main report.

2. Population changes are a critical element of a more comprehensive analysis of the demand for infrastructure. The U.S. Department of Commerce projects these changes to be very modest in New York State through the Year 2000. Thus, population change may not be a major factor influencing infrastructure demand statewide. The projected average annual rate of increase in population is less than 2 percent between 1985 and 2010.

Table S. 1

SUMMARY OF INFRASTRUCTURE NEEDS AND EXPENDITURE GAPS IN NEW YORK STATE

Infrastructure Category	Needs Estimate I. Total	II. 1983-1987	III. 1988-2000(a)	1983-1987 Shortfall IV. Resources(b)	V.(c) Shortfall
		(in billions of 1982 dollars)			
Water Supply (Rehabilitation of systems serving 13 million people-75% of the population)	7.2	3.4	1.0-3.9 (d)	0.9	2.5
Wastewater Treatment	17.3(e)	7.1	10.2	3.9(e)	3.2
Transportation					
Highways	25.5	14.1	11.4		
Bridges	20.1	8.9	11.2		
Subtotal	45.6	23.0	22.6	12.4(f)	10.6
Mass Transit					
MTA:	37.3	8.5	28.8	3.2	5.3(g)
Subways,Buses	27.8	6.5	21.3		
Commuter Rail	9.5	2.0	7.5		
Non-MTA Buses	0.5	0.2	0.3		
Rail	0.3+	0.3	---		
Airports	0.6+	0.6	---		
GRAND TOTAL(h)	108.8	43.1	65.8		

Notes: (a) The 1988-2000 estimates assume that 1983-1987 needs have been met.
(b) These are aggregate resources over the entire five year period, based upon projected capital expenditures.
(c) The shortfall is calculated as the difference between columns IV. and V.
(d) The higher figures assumes the construction of all four stages of the Third Water Tunnel.
(e) This total has been increased to $19.5 billion because of an additional combined sewer overflow correction.
(f) Expenditures are projected from a 1976 base year.
(g) The MTA "shortfall" is actually the difference between the needs in the Amended Capital Program and funds that have been secured so far by the Authority (as of September, 1983).
(h) Totals may not agree with the sum of the individual items due to rounding.

Table S. 2

SUMMARY OF SELECTED INFRASTRUCTURE INVENTORY AND CONDITION CHARACTERISTICS, New York State: 1983

Infrastructure Category	Inventory	Condition
Water Supply	No. of Systems:12,503 Production Capacity:3.68 BGD Population Served:18.05 Million Population Served by Ground-water: 6 Million No. of Dams: 1,400 Water Supply Dams: 161	Minimum Population Affected by Organic Contaminants: 2.2 Million No. of Dams in High Hazard Category ("C"): 357 Minimum "unaccounted for water": 113.5 MGD
Wastewater Treatment	No. of Systems: 535 Total Flow: 3.4 BGD Ave. Flow per Plant: 6.3 MGD	Percentage Operating at Less than Secondary:25.8%
Highways	Miles of Road: 109,706 (1982) Vehicle Miles Traveled: 79.1 billion (1981)	Mileage Deteriorated: 16,249 (15%) Mileage in Fair Condition: 76,813 (70%)
Bridges	Number of Bridges: 19,647	No. of Deficient Bridges: 8,192 (42%)
Subways (NYC)	No. of Cars: 6,500-6,700 Passengers Daily:3.5-5 Million Miles of Track: 710-747 Route Miles: 244 Stations: 479-487	Percentage Exceeding 35 years of Age: 10% (1979) Ave. Mean Distance Between Car Failures(1981):6,640 mi.
Commuter Rail	Passengers/yr.:128 million Miles of track:1,090	
Buses	No. of Buses: 8,173 (1982) No. Systems: 31	No. Exceeding 12 years of Age: 4,602 (1982)
Rail	No. of Major Systems: 6 Route Miles: 4,160 Tonnage Carried: 36.4 Million	

Table S.2 (continued)

References:

Water Supply:
NYS Department of Health, "Summary of Public Water Systems" (Albany, N.Y.: 6/8/83 retrieval); NYS Department of Environmental Conservation, Division of Water, "Dam Safety Project" (Albany, N.Y.: 6/29/83 retrieval); NYS Department of Health, "Organic Chemicals and Drinking Water" (Albany, N.Y.: c.1979).

Wastewater Treatment:
NYS Department of Environmental Conservation, Division of Water, "Descriptive Data of Sewage Treatment Systems in New York State" (Albany, N.Y.: June 1983).

Highways:
U.S. Department of Transportation, Federal Highway Administration. Highway Statistics-1981 (Washington, D.C.: 1982); estimates based on U.S. DOT and NYS DOT data.

Bridges:
NYS Department of Transportation, "Bridges in New York State. Condition Rating Trends" (Albany, N.Y.: May 1983).

Subways:
New York City, Office of the Comptroller, "Rebuilding During the 1980's" (New York, N.Y.: May 1979); New York City, Department of City Planning, "Capital Needs and Priorities for the City of New York" (New York, N.Y.: January 1983).

Buses:
U.S. Department of Transportation, Urban Mass Transportation Administration, "National Urban Mass Transportation Statistics" (Washington, D.C.: November 1982).

Rail:
NYS Department of Transportation, Rail Division, "NYS Rail Plan Annual Update" (Albany, N.Y.: January 1983); "NYS Rail Preservation Program Annual Report (Albany, N.Y.: September 1982).

Table S. 3

ESTIMATES OF 1983-2000 INFRASTRUCTURE SHORTFALLS

Infrastructure Category	Need	Resources* Annual Based on Latest Year	Resources* Annual Based on 1983-7 Average	Resources* Total (1983-2000) Based on Latest Year	Resources* Total (1983-2000) Based on 1983-7 Average	Shortfall Based on Latest Year	Shortfall Based on 1983-7 Average
	(figures given in billions of 1982 dollars)						
Water Supply**	7.2	0.203	0.171	3.7	3.1	3.5	4.1
Wastewater Treatment and Collection***	17.3	0.813	0.771	14.6	13.9	2.7	3.4
Highways and Bridges	45.6	1.914	2.470	34.5	44.5	11.1	1.1
Mass Transit (MTA only)****	37.3	0.782		14.1		23.2	

Notes:

*Resource calculations are based upon projections of capital expenditures; annual averages were computed from the 1983-7 aggregate projected expenditure level; 1983-2000 resources were based upon the 1983-7 annualized average, not the 1983-2000 projections.

**Water supply needs only cover 75% of the State, and include all four stages of the Third Water Tunnel.

***A third alternative calculation can be made using the current federal funding for FY 1983 and 1984 of $271 million per fiscal year. Since this represents a 75% share, the total funds would amount to $361.3 million a year, or a total of $6.5 billion for the 1983-2000 period at that rate. The deficit using this figure would be $10.8 billion.

****The MTA mass transit figures include both subways, buses and commuter rail (LIRR and Metro North). The resources are only based on the latest year of capital commitments (1982) or in the case of the LIRR, the 1982 net additions to real property.

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Infrastructure Needs Estimates

Approximately $43.0 billion will be needed in the near term, between 1983 and 1987, to improve water supply, wastewater treatment, and transportation facilities serving most of the State's population. Assuming that these improvements are implemented, another $66.0 billion will be needed (exclusive of rail and airports) in the period from 1988-2000. These figures represent needs, not shortfalls.

- Expenditures of $3.4 billion for water supply will rehabilitate or replace supply, treatment, distribution and storage facilities. These needs are currently identified in engineering reports for community water systems serving about three-quarters of the State's population. Included in the estimate for water supply, and accounting for the largest share of the total, is the completion of Stage 1 and part of Stage 2 of New York City's Third Water Tunnel, which would allow maintenance of the City's existing tunnels, expansions in the supply, and improvements in water pressure.

- An expenditure of $7.1 billion is the U.S. EPA's estimate for the investment needed to meet the backlog of needs in New York State for the secondary wastewater treatment (biological degradation) requirements of current water pollution control legislation. Legislation requires these needs to be met by 1987.

- An investment of $23.0 billion will provide for improvements in highways currently rated as or estimated to be deteriorated or in fair condition, totalling about 85% of the road system, and improvements in about 42% of the bridges currently rated by the State as deficient.

- An investment of $8.5 billion in the MTA subway, bus and commuter rail systems will provide for about 1,000 new subway cars, the rehabilitation of others, and track and ancillary facility repairs in New York City; purchase of new buses and the rehabilitation bus facilities; and substantial improvements in the Long Island Railroad and Metro North systems.

- $0.2 billion will provide for the purchase of buses outside of the MTA system that have exceeded the UMTA recommended age for replacement.

- Additional investments will provide for expansions in the highspeed rail system westward, the construction of a Trailer-on-Flat-Car Facility

(TOFC) in New York City to provide a railway to highway linkage for freight, and various capacity and other improvements in the State's airports.

Given the expenditure patterns that have existed in the past, a shortfall or gap is expected to be about $2.2 billion for water supply, $3.2 billion for wastewater treatment, and $10.6 billion for highways and bridges during the five year period. As of September 1983 the MTA still needed to secure $5.3 billion for the implementation of its capital program. Shortfalls in rail and airports are difficult to estimate given the absence of expenditure and revenue data exist for these facilities, and the large private contributions that are typically expected to support capital development.

Infrastructure Inventory and Condition

Water Supply

According to New York State's inventory of water supply systems, approximately 12,500 systems exist in the State with a production capacity of 3.68 billion gallons per day for the State's entire population. Approximately ninety percent of the population is served by public water systems that provide 3.2 billion gallons a day.

The components of a water supply system include sources, transmission to a central distribution point, treatment, and storage and distribution to bring water to the ultimate users.

- The supply system in New York State consists of some 1400 dams (of which 161 are explicitly for water supply), reservoirs, well fields, and surface water intake structures. New York State's Dam Safety Project,

an extension of the National Dam Inspection Program, has classified the 1400 dams as to potential hazard (by virtue of location) and structural stability. Some 385 dams (49 of which are water supply dams) are in the high hazard category, potentially endangering lives in the event of a failure. Of these, a large number have structural problems. Unfortunately, no unified cost estimates are available to estimate the rehabilitation needs for these facilities statewide.

The largest transmission project currently underway in the State is the Third Water Tunnel. It is designed to augment New York City's two water tunnels that connect reservoirs with the City's distribution system. The Tunnel, currently designed to be completed in four stages, will enable the two existing tunnels to be maintained, water pressure to be improved, and supplies to be expanded.

The need for large scale expansions in water treatment systems has been underscored by the discovery of potentially toxic organic substances in drinking water. This is exacerbated by the fact that 2.2 million people in the State depend upon groundwater for their water supplies, where many of the organic chemical problems occur. Water treatment requirements are based upon the National Interim Primary Drinking Water Regulations as well as the State's Public Health Code. While a statewide inventory of treatment systems does exist in the State to comply with federal requirements under the Safe Drinking Water Act, no systematic assessment of overall facility deficiencies exists as a basis for a statewide needs estimate.

- Water supply planning, undertaken in New York State for more than a couple of decades under various auspices, has been oriented toward the development of supplies with little comprehensive attention to distribution systems and related facilities. Concern over the distribution systems stems from breakage rates occurring in excess of rule-of-thumb engineering guidelines and leakages, or "unaccounted for water", indicated by recorded differences in production and consumption figures for metered water systems. Known leakage throughout the State (exclusive of New York City) is estimated at 113.5 MGD, or almost ten percent of the existing non-New York City production capacity. Breakage studies have been conducted under Section 214 of the Flood Control Act of 1965 and Section 22 of of the Water Resources Development Act of 1974 for large urban areas. A statewide inventory of breakage is not available, and the urban area studies need to be expanded statewide. The study of the New York City water distribution system for the U.S. Army Corps of Engineers concluded that the breakage rate has increased by sixty percent over the last three years. The study pointed out that age of the pipes was not as significant a factor as stress from construction and use of the streets, implying that management practices are as significant a factor as rehabilitation.

A comprehensive understanding of inventory and condition characteristics of the State's water supply is precluded to a large extent by the decentralization of water supply development. Priority systems and consistent application of performance indicators are needed at the State level.

Wastewater Treatment

The development and construction of wastewater treatment systems currently responds to federally approved state water quality and facility standards. A statewide facility inventory by level of treatment is conducted every two years by the New York State Department of Conservation. The current inventory estimates that 535 facilities exist in the state discharging a total of 3.4 billion gallons a day (BGD). Of this total, a quarter was operating at less than secondary treatment (which is a biological degradation process), required by the Federal Water Quality Act. This is only a minimum estimate of the need for facility upgrading, since the number of systems currently designed to operate at secondary treatment but aren't is not known directly. The U.S. Environmental Protection Agency needs survey ranked New York State needs first in the country, and identified the largest categories of need (in terms of dollars) as the correction of combined sewers, major sewer system rehabilitation, and secondary treatment in that order.

The largest source of funds for wastewater treatment facility construction is provided under Section 201 of the Clean Water Act. This program has typically provided a 75 percent federal share and a 25% state and local match, but as of October 1, 1984, the federal share will be reduced to 55%. Facility applications under that program currently total $5 billion in New York State (which includes construction cost estimates for longer time projects). About $1.0 billion worth of projects were above the State's funding cutoff, $900,000 of which are expected to be funded.

Between 1972 and May, 1983, New York State had received a total of $4.1

billion under the program, and is expected to receive $271 million each year for the next two fiscal years, a much smaller amount than has typically been received in the past.

Transportation

Highways. In 1981 New York State ranked second nationwide in total population and third in the total number of vehicle miles traveled, which amounted to 79.1 billion miles. This increased to 80.5 billion miles in 1982. Total highway mileage in the State is 109,706. Town and county owned roads account for the largest share of the total. Over the last six years, the network has expanded an average of about 166 miles a year.

Road condition is measured in terms of (1) the pavement surface and road base, and (2) the capacity of the roadway to sustain traffic, measured in terms of the ratio of volume to capacity. Federal rating categories for the first measure, pavement condition, are: deteriorated, fair, good or unpaved. Based on Federal, State and other data and analyses, 16,249 miles (15%) of the total road network were actually rated or estimated to be in deteriorated condition and another 76,813 miles (70%) were rated or estimated to be in fair condition. Since condition, and hence, rehabilitation cost, of non-Federal aided roads was not available, it had to be estimated. The estimates for non-Federal aided roads assume that between 1983 and 1987 deteriorated roads will receive an asphalt cover at a unit cost of $125,000 per mile, roads rated in fair condition will receive a chip seal coating at a cost of $35,000 per mile, and unpaved roads will require maintenance amounting to $15,000 per mile. Between 1988 and 2000, all non-Federally

aided paved roads are assumed to get two treatments of chip seal, and unpaved roads get two maintenance treatments.

Major revenue sources for both highway and bridge needs, amounting to about $4.1 billion through 1987, are expected to be from the Surface Transportation and Assistance Act of 1982, motor vehicle fuel taxes, and the Transportation Bond Act.

Bridges. There are currently 19,647 bridges in New York State of which 36.7 percent are state-owned. An extensive bridge inspection and rating program has been undertaken in the State since 1977. Based on a rating scale of 0 through 7, bridges with scale values less than 5 are considered deficient. The scale is based upon visible deterioration and changes in load bearing capacity, and does not measure certain types of deficiency, such as those related to weaknesses in material or design. In 1983, 8,192 or 42% of the bridges were rated as deficient. About two-thirds of these deficient bridges are at the very top of the deficient category, i.e., have scale values close to 5. Non-state owned bridges have a higher proportion of deficient bridges than state-owned bridges, however the percentage of deficient bridges has been rising faster in the state-owned category than in the non-state owned category. In spite of the State's ongoing bridge repair program, the percentage of deficient bridges continues to rise in both ownership categories. The State estimates that the rate of slippage of a bridge in the rating scale is about 0.122 points per year, which means that by the Year 2000 the bridges not repaired in 1983-7 that have ratings of 5 or above, will require repair.

Subways. The major subway system in New York State is in New York City. The City's two systems operated by the New York City Transit Authority and the Staten Rapid Transit Authority (SIRTOA) have between 6500 and 6700 subway cars serving between 3.5 and 5 million passengers daily, along 710-747 miles of track. There are almost 500 passenger stations as well in the system. The condition of the system is primarily guaged by the age of the cars and tracks. The UMTA threshold age of 35 years for cars and 20-30 years for track is used as a general guideline, though in the case of cars, performance and usage can considerably affect this, and in the case of track, the shape of the track can alter the lifetime. These age criteria form part of the basis for the needs estimate. Additional trackwork necessitated by recent derailments may exert an additional demand for subway expenditures during the 1983-7 period.

Commuter Rail. The two major commuter rail lines in the State are the Long Island Railroad and Metro North. These lines are facing increasing demand, and at the same time increased train delays and standing time for commuters. Objectives of the Metropolitan Transportation Authority Capital Plan for these systems is expansion, reduction in the number of standees and system delays.

Buses. In 1981 UMTA reported that 8,173 buses were being run in the State by 31 bus systems each operating more than five vehicles per year. About two-thirds of the buses are located in New York City. As in the case of subway cars, age is the major indicator of bus replacement. The UMTA guideline for buses is 12 years. In 1983, 4,602 buses or 56 percent exceeded the 12 year guideline. The replacement cost for a bus is highly variable

depending upon its capacity. According to the New York City Transit Authority, the cost of a Grumman Flexi bus is $103,000 and a GM bus is $150,000 including the cost of a chair lift for the handicapped.

Rail. The six major rail freight systems in the State currently cover 4160 route miles, of which Conrail accounts for almost two-thirds of the total. The five carriers, classified by the Interstate Commerce Commission as Class I carriers, since their revenues exceed $50 million per year, carried 36.4 tons of freight in 1980. Once again Conrail dominated the picture. Rail needs articulated by the State include the expansion of the existing high speed rail network westward, restructuring some of the railroads, and improvements in freight service in the downstate area by constructing a railway - highway freight link or Trailer-on-Flat-Car facility (TOFC) at the Harlem Rail Yard.

Airports. The two airports in New York City, JFK and LaGuardia, account for two-thirds of the estimated needs for airport facilities in the State. Building capacity is a major constraint at JFK, and LaGuardia is also operating at capacity. Needs for other airports in the State have been formulated in terms of anticipated federal allotments rather than in terms of a comprehensive needs assessment. Buffalo and Syracuse airports account for the largest share of the total of upstate airport needs.

INTRODUCTION[1]

The Nature of and Approach to the Infrastructure Problem

Infrastructure is typically defined as the facilities and services that support the economic and social activities and functions of society. Infrastructure categories include a couple of dozen kinds of facilities in the broad areas of transportation, energy, environmental services, water supply, recreation, and health and social services.

The attention to nationwide infrastructure needs is a result of the demand for higher levels of quality, service, and safety. Of major concern is the risk from facilities approaching their design lifetimes or from the introduction of uncertain or poorly maintained technologies into the service sector.

Estimation of infrastructure needs ideally combines estimates of demand from an identified user population with characteristics of the capacity, condition and fiscal constraints upon the supply. In a sense, such an assessment is an impossible task given the tremendous variation and uncertainty in desirable levels of service, durability and reliability of facilities, performance of new technologies, and the difficulty in identifying and projecting absolute demand for infrastructure from characteristics of the population and economic activity.

Yet, alternative scenarios can be formulated based upon the knowledge of the systems, different tolerance levels for risk, and values associated with quality of service. These gross estimates give enough information to initiate financing some of these improvements. Refinements in the estimates could be initiated when funds are allocated.

This report is restricted to transportation, water supply and wastewater treatment infrastructure in New York State. For each category the emphasis is upon the following characteristics: the existing inventory, its performance in terms of condition and/or level of service, performance indicators and assumptions that underly the performance, unit cost estimates for rehabilitation, replacement and new construction of infrastructure facilities, and existing and projected trends in capital costs and revenues and expenditures.

The report is limited in scope to public, public benefit or community systems, and secondary data sources with no new generation of data.

Only a few simple indicators of infrastructure inventory and condition are used. While many more sophisticated indicators exist, data are not available

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1. This report is the result of a three month study of New York State Infrastructure Needs. It is one of about two dozen state studies prepared for the Joint Economic Committee in Congress under the direction of the University of Colorado.

to systematically apply them throughout the State. A more comprehensive and thorough approach would require extensive research, and should direct future assessments of needs.

Population and Demographic Trends

The State of New York with its 1980 population of 17,588,072 ranks second among the states in the nation in terms of population size and seventh in terms of population density. It accounted for 7.75 percent of the country's population in 1981. While the State's population experienced a modest growth of 8.7 percent between 1960 and 1970, somewhat lower than the national average, it experienced a decline between 1970 and 1980 of 3.7 percent (see Table 1). The preliminary population projections of the New York State Department of Commerce are shown in Table 2. These figures indicate that the 1970-80 decline will reverse itself between 1980 and the Year 2010. The rate of population change, however, is projected to be cyclical: increasing from 5 to 9 percent between 1985 and 1995 and decreasing between 1995 and 2010. In addition to population size and rate of change, the major demographic characteristics that relate to infrastructure needs (in the categories covered here) are: population distribution and density. Other population characteristics, such as age profiles, household composition and income are also important to the extent that they can be linked to actual and potential use of infrastructure facilities and services.

As one might expect, the majority of the population is concentrated in the major urban areas, particularly New York City. In 1980 90.1 percent of the State's population was located in metropolitan areas, compared with a nationwide percentage of 76.6 percent, and, there has been only a slight decline between 1970 and 1980 (of one percent) in the metropolitan population.[2] Looking at this another way, 86.4 percent of the population was classified as urban.[3] New York City accounted for 40.2 percent of the State's population in 1980. The City also accounted for 42.9 percent of the State's housing units in that same year. The twelve areas designated as standard metropolitan statistical areas in the State, including the New York portion of the New York-New Jersey area, altogether accounted for ninety percent of the State's 1980 population. The 1970-80 decline statewide was not evenly distributed over these areas. New York City experienced the largest decline of any urban area, with Buffalo following closely behind, and Utica-Rome, Elmira, and Binghamton experiencing declines as well. The Mid-Hudson area experienced substantial increases in its major urban areas.

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2. U.S. Department of Commerce, Bureau of the Census, "Statistical Abstract of the U.S., 1982-3." Washington, D.C., December 1982. Page 16.

3. Ibid., p. 20.

Table 1

SUMMARY OF SELECTED STATEWIDE POPULATION AND HOUSING CHARACTERISTICS FOR NEW YORK STATE

	1970	1980	1970-1980 Change Number	Percent
Population	18,241,391	17,588,072	-683,319	- 3.7%
Working Population	--	10,728,723		
Percentage of State Population		61 %		
Households	5,883,918	6,340,429	+456,511	7.0
Housing Units	6,298,663	6,867,638	+568,975	9.0
Population Density (1980)		358 persons per sq. mi.		
Land Area		49,108 sq. mi.		
Water Area				
Inland		1,731 sq. mi.		
Other		1,343 sq. mi.		

Sources: U.S. Department of Commerce, Bureau of the Census. Census of Population and Housing. Washington, D.C.: Bureau of the Census, 1982; Statistical Abstract of the United States, 1982-3. Washington, D.C., December 1982.

Table 2

POPULATION PROJECTIONS FOR NEW YORK STATE, 1985-2010

Year	Projected Population	Population Change Period	Number	Percent Change
1980	17,558,072	--	--	--
1985	17,646,994	1980-1985	88,922	5.1
1990	17,763,644	1985-1990	116,650	6.6
1995	17,931,279	1990-1995	167,635	9.4
2000	18,081,542	1995-2000	150,263	8.4
2005	18,168,273	2000-2005	86,731	4.8
2010	18,220,905	2005-2010	52,632	2.9

Source: New York State Department of Commerce. Preliminary Population Projections. Albany, N.Y., February 14, 1983.

Economic Activity and Trends

The economic health of an area is partly measured in terms of its employment, personal income and economic base. In 1980 the State's employed population over sixteen years of age was dominated by administrative support and professional specialty occupations. By type of nonagricultural establishment, employment in the State was distributed as follows in 1981:

Employment Sector	Number Employed (in thousands)
Total	7,281
Manufacturing	1,432
Wholesale and retail trade	1,464
Government	1,300
Services	1,784
Transportation, public utilities	429
Finance, insurance, real estate	655
Construction	211

Source: U.S. Bureau of the Census, "Statistical Abstract of the U.S., 1982-3" (December 1982). P. 395.

The State accounted for eight percent of the country's employment in non-agricultural establishments, approximately equal to its share of the country's population. The category accounting for the majority of the employment is the services sector. Trends over the past decade have been mixed, with declines in employment during the first half of the decade followed by increases in the latter part of the decade.[4] Between 1972 and 1975 total nonagricultural employment fell from 7,039 to 6,830, but rose to 7,281 by 1981.[5]

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4. New York State Council on State Priorities. Report to the Governor. Albany, N.Y.: The Council, December 1982. Page 197.

5. U.S. Bureau of the Census, "Statistical Abstracts, 1982-3" (December 1982), p. 395.

By June of 1982 the State's unemployment rate stood at 8.5%, reflecting almost a steady rise over the last five years, but behind the national average for the first time, as follows:

Year	Percent Unemployed	
	NYS	U.S.
1978	7.7	6.1
1979	7.1	5.8
1980	7.5	7.1
1981	7.6	7.6
June 1982	8.5	9.5

Source: U.S. Bureau of the Census, "Statistical Abstract of the U.S., 1982-3" (December 1982), p. 392-3.

Finally, in terms of personal income, the State has experienced some setbacks though in the past year, there appears to be some improvements. Total personal income in the State continued to rise during the past decade, but at a dramatically lower rate than that of the previous decade. Between 1960 and 1970 the rise in total income, expressed in constant dollars, was 46.5 percent (compared the nation's 57.8 percent rise), but from 1970 to 1980 it was only 8.8 percent (compared to the nation's 39 percent rise). The State's rate of change was below the region's rates as well. Per capita income in 1981 stood at $11,440, ranking the State tenth in the nation, as compared to its rank of twelfth last year. This is still a decline in rank from its position of fifth in 1970.[6]

Financial Patterns and Trends[7]

Trends in Revenues and Expenditures

In 1982 the State's revenues and expenditures were approximately equivalent, and stood at $24.8 billion. In any given year since 1975, taxes have accounted for more than half and often sixty percent of the State's total receipts. Within the tax category, personal income tax predominates. Federal aid typically accounts for about one-quarter of the State's revenues. Over time, the rate of change in total receipts and also taxes received has not kept up with inflation. In fact, since 1975, the annual percentage change has been much more than 5% and was even negative over a couple of years. The slowed growth in tax revenues has been the result of

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6. These trends are summarized from U.S. Bureau of the Census, "Statistical Abstract of the U.S., 1982-3". Washington, D.C., December 1982. Pp. 426-7.

7. This section draws heavily upon and summarizes: The New York State Council on State Priority's, "Report to the Governor". Report of the Panel on Public Finance. Albany, N.Y.: The Council, December 1982.

deliberate state policies.[8]

The rate of change in State expenditures averages only 1.2 percent between 1975 and 1982 when adjusted for inflation. In terms of purchasing power this represents a decline of $82 million over that period. Capital construction expenditures accounted for the largest declines.[9] By function, education continues to account for largest the percentage of State total expenditures, though its relative share has been declining slightly. Transportation accounted for 9.8 percent of total expenditures in 1976-77 and 10.3 percent in 1981-2; Environmental Conservation (which receives heavy federal support) accounted for only 1.4 percent of State expenditures in 1976-77 and 1.5 percent in 1981-2.[10]

Financial Condition

The State's financial health is measured partially in terms of a number trends in key financial indicators, particularly those relating to its borrowing capacity and strength. These various indicators show that prior to 1975, New York State was borrowing at a rate that exceeded its ability to finance the debt, as evidenced by the following:[11]

- Outstanding bonds of the State's major authorities, backed by moral obligation provisions, rose from under $350 million in 1967 to over $4 billion in 1975;
- Total outstanding short term debt for all state and local governmental units rose from $1.7 billion in 1965 to $9 billion in 1975; and
- The Urban Development Corporation's default on over $100 million in short-term notes closed out the State and then New York City from the bond market;

Since 1975 this trend has reversed itself, because there has been a considerable reduction in borrowing, especially relative to the rest of the country. This is the result of mandates as well as a number of institutional changes at the State and local levels.[12]

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8. Ibid., pp. 51-3.

9. Ibid., p. 53.

10. Ibid., p. 54.

11. Ibid., p. 44

12. Ibid., pp. 45-6.

a. In the area of new tax exempt bond issues:

- New York State's average annual volume of issues dropped from 19 percent of country's volume in 1971-75 to 9% from 1975 to 1981;

- The volume dropped in absolute terms from an average annual amount of $4.6 billion in 1971-75 to $3.8 billion in 1975-81.

b. In the area of short-term debt issues:

- All outstanding short-term debt dropped from $9.0 billion in 1975 to $2.8 billion 1980, causing the State's share of the country to drop from 45% to 21%;

- The percentage that short-term debt is of total debt fell from 23% in 1975 to 6% in 1980, fast approaching the national average of 4%; and

- As a percentage of personal income, State and local debt dropped from 33.4% in 1975 to 24.6% in 1980.

While there are certainly strong signs of recovery, the State has had to continually finance a number of public authorities, including those in the transportation area, so they can meet operating expenses and debt service.[13]

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13. Ibid., p. 48.

WATER SUPPLY

Overview of Water Supply Needs

Water supply systems include sources of supply, transmission, water treatment and distribution (and storage). In New York State, with the exception of the Third Water Tunnel (a transmission facility), the largest dollar need is in the distribution component. Distribution lines have been relatively more susceptible to deterioration because of urbanization over many decades, their age, and government's history of paying attention to other parts of the water supply system. The total estimate of minimum needs for community water supply systems serving approximately three quarters of New York State's population is $ 7.2 billion in 1982 dollars. New York City represents the largest municipal share of the estimate, with almost $5.9 billion estimated for total water supply system needs, assuming that all four stages of New York City's Third Water Tunnel are completed (totalling $4.5 billion).

The separation of this estimate into near-term (e.g., 5 year) vs. future (Year 2000) needs is more difficult than it is in other infrastructure areas because needs have not been distributed over time and no consistent priority system exists as a basis for timing the investments. Allocations, however, have been estimated for the Third Water Tunnel. Extrapolating from the New York City Planning Commission's estimates for the Tunnel, $0.673 billion would be spent between 1983 and 1987, and the remainder (the difference between $4.5 billion and $0.673 billion) of $3.8 billion would be spent in 1988-2000, assuming that the entire project is completed. Other water supply projects explicitly planned for the 1988-2000 period total only about $100 million. Thus, using this distribution of costs for the Third Water Tunnel, the statewide needs for 1983-7 are $3.371 billion, and for 1988-2000, $3.937 billion. If Stages 3 and 4 of the Third Water Tunnel are eliminated, then the total 1988-2000 need is reduced to $1.1 billion.

Conceptualizing Water Supply Needs: The Inventory and Its Condition

The amount of water potentially available to New York State is reflected in the 1,731 square miles of inland waterways in the State (see Table 1) with over 4,000 lakes exceeding 0.01 square miles[1], and the abundance of rainfall. An estimated 5,600 gallons per capita per day is potentially available.[2] Actual availability is precluded by a number of system

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1. P.E. Greeson and F.L. Robison, "Characteristics of New York Lakes. Part 1-Gazetteer of Lakes, Ponds and Reservoirs." Washington, D.C.: U.S. Geological Survey, 1970.

2. NYS Council on State Priorities, "Report to the Governor". Albany, N.Y., December 1982. Page 217.

constraints, and distributional and quality problems in the supply.

Approximately 12,500 systems exist in the State with a production capacity of 3.68 billion gallons per day, serving the State's entire population.[3] An estimated ninety percent of the population in New York State is served by 1,791 community water supply systems providing 3.2 billion gallons a day.[4] Community water supply systems, in their entirety, consist of sources of supply, transmission mains connecting supplies with distributors, a distribution point with water treatment capability, an intermediate storage facility to even out short-term differences in production and consumption, and a series of distribution mains to bring water directly to users.[5]

1. Sources of Supply

Water supply and storage systems in New York State consist of direct intake from surface waters, wells to tap groundwater, dams and reservoirs.

Inventories of existing dams and their condition have been carried out since 1972 under the National Dam Inspection Act (P.L. 92-367). New dams are inventoried in connection with the Certificate of Approval program (under the New York State Environmental Conservation Law, Article 15, Section 15-0503). The State of New York currently has about large 1400 dams in its inventory. Only 161 are listed as being used exclusively for water supply, and an unestimated larger number may be used incidentally for water supply.

The State uses two mutually exclusive evaluation systems for the condition of dams.

The first classification system pertains to structural condition. Four codes are defined under this system indicating the relative severity of structural conditions, based on inspection reports under the "Phase 1" program. The U.S. Army Corps of Engineers, originally administrator of the

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3. New York State Department of Health, "Summary of Public Water Systems. Population Ranges for Number of Systems, Production Capacity, Population Serviced, and Number of Services by Program Code" (Albany, N.Y.: June 9, 1983).

4. A "community" system is one that has a number of individual users or service connections as compared with a system serving a single user. The Federal Safe Drinking Water Act of 1974 and the New York State Department of Health define community systems as serving a precise minimum number of people or having a minimum number of service connections. Such a system may be publicly or privately owned or operated.

5. Inventory measures and indicators of system condition, a major determinant of need, are given in the Appendix for each of the components of a typical water supply system.

dam inspection program, has another set of guidelines for conducting safety inspections.[6]

The second classification system measures degree of hazard attributable to exposed populations and property, rather than to characteristics of the dams themselves. The classification system and recommended guidelines for design criteria for dams are given in the Appendix. The distribution of the State's dams by these potential hazard categories is:[7]

Category	New York State definition	No. of Dams
Class A	Rural/agricultural area dams where failure might damage land, buildings, and roads	568
Class B	Primarily rural/agricultural area dams where failure might damage isolated homes, major roads, railroads, and utilities	479
Class C	Failure might cause serious damage to homes, buildings, roads, utilities, and loss of life	357
	TOTAL	1404

The Department of Conservation's Dam Safety Project listing reveals many Class "C" dams (a threat to people's lives) that have structural problems as well, and for which no engineering work has commenced. 49 of the 161 water supply dams are in Class "C". No total or unit cost estimates are systematically available for improvements in these dams.

2. Transmission

A number of larger water supply systems contain transmission mains that connect the source of supply to a water treatment plant or distribution point. These pipes are typically 20" to 48" in diameter. The most extensive of these facilities is the proposed Third Water Tunnel. The Third Water Tunnel would provide an alternative water conduit between New York City's existing water supply reservoirs and the distribution system. It would provide an emergency alternative to existing conduits, Tunnels 1 and 2, and enable them to be shut off for inspection, maintenance, and repair. The two

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6. U.S. Army Corps of Engineers: Appendix D.

7. Compiled from the New York State Department of Environmental Conservation's "Dam Safety Project" (Albany, N.Y.: Computer printout dated 6/29/83).

tunnels, dating from 1917 and 1936 respectively[8], are expected to reach their design lifetimes within the next couple of decades, and have never been shut off for repair. Another purpose of Tunnel No. 3 is to provide a conduit for expansions in supply (such as the implementation of the U.S. Army Corps of Engineers' plan to take water from the Hudson River at Hyde Park), and to improve water pressure in various parts of the City.

Plans for the construction of the Third Water Tunnel have had a long and complicated history.[9] The construction of the Tunnel is currently envisioned to proceed in four stages. Stage 1 is designed as a 13.3 mile concrete lined tunnel, 20-24" in diameter and varying in depth from 200-800' from ground level.[10] Stage 1 extends from Hillview Reservoir just north of the City in Yonkers, through the west side of Manhattan and terminates in Queens.[11] Sixty one percent of the entire Stage 1 project is complete[12] and 88 percent of the excavation alone is complete.[13] Stage 2 would extend the Queens section of Stage 1 10.2 miles into Brooklyn, terminating at Red Hook. It would extend the Manhattan section 6 miles along the west side to the southern end of Manhattan.[14] Stage 3 would link the Kensico Reservoir further north to the Hillview Reservoir. Stage 4 would act as a bypass for Stage 1, connecting the Hillview Reservoir with the western termination point of Stage 1 in Queens. A number of different allocation formulas have been suggested over the past few years for funds for the first two stages.[15]

Another large transmission system that exists in the State is for the City of Rochester. According to a recent Army Corps of Engineers study, this system consists of 90 miles of conduits, averaging about 90 years in age, and is in need of rehabilitation.

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8. New York City Department of City Planning, January 1983: 172.

9. Gordon, 1973: 167-207.

10. New York City Department of City Planning, January 1983: 176

11. New York City Office of the Comptroller, May 7, 1979: 50.

12. New York City Department of City Planning, January 1983.

13. New York City Office of the Comptroller, May 7, 1979: 51.

14. New York State Office of the Comptroller, May 7, 1979: 53.

15. New York City Office of the Comptoller, May 7, 1979: 52-54; New York City Department of City Planning, January 1983; Research & Forecasts, Inc., 1982.

3. Water Treatment

The quality of the water supply is a major determinant of the need for water treatment facilities. Until 1974, when the Safe Drinking Water Act (SDWA) was passed, water quality concerns for drinking water focused upon biological contaminants rather than chemical contaminants. The number of chemical contaminants covered by standards has gradually expanded over the past decades. While extensive monitoring programs for surface water have existed for several decades, their emphasis has been upon preserving fish and the quality of waterways for swimming rather than for drinking. Groundwater quality, the source of a considerable amount of drinking water, has only received attention recently in national and statewide groundwater management strategies. The State of New York has now mapped groundwater aquifers within its borders. It is estimated that about 6 million people or 34 percent of the total State population are dependent upon groundwater as a water supply.[16] In some areas, i.e., Long Island, the percentage reaches almost 100 percent.

Under the Federal Safe Drinking Water Act of 1974 (P.L. 93-523), public water supplies (defined as those with 25 service connections or more) are required to meet the National Interim Primary Drinking Water Regulations. While many water supply systems had water treatment systems prior to the 1974 Act, such as chlorination to prevent bacterial contamination and iron removal systems, the 1974 Act considerably expanded the scope and expense of water treatment. The State currently maintains an Inventory of Community Public Water Systems which includes information on the level of treatment and the capacity of municipal as well as institutional and commercial water supply systems, but an aggregate assessment of facility condition from this data is not available.

The need to cope with synthetic organic chemicals, including pesticides, in drinking water will create the greatest need for water treatment in the next decade. Table 3 lists some of the areas in the State where organic contaminants were found in drinking water or where well systems were closed because of such contamination. It is estimated that some 2.2 million people or over ten percent of New York State's population was affected in 1979 by organic contaminants alone. Since this estimate is based on sporadic data, it is likely that the actual total is considerably higher.

4. Distribution

Distribution system needs consist of replacement of (a) undersized water mains to six inch diameter minimum standards recommended by the American Water Works Association, (b) old cast iron mains that restrict water pressure within the system when tuberculation occurs, and (c) pipes that produce

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16. NYS Department of Health, Division of Environmental Health, 1981: 5.

Table 3

POPULATION IMPACTED BY ORGANIC CONTAMINATION OF WATER SUPPLIES
BY COUNTY, New York State: 1979

County	Population Served	County	Population Served
Albany	88,600	Onondaga	6,000
Allegany	3,150	Oswego	17,600
Cattaraugus	NA	Putnam	3,500
Clinton	25	Saratoga	9,000
Cortland	28,942	Schenectady	110,000
Erie	9,675	Suffolk	958,000
Genesee	17,800	Sullivan	1,600
Jefferson	?	Ulster	11,250
Madison	2,700	Wyoming	1,980
Nassau	933,200	Grand Total	2,203,022

Notes:

The communities considered impacted by organic contaminants in the water supply are those in which the sum of the concentration of organic contaminants exceeded 1 ug/l, with the range being from 1 through 290 ug/l. in areas outside of Long Island. These results are based upon sporadic sampling of selected areas of the State only, rather than being a comprehensive coverage of the State. On Long Island (Nassau and Suffolk counties) the areas tabulated are those in which wells were closed for organic contamination by the local health departments.

Population Served indicates that portion of the county population served by systems in which organic contaminants have been detected, rather than reflecting the total population served by the system.

Source: New York State Department of Health. Organic Chemicals and Drinking Water. Albany, N.Y., Undated, c. 1979. Tabulated from pages 88, 91-94.

losses in the system through breakage and leaking joints.[17] Attempts have been made to associate breakage rates in distribution lines with characteristics of the pipes and their immediate environment to predict where weaknesses will occur. Parameters typically investigated include size, age and type of pipes, and their location relative to heavily traveled roads or construction impacts. Few conclusive findings have emerged from these studies to guide pipeline replacement.

Leakage or what is commonly called "unaccounted for water" is an indicator of gross infrastructure needs in a water supply distribution system. It can be approximated from the difference between water consumption and production, system by system basis. Out of a total of approximately 1.3 billion gallons of water produced by community water systems outside of New York City, a minimum of 113.5 million gallons a day, or 8.7 percent of the non-New York City total, is "unaccounted for" water.[18] This figure is only a minimum, since it excludes private systems, unmetered systems in which no estimates of such losses can be made, systems for which data were contradictory (e.g., water consumed exceeded water produced), and systems that do not appear in the State's files. An important priority should be placed on refining the State's inventory of water production, consumption, and loss, as a means of targetting trouble spots and establishing statewide priorities. In New York City, where water production is practically equivalent to the non-City statewide total, the absence of metering does not allow an estimate of unaccounted for water. The breakage rates that have been recorded in the City by the studies conducted by the U.S. Army Corps of Engineers imply substantial, though not easily quantifiable, losses in the system. One of the conclusions of the Corps study was that "the number of main breaks per mile per year in New York City has increased more than 60% in the last 30 years".[19]

Some of the characteristics of the distribution systems of major water supply systems in the State that are indicators of rehabilitation needs are as follows:[20]

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17. Descriptive parameters and performance standards are summarized in the Appendix.

18. Calculated from average daily production and consumption figures reported in: New York State Department of Health, Office of Public Health, Bureau of Public Water Supply Protection, "Inventory of Community Public Water Systems" (Code 100), Albany, N.Y., Computer printout dated June, 1983.

19. Betz Converse Murdoch, May 1980: xiv.

20. Most of these estimates are based on the Army Corps of Engineers Section 214/22 studies listed in the bibliography.

Mileage and Average Age of Water Distribution Systems for Selected Systems in New York State

Place	Miles of Pipe	Average Construction Date
Albany	373	1929
Binghamton	157	1915
Buffalo	738	1903
New York City	6000	1900s
Poughkeepsie	96	1900
Rochester	700	1873-1920

Current Sources of Estimates for Water Supply Needs in New York State

Statewide water resources planning and management in New York State has been tried, at least in certain portions of the state, over a couple of decades.[21] These efforts were largely restricted to supplies, with little attention to a comprehensive assessment of needs. Thus, total needs have to be pieced together from a variety of sources.

The current sources of data and ongoing data collection efforts for water supply needs estimates in New York State are:

(1) Water supply engineering studies were conducted for about a dozen local areas under Section 214 of the Flood Control Act of 1965 (P.L. 89-298) and later under Section 22 of the Water Resources Development Act of 1974 (P.L. 93-251). These range from details of trouble spots in distribution systems to comprehensive needs estimates for a total water supply. Since these studies were to intitiate comprehensive water supply planning, the choice of study areas was not necessarily based upon any priority system.

(2) The Facility Needs Survey of Community Public Water Systems was conducted in 1981 by the New York State Department of Health, Office of Public Health as the basis of financing water supply infrastructure, and as support documentation for the Water Development Finance Authority and the State's Environmental Health Bond Issue. Findings were based upon interviews and questionnaires to local officials responsible for water supply. An

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21. Examples include the "Level B" river basin studies under the Water Resources Planning Act of 1965 and later, under Section 209 of the Federal Water Pollution Control Act Amendments of 1972. Management plans to preserve the quality of water supplies were also developed in the late 1970's under Section 208 of the Clean Water Act.

overall response rate of 40 percent was obtained.[22]

(3) The SAFWATER Data Management System is a computerized data base for water treatment systems only to meet the requirements of the Safe Drinking Water Act of 1974. It is maintained by the New York State Department of Health.

(4) The Substate Strategy for Water Resources is expected to cover 13 strategies, beginning with the Capital District, and is based upon interview data generated by the New York State Department of Environmental Conservation.

(5) New York State Department of Environmental Conservation, Division of Water's Dam Safety Project inventories dams and their condition throughout the State.

Other water resources planning efforts that have considerable implications for infrastructure needs estimates, but are not always facility specific, are (a) the statewide and regional Groundwater Management Strategies and (b) the Statewide Drought Preparedness Plan[23] for emergency and long term plans for increased flexibility in the distribution of supplies to lessen the severity of drought. These efforts are being performed by the New York State Departments of Health and Environmental Conservation, in coordination with some federal agencies such as the U.S. Environmental Protection Agency, the Department of the Army Corps of Engineers, and the U.S. Water Resources Council. Some other substantial needs estimates have been made over the past decade outside of the context of State programs, particularly for large projects, such as the Hudson Flow Skimming Project.

Using the primary data sources listed above, a compilation of water supply infrastructure needs by type of facility has been made and is presented in Table 4. Table 5 converts these estimates to 1982 dollars. The total need in 1982 dollars currently stands at $7.2 billion for systems covering three-quarters of the State's total population, and a higher percentage of the population served by community systems. Table 6 gives some selected characteristics of these systems in addition to population served.

Though the data sources for these needs estimates do not distribute needs over time, some of the larger costs presented in Tables 4 and 5 can be disaggregated, in particular, those associated with New York City's Third Water Tunnel. The New York City Planning Commission has estimated that over the next five years the completion of Stage 1 will require $373.4 million, and part of Stage 2 to be constructed from 1983-1992 (a ten year period) will cost $600 million. Using an annual amount of $60 million per year for Stage

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22. P. Chiefari, "Facility Needs Survey of Community Water Systems". Albany, N.Y., April 1983.

23. NYS DEC, February 1982.

Table 4

CAPITAL NEEDS FOR WATER SUPPLY, New York State

Cost given in millions of dollars

System Name/Ref.	Supply/Storage Cost	Supply/Storage Purpose	Transmission Cost	Transmission Purpose	Treatment Cost	Treatment Purpose	Distribution and Storage Cost	Distribution and Storage Purpose	Total
Binghamton (2)							4.9	R	4.90
Buffalo C(1)	0.0	-	15.00	U	20.00	R,U	313.00	C,R,V	348.00
Capital District(3)	3.867		47.43		23.74		94.378		169.42
Corning(2)							0.172		0.17
CortlandCty(2)	0.489	E(w)					3.727	t,r,e	4.22
Erie Cty WA(1)							0.00		0.00
Hornell(2)	0.596						1.42		2.02
Jamaica WS Co.(Q)(1)	5.5	E(w)	0.00		6.13	A(w)	22.54	E	34.17
Jamaica WS Co.(N)(1)	2.8	E(w)	0.00		0.40	A(w)	7.90	R	11.05
LI Water Corp.(1)*	0.0		2.70	E	6.00	U	64.30	R	73.00
Metro WB (1)*	0.0		16.00	E	2.00	R	5.00	t	23.00
Monroe Cty WA (1)*	0.0		4.70	R,E	0.00		70.80	C,E,N	75.50
New Rochelle Water Co.(1)*	0.0		3.50	E	0.15	C	15.20	E,N	18.85
NYC(1),(4)**	50.0	R(d)	4510.00	E	500.00	C	800.00	R,E	5860.00
NY Water Service(1)*	1.2	E(w)	0.29	E	0.00		1.10	R, T	2.59
Niagara Falls C. (1)			15.00	E,P	15.00	U	35.00	C,v,N(r),E	65.00
OhioRBasin(5)	3.85	E			2.55	C	14	E,R	20.40
Onondaga Cty WA (1)*	0.00		1.00		12.00	C	2.00	t	15.00
Orange Cty(5)	25.5	E	25.8		21.1	C			72.40
Poughkeepsie (2)	19.99				19.06	E,U	4.22		43.27
Rochester C. (1)	0.00		20.00	C	25.00	C	110.00	R(r),R,E	155.00
Spring ValleyWCo.(1)									
Suffolk Cty WA (1)*	8.00	E(w)	5.40	E	17.50	U	30.90	t,R	61.80
Syracuse C. (1)	0.06	R	0.09	R	0.00		10.60	R(r),R,v,E	10.75
Tonawanda WD (1)*	0.00		4.00	E	1.50	R	2.50	E	8.00
Utica WB*(1)	0.40	R(r)	0.91	E,C,P	35.02	C,R	2.28	t,I	38.61
Yonkers C.(1)	0.03	I	5.00	E,C	1.00	U	15.00	E, C	21.03
TOTAL	122.2		4676.82		708.15		1630.9		7138.14

KEY TO TABLES 4 and 5

Abbreviations under "Purpose" columns:

Activities:

A	Airstripping (type of water treatment system)
C	Cleaning, lining, or relining of pipes
E	Expansion, additions, replacement, interconnections, new diversions, facility relocations
I	Non-specific improvements to equipment; studies and surveys
N	New construction of facilities other than expansion or upgrading of existing facilities
R	Rehabilitation, renovation, minor facility additions
U	Upgrading

Facility Types:

d	Dam
h	Hydrant
p	Pump
r	Reservoir
t	Tank (storage)
v	Valve
w	Well

Notes:

*These are private water companies or authorities; otherwise, the systems are publicly owned, or in the case of regions (e.g., the Capital Region and the Ohio River Basin) there are variable ownership patterns within the region.

**Under the New York City transmission system, $1,673.4 billion would be spent in 1983-7, and the rest, $2,836.6 billion would be spent in 1988-2000 (see text for explanations).

References:

(1) NYS Department of Health, "Water Supply Fact Sheets" (Albany, N.Y.: various dates, revised May, 1983)

(2) U.S. Army Corps of Engineers studies under Section 214 of the Flood Control Act of 1965 (P.L. 89-298) and Section 22 of the Water Resources Development Act of 1974 (P.L. 93-251). See bibliography for exact references.

(3) NYS Department of Environmental Conservation, "Pilot Water Resources Strategy for the Capital Region" and Summary of Existing Water Supply System" tables. Draft. (Albany, N.Y.: Undated, c. July 1983).

(4) New York City Planning Commission, "Capital Needs and Priorities for the City of New York (New York, N.Y.: January 1983).

(5) Ohio River Basin Commission, "ORBC Water Conservation Survey. New York Summary", Draft (Cincinnati, Ohio: January 26, 1981).

(6) Camp Dresser & McKee, "Orange County, New York. Water Supply Development and Management Plan. Volume I: Engineering Report" (New York, N.Y.: December 1982).

Table 5

CAPITAL NEEDS FOR WATER SUPPLY, New York State
(Adjusted to 1982 Dollars)
Cost given in millions of dollars

System Name/Ref.	Supply/Storage Cost	Supply/Storage Purpose	Transmission Cost	Transmission Purpose	Treatment Cost	Treatment Purpose	Distribution and Storage Cost	Distribution and Storage Purpose	Total
Binghamton (2)	0		0				5.5615	R	5.56
Buffalo C.(1)	0.0	-	15.00	U	20.00	R,U	313.00	C,R,V	348.00
Capital District(3)	3.867		47.43		23.74		94.378		169.42
Corning(2)							0.1782		0.18
CortlandCty(2)	0.489	E(w)					3.727	t,r,e	4.22
Erie Cty WA* (1)							0.00		0.00
Hornell(2)	0.617						1.4711		2.09
Jamaica WS Co.(Q)*(1)	5.5	E(w)	0.00		6.13	A(w)	22.54	E	34.17
Jamaica WS Co.(N)*(1)	2.8	E(w)	0.00		0.40	A(w)	7.90	R	11.05
LI Water Corp.(1)*	0.0		2.7972	E	6.81	U	72.981	R	82.59
Metro WB (1)*	0.0		18.16	E	2.27	R	5.675	t	26.11
Monroe Cty WA (1)*	0.0		5.3345	R,E	0.00		80.358	C,E,N	85.69
New Rochelle Water Co.(1)*	0.0		3.9725	E	0.1703	C	17.252	E,N	21.39
NYC(1),(4)**	50.0	R(d)	4510.00	E	500.00	C	800.00	R,E	5860.00
NY Water Service(1)*	1.362	E(w)	0.32915	E	0.00		1.2485	R, T	2.94
Niagara Falls C. (1)			15.00	E,P	15.00	U	35.00	C,v,N(r),E	65.00
OhioRBasin(5)	3.989	E			2.6418	C	14.504	E,R	21.13
Onondaga Cty WA (1)*	0.00		1.135		13.62	C	2.27	t	17.03
Orange Cty(6)	25.5	E	25.8		21.1	C			72.40
Poughkeepsie (2)	22.69				21.633	E,U	4.7897		49.11
Rochester C. (1)	0.00		22.7	C	28.375	C	124.85	R(r),R,E	175.93
Spring ValleyWCo.(1)*									
Suffolk Cty WA (1)*	9.08	E(w)	6.129	E	19.863	U	35.072	t,R	70.14
Syracuse C. (1)	0.068	R	0.10215	R	0.00		12.031	R(r),R,v,E	12.20
Tonawanda WD (1)*	0.00		4.54	E	1.7025	R	2.8375	E	9.08
Utica WB(1)*	0.40	R(r)	0.91	E,C,P	35.02	C,R	2.28	t,I	38.61
Yonkers C.(1)	0.034	I	5.675	E,C	1.135	U	17.025	E, C	23.87
TOTAL	126.3		4685.01		719.61		1676.9		7207.90

Table 6

SELECTED CHARACTERISTICS OF MAJOR WATER SUPPLY SYSTEMS, New York State

System Name	County	Population Served	Design Capacity (MGD)	Production (MGD)	Consumption (MGD)	Per Capita Use (GPCD)	Safe Yield
Binghamton		61,256					
Buffalo C.	Erie	357,870	160	103.7	100.5	281	Unlimited
Capital District		620,897					
Erie CtyWA*	Erie	375,000	139	59.9	58.4	156	Unlimited
Jamaica Water Co.*	Queens	518,312	96	61.1	63.8	123	99.0
Jamaica Water Co.*	Nassau	128,448		18.3	16.2	126	41.9
Long Island WaterCorp.*	Nassau	258,936	82.1	26.8	23.6	91	84.1
Metropolitan Water Board	Onondaga	250,000	36	22.0	20.0	?	Unlimited
Monroe Cty WA*	Monroe	300,000R 200,000W	140	56.0	58.6	?	172.6**
New Rochelle Water Co.*	Westchester	139,229	69.9	--	17.2	123	40.0**
New York C.	--	7,071,030+		1420.0	1,315.0***	?	1290.0
New York Water Service Corp.*	Nassau	172,000	45.0	15.2	13.6	79	43.0
Niagara Falls C.	Niagara	77,384	64.0	45.2	45.2	584	Unlimited
Onondaga Cty WA*	Onondaga	130,000R 30,000W		20.3	42.0		

Rochester C	Monroe	225,000	110.0	40.0	50.0	222	30.0
Spring Valley Water Co.*	Rockland	227,900	10.0	25.8	21.2	93	36.9
Suffolk Cty WA*	Suffolk	1,000,000	684.0	106.0	85.0	85	545.0
Syracuse C.	Onondaga	170,105+		50.0	46.6		43.5
Tonawanda WD	Erie	91,269	24.0	13.8	13.6	149	Unlimited
Utica Water Board	Oneida	116,000	50.0	21.0	15.0	129	50.0
Yonkers C.	Westchester	195,000	15.0	29.3	20.5	105	10.0****

Notes:
*Authority or private ownership, otherwise water system is publicly owned.
**Maximum authorized usage.
***New York City also gets an additional amount of water from the Jamaica Water Company.
****The Yonkers water supply is supplemented by water from New York City and Westchester County Water District No. 1.

Abbreviations:
GPCD=Gallons per capita per day
MGD=Millions of gallons per day
R=Retail water use
W=Wholesale water use
WA=Water Authority
WD=Water District

Sources:
(1) New York State Department of Public Health, Office of Public Health, Bureau of Public Water Supply Protection, Water Supply Fact Sheets (Albany, N.Y.: Revised, May 1983)

(2) U.S. Army Corps of Engineers, Section 214/22 Studies of urban water distribution systems (see bibliography for exact references).

(3) NYS Department of Environmental Conservation, "Pilot Water Resources Strategy for the Capital Region" and "Summary of Existing Water Supply System" tables. Draft. (Albany, N.Y.: undated, c. July 1983). While capacity deficits are distributed over time for the Capital Region for storage, treatment and distribution, dollar estimates of capital improvements are not, and the allocation of needs by capacity to obtain such a distibution would be erroneous.

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2, an estimated $300 million to the 1983-7 period and another $300 million to the 1988-2000 period.[24] Thus, using $673.4 million for the 1983-7 portion of the Third Water Tunnel, the total water supply need for that period is $3.371 billion. For the 1988-2000 period, the remaining portions of the Tunnel amount to $3.8366 billion.[25] Other Year 2000 needs mentioned in the New York State Water Supply Fact Sheets for the Jamaica Water Company and the Spring Valley Water Company amount to about $100 million. This brings the total 1988-2000 water supply need to $3.9366. If Stages 3 and 4 of the Third Water Tunnel are not built, the total 1988-2000 need is reduced to $1.1 billion.

Expenditure and Revenue Patterns in Water Supply

Unlike other states in the country, New York State does not have an overall statewide capital plan for water supply. There are numerous independent water supply systems in the State, and the capital planning for these systems is done system by system or for individual geographic subunits at best.

Estimates of water supply expenditures are collected on an annual basis from municipalities, utilities and special districts throughout the State by the New York State Comptroller, and are published in the Comptroller's Special Report on Municipal Affairs. The historical and projected patterns of total expenditures in New York State excluding New York City,[26] based on the Comptroller's figures are given in Table 7, adjusted for inflation with two different cost indices. Figures 1 and 2 compare past and projected trends in total expenditures for the two different indices. When water supply expenditures are adjusted for inflation, a clear downward trend emerges since 1972 (unadjusted data shows a slight increase over time) regardless of the cost index used.[27]

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24. Actually only $31 million of the $300 million has been programmed by the City Planning Commission for the three year capital program extending from 1984 through 1986 (New York City Planning Commission, January 1983: 176).

25. This is computed from the remainder of Stage 2 costs of $300 million not allocated during 1983-7, plus another $700 million (since the total Stage 2 cost is estimated at $1.3 billion), and the costs of Stages 3 and 4, which is the difference between the total of $4.51 billion and the $1.6734 spent on Stages 1 and 2 (between 1983 and 2000).

26. After 1976 changes in the accounting system within the City precluded the Comptroller's office from incorporating New York City figures into the statewide figures.

27. During the 1983-7 period, total expenditures differ from ten percent in 1982 to fifty percent by 1987 between the two different cost indices, i.e., the difference increases over time.

Capital expenditures only are also projected for areas outside of New York City and added to actual and proposed capital expenditures and commitments in New York City for a total estimate of capital expenditures statewide.[28] These figures are shown in Part B of Table 7, and can be used as a basis of computing the shortfall. Between 1983 and 1987 capital expenditures for the State totalled $0.855.[29] This amounts to an annual average capital expenditure of $0.171 billion. Assuming this remains constant over the entire 1983-2000 period (a very rough estimate of future capital expenditures at best), total aggregate capital expenditures for that period would be $3.1 billion.

A partial picture of the revenue base can be obtained from special Comptroller Office files, supplemented by interviews of directors of individual systems. These figures are shown for selected years for some of the larger systems in the State in Table 8. The rates are shown for these systems as well. Revenues cannot be used as the basis for computing shortfalls, since they cannot easily be separated into those targetted for capital vs. operating expenditures, and, in the case of New York City, water revenues are often used to subsidize other urban services.

The Shortfall

Assuming that the capital expenditure level projected for 1983 through 1987 of $0.855 reflects what is likely to be the available resources without any special intervention, and using the $3.371 billion minimum need, the minimum shortfall for 1983-7 is $2.52.

A shortfall is not possible to predict reliably for the entire 1983-2000 period. Revenue or expenditure estimates, upon which a shortfall is based, are difficult to project due to the variability in and sparsity of the historical trend data. The declining projected expenditure curve (for both total and capital expenditures) also precludes a shortfall calculation based on expenditure projections out to the Year 2000. If one assumes that the average annual expenditure between 1983-1987 of $0.171 billion remains constant through the Year 2000, then the aggregate capital expenditures on

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28. Since reliable expenditure figures for the City are available only after 1980 (after the dissolution of the Board of Water Supply, which complicated the accounting system), expenditures projections are not possible for the City. Therefore, the City's own estimates of projected and proposed expenditures in the Executive Budget are used.

29. Total capital expenditures consist of projections from the Comptroller's figures for areas outside of New York (adjusted for inflation using the Building Cost Index) plus actual and proposed capital commitments estimated by the Mayor's Office and the Office of Management and Budget and Office of the Director of Construction.

Table 7

EXPENDITURE PATTERNS FOR WATER SUPPLY IN NEW YORK STATE

(excluding New York City)

A. Total Expenditure Levels in Millions of Dollars

Year	Real Dollars	1982 Dollars PI Adjusted	1982 Dollars BCI Adjusted
Actual:			
1976	193.4	317.6	300.9
1977	236.8	364.9	332.9
1978	213.0	304.4	282.9
1979	231.9	298.2	297.5
1980	219.8	249.5	251.7
1981	240.8	249.5	269.7
Projected:			
1982		228.1	250.8
1983		208.3	239.8
1984		188.5	228.8
1985		168.7	217.8
1986		148.9	206.8
1987		129.1	195.8
1988		109.3	184.8
1989		89.5	173.8
1990		69.7	162.8
2000		- 128.3	52.8

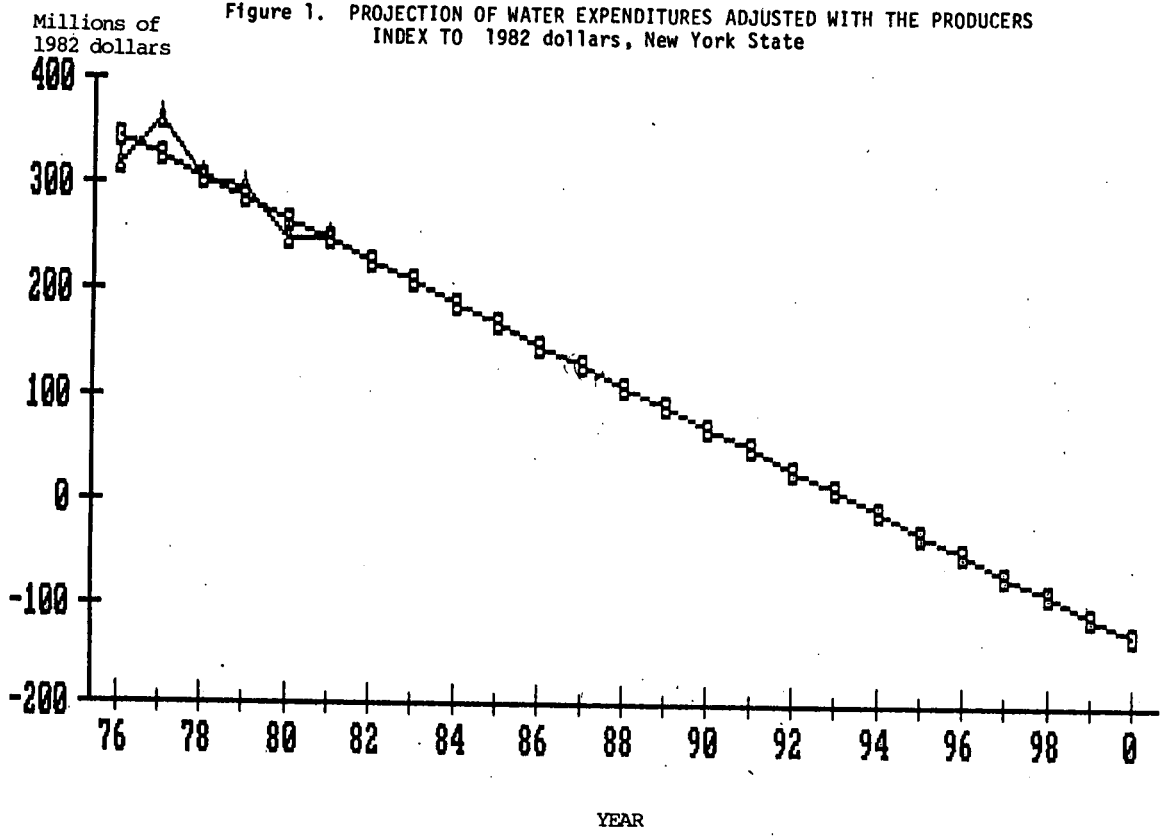
B. Capital Expenditure Levels in Millions of Dollars

	Outside of NYC			NYC	Total
	Real $s	1982 Dollars PPI Adj.	BCI Adj.		
Actual:					
1976	77.5	127.26	120.59		
1977	106.6	164.27	149.88		
1978	73.0	104.32	96.94		
1979	84.5	108.67	108.41		
1980	58.5	66.40	66.98	137.75	
1981	59.5	61.64	66.64	212.87	
Projected:					
1982			50.88	152.10*	202.98
1983			36.39	173.85**	210.24
1984			21.91	76.25	98.16
1985			7.42	184.47	191.89
1986			(00.00)	184.55	184.55
1987			(00.00)	170.49	170.49

Source: New York State Office of the Comptroller. Special Report on Municipal Affairs. Albany, N.Y., February 1983. Table 1-Mm, P. 34. Supplementary data for capital and operating breakdowns provided by the Research and Statistics Unit.
Abbreviations: PI = Producer Cost Index; BCI = Building Cost Index

Notes: *Source of this figure is the NYC Office of Management and Budget and Office of Construction.
**This and subsequent numbers are from the Mayor's Executive Budget.

Figure 1. PROJECTION OF WATER EXPENDITURES ADJUSTED WITH THE PRODUCERS INDEX TO 1982 dollars, New York State



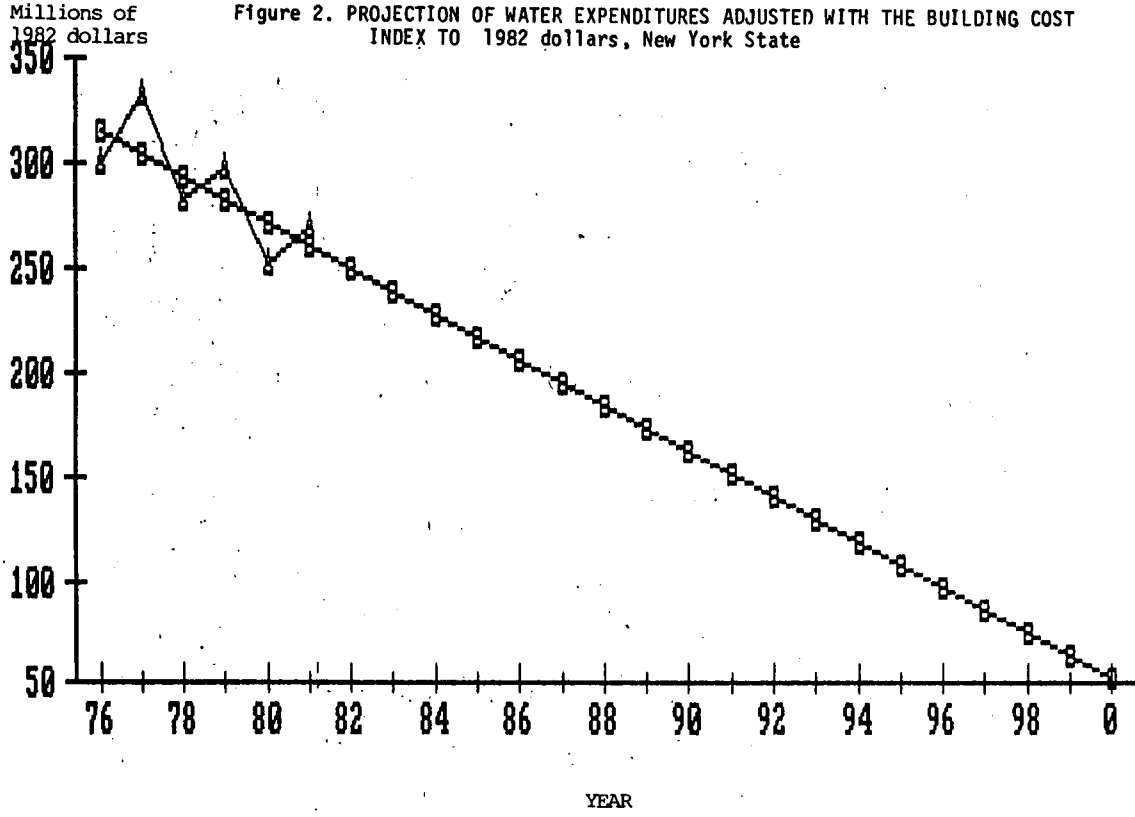


Figure 2. PROJECTION OF WATER EXPENDITURES ADJUSTED WITH THE BUILDING COST INDEX TO 1982 dollars, New York State

Table 8

WATER SUPPLY REVENUES FOR MAJOR WATER SUPPLY SYSTEMS IN NEW YORK STATE, 1982

Water Supply System	Year Est.	Water Consumed	Water Rate (per 1000 gals.)	Total Revenues (in millions of 1982 dollars) 1980	1981	1982
Binghamton	1980			2.012	1.846	2.307
Buffalo	1980	100.5	0.71	12.574	15.306	16.031
Capital District (Albany)	1983	102.2		4.319	4.690	4.692
Corning	1981					
Cortland Cty	1983					
Hornell	1981					
Jamaica WS	1983	80.0	Variable		25.964	31.023
LI Water Corp	1980	23.6			16.138	18.300
Metro WB	1980	20.0				
Monroe Cty WA	1980	58.6	1.24		15.865	16.262
New Rochelle	1980	17.2	1.50		8.790	9.743
NYC	1983	1315.0	Variable			195.489
NY Water Serv.	1980	13.6	1.83	(9.084)		
Niagara Falls	1980	45.2	0.748	3.902	5.204	5.000
Ohio R. Basin	1981					
Onondaga WC	1980	42.0		1.173		
Orange Cty	1982	32.4				
Poughkeepsie	1980					
Rochester C	1980	50.0	1.14	(20.805)		
Schenectady				2.403	2.949	3.188
Spring Valley Water Co.	1983	21.2				
Suffolk Cty SA	1980	85.0	0.88	(27.300)		
Syracuse C	1980	46.6	0.74 (1.11)	4.758	4.931	4.993
Tonawanda WD	1980	13.6				
Troy				2.993	2.945	2.805
Utica WB	1983	15.0	0.602 (0.730)	4.448	2.905	3.320
Yonkers	1980	20.5	1.04	8.997	11.799	10.928

Note: Numbers in parenthesis in the Total Revenues column are those that have been computed from water rate and water consumed rather than having been obtained from the water purveyors themselves. Numbers in parenthesis in Water Rate column are rates for other than residential, e.g., commercial or out of city users.

Source: City water departments and water authorities.

that basis are $3.1. The 1983-2000 (partial) need of $7.2 billion, then, would produce a shortfall of $4.1 billion and practically a zero shortfall if the Third Water Tunnel Stages 3 and 4 are not built. As an alternative approach, if one uses the latest year of capital expenditures as a typical annual expenditure over the 1983-2000 period, the aggregate level on this basis is $3.7 billion and the shortfall is $3.5 billion.

These estimates are partial in that they still only cover three-quarters of the State's population. This estimate is not only a minimum from the point of view of its limited coverage of the State's population, but from the point of view of the limited predictability of future water supply needs also. Unlike other areas of infrastructure, there is no one agency either at the State or Federal level that is overseeing the inventorying and development of water supply facilities. Empirical studies in the professional literature have not conclusively linked even age to system condition as a basis for a replacement criterion. The 1983-2000 estimate does not have built into it estimates of system replacement other than those known to exist in 1982.

WASTEWATER TREATMENT AND COLLECTION

Overview of Wastewater Treatment Needs

Near-Term Needs:

Near term needs for wastewater treatment and collection were first estimated by the U.S. EPA Needs Survey in 1982, though the surveys began in 1973. This 1982 estimate, called "backlog needs for present populations",[1] is $16.128 billion for New York State. Since many of the projects comprising this backlog should be built between 1983 and 1987 (because of federal requirements), approximately $7.1 billion covering only secondary wastewater treatment systems and sewer system rehabilitation is allocated to the 1983-7 with the remainder for construction beyond 1988.

Another source of near term needs estimates is the state priority list prepared annually for funding under the Clean Water Acts. These projects approximate five to ten year needs.[2] For FY 84 the total cost of projects eligible for funding under the construction grants program (exclusive of planning grants) was $982,013,351 million dollars.[3] Of this total, only about $900 million was slated for funding during FY 84. Seven projects accounted for more than half of that amount.

The Year 2000:

According to the U.S. EPA Needs Survey of 1982, the national need for wastewater treatment and collection systems for the Year 2000 is $118.4 billion, and the corresponding New York State total is $17.3 billion.[4] New York State accounted for 14.6 percent of the nation's total Year 2000 need, and ranked first among all of the states in the dollar estimate of need for publicly owned wastewater treatment facilities in the nation. This $17.3

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1. U.S. EPA, 1982.

2. The exceptions are an unknown number of projects that are necessary, but for some reason have not been entered on the state priority list because municipalities were not quite ready to submit plans.

3. The category of planning grants, which are expressed as construction costs for projects planned for future consideration, are considered more long term. These add another $4,050,473,959, bringing the total needs estimate from the construction grants program to over $5 billion in the near future.

4. U.S. EPA, 1982: 75. This total was adjusted a few months later to $19.5 billion, because of additions to the combined sewer overflow correction category (U.S. EPA, March 1983: 4).

billion total includes the $16.1 billion "backlog"[5]; in other words, if all of the $16.1 billion backlog improvements are in fact made, then the net would be $1.2 billion.[6] The 1988-2000 need is the sum of this $1.2 billion plus the backlog of $9 billion not allocated to the 1983-7 period, or a total of $10.2 billion.

The largest single component of New York State's needs is the correction of combined sewer overflows, followed by secondary treatment and sewer system rehabilitation (see Table 10).

The Wastewater Treatment System Inventory and Condition

Wastewater treatment systems have been inventoried by the State of New York Department of Environmental Conservation since 1927. Some of the recent trends are given in Table 9. Some 535 municipal wastewater treatment facilities (or raw discharges that ultimately will become facilities) operate in New York State, with a total design flow of over 3.4 billion gallons per day. In terms of wastewater treatment plant size or design capacity, gross average size per plant has not changed very substantially since 1952, being 6.9 MGD in 1952 and 6.3 in 1982.[7] This is surprising in light of an aggressive policy of regionalization of wastewater treatment systems throughout the country. Regionalization has the effect of increasing plant size, in order to achieve unit cost economies. In addition to these municipal wastewater treatment facilities, there are industrial, commercial and institutional facilities. The Federal government compiles statewide inventories of treatment and collection facilities, as well, every two years. According to the Federal survey, 71.2 percent of the State's population has its wastewater treated at a facility "operated by an established sewerage authority".[8] An estimated 9 percent of the flow to

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5. The New York State backlog represents 93 percent of the Year 2000 needs: nationally backlogs only averaged 78.2 percent of the Year 2000 needs.

6. The difference between the backlog and year 2000 categories reflects reserve capacity for increased growth and changes in the population served by municipal facilities that come under the construction grants program. In New York State these changes are relatively low, since the population is only projected to grow by about 524,000 or 3 percent between 1980 and the year 2000 (see Table 2).

7. New York State Department of Conservation, "Descriptive Data of Sewage Treatment Systems in New York State" (June 1981 and June 1983), Albany, N.Y.

8. U.S. EPA, June 15, 1983: 33.

Table 9

TRENDS IN WASTEWATER TREATMENT LEVELS AND CAPACITY IN NEW YORK STATE, 1952 through 1982

	Year							
	1952		1976		1980		1982	
	No. of Plants	Design Flow	No. of Plants	Design Flow	No. of Plants	Design Flow	No.of Plants	Design Flow
	Percentages							
Level of Treatment								
Less than secondary	67.8%	59.4%	27.6%	20.1%	16.7%	22.1%	19.6%	25.8%
Secondary	30.9	40.2	53.0	71.3	63.1	73.4	60.9	70.9
Advanced treatment	1.3	0.4	19.4	8.7	20.2	4.6	19.5	3.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Design Flow								
Less than 1.0 MGD		69.1		63.6		65.6		68.4
1-10		22.2		28.7		26.9		24.1
10-100		7.4		6.0		6.1		6.0
100+		1.3		1.7		1.4		1.5
Total		100.0		100.0		100.0		100.0
Total number of plants		298		536		509		535*
Total design flow(MGD)		2059.95		3100.45		3229.59		3390.75
Average MGD per plant		6.91		5.78		6.35		6.34

Source: Compiled from the New York State Department of Environmental Conservation. Descriptive Data of Sewage Treatment Systems in New York State. June 1981 and June 1983.

Notes: * The increase in the number of facilities less than secondary (actually appearing in the "less than primary" category) is caused by a change in the accounting system. In 1982, for the first time, permitted raw sewage, scavenger holding tank, combined sewer overflow discharges, were counted even though they are not facilities. The discharges from the service areas of the proposed North River and Red Hook wastewater treatment plants in New York City account for the bulk of this increase.

these wastewater treatment plants was from industrial establishments in 1982.[9]

Of the 1982 total of 535 facilities reported by the State, almost three-quarters of the plants are operating at secondary treatment levels, which removes organic material as well as solids. Three percent, are operating at a more advanced level, which removes nutrients and metals. This leaves nearly one-quarter operating at less than secondary, not typical of the requirements of the Federal Clean Water Act. These trends do not include plants that are rated as operating at secondary treatment levels, but are not actually doing so.[10] The Federal needs survey provides some perspective on removal efficiency: the U.S. EPA estimates that the average removal efficiency of the State's treatment plants in terms of biochemical oxygen demand is 74.9% and for suspended solids, 75.6%, which is below the average for secondary treatment.[11]

The percentage of plants operating below secondary treatment has dropped dramatically since 1952.[12]

The Needs Assessment

A nationwide survey of wastewater treatment and collection needs is conducted biennially as a basis for construction grant allocations under the Federal Clean Water Acts.[13] The needs assessments are for (1) an immediate "backlog": systems that are needed for "present populations", and (2) for the Year 2000. A detailed breakdown of the U.S. EPA needs estimate for New York

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9. Ibid.: 23.

10. This information is available from data on violations of wastewater discharge or State Pollutant Discharge Elimination permits, which each system is required to obtain. The New York State Department of Environmental Conservation estimates that about 21-25 percent of the municipal plants are not in compliance with the terms of their wastewater discharge permits issued under SPDES.

11. U.S. EPA, June 15, 1983: 29.

12. The percentage of plants operating at less than secondary treatment dropped from 67.8 percent of the plants in 1952 to 16.7 percent of the plants in 1980 - the rise between 1980 and 1982 is due to an expansion in the items included in the category rather than a deterioration of facilities. In terms of design flow rather than number of plants, the percentages for plants operating below secondary treatment are 59.4 percent and 22.1 percent for 1952 and 1980 respectively, not reflecting quite as dramatic a decline.

13. The needs assessment is called for under Sections 205 (a) and 516 (b) (1) of the Clean Water Act.

State is given in Table 10 by category of needs. The estimates were described in the overview section: a $16.128 billion backlog (defined as meeting the needs of present populations). $7.1 billion is allocated to the 1983-7 period for secondary wastewater treatment and sewer system rehabilitation because of the federal deadline of July 1, 1988 for the installation of secondary wastewater treatment systems.

$10.2 billion is estimated for the 1988-2000 period.[14]

Another nationwide procedure supplements the EPA needs estimate: the construction grants program for financing wastewater treatment systems, now administered by the State of New York. Under this system, approximately $5 billion worth of facility planning, design and construction needs have been identified as of June 1983 for eligibility during FY 1984. About ten percent of this total is accounted for by seven major facilities listed in Table 11.

While the federal government initiated the construction grants program under P.L. 92-500, the EPA 1990 construction grants strategy urged carrying out the provisions in the Clean Water Act for delegation to the states.[15] New York State was delegated the program in December of 1978.

The process by which the State's share (appropriation or allocation) becomes distributed among eligible projects within the State is governed by a priority system developed under the Clean Water Acts. Regulations passed in 1975 established priority system criteria to choose among eligible projects.[16] Each state is required to develop a comprehensive list of eligible treatment works and a priority system for ranking these works on an annual basis. While only a small portion of any given list is ever funded in a particular fiscal year, treatment work needs are estimated as accurately as possible statewide to be eligible for funding in future years.

The New York State Municipal Sewage Treatment Works Priority Rating System:

New York State's procedure for listing and prioritizing wastewater treatment projects for funding consists of the following steps: (1) identification of projects by local, state or the federal government; (2) rating of each project listed by the criteria developed under the Project Ranking System; and (3) ranking of each project by the rating, breaking ties

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14. This consists of the difference of $1.2 billion between the backlog need of $16.2 billion and Year 2000 need of $17.3 billion plus the $9 billion portion of the backlog, not allocated to the 1983-7 period. The Year 2000 estimate has been expanded by the U.S. EPA to $19.5 billion if certain combined sewer overflow corrections are included.

15. U.S. EPA, January 1981.

16. 39 Federal Register 5252, Article 35.915 (c) (1) -- 40 CFR 35.

Table 10

1982 U.S. EPA NEEDS ASSESSMENT FOR NEW YORK STATE PUBLICLY-OWNED WASTEWATER TREATMENT PLANT CONSTRUCTION FOR THE YEAR 2000

Category of Need	Need Estimate (in millions of 1982 dollars) Near Term	Year 2000
Secondary Treatment	3,290	3,762
Advanced Secondary Treatment	122	174
Advanced Treatment	56	70
Infiltration/Inflow Correction	186	186
Major Sewer System Rehabilitation	3,759	3,759
New Collectors and Appurtenances	2,327	2,670
New Interceptors and Appurtenances	765	1,051
Correction of Combined Sewer Overflows	5,620	5,620
Total	16,128	17,295

Source: U.S. Environmental Protection Agency. Needs Survey (1982): Cost Estimates for Construction of Publicly-Owned Wastewater Treatment Facilities. Springfield, Va.: National Technical Information Service, December 31, 1982. Tables 15 and 21 for year 2000 needs and Table 1 for near-term needs.

Note: The near-term needs is the "backlog" in the EPA Needs Survey. The sum of individual items may not equal totals due to rounding.

Table 11

MAJOR WASTEWATER FACILITY NEEDS FOR FY-84 IN NEW YORK STATE

Facility/Location	Eligible Cost*
City of Glens Falls	$ 27,000,000
Rochester	118,610,000
Rockland County Sewer District #1	29,600,000
North River (New York City)	106,661,184
Red Hook	62,646,416
Coney Island	58,000,000
Owls Head	55,733,350
Total	$ 458,250,950

*These are the seven largest facilities by cost estimated for wastewater treatment facilities.

Source: New York State Department of Environmental Conservation. Project Priority System and List. FY 84. Albany, N.Y., February 22, 1983.

by means of a specific set of rules. This system is called the NYS Project Priority System (PPS) and the Project Priority List (PPL), and is revised annually.

The Project Priority System (PPS): The project priority ranking system is a scoring system for eligible projects based on the following conditions: (1) meeting existing water quality requirements including levels of treatment required to meet surface water water quality standards under the State Pollutant Discharge Elimination System (SPDES) Permits, and to remove existing water quality violations; (2) improving water quality calculated from the classification of the waterway into which the discharge occurs and characteristics of the discharge itself; and (3) meeting needs, requirements and mandates of various government agencies relating to the project. The details of the ranking system are given in the Appendix. A minimum of 100 points is required for consideration for funding regardless of the number of eligible projects.

The Project Priority List (PPL): The PPL lists projects in decreasing order of rank within four population categories (Table 12 lists these categories with the June 1983 proposed allocation of funds to them) and three funding categories within each population group: a funding portion, which consists of projects expected to be approved for funding when funds are available, and further sub-divided into fundable and non-fundable projects; a deferred portion, indicating projects whose grant amounts have not been estimated due to unavailability of funds, but are expected to be ready for funding during the funding period of grants become available; and a planning portion which lists other projects that may become eligible for funding in the future.[17]

Uncertainties in Cost Estimates for Wastewater Treatment:

While of all of the areas of infrastructure, wastewater treatment costs are generally the most predictable given the detail required by the federal construction grants program, a number of uncertainties still exist. These relate to level and type of treatment, and could considerably effect the cost estimates for wastewater treatment needs statewide.

The first area of uncertainty relates to level of treatment required by the U.S. EPA under the Clean Water Acts. Current levels are targetted to secondary treatment, originally defined in Part 133 of the Clean Water Act regulations. Secondary treatment is generally accepted to mean a process that results in 30 parts per million of biochemical oxygen demand, 30 parts per million of suspended solids, and 85 percent removal efficiency for biochemical oxygen demand. Complicating the definition now is the fact that

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17. The only exception to this system is a project necessitated by a public health emergency, which then supercedes all other projects on the list regardless of rank. Projects on the list can be bypassed (if the application is withdrawn by the municipalities or fails to meet scheduled deadlines), can be moved from one portion of the list to the other under a specific set of conditions, and can be de-obligated.NYSDEC, February 22, 1983: 8-9.

Table 12

POPULATION CATEGORIES ESTABLISHED UNDER THE PRIORITY RANKING SYSTEM FOR WASTEWATER TREATMENT PLANTS, New York State, 1983

Population Category	Population (1980)	Percentage of federal funds Allotted to Category for 1983*
A	25,000 or less	8.0 %
B	25,001 - 100,000	8.5
C	100,001 - 2,000,000	23.5
D	2,000,001 and above	60.0

Source: New York State, Department of Environmental Conservation. FY 82 Project Priority System and List. Albany, N.Y.: NYS DEC, April 15, 1983.

Note: *This is for the distribution of funds after reserve amounts are deducted for program administration, water quality management planning, grant increases, advances for Steps 1 and 2 allowances for small communities, innovative/alternative technologies, and pipe related projects (NYS DEC, April 15, 1983: 14-15). The purpose of this percentage distribution is to place the funding line at a comparable place for each population category (NYS DEC, April 15, 1983: 8). These percentages are periodically readjusted (usually within 10%).

the 1981 Act included a new category of wastewater treatment, trickling filters, under secondary treatment, even though they do not operate year-round as secondary treatment systems.

The second area of uncertainty relates to exemptions from secondary treatment for coastal communities that could discharge wastes to the marine environment, where extensive dilution of the wastes justifies lower treatment levels. Such exemptions are possible under Section 301 (h) of the Clean Water Act. During the first phase of application submissions under 301 (h), the U.S. EPA estimated that $1.5 billion could be saved nationwide from 70 waivers. The U.S. General Accounting Office estimated that if all of about 800 communities identified as potentially eligible for 301 (h) waivers nationwide were granted the waivers, the savings would be as high as $10 billion.[18] All of the applications in New York State (primarily from Westchester, New York City, and Long Island) have been denied.

The third area of uncertainty relates to toxic substance limits (rather than biological or physical limits) to which treatment plants will have to adhere. These limits will be required as conditions for permits for wastewater discharges under the National Pollutant Discharge Elimination (Section 402 of the Clean Water Act),[19] which all wastewater treatment plants are required to obtain. The schedules for funding wastewater treatment plant construction are now closely coordinated with schedules for compliance under SPDES.[20] The costs of additional systems for such compliance is currently unknown.[21]

Expenditure and Revenue Patterns

Wastewater treatment expenditures have been directly a function of the federal construction grants program for several decades. This has been

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18. U.S. GAO, 1981: 7

19. New York State was delegated this program in October 1975, and the program is now called the State Pollutant Discharge Elimination System (SPDES) in New York State.

20. If a plant can show a good reason for not complying with the terms of its SPDES permit because it did not receive a construction grant or for some other reason, it can qualify for an extension for compliance under Section 301 (i) (1) of the Clean Water Act.

21. Cost estimates are particularly difficult to make, since in setting toxic limits EPA does not have to consider economic effects, but in setting limits for "non-conventional" pollutants it does. At the moment, New York State is in the process of formulating a "best professional judgment" strategy for dealing with permits in the absence of definitive limits for toxics.

especially true since the mid-1970's.[22] The financing and hence, systematic estimation of needs for wastewater treatment systems by the federal government actually dates from the Federal Water Pollution Control Act of 1956. The history of such programs and their coverage of facility financing since that time is summarized in Table 13. The current system was developed under Section 201 of the Federal Water Pollution Control Act Amendments of 1972 and modified by subsequent amendments. It provides construction grants for part of the costs of publicly owned wastewater treatment works. The nationwide authorizations and appropriations under the construction grants program since 1972 are given in Table 14. The Congressional Budget Office's projections of authorizations through 1990 (based on current levels) are shown in Table 15. New York State's share over the past decade is given in Table 16. This allocation is based on the State's share of population relative to the rest of the country. The 1981 amendments to the Clean Water Act increased New York State's percentage of the annual allotment to 11.3097 percent from a previous 10.7 percent (P.L. 97-117, Section 17). Under the Federal Water Pollution Control Act Amendments of 1972 and subsequent authorizations, New York State has received over 4 billion dollars for construction grants.[23] P.L. 97-117 has appropriated $271 million per year for New York State in FY 84 and 85. No appropriations have been made for any subsequent years, which would require a revision of the Clean Water Act.

The State Comptroller compiles figures for expenditures by local units of government for wastewater treatment and sewers, exclusive of systems run by authorities or private companies. Projections of total expenditures based on this source of data indicate that between 1983 and 1987, a total of $2.714 billion would be expended over the five year period for wastewater treatment by local government in the State (excluding New York City). The U.S. Bureau of the Census also compiles figures that include the City in its Government Finance Series. Projections of total expenditures based on the Government Finance series for the five years is $5.929 billion. The past trends and projected trends for both of these data sets for total expenditures are shown in Figures 3 and 4.

Capital expenditure trends and projections are shown in Table 17 covering the entire state, which serves as the basis of the shortfall calculation below. Over the 1983-7 five year period, capital expenditures amount to

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22. Before that time other local, state and federal programs covered sewer systems and costs for wastewater treatment not covered by the construction grants program.

23. As of May 1, 1983, $3,678,532,352 had been allocated, leaving an unobligated balance of about $460 million. The unobligated balance was reduced to about $373 million by June 1; it is expected that $328 million will be applied to the current FY 84 priority list, which includes anticipated appropriations and unobligated funds from the last fiscal year minus reserve funds. Personal communication, New York State Department of Environmental Conservation, Fred Esmond.

Table 13

HISTORY OF FEDERAL FINANCING PROVISIONS FOR WASTEWATER TREATMENT PLANT CONSTRUCTION, 1948-1982

Legislation	Funding Provisions	Applicable Facilities
FWPCAA 1948	A loan program authorized for which funds were never appropriated	
FWPCAA 1956	30% federal share; limitation of $250,000 on any given project	Sewage treatment plants;interceptors
Clean Water Restoration Act of 1966	40% federal share with a 30% state share; 50% federal share with 25% state share and compliance with water quality standards; additional 10% with compliance with metropolitan plans (to a maximum of 55%)	Sewage treatment plants;interceptors
FWPCAA 1972	75% federal share, 25% state share	Sewage treatment plants;interceptors
Clean Water Act of 1977	75% federal share, 25% state share	Extension to rehabilitation and combined sewers
P.L.96-483 of 1980	75% federal share, 25% state share	
Municipal Waste-Water Treatment Construction Grant Amendments of 1981	55% federal share after October 1984	

Table 14

AVAILABILITY OF FUNDING FOR WASTEWATER TREATMENT PLANT CONSTRUCTION UNDER THE FEDERAL WATER POLLUTION CONTROL ACT CONSTRUCTION GRANTS PROGRAM, 1973-1983

(figures given in billions of dollars)

Fiscal Year	Authorization	Federal Appropriation	Obligations
73	5.0	2.0	1.532
74	6.0	3.0	1.444
75	7.0	4.0	3.616
76	---	9.0	4.814
77	0.7	1.42	6.664
78	5.5	4.5	2.301
79	5.0	4.2	3.872
80	5.0	2.52	4.376
81	5.0	2.55	3.612
82	2.4	2.4	0.250
83	2.4	2.4	---

Source: Council on Environmental Quality, Environmental Quality 1981. 12th Annual Report. Washington, D.C.: CEQ, 1982. Page 76.

Table 15

CONGRESSIONAL BUDGET OFFICE PROJECTED LEVELS OF FEDERAL AND NON-FEDERAL OUTLAYS FOR THE CONSTRUCTION OF WASTEWATER TREATMENT FACILITIES, NATIONWIDE, 1983-1990

	Source of Funds(in billions of dollars)			
Year	U.S. EPA	Other Federal (FmHA, HUD)	Non-Federal	Total
1983	3.4	0.5	1.1	5.0
1984	2.8	0.5	0.9	4.2
1985	3.0	0.5	2.5	6.0
1986	2.7	0.5	2.2	5.4
1987	2.4	0.5	1.8	4.5
1988	2.5	0.5	2.0	4.9
1989	2.5	0.5	2.1	5.1
1990	2.6	0.5	2.1	5.2

Source: Congressional Budget Office. Public Works Infrastructure: Policy Considerations for the 1980's. Washington, D.C.: CBO, April 1983. Page 63.

Table 16

TRENDS IN TOTAL STATE AND FEDERAL GRANT AWARDS FOR WASTEWATER TREATMENT AND COLLECTION IN NEW YORK STATE, 1973-1983

Calendar Year	Federal Grants Awarded (figures given in real dollars)	State Grants Awarded
1973	211,583,980	38,497,714
1974	302,207,802	50,590,637
1975	259,955,903	44,044,475
1976	337,471,374	52,754,888
1977	1,028,452,332	71,715,925
1978	76,696,692	3,682,728
1979	417,623,138	54,846,780
1980	533,055,148	56,825,959
1981	374,930,105	58,334,111
1982	21,484,413	81,079,019
1983 (1st 9 months)	515,459,769	74,973,499
Total (1/1/73-9/30/83)	4,078,920,656	587,345,731

Notes: Grant awards are those made under the Clean Water Act's construction grants program (Section 201). Figures do not include grant payments to municipalities.

Source: New York State Department of Environmental Conservation, Division of Construction Management, Bureau of Technical Resources. October 20, 1983.

Table 17

TRENDS IN ACTUAL AND PROJECTED CAPITAL EXPENDITURES FOR WASTEWATER TREATMENT AND COLLECTION IN NEW YORK STATE, 1976-2000

	Year	Capital Expenditures* (in millions of 1982 dollars)
Actual**	1976	978.2
	1977	806.4
	1978	797.6
	1979	838.1
	1980	992.1
	1981	760.4
Projected***	1982	813.0
	1983	799.0
	1984	784.9
	1985	770.9
	1986	756.8
	1987	742.8
	1988	728.8
	1989	714.7
	1990	700.7
	1991	686.6
	1992	672.6
	1993	658.6
	1994	644.5
	1995	630.5
	1996	616.4
	1997	602.4
	1998	588.4
	1999	574.3
	2000	560.3

Notes:

*Expenditure figures are adjusted to 1982 dollars using the U.S. Environmental Protection AGency construction cost combined index for sewage treatment plants and sewers for New York City, since it accounts for a major portion of the State's capital expenditures for wastewater treatment. Figures account for transfers of federal and state funds to local governments to avoid double counting.

**These figures are from the Government finances annual series published by the U.S. Bureau of the Census. Other sources were not comprehensive geographically or across all units of government

***Even though projections were made linearly through the Year 2000, only the projections from 1983 through 1987 were used as the basis of projections through the Year 2000 (the five year average for 1983-7 was assumed to hold through the Year 2000-see text).

Figure 3. PROJECTION OF SEWERAGE EXPENDITURES (State Data), New York State
(Total Expenditures shown, adjusted to 1982 dollars)

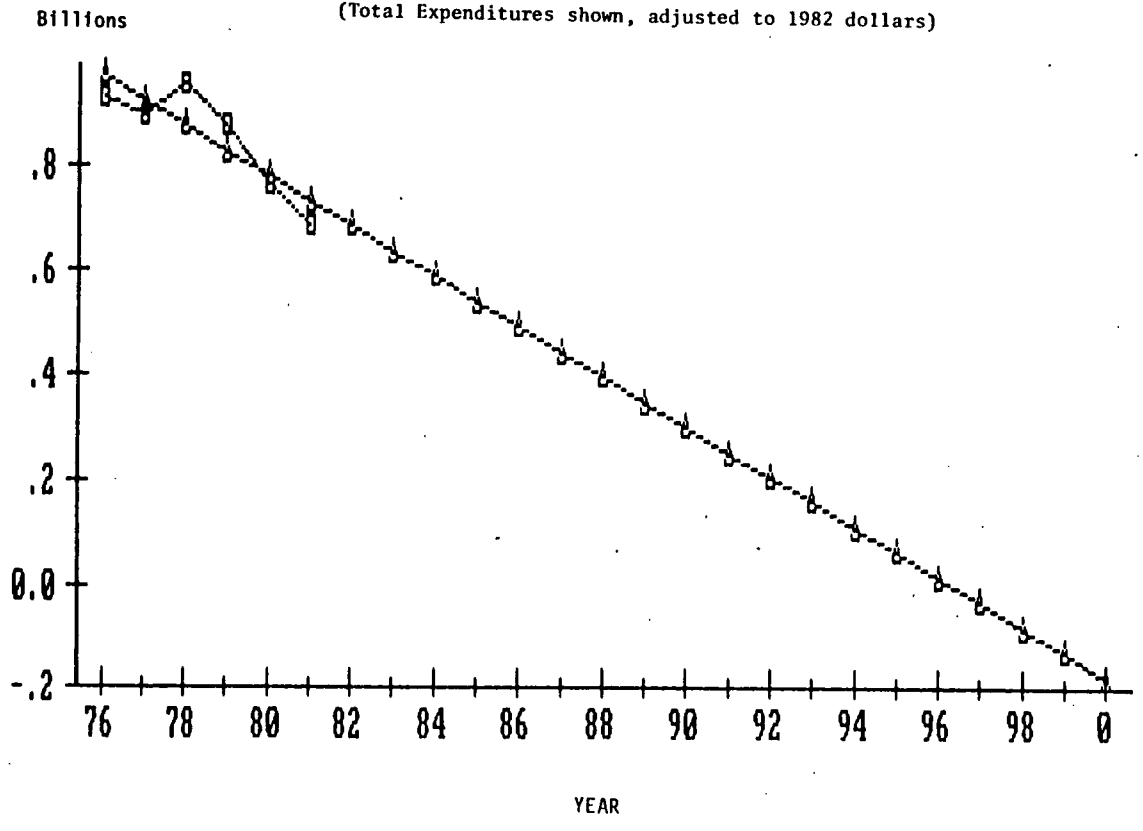

Figure 4. PROJECTION OF SEWERAGE EXPENDITURES (Federal Data), New York State
(Total expenditures shown, adjusted to 1982 dollars)

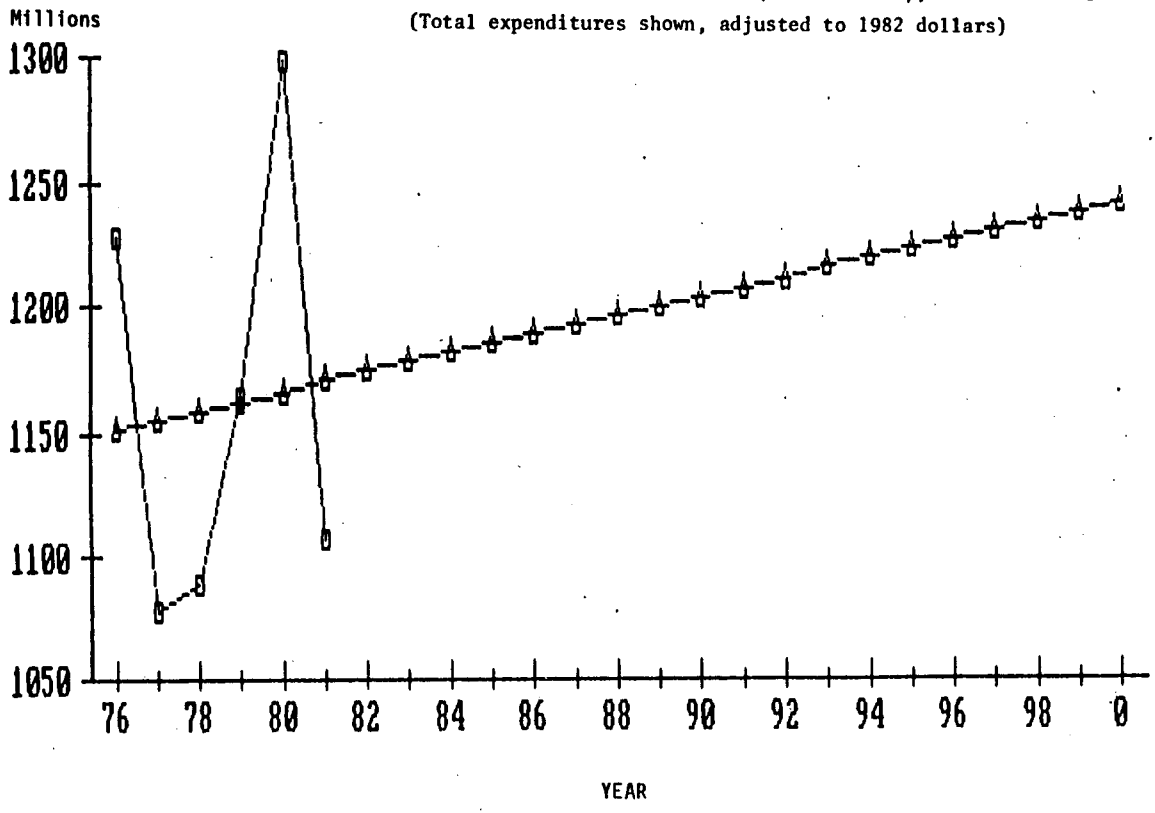

Table 18

SHORTFALL BETWEEN CURRENT EXPENDITURE LEVELS FOR WASTEWATER TREATMENT AND NEED, 1983-7

	Five-Year Aggregate Expenditures	Aggregate Annual Expenditure	1983-7 Need	1983-7 Shortfall*
	Figures given in millions of 1982 dollars			
Total Expenditures				
Excluding New York City	2,714.0	542.9	5,854.0**	3,140.0
Including New York City	5,928.7	1,185.7	7,100.0	1,171.0
Capital Expenditures	3,854.4	770.9	7,100.0	3,245.6

Notes:

*Computed as the difference between expenditures and 5-year needs.

**The annualized ten year need estimate from the NYC Department of City Planning, Capital Needs and Priorities, January 1983, p. 185 was subtracted from the U.S. EPA annualized needs estimate.

$3,854.4 billion.[24]

The Shortfall

The shortfall between funds available and needs can be estimated from both total and capital expenditures and from both the state data (with adjustments for New York City, since the state data excludes New York City) and the Federal data (that includes New York City).[25] As is shown in Table 18, using total expenditures, over the five-year period, the shortfall is $3.1 billion outside of New York City, and $1.2 billion, including the City. Using capital expenditures only (for consistency with other infrastructure areas) statewide, the shortfall is $3.2 billion for 1983-7.

These calculations assume that previous levels of expenditures from the construction grants program, embodied in the trend data, will continue into the 1983-7 period. In reality, declines are expected in this level of funding from the federal government, which would cause the shortfall for the State to increase.

Estimates of shortfalls for the entire 1983-2000 period are precluded not only by the uncertainties in construction grants financing, but increasing lack of validity of any expenditure projection over time. If one assumes that the average annual capital expenditure rate of $0.771 billion (see Table 18) remains the same in the 1983-2000 period, then the shortfall for 1983-2000 would become $3.4 billion. If one takes the latest year of capital expenditure of $0.813 billion as an alternative, then the shortfall is $2.7 billion. A third alternative can be derived from assuming that the annual allotment to New York State under the construction grants program of $271 million for the next two fiscal years remains the same through the Year 2000. Adjusting this for the state and local contribution, this figure is $361.3 million a year. This figure generates a shortfall of $10.8 billion between 1983 and 2000.

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24. The national Congressional Budget Office projections for 1983-7 in Table 15 give a total expenditure level of $25.1 billion for the nation. If the New York State percentage of the nationwide total stays at 10.7%, then New York State would get $2.69 billion over the five years: this roughly is comparable to the expenditure projections made with state and federal data.

25. Total expenditures can be used rather than capital expenditures for sewerage, since over the past few years, capital expenditures account for a large percentage of total expenditures. In addition, a substantial part of what is considered non-capital expenditures are capital related.

TRANSPORTATION

Overview of Transportation Needs

Transportation infrastructure includes: (1) highways and bridges, (2) transit [1], and (3) airports. Total short-term needs for rehabilitation and repair in these areas are estimated at $ 32.6 billion over the five year period between 1983 and 1987. Almost two-thirds of this total is for highways and bridges.

Highway needs are estimated primarily on the basis of deterioration of surface and subsurface components of the roadbed. In New York State estimates of condition only exist for about one third of the total state highway mileage. Therefore, condition and capital needs of the local road system had to be approximated. Transit estimates are drawn heavily from the Capital Programs of the Metropolitan Transportation Authority, which runs the majority of the transit systems in the State. These were supplemented by and compared against estimates of individual transit components, namely, subway cars and tracks. In order to obtain consistency statewide in the area of bus needs, estimates were developed based on the assumption that bus replacement occurs when buses exceed a 12 year lifetime (and exclude ancillary facilities). Freight rail needs were expressed in terms of current projects needed over the next five years for which no funds have been identified. The source of airport needs is the State and Port Authority estimates of capital projects needed at airports throughout the State, since the calculation of such needs from performance and capacity indicators is precluded due to the complexity and diversity of airport facilities.

Shortfalls are estimated as the difference between needs and projected expenditure patterns as the basis for resources. The shortfall for highways and bridges varies according to whether total or just capital expenditures are used as the basis of the projection. Mass transit shortfalls are largely a function of needs and expenditures estimated for subway, bus and commuter rail systems operated by the Metropolitan Transportation Authority. Airport and rail resources are too variable for computing a shortfall.

Transportation needs and shortfalls are summarized in Table 19.

Transportation Facility Identification and Prioritization Processes

Statewide Transportation Planning

The State of New York Department of Transportation (DOT) revised the Statewide Master Plan for Transportation in April 1973, as mandated by the New York State Transportation Law. The goals of the plan were to develop and allocate transportation resources to increase mobility, achieve environmental compatability and desirable development patterns, improve operational

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1. Transit is further subdivided into subways and other intracity train lines, rail or intercity train lines, and buses

Table 19

SUMMARY OF TRANSPORTATION NEEDS AND SHORTFALLS OR SURPLUSES, 1983-7

Category	I. Need	II. Expenditures/Revenues (figures are in billions of dollars)	III. (I. minus II.) Shortfall/Surplus
Highways and Bridges(1)	23.0	20.3 - 12.4	2.7 - 10.6
Highways	14.1		
Bridges	8.9		
Mass Transit			
MTA (1982-6) (2):	8.5		5.3
Subways	5.7		
Buses	0.8		
Commuter Rail (LIRR, Conrail)	2.0		
Non-MTA (Buses) (3)	0.2	---	---
Rail (4)	0.3	n.a.	n.a.
Airports(5)	0.6	n.a.	n.a.
Total (1983-7)	32.6		

Notes:

1. Source of needs estimate for State roads is the NYS DOT; for local roads, estimates were made using State and Federal data on road condition for non-local roads and extrapolating these to local roads; Expenditures are those for all local units within the State (reported by the U.S. DOT, FHWA. Highway Statistics.), added up from Table 29 for the years 1983 through 1987. The first figure under revenues and expenditures is derived from total expenditures and the second is from capital expenditures (projected from a 1976 base year). Similarly, the first figure under the shortfall column is based on total expenditures, and the second, capital expenditures.
2. The source of the MTA estimates is from the MTA, Amendment to the Capital Program Submitted to the MTA Capital Program Review Board, New York, N.Y., July 25, 1983.
3. The bus needs outside of the MTA system are computed from the number of buses exceeding 12 years of age and average dollar estimates for bus replacement. This figure is for bus replacement only, exclusive of ancillary facilities, such as garages and stations.
4. Rail estimate of needs is from the NYS DOT, Rail Division.
5. Airport needs are from the NYS DOT, Aviation Division and the Port Authority of New York and New Jersey.

efficiency, and equitably distribute transportation benefits.[2] The 1973 plan estimated that the State would need a public investment of $27 billion (at 1972 prices) from all governmental sources over twenty years at an annual rate of $1.4 billion to meet the State's highest transportation priorities. Another $50 billion would be required for other needs.[3] The largest component of the need was identified to be urban transit. The State DOT is currently in the process of updating the 1973 Master Plan.

The Capital Development Plan is another mechanism for identifying and prioritizing statewide needs in all transportation areas, and is required to be consistent with the State's Transportation Master Plan. The most recent Development Plan was issued in draft form in June 1983. In addition to assessing needs, the plan devises a 5 year development strategy. Prior to the current Capital Development plan capital needs were identified in a Five Year Transportation Plan, which was initiated in July of 1976.

Regional Transportation Planning: Transportation Improvement Programs

Transportation Improvement Programs (TIPs) are conducted at the regional level throughout New York State in accordance with the provisions of the Urban Mass Transportation Act of 1964, as amended, and U.S. Code, Title 23: Highways. The TIPs are a vehicle for estimating and prioritizing near-term regional infrastructure needs for a five year period. Federal regulations require that they list all Federally-aided projects. The statewide Capital Development Plan is supposed to incorporate the elements of the TIPs.[4] The TIPs are updated annually using extensive public participation. The program covers both transit and highways and is jointly funded by the Urban Mass Transportation Administration (UMTA) and the Federal Highway Administration (FHWA). In New York State, nine agencies, designated as Metropolitan Planning Organizations (MPOs) are responsible for the TIPs and the regional transportation plans.[5]

The selection of projects for funding is based upon several criteria: compliance with air quality goals as expressed in a federally approved State

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2. New York State Department of Transportation, April 1973 (Volume 1): 4.

3. NYS DOT, April 1973: 1.

4. NYSDOT, June 1983: 52.

5. These agencies are: New York Metropolitan Transportation Council (NYMTC); Newburgh-Orange County Transportation Council (NOCTC); Poughkeepsie-Dutchess County Transportation Council (PDCTC); Glens Falls Urban Area Transportation Council (GFUATC); Executive Transportation Committee of Chemung County (ETCCC); Genessee County Transportation Council (GCTC); Syracuse Metropolitan Transportation Council (SMTC); Binghamton Transportation Council (BTC); and Herkimer-Oneida Transportation Council (HOTC).

Implementation Plan (SIP), benefits to the elderly and handicapped, energy conservation, and the provision of a continuous transportation planning process.

Air quality: The Clean Air Act (CAA) Amendments of 1977 set forth the requirements for State Implementation Plans (SIPs) and the conformance of Transportation Improvement Programs with the SIPs.[6] In 1979, New York State revised its SIP to conform to the requirements of the CAA of 1977. The SIP included Reasonably Available Control Measures (RACMs), many of which are transportation based. The New York State Environmental Action Plan established classifications I, II, and III, as a basis for determining the consistency between air quality and transportation projects.[7] In 1982 the New York State SIP was revised again, in light of the postponement of attainment of air quality standards to 1987, and submitted to the U.S. EPA for review and approval. Non-attainment was occurring throughout the State for ozone, and areas of non-attainment for carbon monoxide existed throughout the State, such as in New York City. On February 3, 1983, the U.S. EPA disapproved New York State's ozone plan. New York State is in the process of resubmitting the plan for carbon monoxide for the New York Metropolitan Area.

Energy Conservation: The incorporation of energy conservation into the transportation planning process, and hence, the estimation of transportation facility needs, has its origins in the Emergency Highway Energy Conservation Act of 1979, the Energy Policy and Conservation Act of 1975, the Surface Transportation Act of 1978, and the FHWA/UMTA Joint Planning Regulations (23 CFR Section 450.120).[8]

Elderly and Handicapped: Facility requirements for the elderly and handicapped in transportation plans stem from Section 504 of the Rehabilitation Act of 1973. Final rules under this Section were published by the U.S. Department of Transportation (DOT) in 1979, and overturned by a federal court in 1981 for being too restrictive. Interim Final Rules were passed in 1981, requiring certification that special provisions were being made for this sector of the population. Funds are provided by UMTA Section 16 (b) (2) for the elderly and handicapped.

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6. Section 176 (a) of the Amendments require that federally funded projects, such as the TIP, be consistent with the SIP (23 CFR 770). Section 108 (e) of the Act integrates air quality and transportation planning processes for non-attainment areas. Furthermore, planning guidelines were established jointly by NYS DOT and the U.S. Environmental Protection Agency (EPA) in 1978 to assure such consistency.

7. SMTC, 1982: 31; NYMTC, 1983: V-28.

8. NYMTC, 1983: V-29 to 31

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Transportation Planning Process: The transportation improvement program is required to conform to the goals set forth in a transportation plan.[9] Most of the Councils have developed such plans, but many date from the late 1960's, and have not been revised.

Highways and Bridges

Highways

The Inventory and System Condition:

In 1980, New York State ranked thirtieth in the nation in terms of total land area, second in total population, and, in 1981, third in the nation (exceeded by California and Texas) in annual vehicle miles of travel.[10] This total was 79.1 billion miles of travel (see Table 20). In 1982, the number rose to 80.5 billion vehicle miles of travel.

In 1982, New York State reported 109,706 miles of highways in New York State.[11] As shown in Table 21, towns and counties owned over two-thirds of this mileage, cities owned another 11 percent, and villages another 5 percent. The state owned 15 percent of the highway system by mileage, however, these state-owned roads got the most usage accounting for the largest share of total mileage. In terms of location, a larger percentage of New York State roads are urban than is true of the nation as a whole. Over time, the inventory has not changed substantially: between 1977 and 1982 the total inventory changed by only 1000 miles or less than one percent, amounting to an average of about 166 miles per year (see Table 22). The largest share of the growth occurred in town roads.

System safety is a major goal of highway maintenance.[12] One indicator of safety is the accident rate. Some of these rates are shown in Table 23 for

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9. Section 134, Title 23 U.S. Code; Section 1602, Title 49, U.S. Code

10. U.S. DOT, FHWA, September 1982: 168

11. The highways in the State are categorized in a number of different ways for descriptive purposes: by jurisdiction or ownership (town, county, village, and state owned), by federal-aid class (federal aided or non-federal aided), by functional class (Interstate, Freeways and Expressways, Arterials, Collectors, and Local functional class), and location (urban and rural). Furthermore, the State Touring Route System, which accounts for about 15,000 miles, is a system of roads classified by the State as an aid to motorists. This State system of roads cuts across various federal-aid categories.

12. Safety is also an indicator of other factors as well related to the driving population, vehicle miles traveled and the quality of the vehicles themselves

Table 20

ANNUAL VEHICLE MILES TRAVELED BY ALL MOTOR VEHICLES, New York State and the Nation, 1981

Functional Class of Highway	New York State (numbers given in millions of miles) Number	Percent	National Number	Percent
Rural:				
Interstate	3,837	4.9	138,395	8.9
Other Principal Arterial	3,471	4.4	135,463	8.7
Minor Arterial	5,414	6.8	132,407	8.5
Major Collector	3,792	4.8	154,254	10.0
Minor Collector	4,151	5.3	41,331	2.7
Local	5,090	6.4	85,049	5.5
Total	25,755	32.6	686,899	44.3
Urban:				
Interstate	7,991	10.0	166,817	10.8
Other Freeways and Expressways	9,242	11.7	82,051	5.3
Other Principal Arterial	12,321	15.6	234,309	15.1
Minor Arterial	10,807	13.7	173,088	11.2
Collector	3,909	4.9	81,705	5.3
Local	9,105	11.5	125,402	8.1
Total	53,375	76.5	863,372	55.7
Grand Total (all areas)	79,130	100.0	1,550,271	100.0

Source: U.S. Department of Transportation, Federal Highway Administration. Highway Statistics-1981. Washington, D.C., September 1982. Page 168.

Table 21

HIGHWAY MILEAGE BY TYPE OF JURISDICTION AND TYPE OF ROAD, 1981 and 1982

Jurisdiction	Type of Road by Ownership: Town, Village or City	County	Total Local	State Highway System	Other State	Total State and Local
			1981			
Town	54735.10	20086.36	74821.46	13125.60	1213.79	89160.85
Village	5816.76	528.45	6345.21	1029.61	121.66	7496.48
City	11920.67	90.16	12010.83	450.72	365.93	12827.48
Total	72472.53	20704.97	93177.50	14605.93	1701.38	109484.81
			1982			
Town	54862.22	20081.97	74944.19	13226.99	1212.18	89383.36
Village	5871.22	522.14	6393.36	1030.28	114.53	7538.17
City	11917.61	93.81	12011.42	413.36	359.04	12783.82
Total	72651.05	20697.92	93348.97	14670.63	1685.75	109705,35

Source: New York State Department of Transportation, Planning Division, Data Services Bureau, Transportation Statistics & Analysis Section. 1981 and 1982 Highway Mileage Report for New York State. Albany, N.Y.: NYS DOT, April 1982 and April 1983. Page 1.

Table 22

HIGHWAY MILEAGE IN NEW YORK STATE BY JURISDICTION, 1977-1982

Year	Jurisdictional Area					
	City	Village	Town	County	State	Total
1977	12007.72	5761.84	54000.82	20624.21	16318.06	108712.65
1978	12019.72	5774.41	54203.63	20620.83	16305.28	108923.87
1979	12029.11	5791.42	54396.28	20630.47	16352.17	109199.45
1980	12035.25	5799.67	54590.36	20657.72	16301.94	109384.93
1981	11920.67	5816.76	54735.10	20704.97	16307.31	109484.81
1982	11917.61	5871.22	54862.22	20697.92	16356.91	109705.88

Source: New York State Department of Transportation, Planning Division, Data Services Bureau, Transportation Statistics & Analysis Section. 1982 Highway Mileage Report for New York State. Albany, N.Y.: NYS DOT, April 1983. Page iii.

Table 23

SELECTED MOTOR VEHICLE TRAFFIC FATALITY AND INJURY STATISTICS, New York State and the Nation: 1981

	New York State	National
	(per 100 million vehicle-miles of travel)	
Fatal Accident Rate	2.88	2.83
Nonfatal Injury Accident Rate	220.10	132.97
Fatality Rate	3.14	3.17
Nonfatal Injury Rate	329.39	196.95

Source: U.S. Department of Transportation, Federal Highway Administration. Highway Statistics. Washington, D.C., September 1982. Page 170.

New York State and the Nation. The New York State fatal accident rate and fatality rate approximated the national average in 1981, which is low relative to its position among other states in terms of vehicle miles traveled. The nonfatal injury accident rate and nonfatal injury rate, however, far exceeded the national average, and in fact, New York State ranked second in the nation for both statistics (second only to the District of Columbia). This is comparable, though, to its rank nationwide in vehicle miles traveled. Speed does not seem to account for the accident rate, since in 1981, the average speed recorded for New York State highways with speed limits of 55 miles per hour was 53.5 miles per hour for all vehicles and the national average was 54.9. The New York State median speed was similarly below the national median.[13]

Highway needs are determined by two aspects of highway condition: (1) the condition of the pavement (both the road surface and the base material) and (2) the ability of the roadway to accommodate traffic. Table 24 gives the distribution of a portion of the State's roadways by both characteristics.

The condition of the pavement is based upon a rating system developed by the State under federal guidelines. The details of the system are given in the Appendix. According to Table 24, some 3,700 miles of state road or ten percent of the total were rated as deteriorated, and another 20,700 miles or 58.2 percent of the total were rated as being in only fair condition in 1981. A slightly larger share of deteriorated highways were located in rural rather than urban areas. A detailed estimate of condition is described below for local roads. According to these calculations, 16,249 miles of roadway (15% of the total roadway mileage) were deteriorated and 76,813 miles (70% of the total) were in fair condition.

The congestion of the roads, measured by the ratio of volume of traffic to capacity, is a gross indication of the need for roadway expansions. In 1980, fourteen percent of urban roads and six percent of rural roads (or a combined percentage of 8% of all roads) were in the highest category of congestion with volume almost equivalent to capacity. Another 14% of all roads exceeded a volume to capacity ratio of 0.7. Estimates of expansion based on this characteristic are not dealt with in the needs estimate.

Needs Assessment:

The estimate of highway needs is based upon the (a) the State's estimate of pavement condition needs in the New York State Touring Route System (a system of roads marked by the State for the convenience of the public) and (b) an estimate of local road needs based on state and federal data on condition and unit costs for repair. The approach for local roads is necessitated by the absence of a condition inventory for local (non-federally aided) roads, which constitute the bulk of the statewide inventory in terms of mileage.

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13. U.S. DOT, FHWA, 1981: 171.

Table 24

CHARACTERISTICS OF HIGHWAY CONDITION, New York State: 1981

Numbers given in actual mileage

	Interstate	Other Freeways & Expressways	Other Principal Arterial	Minor Arterial	Major Collector	Minor Collector	Total
A. Volume to Capacity (V/C) Ratio							
V/C							
Urban Areas:							
Total	552	730	2319	4025	3202		10828
.21	52	204	501	1368	1824		3949
.21-.30	148	41	225	208	448		1070
.31-.40	110	75	209	476	370		1240
.41-.70	76	203	413	1055	257		2004
.71-.95	40	27	329	488	148		1032
.95	126	180	642	430	155		1533
Rural Areas:							
Total	860		1806	4692	6346	11021	24725
.21	568		857	2601	1539	7557	13122
.21-.30	241		312	838	962	1401	3754
.31-.40	29		266	514	855	543	2207
.41-.70	22		280	282	1707	924	3215
.71-.95	--		55	291	548	86	980
.95	--		36	166	735	510	1447
Grand Total (all areas)	1412	730	4125	8717	9548	11021	35553
B. Pavement Condition							
Rating							
Urban Areas:							
Total	552	730	2319	4025	3202		10828
Deteriorated	38	47	100	326	391		902
Fair	228	328	1276	2480	2192		6504
Good	286	355	943	1219	608		3411
Unpaved	--	--	--	--	11		11
Rural Areas:							
Total	860		1806	4692	6346	11021	24725
Deteriorated	50		47	179	655	1839	2770

Fair	260		733	2539	3400	7259	14191
Good	550		1026	1974	2291	1733	7574
Unpaved	--		--	--	--	190	190
Grand Total (all areas)	1412	730	4125	8717	9548	11021	35553

Source: U.S. Department of Transportation, Federal Highway Administration. Highway Statistics-1981. Washington, D.C. Pp. 157-164.

Note: (1) Source of data is from state agency submissions; New York State submitted incomplete 1981 data, and the U.S. DOT had to make adjustments in the data (see note 3 to Tables HM-61 and HM 63)

(1) The Federal-Aid System of State Roads. The current estimate of needs developed by the New York State DOT for state roads[14] in the Federal-Aid System of roads between 1983-7 is $10.9 billion. Assuming that these improvements are made during those five years, the estimate of additional improvements is $5.6 billion from 1988-2000.[15]

(2) The Non-Federal Aid System (Local and Non-Local Roads). The roads in New York State that do not receive federal aid are predominantly in the local functional class (about 74,000 miles) with the remainder (about 12,000) in the federal functional categories of other principal arterials, minor arterials, and collectors. The condition of the non-federal aid, local functional class roads was based upon extrapolations from about 12,000 miles of non-federal aided, non-local roads for which condition was known. Briefly, the following assumptions were made in arriving at the condition of the local functional class roads:

-the distribution by condition of the 74,000 miles of non-federal aid local functional class roads was assumed to be equal to the distribution by condition of the 12,000 miles of non-federal aided, non-local roads;

-non-local and local roads in the non-federal aid category were treated the same way with regard to level of remedial work, and urban and rural roads were assumed to require the same unit costs for rehabilitation;

-roads that were in the "deteriorated" or "fair" categories in 1980 were assumed to require an asphalt cover approximately midway in cost between a 1" and 2" layer (this cost was estimated at $125,000 per 2 lane mile); roads in "good" condition were assumed to require no work; unpaved roads were assumed to require work equivalent to about $15,000 per 2 lane mile;[16]

-roads that were in "deteriorated", "fair", or "good" categories during the 1988-2000 period were assumed to require a chip seal (oil and stone) treatment twice during that period at a cost of $35,000 per 2 lane mile for

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14. This includes 969 miles of Non-Federal Aid roads, subtracted from total needs in Table 27 to avoid double counting: see Table 27 notes.

15. The NYS Touring Route System (14,230 miles) accounts for $6.913 billion of the $10.9 billion five year estimate, and $4.838 billion of the $5.6 billion year 2000 estimate. NYS DOT. Memorandum, "Estimates of Future Infrastructure Needs, NYS Highways". From D.T. Hartgen to G.H. Preiss. June 3, 1983.

16. Unit costs were based upon estimates developed by and discussed with the New York State Department of Transportation, Planning Division staff, and are in the range of estimates that have been developed in the literature for low-volume roads, such as those maintained by the U.S. Forest Service (Luhr and McCullough, 1983: 25; Durston and Fong-Lieh Ou, 1983: 51); see Appendix for some of these unit cost estimates.

each treatment.

The details of the extrapolation are given in the Appendix, and summarized in the notes to Table 25. Unit cost figures were obtained from the State and other data sources for local road improvements, and are itemized in the Appendix. The non-federal aid, local road condition and needs estimates are shown in Table 25; similar figures for the non-federal aid non-local roads are shown in Table 26. The composite estimates for all non-federally aided roads is given in Table 27. The resulting total need for the 1983-7 period is $14.078 billion and for the 1988-2000 period, $11.428 billion.

In contrast to the statewide estimate, the total estimate given in the TIPs for highway rehabilitation from 1983 to 1987, which covers only major urban areas, is $3.9 billion (shown in Table 28).

Expenditures and Revenues:

Table 29 gives both existing and projected trends for expenditures and revenues for highways and bridges. The figures are adjusted to 1982 dollars using the Building Cost Index (represented for New York State by New York City) as recorded by Engineering News Record.[17] The data from Highway Statistics published by the U.S. DOT appears to give the most complete data for revenues ("receipts) and expenditures ("disbursements"), and are therefore used as the basis of the computation of the shortfall. Capital expenditures were used to compute the shortfall. Since it can be argued that certain components of maintenance expenditures are capital related, total expenditures were also used to compute a shortfall, and are shown in Table 19 along with those computed from capital expenditures only.[18] Expenditures were used to project available resources rather than revenues, since revenues cannot be targetted easily to capital components. Known revenue sources have

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17. By adjusting both historical and projected figures to 1982 dollars, they are adjusted for inflation and are made comparable to the needs estimates. Other indices were examined as well such as the producers price index (PPI) to see the effect of using different indices on the projections. The PPI and BCI indices generate numbers that usually differ by between 10 and 20%. The choice of the BCI over the PPI was based on the greater closeness of cost components in the BCI to highway construction components.

18. A criticism of using total expenditures, rather than capital expenditures is that total expenditures are not comparable to needs estimates. However, the maintenance portion of the non-capital expenditures includes substantial expenditures for factors that strongly influence capital investment, such as condition maintenance expenditures (e.g., pothole repairs and patching). This maintenance portion is difficult to disaggregate from other maintenance expenditures that are not related to capital outlay, such as deicing (the maintenance figures do not include street cleaning and drainage) (U.S. DOT, FHWA, Highway Statistics 1981: 38). The true resource base to meet the needs probably lies between the capital and the total figures.

Table 25

ESTIMATED CONDITION AND COST OF REHABILITATION OF LOCAL ROADS
IN THE LOCAL FUNCTIONAL CLASS NOT RECEIVING FEDERAL AID, New York State

Condition	Estimated Distribution of Local Functional Class Roads by Condition, 1980 (a) Mileage (figures in thousands of 2-lane miles)			Cost of Rehabilitation (b) (figures in millions of 1982 dollars)	
	Urban	Rural	Total	1987 (c)	2000 (d)
Deteriorated	2,552	8,125	10,677	1334.625	747.39
Fair	16,401	32,066	48,467	1696.345	3392.69
Good	6,402	7,658	14,060	--	984.20
Unpaved	43	837	880	13.200	26.40
Total (e)	25,396	48,681	74,077	3044.170	5150.68

Notes:

a. For a detailed discussion of the estimation procedure, see the Appendix. The estimates are based upon 1980 condition data published by the U.S. Department of Transportation, Federal Highway Administration in Highway Statistics. No roadway expansion is included in any estimates.

b. The estimation procedure assumes no unit cost differential between urban and rural roads. While urban roads may have a larger square footage per mile, the cost of shipping construction material to rural roads may compensate.

c. 1987 estimates assume that deteriorated roads will be treated with asphalt at a unit cost of $125,000 per mile; fair roads will use chip seal (oil and stone) at a cost of $35,000 per mile, and unpaved roads will require maintenance of about $15,000 per mile.

d. Year 2000 estimates assume that roads in the deteriorated, fair and good condition categories will require chip seal (oil and stone) treatment twice in the period from 1988 to 2000 at a cost of $35,000 per 2 lane mile. Unpaved roads would require maintenance twice at $15,000 per 2 lane mile.

Table 26

ESTIMATED CONDITION AND COST OF REHABILITATION OF NON-LOCAL ROADS NOT RECEIVING FEDERAL AID, New York State

Condition	Estimated Distribution of Roads, 1980 (figures in thousands of 2-lane miles)			Cost of Rehabilitation (figures in millions of 1982 dollars)	
	Urban	Rural	Total	1987	2000
Deteriorated	61	1839	1900	237.50	133.00
Fair	392	7259	7651	267.79	535.57
Good	153	1733	1886	--	132.02
Unpaved	1	190	191	2.87	5.73
Total	607	11021	11628	508.15	806.32

Note: This category of road includes principal arterials, minor arterials and collectors in urban areas and minor collectors only in rural areas. The same assumptions made in computing the previous table pertain to this table also.

Table 27

SUMMARY OF COST OF ROAD REHABILITATION, New York State:
1983-1987 and 1988-2000

Road Category	Approximate Mileage	1983-1987 (figures given in billions of 1982 dollars)	1988-2000
Federal-aided roads (a)	(24,029	10.938	5.557)
Adjusted total (b)	23,060	10.526	5.486
Non-federal aided roads, local functional class	74,000	3.044	5.151
Non-federal aided roads, non-local	12,000	.508	.806
Total	109,000	14.078	11.443

Notes: a. Includes the State Touring Route System (all federal aided) and some non-federal aided roads

b. The adjustment subtracts .412 billion and .271 billion from the 1983-7 and 1988-2000 figures respectively to avoid double counting in the non-federal aided category.

Table 28

ESTIMATES OF 5-YEAR CAPITAL NEEDS FOR HIGHWAYS, Transportation Improvement Program Areas: 1983-1988

Transit Improvement Program (TIP) Area	Cost (in millions $'s)	Page Reference in TIP
Binghamton	125.652	p. 22-29
Capital District	175.535	p. 24
Chemung County	39.926	p. 17
Genessee	146.230	p. 30
Glens Falls	11.225	p. 19
Herkimer-Oneida Counties	131.980	p. 51-2
Niagara Frontier	135.132	Table 7.2
Syracuse Metropolitan	63.100	p. 47
Upstate Subtotal	878.780	
NY Downstate Metropolitan		
Mid-Hudson	194.1	p. II-10
Nassau-Suffolk	268.1	
New York City	2,554.5*	
Downstate Subtotal	3,016.8*	
GRAND TOTAL	3,845.58*	

Note: *Westway accounts for $1,467.7 million in these figures.

Table 29

TRENDS IN EXPENDITURES (TOTAL AND CAPITAL) AND REVENUES FOR HIGHWAYS AND BRIDGES, All Units of Government, New York State

Year	Total Revenues	Total Expenditures	Capital Expenditures	
	(figures given in millions of 1982 dollars)			
Actual:				
1970			2,062.44	
1971			1,589.77	
1972			1,742.76	
1973			1,664.22	
1974			1,471.05	
1975			1,337.71	
1976	3,256.20	3,194.47	858.13	
1977	3,029.57	2,945.73	695.48	
1978	3,700.57	3,646.71	1,375.67	
1979	4,258.43	4,121.70	1,602.22	
1980	4,168.39	3,483.86	1,331.39	
Projected:				
			1970 base	1976 base
1981	4,055.41	3,691.75	1,034.23	1,728.56
1982	4,212.59	3,781.81	968.26	1,913.88
1983	4,369.77	3,871.88	902.29	2,099.21
1984	4,526.95	3,961.94	836.31	2,284.53
1985	4,684.13	4,052.01	770.34	2,469.86
1986	4,841.31	4,142.07	704.36	2,655.19
1987	4,998.49	4,232.13	638.39	2,840.51
1988	5,155.67	4,322.20	572.42	3,025.84
1989	5,312.85	4,412.26	506.44	3,211.16
1990	5,470.03	4,502.33	440.47	3,396.49
1991	5,627.21	4,592.39	374.50	3,581.82
1992	5,784.39	4,682.46	308.52	3,767.14
1993	5,941.57	4,772.52	242.55	3,952.47
1994	6,098.75	4,862.59	176.57	4,137.79
1995	6,225.93	4,952.65	110.60	4,323.12
1996	6,413.11	5,042.72	44.63	4,508.45
1997	6,570.29	5,132.78	- 21.35	4,693.77
1998	6,727.47	5,222.85	- 87.32	4,879.10
1999	6,884.65	5,312.91	-153.30	5,064.42
2000	7,041.84	5,402.98	-219.27	

Source: U.S. Department of Transportation, FHWA. Highway Statistics. Washington, D.C.: FHWA, 1970-1981. Adjustments to 1982 dollars were made using the Building Construction Cost Index.

been taken into account, though, in the overall assessment of the shortfall (see below).

The expenditure and revenue figures are shown in Table 29. Aggregate capital expenditure levels projected for the years 1983 through 1987 range from $3.852 billion to $12.349 billion, depending upon whether the projections start from 1970 or 1976.[19] Total aggregate expenditure levels for 1983 through 1987 are $20.26 billion, and aggregate revenues are $23.42 billion for all units of government.[20] Figures 5 and 6 show existing and projected trends for total expenditures and revenues and Figures 7 and 8 show the trends for capital expenditures for projections from 1970 and 1976 respectively (with expenditures adjusted with the BCI). To summarize, variations in the resource base to meet highway and bridge needs occur on the basis of using total vs. capital expenditures, and within the capital expenditure category, whether near term or more long term historical trends are more representative of future expenditure patterns.

Two other partial data sets on expenditures exist as well. The first set, shown in Column 3 of Table 30, is for state capital construction expenditures for state roads only. The other set, shown in Columns 1 and 2 of Table 30, is provided by the State Comptroller for expenditures by all units of local government. The two figures combined do not equal the figures shown in Table 29, since there may be some double counting of state monies in the local expenditure category.

The Shortfall:

Table 19 summarizes the shortfall between an anticipated resource base (based on projected expenditures only) and needs during the 1983-7 period for both highways and bridges.[21] The shortfall in the highway and bridge area is the difference between the total needs (see next section for bridges) of

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19. The variation reflects projections from a 1970-1980 and 1976-1980 data base respectively. The reason for doing both projections is that capital expenditure patterns for highways between 1970 and 1979 reflect a U-shaped curve with the lowest point occurring during 1976 and 1977. (In 1980 expenditures decline slightly relative to 1979.) Thus, using the entire 10-year time period as a basis for the projections assumes that a longer time period is more representative of historical trends, but the period between 1976 and 1980 may be more be a more accurate portrayal of recent expenditure trends, i.e., be a firmer basis upon which to base projections. Because of the difficulty in choosing between these two approaches, projections based on both time periods are presented, and reflect a range of possible expenditure values as a basis for shortfall computations.

20. This surplus in revenues over expenditures is consistent for most years.

21. Highway and bridge expenditures cannot be disaggregated from one another due to the way the data are collected.

Figure 5. PROJECTION OF HIGHWAY EXPENDITURES (Federal Data) For All Units of Government, New York State

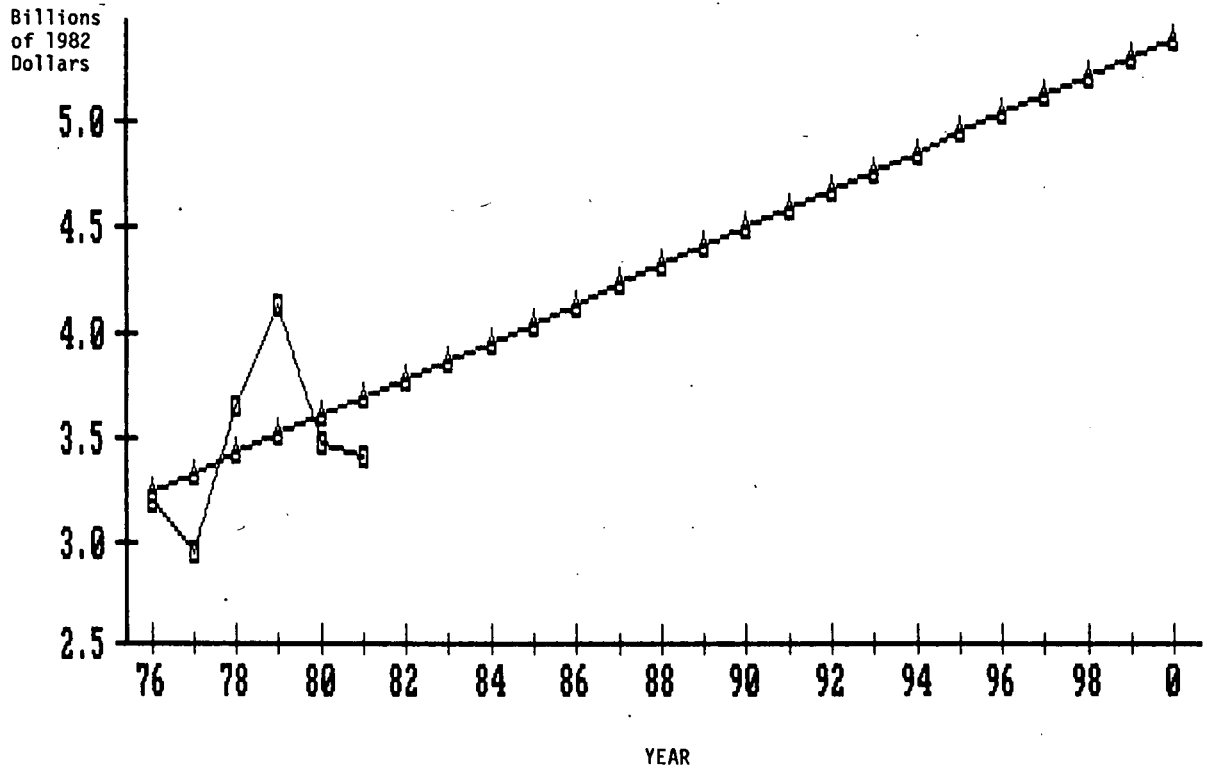
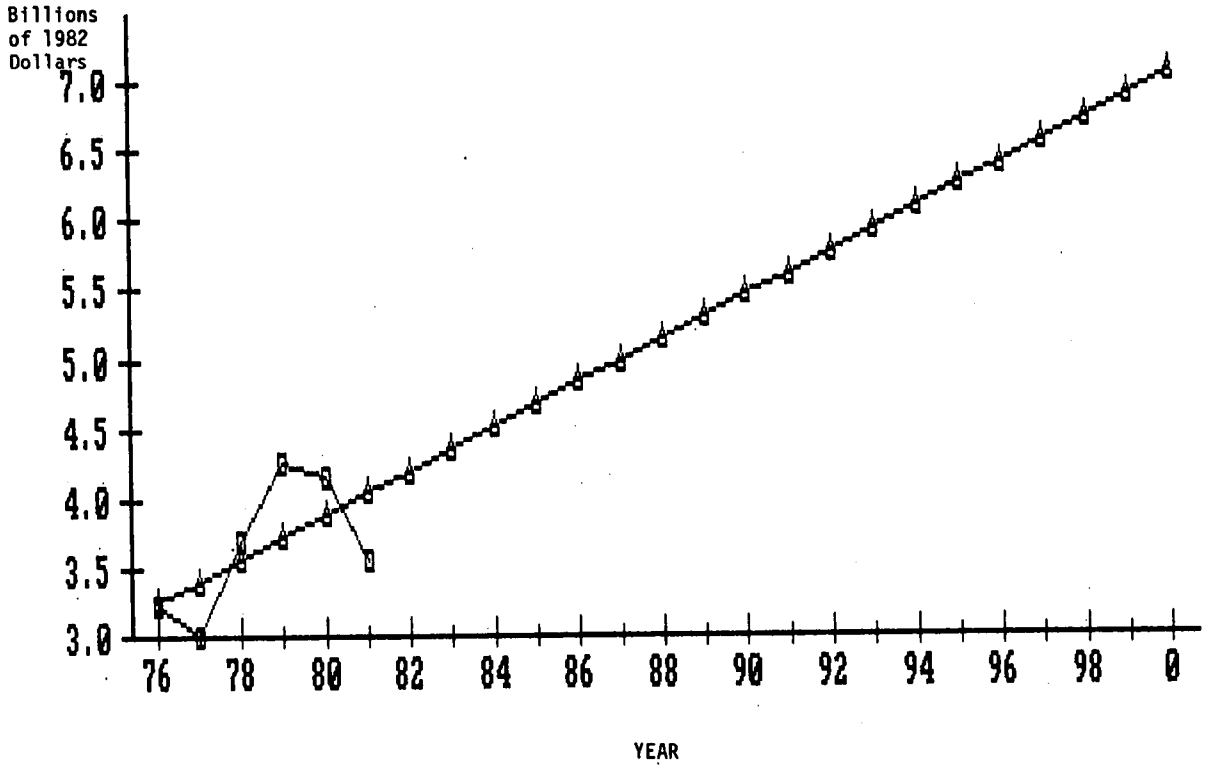


Figure 6. PROJECTION OF HIGHWAY REVENUES (Federal Data) for All Units of Government, New York State



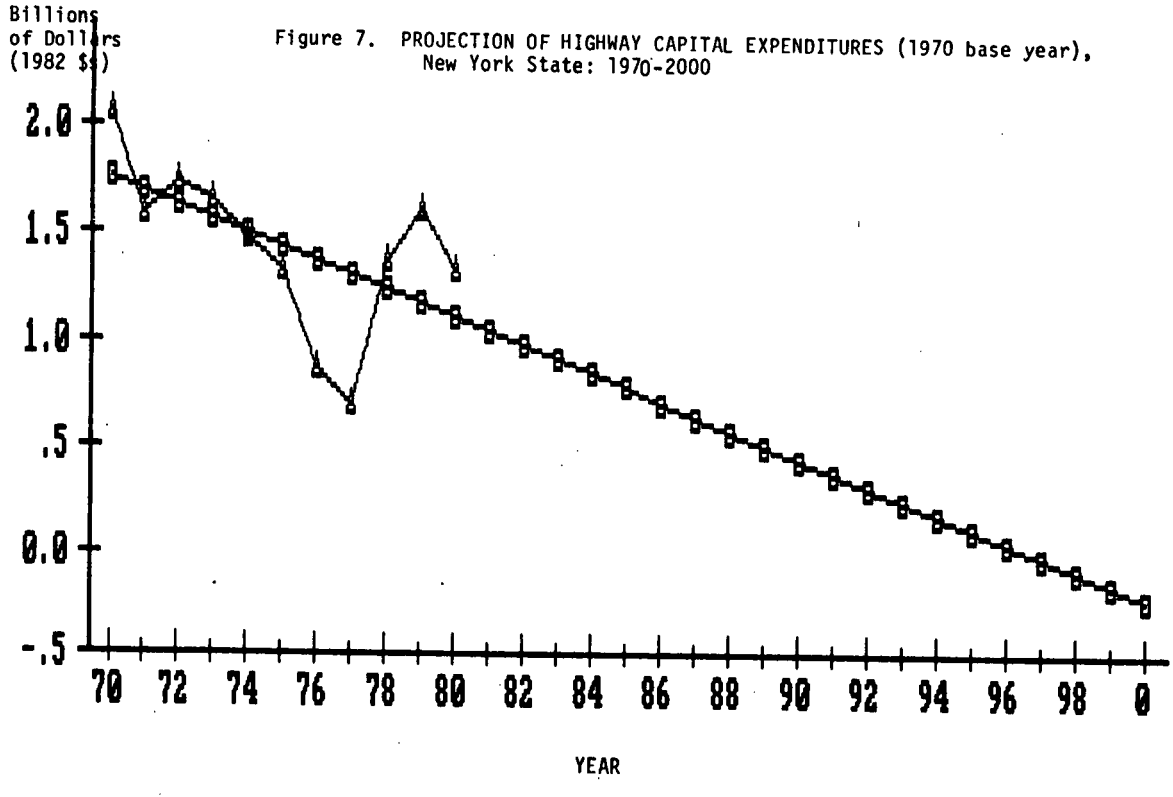


Figure 7. PROJECTION OF HIGHWAY CAPITAL EXPENDITURES (1970 base year), New York State: 1970-2000

Figure 8. PROJECTION OF HIGHWAY CAPITAL EXPENDITURES (1976 base year), New York State: 1976-2000

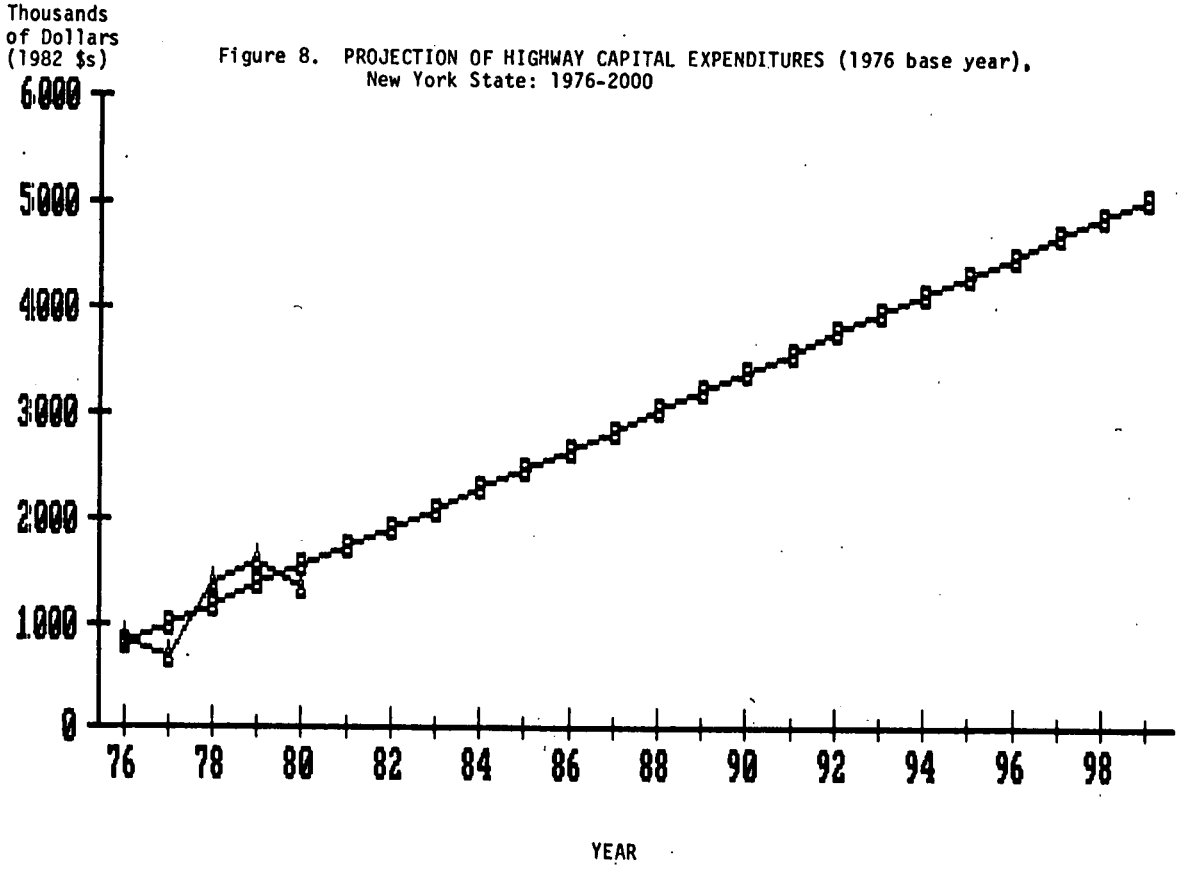


Table 30

STATE AND LOCAL EXPENDITURES FOR HIGHWAYS, New York State*

Year	Local Expenditures** Total	Local Expenditures** Capital Only	State Construction Expenditures***
	(all figures are in millions of 1982 dollars****)		
1976	970.3	242.6	457.8
1977	1,067.7	236.2	555.1
1978	1,002.0	272.0	822.4
1979	1,003.3	291.1	953.7
1980	944.9	251.3	821.3
1981	1,012.7	260.0	795.0
1982			592.4

Notes:

* Figures for local and state capital expenditures will not add up to the total capital expenditures given in the previous table, since local expenditures may include some state expenditures on local government.

** Source: New York State Office of the Comptroller, Special Report on Municipal Affairs. Albany, N.Y., Comptroller, 1983. Table 1-m. Also, special tabulations produced by the Comptroller's office.

*** Source: New York State Department of Transportation, "Annual Capital Construction Activity". Highways, Grade Crossings, Parkways, etc. Unpublished Table. Albany, N.Y.: NYS DOT, October 1981 and updated to 1983.

$22.98 billion and various expenditure level alternatives:

(1) aggregate 1983-7 capital expenditures computed from a 1976 base, reflective of recent expenditure patterns, of $12.349 billion or: a $10.631 billion shortfall;

(2) aggregate 1983-7 capital expenditures computed from a 1970 base amounting to $3.851 billion or: a $18.409 billion shortfall; or

(3) aggregate total expenditures of $20.26 billion over the 1983 to 1987 period, or a shortfall of only $2.7 billion.

Table 19 summarizes the resources and shortfalls for (1) and (3) only, since (2), using a 1970 base, does not reflect near-term trends in expenditures, and hence resources.

Anticipated Revenue Sources (Near-Term):

A number of revenue sources are expected to impact this shortfall, by adding another $4.4 billion, to the extent that they are not already implicitly included in the expenditure projections. These sources are as follows:

-The Surface Transportation and Assistance Act of 1982 is expected to allocate the following funds to New York State for highways and bridges:

Transportation Area	Annual Amount (in millions of dollars)	Four Year Total
Secondary Roads	19.6	78.4
Primary Roads	103.0	412.0
Urban System	67.5	270.0
Bridges	136.8+	547.2+
Total	326.9	1,307.6

-The proposed Transportation Bond Act is expected to allocate $1.005 billion to the rehabilitation of highways and bridges.[22]

-The motor vehicle fuel tax on both gasoline and diesel fuel is projected to contribute a total of $ 2.131 billion between 1983 and 1987 for both gasoline and diesel fuel. A breakdown of this revenue source annually is shown in Table 31.

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22. Other facilities are covered under this amount as well, such as highway and bridge grade crossings and commuter rail parking facilities. Source: New York State Bond Information Task Force, "Proposition 1. Rebuild NY Bond Issue. Fact Sheet." Albany, N.Y.: NYS Task Force, 1983. Page 3.

Table 31

ESTIMATED REVENUES FROM MOTOR FUEL TAXES, New York State: 1983-1987

Year	Projected Change in fuel consumption (millions of gallons)		Projected Change in fuel revenues (millions of 1982 dollars)	
	Gasoline	Diesel	Gasoline	Diesel
1983	5,508	409	$ 405	$ 35
1984	5,458	402	401	35
1985	5,408	395	398	34
1986	5,243	392	386	33
1987	5,058	390	372	32
Total	26,675	1,988	$1,962	$ 169

Note: Assumes a tax rate of $0.08 per gallon for gasoline and $0.10 per gallon for diesel fuel. Historically, additions to the tax rates in the NYS Tax Law have been as follows-

Gasoline		Diesel	
Sec. 284	$0.04	Sec. 282a	$0.06
Sec. 284a	0.03	Sec. 282b	0.03
Sec. 294c	0.01	Sec. 282c	0.01

Multiplying the number of gallons by the tax rate will not be equivalent to the revenues indicated in the Table, since not all fuel is taxable.

Source: Computed from-New York State Energy Office, Energy Master Plan. Long Range Forecast of Transportation Energy Consumption in New York State, 1980-2000. Albany, N.Y.: NYS Energy Office, August 1983.

Bridges

Overview of Needs:

Using the State's rating system for bridges, about 42% of the State's bridges or 8,192 bridges are rates as deficient. Assuming an average cost of $1 million per bridge for rehabilitation or replacement (based on a range of $0.2-5.0 million), the needs estimate currently stands at about $8.2 billion. The State Department of Transportation estimate based upon a detailed breakdown of costs by category (exclusive of new bridges) is $8.9 billion.[23] This does not include bridges that will move from the not deficient to the deficient categories over the next five years. This is difficult to project due to changing maintenance levels, which influence rate of deterioration, and the unavailability of data on the actual number that has moved between the two categories over time. Assuming the State's rule-of-thumb estimate of the rate of deterioration, all bridges that in 1983 had ratings above 5.0 (non-deficient), will need rehabilitation by the Year 2000 at an additional cost of $11.2 billion.

Inventory and Condition:

Under the New York State Highway Law a bridge is defined as "a structure whether of single or multiple span construction with a clear span in excess of twenty feet".[24] There are a number of indicators of bridge condition as a basis for rehabilitation or new construction needs estimates, most notably, the physical or structural condition and its capacity to meet traffic needs. With regard to structural condition, a federally mandated program, the National Bridge Inspection Program, was initiated by the Federal Highway Administration in the late 1960's. While New York State has had a bridge inspection program for over forty years, the program was considerably revamped after the federal program came into being: procedures were standardized and a computerized inventory was created.[25] The inventory of the system was completed in 1975, the first inspection of state-owned bridges in the state was recorded in 1977 under a program mandated by the Laws of 1977, Chapter 460, and expanded to non-state owned bridges in 1979.[26] The State law requires consistency with the Federal Highway Administration standards for condition. The classification system used to categorize bridges by structural condition is explained in the Appendix. Briefly, the State uses a scale from 0 to 7, and any bridge with a rating below 5 is considered

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23. New York State Department of Transportation. Memorandum. R.C. Keating to D.J. Egan, "Cost of Bridge Program". Albany, N.Y.: August 11, 1983

24. Section 230, Part 2; NYS DOT, September 1979

25. New York State DOT, September 1979

26. NYS DOT, September 1979

deficient and in need of rehabilitation.[27] The application of the State's condition rating system to the bridges in the State is shown in Table 32. The proportions of bridges that have been rated deficient over time are given in Table 33.

What is apparent from the State statistics on bridge condition is the following:

- The total number of bridges categorized as deficient in the State stands at 8,192 or 42% of the total; it is important to realize that about 5,647 of these bridges are at the very top of the deficient category, i.e., they may not need as much rehabilitation as those at the lower end, assuming some correspondence between the rating and level of repair can be established;

- The inventory of non-state owned bridges has a much higher percentage of structurally deficient bridges than state-owned bridges (the non-state percentage is consistently more than double state percentage); the percentage of state owned bridges that were deficient as of the December 1982 inspection period was 21 percent (1,684 bridges) and the percentage of non-state owned bridges that were deficient was 52 percent (6,508 bridges); 175 bridges were added to the structurally deficient state-owned bridges and 56 to the deficient non-state owned bridges since December 1982. While it appears from these statistics on numbers of bridges that state-owned bridges are in much better condition than non-state owned bridges, two factors must not be overlooked. First, the percentage of deficient state bridges has been rising at a much faster rate than that of non-state bridges. Second, the cost of rehabilitation per bridge is probably higher for state bridges, since the cost is a function of bridge size, and state owned bridges are much larger in size than non-state bridges. In terms of deck area, the average size of a non-state owned bridge is 5,973 square feet as compared with 9,673 square feet for state bridges. In addition, state bridges carry more traffic, and hence, experience more wear and tear.

- The percentage of structurally deficient bridges in both the state and non-state owned categories continues to increase slightly year by year (since 1977) in spite of programs to rehabilitate or replace bridges; this does not include bridge abandonment;

- By region in 1981, the structurally deficient bridges were largely located in and around older urban areas of the state: Regions 4 (Rochester), 5 (Buffalo), 1 (Albany), 3 (Syracuse), 9 (Binghamton), 11

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27. This scale is applied differently to bridges by the maintenance and the structures divisions of the State Department of Transportation.

Table 32

CONDITION RATING TRENDS OF BRIDGES IN NEW YORK STATE, 1977-1983

Year	Owner-ship*	Condition Rating ** 1.0-1.9	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0	NR	Total
					A. Number of Bridges					
1977	S	7	59	226	681	1,581	3,315	1,021	186	7,076
1978	S	8	66	254	716	1,615	3,278	994	142	7,073
1979	S	8	60	275	800	1,777	3,056	848	71	6,895
	NS	52	393	1,757	4,163	4,107	1,572	309	542	12,895
	Total	60	453	2,032	4,963	5,884	4,628	1,157	613	19,790
1980	S	11	78	290	912	1,980	2,946	657	43	6,917
	NS	50	400	1,812	4,258	4,171	1,577	273	199	12,740
	Total	61	478	2,102	5,170	6,151	4,523	930	242	19,657
1981	S	10	88	312	1,057	2,202	2,702	595	141	7,107
	NS	52	393	1,821	4,334	4,109	1,558	267	99	12,633
	Total	62	481	2,133	5,391	6,311	4,260	862	240	19,740
1982	S	11	75	347	1,076	2,289	2,618	694	85	7,195
	NS	38	352	1,769	4,293	4,079	1,537	265	149	12,482
	Total	49	427	2,116	5,369	6,368	4,155	959	234	19,677
1983*	S	9	63	386	1,226	2,280	2,537	614	42	7,212
	NS	38	325	1,724	4,421	4,103	1,389	250	161	12,435
	Total	47	388	2,110	5,647	6,383	3,926	864	203	19,647
					B. Percentages					
1977	S	0.10	0.83	3.19	9.62	22.34	46.85	14.83	2.63	100.00
1978	S	0.11	0.93	3.59	10.12	22.83	46.34	14.05	2.01	100.00
1979	S	0.12	0.87	3.99	11.60	25.77	44.32	12.30	1.03	100.00
	NS	0.40	3.05	13.62	32.28	31.85	12.19	2.40	4.20	100.00
	Total	0.30	2.29	10.27	25.08	29.73	23.37	5.85	3.10	100.00
1980	S	0.16	1.13	4.19	13.18	28.62	42.59	9.50	0.62	100.00
	NS	0.39	3.14	14.22	33.42	32.74	12.38	2.14	1.56	100.00
	Total	0.31	2.43	10.69	26.30	31.29	23.01	4.73	1.23	100.00

1981	S	0.14	1.24	4.39	14.87	30.98	38.02	8.37	1.98	100.00
	NS	0.41	3.11	14.41	34.31	32.52	12.33	2.11	0.78	100.00
	Total	0.31	2.44	10.80	27.31	31.97	21.58	4.37	1.22	100.00
1982	S	0.15	1.04	4.82	14.95	31.81	36.39	9.65	1.18	100.00
	NS	0.30	2.82	14.17	34.39	32.68	12.31	2.12	1.19	100.00
	Total	0.25	2.17	10.75	27.29	32.36	21.12	4.87	1.19	100.00
1983*	S	0.13	0.87	5.35	17.00	31.61	35.18	8.53	0.58	100.00
	NS	0.31	2.61	13.87	35.56	33.00	11.16	2.00	1.30	100.00
	Total	0.24	1.98	10.74	28.74	32.49	19.98	4.40	1.03	100.00

Notes:

*The 1983 total includes 55 state-owned bridges that were replaced or rehabilitated (0.76% of the 1983 state-owned total) and 24 non-state owned bridges that were replaced or rehabilitated (0.19% of the 1983 non-state owned total). Together, the replaced or rehabilitated bridges account for 0.40% of the combined total. (Percentages for 1983, therefore, will not total 100.0%.)

Ownership: S=state-owned bridges; NS=Non-state-owned bridges

**Condition Ratings: The categorization of bridges is actually carried out to three decimal places. Bridges whose rating falls below 5.0 are classified as deficient. The basis of the condition rating is given in the Appendix Table.

The condition ratings are for inspections conducted in March of the specified year between 1977 and 1980, and December of the specified year from 1981 through 1983.

1982 and 1983 figures exclude abandoned bridges.

NR=Bridges for which no inspection report is on file.

Source: New York State Department of Transportation. "Bridges in New York State. Condition Rating Trends."

Table 33

PERCENTAGE DISTRIBUTION OF BRIDGES CLASSIFIED AS DEFICIENT IN NEW YORK STATE, 1977-1983

Year	Ownership	Deficient Bridges Number	Percentage
1977	State	973	15.38 %
1978	State	1,044	14.86
1979	State	1,143	16.58
	Non-state	6,365	49.36
	Total	7,508	37.94
1980	State	1,291	18.66
	Non-state	6,520	51.18
	Total	9,811	39.74
1981	State	1,467	20.64
	Non-state	6,600	52.24
	Total	8,067	40.87
1982	State	1,509	20.97
	Non-state	6,452	51.71
	Total	7,961	40.77
1983	State	1,654	23.34
	Non-state	6,508	52.34
	Total	8,192	41.70

Note: A deficient bridge is one that has a New York State condition rating less than 5.0. The basis of the calculation is given in the Appendix Table.

Source: Calculated from New York State Department of Transportation, "Bridges in New York State. Condition Rating Trends".

(New York City), and 6 (Hornell) - this distribution is shown in Table 34;[28]

- Of a total of 6,335 bridges inspected in 1980, the median construction year was 1956, and bridge condition was found to be clearly a function of bridge age[29]

A key missing component in the estimate of bridge needs is the rate at which bridges move from the non-deficient to the deficient category. Based on changes in estimates of bridge condition over time, the New York State Department of Transportation has developed a rule-of-thumb estimate that a state bridge will fall 0.122 points on the 0 to 7 rating scale per year.[30]

The changes indicated in Table 32 mask bridges that are currently under repair in both the deficient and non-deficient categories. The level of repair that has occurred over the last three years is as follows:

	Category of Repair			
	Replacement	Rehabilitation	Removal	Deck Repair*
Fiscal Year	Number of Bridges			
1980-81	50	77	20	51
1981-82	36	44	7	27
1982-83	79	52	9	95

*Note: This refers to the monolithic bridge deck repair program. Steel decks were prone to rusting, expansion (rusted steel occupies about eight times the volume of regular steel), and concrete breakage. Rusted steel is being scraped and coated with epoxy and concrete is being replaced. It is anticipated that salt from road salting will take 25 to 50 years to reach the steel with the epoxy coating.(NYS Department of Transportation, June 1983)

A number of practices by the State influence the rate at which non-deficient bridges will enter the deficient category. First, the State repairs or rehabilitates bridges in the non-deficient categories, because of convenience (e.g., they may be working in deficient areas nearby) or safety. Over the years, this work accounts for about 25 percent of the total bridge

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28. NYS DOT, Albany, N.Y.: May 1983.

29. M.W. Fitzpatrick, D.A. Law and W.C. Dixon, "The Deterioration of New York State Highway Structures" (Albany, N.Y., NYS DOT, December 1980).

30. Ibid., p. 4. This estimate of slippage is from the State's maintenance division. While the structures division estimate differs somewhat, the difference is only slight.

Table 34

BRIDGE CONDITION BY NEW YORK STATE DEPARTMENT OF TRANSPORTATION REGION AND OWNERSHIP, May 1983

New York State Department of Transportation Region	State-owned Bridges Total Bridges	State-owned Bridges Deficient Bridges	Non-state owned bridges Total Bridges	Non-state owned bridges Deficient Bridges
1 Albany	821	199	1062	530
2 Utica	446	90	876	302
3 Syracuse	653	177	854	482
4 Rochester	755	335	844	416
5 Buffalo	762	290	1854	994
6 Hornell	613	153	1201	772
7 Watertown	408	61	888	471
8 Poughkeepsie	1069	85	1693	880
9 Binghamton	815	137	1190	625
10 Hauppauge	252	7	578	163
11 New York	618	150	1393	873
Total	7212	1684	12433	6508

Source: New York State Department of Transportation

replacements and rehabilitations in any given year.[31] Second, maintenance activity, which influences the rate of deficiency, is not a constant from year to year. In the past year, the State (exclusive of maintenance by local areas) spent $1.8 million for bridge maintenance. In previous years this has been many times greater.

Structural deficiency does not include capacity deficiency.

Needs Assessment:

Several unit cost figures are currently in use in New York State to estimate the cost of reducing structurally deficient bridges. In the State's September 1979 report, "Bridge Needs in New York State. Final Report of the NYS DOT to the Governor and Legislature of the State of New York in compliance with Chapter 460 of the Laws of 1977", an average unit figure of $900,000 per bridge was quoted for both replacement and rehabilitation. In the State DOT's most recent Capital Development Plan an average figure of $250,000 per bridge was used for rehabilitation only.[32] The most recent unit cost estimates have been based upon the following:

	State Bridges	Non-State Bridges
	(figures in millions of dollars)	
Replacement	1.6	1.2
Rehabilitation	0.8	0.6
Removal	0.2	0.2

Source: NYS Department of Transportation. Memorandum. R.C. Keating to D. Egan, "Cost of Bridge Program" (Albany, N.Y.: August 11, 1983)

Rehabilitation costs have been known to be as high as $5 million for a single bridge. According to the Fitzpatrick, et al. study, the unit cost of bridge rehabilitation does not change significantly for bridges with ratings of between 0 and 4. For bridges rated between 4 and 5, the unit cost is estimated at half the cost of the bridges in lower categories.[33] Assuming an average figure of $1,000,000 for bridge replacement in 1982 dollars the cost of replacing or rehabilitating the 8,192 structurally deficient bridges (as of June 1983) would be approximately $8.2 billion. A detailed estimate of bridge needs recently completed by the State, based upon unit costs, has arrived at a figure of $8.9 billion.[34]. This estimate is comprised of $1.9 billion for state-owned bridges and $7.0 billion for non-state owned bridges;

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31. Personal communication. NYS DOT, Bob Keating. August 12, 1983.

32. NYS DOT (Draft), 1983: 73.

33. M.W. Fitzpatrick, et al., Ibid., p. 5.

34. NYS DOT. Memorandum. R.C. Keating to D. Egan, Ibid.

geographically, the breakdown is $4.1 billion for New York City and $4.8 billion for the rest of the State.[35]

The State has developed an estimate for bridges for its 5-year capital program of $1.2 billion covering the replacement, rehabilitation, repair and removal of 915 bridges and the construction of 152 new bridges (see Table 35).

To calculate the Year 2000 needs estimates for bridges, the rate of bridge deterioration needs to be known. Assuming the NYS DOT estimate of slippage in the rating scale of .122 per bridge per year for all bridges in the State, by the Year 2000 all of the bridges that had not been scheduled for repair during the 1983-7 period (i.e., had a rating greater than 5 in 1983) would all be below 5 and require repair at least by the Year 2000. This total (assuming no increase in the inventory from new construction) is 11,173. At $1 billion per bridge, the 1988-2000 needs estimate would therefore be $11.2 billion.

Expenditures and Revenues and Shortfall:

Expenditures and revenues, and hence the shortfall calculation, for bridges have been combined with the estimate given for highways above.

Mass Transit

Mass transportation or urban transit as it is also called, typically encompasses buses, subways, commuter rail (e.g., the Long Island Railroad and Metro North), and light rail (e.g., trollies). The Metropolitan Transportation Authority (MTA) mass transit systems comprise the majority of the transit systems throughout the State, and, except in the area of buses, the MTA sytem will be the focus of mass transit needs estimates. By 1983 the MTA consisted of the following agencies, affiliates and subsidiaries in the mass transit area: the New York City Transit Authority (NYCTA) and the NYCTA subsidiary the Manhattan and Bronx Surface Transit Operating Authority (MBSTOA), the subsidiary corporations of the Staten Island Rapid Transit Operating Authority (SIRTOA) and the Metropolitan Suburban Bus Authority (MSBA), two commuter rail lines - Long Island Rail Road Company (LIRR) and Metro-North Commuter Railroad Company (formerly, Conrail, consisting of the New Haven, Hudson and Harlem, and Port Jervis lines), and the affiliate agency, the Triborough Bridge and Tunnel Authority (TBTA). In addition MTA supervises the Metropolitan Airports Authority (MAA) and the Stewart Airport Land Authority (SALA).

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35. The cost structure for repairing a New York City bridge is very different from that of an upstate bridge: the cost of rehabilitation for an upstate bridge averages 70% for highway work, whereas the highway work portion of New York City costs is much less. (Personal communication. R. Keating, NYS DOT, August, 1983).

Table 35

5-YEAR CAPITAL PROGRAM FOR BRIDGES, New York State

Program	Number of Bridges	Cost (Millions of dollars)
New bridges	152	$ 169.8
Replacement	334	399.6
Rehabilitation	291	542.2
Removal	57	35.1
Deck repairs*	233	67.3

Note: *The category of deck repairs is expected to be enlarged to 333 or 350 bridges at a cost of up to $100 Million.

Source: New York State Department of Transportation.

The MTA draws from a wide variety of revenue sources. Expenditures by the State only for mass transit to the MTA and other transit systems have only been tabulated on a regular basis for the past three years by the FHWA. The figures for these years, are as follows:

Date	Total Receipts/Disbursements Unadjusted	Adjusted (1982 $s)
	(figures given in thousands of dollars)	
1979	197,373	253,230
1980	259,427	295,899
1981	391,410	438,379

Note: Source-U.S. DOT, FHWA. Highway Statistics. Washington, D.C., various years. Table SMT.

The State's expenditures for mass transit have been increasing, in spite of adjustments for inflation.

Needs estimates on a statewide basis for mass transit for systems other than those owned or operated by the Metropolitan Transportation Authority (MTA) have been done only through the TIPs, which only cover major urban areas. The TIPs estimate that some $3.7 billion will be needed over the next five years for mass transportation (see Table 36), but the needs given in the downstate area are much lower than those estimated by the MTA.

Inventory and Condition

Subways and Other Intracity Rail Systems

The major subway system in the State is in New York City. Trends in ridership and revenue miles traveled over the past six years are shown in Table 37. As shown in the Table, revenue passengers were on the increase up until 1979 when fluctuations in ridership began to occur systemwide. In spite of the decline in passengers in certain years, the number of vehicle miles traveled has generally continued to increase. Characteristics of the inventory and the performance of the New York City subway systems are summarized in Table 38. Regardless of the indicator used, declines in performance are obvious: the mean distance between subway car failures continues to shorten and the number of abandonments of trains due to failures generally has been on the increase. MTA attributes the decline in MDBF to: "(i) an increase in the average age of the subway fleet, particularly the IRT fleet; (ii) an inadequate car maintenance program, including the absence of a comprehensive preventive maintenance program; and (iii) design defects in cars introduced onto the System in 1973 and 1975 and the poor performance of older cars which were consequently retained in service".[36] The MTA has further noted that between September 1980 and 1981 45% of the failures were

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36. MTA, "Transit Facilities Revenue Bonds, Series A. New Issue". New York, N.Y.: MTA, October 14, 1982. P. 36.

Table 36

ESTIMATES OF 5-YEAR CAPITAL NEEDS FOR TRANSIT IN NEW YORK STATE,
Transit Improvement Programs: 1983-1988

Transit Improvement Program (TIP) Area	Cost (in millions $'s)	Page Reference in 1983 TIP
Binghamton	17.931	p. 36-8
Capital District	73.612*	p. 28
Chemung County	13.716	p. 17
Genessee	74.240	p. 50
Glens Falls	1.670	p. 19
Herkimer-Oneida Counties	5.243	p. 53
Niagara Frontier	293.409**	Table 7.2
Syracuse Metropolitan	77.980	p. 47
Upstate Subtotal	557.801	
NY Downstate Metropolitan		p. II-9
Long Island Railroad	462.900	
Mid-Hudson	51.719	
Nassau-Suffolk	92.480	
New York City***	2,569.680	
Downstate Subtotal	3,176.779	
GRAND TOTAL	3,734.580	

Notes: *A slightly different total of $74.12 million is given on page 24 of the TIP.

**The Buffalo Light Rail accounts for a large portion of this total.

***This estimate is substantially lower than that contained in the MTA capital plan and the NYC capital needs study for mass transportation.

Table 37

SELECTED CHARACTERISTICS OF MASS TRANSIT OPERATIONS BY TYPE OF SERVICE, Metropolitan Transportation Authority: 1977-1982

Service	Year 1977	1978	1979	1980	1981	1982
	A. Number of Revenue Passengers in millions*					
Subways:						
TA	998.455	1,042.730	1,077.026	1,009.333	1,011.346	989.092
SIRTOA	4.419	4.687	5.380	6.020	5.934	5.758
Buses:						
TA	305.389	329.995	342.858	317.745	292.148	280.188
MBSTOA	287.605	283.224	300.262	271.523	241.254	231.783
MSBA	17.362	18.511	25.420	20.455	20.956	21.607
Commuter:						
LIRR	69.463	72.455	77.359	80.842	83.273	83.661
Conrail,N-H	18.961	20.238	21.930	23.498	23.437	23.189
Conrail,H-H	22.134	23.432	24.911	26.218	12.640	24.499
Conrail,P-J	0.401	0.436	0.500	0.554	0.602	0.593
Conrail,P-V						0.467
Total	1,724.189	1,795.708	1,797.928	1,756.188	1,691.590	1,660.837
	B. Total Revenue Vehicle Miles in Millions of Miles**					
Subways:						
TA		244.345	255.005	252.645	266.321	271.377
SIRTOA		9.754	1.932	1.904	1.848	1.916
Buses:						
TA		63.301	65.249	60.053	58.859	58.708
MBSTOA		38.909	38.909	37.767	37.875	36.467
MSBA		7.787	7.734	7.912	8.209	8.690
Commuter:						
LIRR		47.628	46.769	48.723	47.323	47.804
Conrail,N-H		11.030	11.383	13.483	13.689	14.720
Conrail,H-H		10.034	10.934	12.681	12.640	12.599
Conrail,P-J		0.395	0.470	0.471	0.469	0.561
Conrail,P-V						0.122
Total		433.183	438.385	435.639	447.233	452.964

Source: Metropolitan Transportation Authority. Annual Reports. "Summary of Operations". New York, N.Y.: MTA, 1977-1982.

Abbreviations:

TA-New York City Transit Authority
SIRTOA-Staten Island Rapid Transit Operating Authority
MBSTOA-Manhattan and Bronx Surface Transit Operating Authority
MSBA-Metropolitan Suburban Bus Authority
LIRR-Long Island Railroad
N-H-New Haven Line (operated by Metro North as of 1/1/83)
H-H-Hudson and Harlem Lines (operted by Metro North as of 1/1/83)
P-J-Port Jervis Service (operated by NJ Transit as of 1/1/83)
P-V-Pascack Valley Service (operated by NJ Transit as of 1/1/83)

Notes:

Changes in fares since 1972 have been as follows-

January 1972:	$ 0.35
September 1975:	0.50
June 1980:	0.60
July 1981:	0.75

*"Revenue Passengers are defined as all passengers for which revenue is received, either through direct fare payment (cash, tokens) or fare reimbursements (senior citizens, school children)." (MTA, "Transit Facilities Revenue Bonds, Series A," Oct. 14, 1982. P. 34.)

**"Vehicle Miles Traveled is the number of route miles traveled by subway cars or buses while in revenue service and includes run-on/run-off miles. For example, if a subway train comprised of ten cars travels ten route miles, the trip would consist of 100 VMT." (MTA, "Transit Facilities Revenue Bonds, Series A," Oct. 14, 1982, P. 35.)

Table 38

SUMMARY OF CHARACTERISTICS OF THE NEW YORK CITY SUBWAY SYSTEM

A. Inventory

	NYCTA	SIRTOA
Miles of Track	700-710	37
Route Miles	230	14
Stations	457-465	22
Rapid Transit Cars	6500-6700	52
Passengers per day	3.5-5 Million	

Source: NYC Department of City Planning, Capital Needs and Priorities, January 1983, p. 202-3; Metropolitan Transportation Authority (November 1980).

B. Performance

(1) Average Daily Train Abandonments

Year	Terminal Abandonments	Enroute Abandonments	Average Daily Trains Scheduled
1977	65	42	6,340
1978	87	47	6,325
1979	91	56	6,413
1980	142	85	6,476
1981	206	119	6,479
1982 (preliminary)	169	125	6,390

(2) Mean Distance Between Subway Car Failure (in miles per car)

Year	MDBF	Year	MDBF
1973	20,020	1978	13,470
1974	18,000	1979	10,960
1975	15,900	1980	8,210
1976	13,580	1981	6,640
1977	13,760	1982 (prelim.)	7,200

Source: MTA, "Transit Facilities Revenue Bonds, Series A." New York, N.Y.: MTA, October 14, 1982. P. 36.

due to "traction motors and other electrical failures", 30% to "door defects", 16% to the "braking system" and the rest to all other causes.[37] The same report noted that the decline in MDBF or increase in the frequency of failures, was clearly a function of car age.

In the absence of more detailed information, age of facilities is usually used as a gross indicator of system condition. The lifetime of a typical subway car has been estimated to be 35 years by UMTA.[38] The New York City Transit Authority maintains an inventory of subway cars by age and type.[39] The 1979 inventory indicated that by 1987, 667 cars (of models R-10, 12, 14, 15) or ten percent of the inventory at that time, would exceed the 35 year recommended replacement age. By the year 2000, a number of other types of cars, totalling 4,125, or 62% of the inventory will exceed the 35 year limit. There are also another 352 R-44 model cars that, while not exceeding the age limit, might also need to be replaced because they are considered to be poor performers. These would bring the total number of cars to be replaced by the Year 2000 to 4,477.

A substantial part of the problem of subway condition has to do with a consistent pattern of deficits in operation and maintenance within all of the MTA systems. These deficits are shown in Table 39 for the years 1976 through 1982. A mounting deficit problem is apparent. While in many cases the deficits are made up with subsidies, the impact on the quality of the system is apparent.

Buses

There are currently 31 bus systems in the State of New York that operate over five revenue vehicles each. Various characteristics of these systems are summarized in Table 40. The total number of revenue vehicles (vehicles that can be put into service, rather than the number that are actually operating-an overstatement of the actual number of buses in service) is about 8,173, 60% of which are operated by the New York City Transit Authority.[40] The major determinant of infrastructure needs in the area of buses is the number of buses that exceed 12 years of age. There are many other indicators

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37. MTA, "Submission to the MTA Capital Program Review Board". New York, N.Y.: MTA, September 25, 1981. P. III A 1.3.

38. There is disagreement about the 35 year criterion for New York City. The MTA report, "The 1980's and Beyond" aims for "a state of good repair" (p. III-3), such that "each component is within its useful economic life" (p. II-1). The MTA Capital Program submission of 9/25/81 argues for a TA objective for vehicles of 17.5 (p. III A 1.1).

39. New York City Office of the Comptroller, 1979: 156

40. UMTA, 1982.

Table 39

OPERATING EXPENSE DEFICITS AND SUBSIDIES, Metroplitan Transportation Authority: 1977-1982

System	Year 1976	1977	1978	1979	1980	1981	1982
	(figures in Millions of Real Dollars)						
	A. Operating Deficits						
LIRR	87.7	96.3	103.8	138.2	169.8	172.5	184.5
Conrail	132.4	159.6	165.4	224.7	279.4	302.6	273.0
Hudson-Harlem	25.2	41.0	43.7	60.6	75.8	86.7	45.8
New-Haven (NYS)	6.2	12.6	10.5	15.9	20.2	25.4	22.7
Port Jervis/ Pascack V.(NYS)	0.4	0.3	0.1	0.1	0.4	3.1	1.9
TA	557.9	518.2	577.1	577.1	690.1	801.9	763.2
SIRTOA	3.4	3.9	4.1	4.8	4.4	5.9	6.4
MSBA	7.8	9.7	10.6	12.1	14.2	15.7	17.6
	B. Subsidies						
LIRR							
Conrail	130.9	170.2	165.3	161.9	349.4	298.2	297.1
Hudson-Harlem							
New-Haven(NYS)							
Port Jervis/ Pascack V.(NYS)							
TA	559.7	516.7	558.0	558.0	679.4	800.8	759.1
SIRTOA	3.4	3.9	4.1	4.8	5.1	5.2	7.0
MSBA	7.8	9.5	11.1	12.1	14.0	15.9	17.5

Source: Metroplitan Transportation Authority, Unpublished Table- "Revenue & Expense Analysis by Division". Sept. 1983.

Table 40 SUMMARY OF CHARACTERISTICS OF BUS SYSTEMS IN NEW YORK STATE

TRANSIT SYSTEM	Total Revenue Vehicles	Passengers per line mile	Fuel Consumption (gals./ vehicle mile	Road Calls for Mechanical Failure	Collisions	Total Revenues ($000)	Fleet Age Ave. Age	#Revenues Vehicles Exceeding 12 years
NYCTA	4,882	642.4	0.29	203,118.0	6194	1,715,189.5	10.8	2727
Niagara Fr. TA	486	19.1	0.28	2,204.0	769	29,739.5	11.2	293
Metro Sub. Bus Auth.	339	22.7	0.25	6,575.0	399	27,121.1	11.4	212
Regional TS Rochester	253	39.2	0.27	3,281.0	457	20,157.7	9.7	162
Albany-Capital DTA	238	17.9	0.23	3,050.0	74	13,461.5	10.5	140
Queens Transit Corp.	239	257.7	0.35	9,102.0	441	20,041.4	10.8	118
Green Bus Lines	241	117.7	0.28	6,040.0	219	23,287.3	11.7	154
Central NY RTA	160	70.2	0.27	545.0	147	10,683.9	9.4	35
Triboro Coach Corp.	222	193.5	0.39	2,169.0	301	15,797.4	12.6	140
Jamaica Buses	140	162.4	0.43	1,141.0	129	10,712.7	11.8	85
Steinway Transit Corp.	133	147.0	0.29	3,618.0	241	11,920.5	11.0	76
Mountain View Coach	94	0.6	0.15	85.0	70	5,078.4	9.5	57
Riverdale Transit Corp.	124	46.2	0.31	193.0	91	7,814.2	11.1	64
Command Bus Co. Inc.	91	43.0	0.33	724.0	146	6,264.8	10.7	44
Westchester St. Tr. Co.	138	52.3	0.32	195.0	57	7,669.4	10.7	80
Club Transp. Co.	73	74.6	0.29	228.0	42	6,129.9	8.8	39
Westchester Cty DOT	43	1.9	0.67	56.0	12	7,693.5	11.3	24
Utica TA	46	8.0	0.22	57.0	32	1,604.1	14.8	46
Broome Cty Transit	36	7.1	0.21	617.0	54	2,087.3	11.2	30
Pelham Pky Bus Service	26	46.7	0.33	32.0	27	2,706.7	7.9	2
Syracuse & Oswego ML	32	2.1	0.14	59.0	42	792.6	10.2	10
Liberty Coaches, Inc.	36	43.1	0.32	18.0	28	2,697.5	11.9	33
Central NY Coach Lines	16	0.8	0.32	5.0	8	1,231.9	11.9	11
West Fordham Trans. Corp.		39.3	0.31	18.0	14	1,880.4		
Suffolk Cty DOT	14	3.3	0.23	15.0	5	952.8	14.6	11
Huntington Area RT	14	4.7	0.23	49.0	8	1.085.0	5.5	3
Dutchess Cty Loop	14	0.9	0.16	150.0	15	740.1	18.9	14
Onondaga Coach Corp.	12	1.7	0.37	6.0	9	935.1	9.3	6
City of Long Beach	12	56.1	0.55	8.0	1	595.0	5.3	0
C. of Poughkeepsie	12	9.8	0.32	3.0	4	459.8	8.1	4
C. of Rome VIP	7	4.1	0.09	21.0	4	303.7	5.0	0

Source: U.S. Department of Transportation, Urban Mass Transportation Administration. National Urban Mass Transportation Statistics. 1981 Section 15 Report. Washington, D.C., UMTA. November 1982.

such as mechanical failures, accidents, fuel usage efficiency, etc. that have been tabulated on an annual basis by UMTA since 1980, and are shown in Table 40.

Mechanical Failures. In the City of New York, whose bus fleet accounts for a large share of the State's, an increasing frequency of road calls (measured by a decline in the Mean Distance Betwen Road Calls) has been reported over the years. The trend is as follows:

	Mean Distance Between Road Calls (miles per bus)	
Fiscal Year	Transit Authority	MaBSTOA
1977	1,089	469
1978	978	400
1979	803	319
1980	718	315
1981	756	329
1982 (preliminary)	1,105	471

Source: MTA, "Transit Facilities Revenue Bonds, Series A". New York, N.Y.: MTA, October 14, 1982. P. 37.

Fuel Usage Efficiency. Fuel economy varies according to the duty cycle of a bus, air conditioning, bus weight, engine and transmission systems, and various other structural characteristics.[41] In a recent study, fuel usage was defined for six types of routes, defined as a function of terrain, speed limit, number of stops per mile, and number of passengers. The average fuel usage in gallons per mile ranged from 0.18 to 0.39, and the range spanned from a low of 0.17 to a high of 0.51. The 31 systems in New York State are distributed by fuel usage as follows:

Fuel Usage (gallons per mile)	Number of Bus Systems
Less than 0.2	4
0.21-0.25	6
0.26-0.30	7
0.31-0.35	9
0.36-0.40	2
Above 0.40	3

There are four bus systems with an average gallons per mile figure below the lowest end of the range, and three systems operating above the upper limit.

Looking at the age category distribution, it is clear that the average age of many of the vehicles in the systems was approaching 12 in 1981, and by 1983 exceeded that limit. Using the distribution tabulated by UMTA in 1981, the total number of buses in the State with lifetimes now exceeding 12 years

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41. Riviera and Silies, 1982.

is 4,602, of which most are operated by the New York City Transit Authority. By the Year 2000, the entire fleet of 8,173 buses will require replacement.

Commuter Rail

The major commuter rail systems in the State of New York are the Long Island Railroad (LIRR) and Metro North, both under the jurisdiction of the Metropolitan Transportation Authority. The patterns in ridership shown in Table 37 show continual increases between 1977, with a few exceptions within some of the Metro North (Conrail) systems. Table 41 gives some of the major chararacteristics of each of the two systems. The major problem areas in these systems are defined in terms of train delays and the number of standees and the length of time standees have to stand.

Needs Assessment

Estimates of needs for subways, buses and commuter rail lines throughout the MTA system were assessed by the MTA for a ten year period, 1980-1990.[42] The New York City Planning Department reviewed these needs for the New York City systems only.[43] Since the capital plan was published in 1980, various capital program submissions have been made by the MTA on an annual basis, allocating the needs and targetting revenue sources to meet the needs over time. The calculation of systemwide 1983-7 needs and 1988-2000 needs is displayed in Table 42, with a slight adjustment in the definition of the time period to be consistent with the MTA capital planning effort. As shown in the Table, the 1982-6 need is comprised exclusively of that portion of the 1980-1990 falling within the five year period, but amended by the most recent capital program, amounting to $8.5 billion (see Column 8). The 1987-2000 need is comprised of the remainder, plus the annual recurring need that is estimated for 1991 and beyond in the 1980 Plan, amounting to $27.4 billion (see Column 9).

Subways

Cost estimates are generally broken down into ten categories by MTA: line structures, track, line equipment, signals and communication, power equipment, stations, rapid transit cars, shops, yards and other maintenance facilities, service vehicles and security. Of these categories, the rehabilitation of rapid transit cars represents the largest category of needs between 1981 and 1991, followed by track repair. The MTA, quoting Transit Authority policy, is that a rapid transit car should be replaced after 35 years. At that time "the average car has travelled between 1-1/4 and 1-1/2

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42. MTA, 1980.

43. New York City Planning Department, January 1983.

Table 4-1

SELECTED SYSTEM CHARACTERISTICS FOR MASS TRANSIT IN NEW YORK STATE,
Metropolitan Transportation Authority

Inventory Characteristic (a)	Metro North	Long Island Railroad
No. of passengers per year	49,000,000	79,000,000
No. of passengers per week day	168,000	285,000
Route-miles	281(b)	325
Miles of mainline track	560	530
No. of passenger stations	79	140
No. of self-propelled electric cars	380	764
No. of diesel pulled coaches	128	250
No. of diesel pulled locomotives	40	67
No. of self-propelled diesel cars	16	
No. of electric power generating stations		24
Passenger density (no. of per mile at morning peak hours)		160 (Oyster Bay) -1,180 (Montauk)(c)

Service(d)	New Haven Line	Hudson Line	Harlem Line	
Headway				
Peak	15-20		15-20	10-30
Off-peak	30		60	30-60

Performance(e)		
No. of standees		
On 52 peak period trains	5500	9500
Other		12,000 stand 20-65 min.
Length of time a standee stands		20 min. on 11.2 mi. 57 min. on 38.3. mi.
Train delays		1980: 267 per week 1982: 206 per week

Notes:

(a) Source: MTA, "Staff Report of Capital Revitalization for the 1980's and Beyond". New York, N.Y., Nov. 25, 1980. Page IV-2(LIRR) and V-1(Metro North).

(b) By system within Metro-North, route miles are broken down as follows: Hudson: 75 mi.; Harlem: 77 mi.; New Haven: 72; Erie-Lackawana:57 mi.

(c) MTA, "Submission to the MTA Capital Program Review Board of an Amendment to the Capital Programs of the MTA Transit Systems." New York, N.Y., April 29, 1983. P. III A 3.6.

(d) MTA, Nov. 25, 1980, op cit., p. V-2.

Table 42

NEEDS ESTIMATION FOR MASS TRANSIT FACILITIES
Metropolitan Transportation Authority

Needs Estimate

	1980-1990(a)		1982-1986(b)	Remainder(c)	Annual Recurring(d)		Recurring 1991-2000
	1980 $s	1982 $s	1982 $s	1982 $s	1980 $s	1982 $s	1982 $s
	1.	2.	3. (Col.2/2)	4. (Col.2-3)	5.	6.	7. (10 x Col.6)
	(all figures given in billions of dollars)						
SYSTEM							
Transit							
NYCTA/ MaBSTOA	12.51	15.01	7.51	7.51	1.00	1.20	12.00
SIRTOA	2.06	2.50	1.25	1.25	0.02	0.03	0.30
MSBA	0.12	0.14	0.07	0.07	0.01	0.01	0.10
Commuter Rail							
LIRR	2.89	3.46	1.73	1.73	0.27	0.32	3.20
METRO-N	1.66	1.99	1.00	1.00	0.13	0.16	1.60
TOTAL	19.24	23.10	11.56	11.56	1.43	1.72	17.20

	1982-86 Needs(e)	1987-2000 Needs
	8.	9. (Col.s 4+7)
Transit		
NYCTA/ MaBSTOA	6.46	19.51
SIRTOA	0.03	1.55
MSBA	--	0.17
Commuter Rail		
LIRR	1.02	4.93
METRO-N	0.87	2.60
Unassigned	0.17	
TOTAL	8.54	28.76

Table 42 (continued)

Notes:

(a) Source: MTA, "Staff Report of Capital Revitalization for the 1980's and Beyond", New York, N.Y., November 25, 1980.

(b) This is arrived at by annualizing the 1980-1990 need, and computing the five year total.

(c) Similarly, this is the difference between the 1980-1990 need and the 1982-86 need. While it can be argued that the 1980-82 need is past history, apparently not much of that identified need has been met.

(d) Source: MTA, "Staff Report of Capital Revitalization for the 1980's and Beyond", New York, N.Y., November 25, 1980.

(e) Source: MTA, "Submission to the MTA Capital Program Review Board of an Amendment to the Capital Programs of the MTA Systems", New York, N.Y., April 29, 1983. P. II A a,b (transit) and p. II B I.2 (commuter rail).

Figures were adjusted to 1982 dollars using the Consumer Price Index for the New York-Northeastern NJ area. The multiplier for the conversion of 1980 to 1982 dollars was 1.2.

million miles and its wheels, motors and trucks have been replaced five times".[44] The MTA's ten year estimate of needs assumes the purchase of 1,045 cars ($1 million per car) the rebuilding of 280 cars ($ 0.5 million per car), and rehabilitation and improvements on a number of other cars.[45] The MTA estimates that the useful lifetime of elevated tracks is 20 years and subway tracks, 30 years.[46]

Buses

The cost of completely replacing a bus is estimated at between $80,000 (30 passenger bus, 30-32 feet long) and $220,000 (72 passenger, 62 feet long).[47] However, the NYC Transit Authority estimates that their new buses cost either $103,000 for a Grumman Flexi bus or $150,000 for a GM RTS-04.[48] Assuming Grumman buses for the total supply, the statewide estimate is $474 million, and assuming GM buses, the total is $690 million for buses needing replacement immediately. Using an average cost of $125,000 per bus, the total is $575 million for buses alone, exclusive of ancillary facilities such as garages and depots. Since the bus needs for systems operated by the MTA have been included in the estimate above, the net need for buses outside of the MTA system is approximately $200 million. By the Year 2000, the total cost of fleet replacement would be $1.0216 billion statewide or approximately $300 million for buses outside of the MTA system.

Revenues, Expenditures and Shortfall (Mass Transit-Subways, Buses, Commuter Rail):

The history of capital commitments of MTA, the largest mass transit operator in the State, is shown in Table 43 between 1976 and 1981. While there has been a sizable increase in the total for buses and subways alone in recent years, the overall level has typically been far below the needs estimates. The anticipated short-term revenue sources by source to meet the needs of the latest five year development program are given in Table 44. As of 9/23/83, these sources still left a deficit of $3.716 billion for mass transit and $1.628 billion for commuter rail for the 1982-1986 period.

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44. MTA, 1980: III-30.

45. MTA, 1980: III-3.

46. MTA, 1980: III-11.

47. Personal Communication. Robert Perry, New York State DOT, June 1983.

48. These New York City Transit Authority prices include lifts for the handicapped, which, if installed separately, would cost $17,000 per bus.

Table 43

CAPITAL COMMITMENTS FOR MASS TRANSIT, Metropolitan Transportation Authority: 1976-1981

Fiscal Year	Subways: Transit Rehabilitation	Subways: Authority New Routes	SIRTOA	Buses: Rolling Stock	Buses: Rehabilitation	Total
	(figures given in millions of real dollars)					
	A. Transit					
1976	26.3	255.3	n/a	0.0	1.3	282.9
1977	65.7	7.2	0.0	22.3	3.0	98.2
1978	83.2	196.0	3.5	0.0	16.6	299.3
1979	152.6	95.5	0.0	121.5	0.4	370.0
1980	258.5	62.2	2.1	0.0	5.7	328.5
1981	299.3	102.2	0.1	128.7	21.6	551.9*
1982**						523.2
1983** (est.)						216.0

Source: Metropolitan Transportation Authority, Capital Programs Financing. Unpublished Table: "Commitments (Not Expenditures), NYCTA". New York, N.Y.: MTA, 9/23/83.

Notes: *The New York City Office of Management and Budget and Office of the Director of Construction's Quarterly Capital Plan-FY 1983 give a total of 435.3 million actually spent in 1981, and a planned amount (in the Executive Budget, FY 1981) of $858.7 million for transit.

**NYC Office of Management and Budget and Office of the Director of Construction, NYC Quarterly Capital Plan-FY 83.

B. Commuter Rail

Year	Long Island Railroad Net Additions-Properties, Equipment	Metro-North Capital Commitments
1976	$ 11,707,602	$ 10,300,000
1977	20,894,045	14,900,000
1978	6,275,114	12,800,000
1979	6,586,674	22,500,000
1980	21,532,889	17,800,000
1981	17,414,186	97,900,000
1982	168,452,099	90,700,000

Source: Metropolitan Transportation Authority, Comptroller. "Net Additions to Properties and Equipment" and "Capital Commitments-Metro North". New York, N.Y.: Sept. 26, 1983.

Table 44

ANTICIPATED CAPITAL NEEDS, REVENUES SECURED, AND SHORTFALLS BY REVENUE SOURCE FOR MASS TRANSIT, Metropolitan Transit Authority: 1982-1986

Revenue Source	Mass Transit Capital Needs (Amended Plan)	Funds Secured	Commuter Rail Capital Needs (Amended Plan)	Funds Secured
	(figures in millions of dollars)			
Federal	$ 2,315	$ 711	534	44
State	212	107	270	144
City	604	38		
PA	92	88		
Parking Bonds			30	0
TBTA Bonds	643	109	429	72
Service Contract Bonds	514	304	277	162
Revenue Bonds	1,542	941	388	0
Lessor Equity	394	21	106	3
Other	173	103	19	0
Total	6,489	2,773	2,053	425

Source: Metropolitan Transportation Authority, Capital Programs Financing. Unpublished Tables-"5-Yr. Funding Status as of 9/23/83".

Rail Freight

Overview

A comprehensive estimation of statewide needs for rail facilities is inhibited by the absence of an inventory and quality assessment procedure across all systems, though some of this information is available for individual systems. Statewide aggregate estimates are also made difficult by the fact that many rail systems span several states and do not compile information on finances and needs on a state by state basis. The rail system is marked by continued abandonments of rail lines thoughout the State. Revenue deficits are experienced for passenger travel. Revenues from State bond issues and federal programs are gradually becoming exhausted, which will exacerbate whatever shortfall currently exists. The State DOT currently places the needs for rail facilities over the next five years at $250 million, primarily for intermodal terminal facilities in the downstate area and statewide improvements in inner city passenger service and continuation of high speed rail lines.

Inventory

There are currently about 4,000 route miles of rail in the State of New York. Route miles do not include yards and sidings, and where two parallel tracks coincide, the mileage is only counted once. This mileage is broken down by major system in the State as follows:

Conrail	2,540 route miles
Delaware & Hudson	495
Long Island Railroad	335
Chessie System	160
Norfolk & Western	70
Boston & Maine	60
Other	500
Total	4,160 route miles

Source: NYS DOT, Rail Division, July 22, 1983

Conrail accounts for 63.8 percent of the total.

The total tonnage of the major carriers, whose revenues exceed $50 million per year (classified as "Class I" by the Interstate Commerce Commission), was 36.4 million in 1980. Broken down by major system this is as follows:

Conrail	27,334,000 tons
Delaware & Hudson	3,696,000
Baltimore & Ohio	2,723,000
Long Island Railroad	1,660,000
Norfolk & Western	991,000
Total	36,404,000 tons

Source: NYS DOT, Rail Division, New York State Rail Plan Annual Update, Albany, N.Y., January 1983. P. 11.

As in the case of route miles, Conrail dominates the picture with 70 percent of the tonnage.

Needs

The NYS DOT, Rail Division has estimated that the total five year need for rail facilities is about $250 million. Resources are currently not targetted to meet these costs. This estimate covers downstate and upstate facilities. In the downstate area it is for intermodal terminal facilities, i.e., a Trailer-on-Flat-Car (TOFC) facility at the Harlem Rail Yard. This facility would provide a railway-highway intermodal linkage for freight. Truck trailers would be placed on flat cars for shipment via a railway, and then connected up again to a truck body for highway transport. In the upstate area, it is for statewide improvement of inner city passenger service, continuation of the Schenectady to New York City high speed rail line (110 miles an hour) into Western New York, and funding for the restructuring of various railroads (e.g., Conrail).

Expenditures and Revenues

Expenditure patterns are not recorded consistently for rail facilities in such a way as to be able to project them, and compute a shortfall against needs. Revenue sources for rail facilities in New York State have been dominated by the 1974 and 1979 bond issues, the former being completely exhausted and the latter 80 percent exhausted, and several federal programs, which are stopping shortly.

Airports

In 1981, the Federal Aviation Administration reported 83 public airports and 403 private airports in New York State. A total of $195 million in airport development aid under the Airport Development Aid Program was allocated to the State's airports (exclusive of state, local and private operator contributions) between 1970 and 1981.[49]

The total capital needs for airport improvements in New York State has roughly been estimated at about $589 million over the next five years. An estimated $214 million is estimated for non-Port Authority airports (see Table 45) and $375 million for La Guardia and JFK airport improvements (see Table 46).

At JFK, international arrivals are approximately 3,000 passengers per hour. The airport is constrained by building capacity, not runway capacity. The Port Authority wants to expand to 50% of the capacity by the Year 2000. There are no constraints on domestic travel, except that there is a quota system being lifted by the FAA during peak hours, according to the Port Authority, Aviation Division. At LaGuardia, the capacity is about 18.5

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49. U.S. Bureau of the Census, "Statistical Abstract of the U.S.-1982-3". Washington, D.C. (December 1982). P. 634.

Table 45

5-YEAR COSTS FOR MAJOR AIRPORT INFRASTRUCTURE, REHABILITATION, AND DEVELOPMENT, by New York State Department of Transportation Region and airport location, New York State: 1983-1984

(exclusive of airports located in New York City)

DOT Region and Airport	Project Cost (in thousands of dollars)	State Share (in thousands of dollars)
Region 1: Albany-Total	10,300.0	838.0
Albany County	2,900.0	290.0
Saratoga County	2,100.0	150.0
Schenectady County	2,000.0	150.0
Ticonderoga	1,300.0	98.0
Warren County	2,000.0	150.0
Region 2: Utica-Total	800.0	60.0
Oneida County	800.0	60.0
Region 3: Syracuse-Total	48,900.0	9,033.0
Cayuga County	7,000.0	525.0
Cortland County	600.0	45.0
Oswego County	4,300.0	323.0
Syracuse	29,000.0	6,380.0
Tompkins County	8,000.0	1,760.0
Region 4: Rochester-Total	11,300.0	1,635.0
Dansville	2,600.0	195.0
Genesee County	2,400.0	180.0
Monroe County	6,300.0	1,260.0
Region 5: Buffalo-Total	67,500.0	22,898.0
Buffalo	63,000.0	22,500.0
Chautauqua County	2,400.0	240.0
Dunkirk	1,300.0	98.0
Olean	800.0	60.0
Region 6: Hornell-Total	9,000.0	1,103.0
Chemung County	5,700.0	855.0
Wellsville	3,300.0	248.0
Region 7: Watertown-Total	17,500.0	1,316.0
Clinton County	2,900.0	218.0
Malone	1,600.0	120.0
Massena	5,500.0	413.0
Ogdensburg	1,000.0	75.0
Watertown	6,500.0	490.0

Region 8: Poughkeepsie-Total	22,700.0	2,109.0
Columbia County	1,700.0	128.0
Dutchess County	1,200.0	108.0
Orange County	4,300.0	323.0
Westchester County	15,500.0	1,550.0
Region 9: Binghamton-Total	9,700.0	743.0
Broome County	3,000.0	240.0
Endicott	2,600.0	195.0
Oneonta	2,200.0	165.0
Sidney	1,600.0	120.0
Sullivan County	300.0	23.0
Region 10: Hauppauge-Total	16,358.5	1,231.0
Bayport	500.0	40.0
Brookhaven	6,500.0	490.0
East Hampton	3,158.5	236.0
Long Island-MacArthur	4,400.0	330.0
Suffolk County	1,800.0	135.0
New York State Total	214,058.5	40,966.0

Source: New York State Department of Transportation, Aviation Bureau. Albany, N.Y. 1983. According to the Aviation Bureau, these figures use anticipated federal allotments over the next five years as a framework for the estimate of needs. The rule-of-thumb used by the Bureau to obtain the New York State share of the federal total allotment is: 5-1/2 percent of the federal total is allocated to New York State for the next five years.

Table 46

AIRPORT IMPROVEMENT NEEDS AT LAGUARDIA AND JFK AIRPORTS, 1984-1988

Category of Improvement	JFK (figures given in millions of dollars)	LaGuardia (figures given in millions of dollars)
Infrastructure (paving, utilities, roadways, etc.)	160	35
Buildings (cargo and maintenance)	25	40
Public aircraft facilities (runways, taxiways)	35	25
Terminal improvements	15	15
Major work programs	15	10
Total	250	125

Note: These figures only include public investments at the airports; expenditures by airlines or other private entities are not included.

Source: Port Authority of New York and New Jersey, August 1983.

million passengers per year. The airport is currently operating at capacity now. The goal is to expand to 21.0 million by 1993.[50]

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APPENDICES

Inventory and Performance Measures

Unit Costs

Inventory and Performance Measures

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WATER SUPPLY SYSTEM CHARACTERISTICS

System Components	Inventory/Quality	Condition Indicators
Water Collection & Storage of Supply:		
Dams		Spillway capacity Stability of structural components Seepage Operability of components
Reservoirs		
Water Treatment:		
Water Purification Plants	Capacity Treatment level	Removal efficiency Compliance with National Interim Drinking Water Standards Chlorine Residual
Water Distribution:	Pipe size (inches)	Leakage (gpd/mile of main); water unaccounted for
Aqueducts Tunnels Transmission mains Distribution mains	Type of pipe Galvanized iron Cast iron Concrete Steel	Breakage (no. of breaks/mile/yr.) Head loss (ft. of ht. per pipe length) "C" Factor Water stoppage
	Length (miles)	Complaints Age
	Accessibility (number of manholes)	
Valves	Number per mile of pipe	Number of turns
Hydrants	Number per area or lane mile	Pressure (psi)

PERFORMANCE MEASURES FOR WATER SUPPLY FACILITIES

Water Distribution Systems

Pipe Size
A. Length:
12" or more for transmission mains
6-8" for distribution mains
(Betz, Converse, Murdoch, Cohoes, NY, May 1982: 23)

6" minimum size; 600' maximum length for a 6" pipe (AWWA)

8" minimum size (NYSDOH, "Recommended Standards for Waterworks", Bulletin No. 42)
B. Thickness (Cast Iron Pipe Research Association. Handbook. Ductile Iron Pipe, Cast Iron Pipe. 5th edition, 1978.

Network Geometry

Grid system (Insurance Services Office)

Breakage (number per 1000 feet or mile of main)

max. of 3 breaks per 1000 feet of pipe (15.8 breaks per mile), beyond which point pipe should be replaced (Morris, R.E., Jr., "The Distribution System", Manual of Water Utility Operations, Texas Water Utilities Board, Austin, TX, 1975. P. 423 - no methodology given)

Leakage (gpd per mile of main)

Old systems: 3000 gpd per mile of main
New systems: 2000 gpd per mile of main

(E. Shaw Cole, "Revenue Producing versus Unaccounted for Water", JAWWA (December 1957; Albany report, p. 6-2)

Pressure

3 ft. of head per 1000 ft. of pipe (Betz, Converse, Murdoch, Cohoes, NY, May 1982: 30)

Hydrants: min. of 20 psi residual pressure (National Fire Protection Association, Fire Protection Handbook, 14th ed.; Betz, Converse, Murdoch, Hornell, NY, 1982: 28)

Location relative to the frost line: percentage of the system lying above the frost line.

Age
-Ratio of actual age to design lifetime

Water Treatment Systems

Hydraulic efficiency:
- -Ratio of actual capacity to design capacity - maximum of 80%
- -Ratio of peak (maximum) to average daily demand - 1.5

HYDROLOGIC DESIGN CRITERIA TABLE

Hazard Classification of Structure	Drainage Area	Spillway Design Flood	Service Spillway Design Flood (in years)	Minimum *Freeboard (in feet)
Class "a" structure located in rural or agricultural area where failure may damage farm buildings, agricultural land, or township or county roads.	Less than 100 ac.	50 Year	**2	1
	100 ac. to 1000 ac.	100 Year	5	1
	1000 ac. to 10 sp. mi.	150% of 100 Year	10	2
	10 sq. mi. to 50 sq. mi.	225% of 100 Year	25	3
Class "b" structure located in predominantly rural or agricultural area where failure may damage isolated homes, main highways or minor railroads, or interrupt use or service of relatively important public utilities.	Less than 100 ac.	100 Year	5	1
	100 ac. to 1000 ac.	150% of 100 Year	10	1
	1000 ac. to 10 sq. mi.	225% of 100 Year	25	2
	10 sq. mi. to 50 sq. mi.	40% of MPF***	50	3
Class "c" structure located where failure may cause loss of life, or serious damage to homes, industrial or commercial buildings, important public utilities, main highways, or railroads.	Less than 100 ac.	225% of 100 Year	10	1
	100 ac. to 1000 ac.	40% of MPF***	25	1
	1000 ac. to 10 sq. mi.	60% of MPF***	50	2
	10 sq. mi. to 50 sq. mi.	80% of MPF***	100	3

*Distance from maximum design high water to top of dam.
**A Class "a" structure with drainage area less than 5 acres and not spring fed, when provided with an auxiliary spillway capable of passing the spillway design flood need not be provided with a service spillway.
***Maximum Probable Flood

Source: New York State Department of En vironmental Conser vation

PERFORMANCE STANDARDS FOR ROADWAYS

A. Capacity

Service Level	Volume to Capacity Ratio (V/C)
A	0.00-0.60
B	0.61-0.70
C	0.71-0.80
D	0.81-0.90
E	0.91-1.00
F	variable

Source: Transportation Research Board, National Academy of Sciences. Transportation Research Circular #212. Washington, D.C.: TRB, January 1980. ISSN 0097-8515. Page 12.

Definition: "The V/C is the ratio of actual volume of traffic to the theoretical maximum of traffic a highway can accommodate (capacity) each hour. This measure is computed for the peak period characterized by morning and evening peak period in cities and weekend periods in rural areas. Generally, ratios in the range of .80 to .90 indicate congestion problems, and ratios above .90 indicate congestion that seriously inhibits traffic flow." (U.S. DOT, FHWA, 1982: 88).

Source: Highway Research Board, 1965.

Minutes of delay

Average daily vehicle miles travelled (DVMT) / lane-mile (product of number of lanes and total mileage)

Peak-Hour Operating Speed ("the highest speed at which vehicles can safely be driven under prevailing peak-period conditions" (U.S. DOT, FHWA, 1982: 91))

Average speed relative to speed limit

B. Safety

Accident Rate

C. Structural Features

Pavement condition:

a. Pavement Serviceability Rating (PSR) (U.S. DOT, FHWA)-based upon subjective assessment of pavement condition by a group of experts for a sample of roads.

5.0 - completely deteriorated

0.0 -2.0: Poor

2.0 - minimum standard for non-high speed roads
2.5 - minimum standard for high speed roads (Interstate)
2.0 -3.5: Fair
3.5 -5.0: Good
5.0 - new

b. Pavement Serviceability Index (PSI) (American Association of State Highway Transportation Officials)-analogous to the PSR, but based on a series of physical measures: cracking, patching, roughness, and depth of ruts (for flexible pavements only) (Hatry, 1981: 23).

Pavement type:

Unpaved	"Gravel or graded and drained"
Low	"Bituminous surface course less than 1-inch thick on a base suitable for carrying occasional heavy axle loads"
Intermediate	"bituminous mix on a preapared base with a combined thickness of less than 7 inches"
High	"portland cement concrete or bituminous mix on a prepared base with a combined thickness of 7 inches or more" (U.S. DOT, FHWA, 1982: 94)

Pavement flexibility:

Flexible	Entirely asphalt or other flexible material
Overlays	Asphalt over a base of concrete or other material
Rigid pavement	Portland cement concrete (NYS DOT, Transportation Analysis Report No. 4: page 4)

Miscellaneous indices for roadway surface (NYS DOT):

(1) "Surface Score: a 1-10 scale indicating condition of roadway surface"

(2) "Rupture and Displacement (Base) Score: a 1-10 scale representing the condition of the base material underlying the surface"

(3) "Maintenance Index: A 1-10 scale indicating whether maintenance on a particular segment is greater than normal, average, or less than normal"

(4) "Structural Score: a weighted combination of the first three items, a 1-100 scale, computed as follows -
3 x (surface) + 4 x (base score) + 3 x (maintenance score)"
(New York State, DOT, Planning Division. Transportation Analysis Report No. 4. Albany, N.Y., December 1981. P. 1-2)

Alignment

Access

Lane Width (a minimum has been defined as that width, 20 feet of road width allowing two school buses to pass without having to go off the paved portion of the road (Fink, 5/83: 61))

Shoulder Type (in order of increasing load bearing capacity):

Earth (with or without grass)
Stabilized (load bearing material, e.g. gravel)
Surfaced/Paved

Source: U.S. DOT, FHWA. Condition of the Nation's Highways. Washington, D.C.: U.S.DOT, 1982: 139

Drainage

D. Combination Measures for Traffic and Structure

Sufficiency Rating (New York State): Combines the V/C ratio with the structural score (above), on a scale from 1-100 (NYSDOT, Transportation Analysis Report No. 4, p. 2)

Present Rideability Index (PRI): A roadway roughness indicator, measured mechanically, and expressed in terms of a 1-5 psychometric scale. (NYSDOT, Transportation Analysis Report No. 4, p. 2)

PERFORMANCE STANDARDS FOR BRIDGES

Definitions:

Structural deficiency-"closed or restricted to light vehicles only" (U.S. DOT, FHWA, 1982: 85); a bridge "whose condition, as determined from a general inspection, is such that the bridge requires corrective work" ranging from "repairs performed by maintenance forces employed by the owner to extensive rehabilitation or replacement" . . . "A bridge with a Condition Rating of less than 5 is considered structurally deficient" (NYS DOT, September 1979:5-6).

Functional obsolescence-"deck geometry, load carrying capacity, clearance or approach roadway alignment can no longer serve its respective system safely" (U.S. DOT, FHWA, 1982: 85).

a. Width deficiency - "A bridge with deficient width is one with a width less than required by the standards of the American Association of Highway and Transportation Officials. The primary determinant in establishing acceptable bridge width is the volume of traffic. Any bridge with a width of less than 24 feet is considered deficient, with bridges carrying higher traffic volumes requiring greater widths." (NYS DOT, September 1979: 6)

b. Load capacity - Bridge load ratings are a function of the condition of the bridge, and, since condition changes over time, the rating is computed periodically. The ratings are the basis of allocations of funds for bridge rehabilitation by FHWA. (NYS DOT, September 1979)

c. Vertical clearance - The New York State standard for bridge clearance is fourteen feet. Vehicle heights are required by law to not exceed 13'-6", except where a special hauling permit is obtained (NYS DOT, September 1979).

d. Horizontal clearance

e. Deck configuration

f. Waterway adequacy

Source: New York State Department of Transportation. "Bridge Needs in New York State". Final Report of the New York State Department of Transportation to the Governor and the Legislature of the State of New York in Compliance with Chapter 460 of the Laws of 1977. Albany, N.Y.: NYS DOT, September 1979.

U.S. Department of Transportation. Federal Highway Administration. 1982.

CONDITION RATING SYSTEM FOR BRIDGES IN NEW YORK STATE

A. Condition Categories

Scale	Definition
1	Potentially hazardous
2	Intermediate between 1 and 3
3	Serious deterioration or not functioning as originally designed
4	Intermediate between 3 and 5
5	Minor deterioration and is functioning as originally designed
6	Intermediate between 5 and 7
7	New condition

B. Bridge Elements and Weights

Element	Weight
Primary members	10
Abutments	8
Piers	8
Structural Deck	8
Bridge Seats	6
Bearings	6
Wingwalls	5
Backwalls	5
Secondary Members	5
Joints	4
Wearing Surface	4
Sidewalks	2
Curbs	1

Note: "The first four elements are considered as the principal structural elements."

"When a bridge has several of one kind of element, such as multiple piers, the rating of the worst of the elements is used since this is the condition which establishes the limit of use of the bridge."

C. Condition Rating Computation

$$\text{Condition Rating} = \frac{\text{Sum of Weighted Ratings}}{\text{Sum of Weighting Factors Used}}$$

Note: A rating less than 5.0 is considered deficient.

D. Priority Rating

The addition of a traffic volume factor within condition categories.

Source: New York State Department of Transportation. "Structural Condition Formula". Albany, N.Y.: NYS DOT, 1/14/80. Mimeograph.

Unit Costs

UNIT COSTS FOR REPAIR AND REHABILITATION OF WATER MAINS

Size of Pipe (inches)	Repair Cost $ per break	Replacement Cost $ per foot
4	1,266	57.51
6	1,355	61.17
8	1,461	64.17
10	1,549	71.18
12	1,629	75.67
16	2,014	97.36
20	2,118	118.56
24	2,397	141.19
30	2,861	174.08
36	3,032	222.56
48	3,573	325.54

Source: Based upon Uri Shamir and Charles Howard, "An Analytical Approach to Scheduling Pipe Replacement," J. of the American Water Works Association (May 1979), p. 248.

UNIT COSTS FOR HIGHWAY REHABILITATION

Source	Cost per mile (in millions of dollars)	Year of Estimate	Comments/Qualifications
Irwin (March 1983) (1: 16,17)	$ .065	3/82	To increase condition from fair to very good
	.650	3/82	Complete reconstruction, except for drainage
NYSDOT, Region 3 (1:45)	.070-2.0	11/81	
NYSDOT, Region 5 (1:62)	.070	12/81	Minor resurfacing
	More than 8.0	12/81	Complete reconstruction
Broome County (1:50)	.10-.20	11/81	
NYSDOT, Region 9 (1:51)	.090	11/81	Rehabilitation
	2.0	11/81	Complete reconstruction
NYSDOT, Region 10 (1:66)	.10	12/81	Rehabilitation
	12.00	12/81	Construction
Hartgen (2: 10)	2.0	8/82	Complete reconstruction
	1.5		Major reconstruction
	1.0		Medium reconstruction
	0.50		Reconstruction/ resurfacing
	0.25		R & P/2.5" resurfacing
	0.07		Armorcoat/1 inch
	0.03		Heavy maintenance
	0.01		Medium maintenance
	0.005		Light maintenance
Luhr and McCullough (3: 25)	0.015	1983	Aggregate Surface, 6"
	0.025		Aggregate Base, 6" and 0.5" surface treatment
	0.090		Base, 6"; Asphalt concrete surface, 4"
Durston and Fong-Lieh Ou (4: 51)		1983	Side slope:
	0.080		0-30 %
	0.105		30-40
	0.142		40-50
	0.204		50-60
	> 0.237		> 60

Unit Costs for Highway Rehabilitation (continued)

Source: 1. Stanley Fink, Chairman, New York State Assembly Infrastructure Task Force. First Interim Report on New York's Infrastructure. Albany, N.Y., May 1983.

2. David T. Hartgen, "Long-Term Projection of Highway System Condition". Transportation Analysis Report No. 17. Albany, N.Y.: New York State Department of Transportation, Planning Division, August 1982.

3. D.R. Luhr and B.F. McCullough, "Economic Evaluation of Pavement Design Alternatives for Low-Volume Roads". Washington, D.C.: National Academy of Sciences, Transportation Research Board. Transportation Research Record No. 898, 1983.

4. T.A. Durston and Fong-Lieh Ou, "Simplified Cost-Estimation Method for Low-Volume Roads". Washington, D.C.: National Academy of Sciences, Transportation Research Board. Transportation Research Record No. 898, 1983.

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