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DR. 869

ENERGY

CONSERVATION

COO-4977/1(Vol.2)

DISTRICT HEATING AND COOLING SYSTEMS FOR COMMUNITIES THROUGH POWER PLANT RETROFIT DISTRIBUTION NETWORK

Volume 2, Final Report for September 1, 1978—May 31, 1979

MASTER

October 1979
Report Date

Work Performed Under Contract No. EM-78-C-02-4977

Public Service Electric and Gas Company
Newark, New Jersey

U. S. DEPARTMENT OF ENERGY

Division of Buildings and Community Systems

DISCLAIMER

DISCLAIMER

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DISTRICT HEATING AND COOLING SYSTEMS FOR COMMUNITIES THROUGH POWER PLANT RETROFIT DISTRIBUTION NETWORK

Volume II

Final Report - September 1, 1978 - May 31, 1979

Prime Contractor:

Public Service Electric and Gas Company
80 Park Place
Newark, NJ 07101

Subcontractors:

Stone and Webster Engineering Corporation
Stone and Webster Management Consultants
Transflux International, Ltd.

Report Date: October 1979

Prepared for the

U.S. Department of Energy
Assistant Secretary for Conservation and Solar Applications
Office of Buildings and Community Systems

Work Performed under Contract No. EM-78-C-02-4977

FOREWORD

This is the Final Report of Phase 1 of "District Heating for Communities Through Power Plant Retrofit Distribution Network." It is separated into four volumes:

Volume I:	Executive Summary	
Volume II:	Task 1:	Demonstration Team
	Task 2:	Identify Thermal Energy Sources and Potential Service Areas
	Task 3:	Energy Market Analysis
Volume III:	Task 4:	Technical Review and Assessment
Volume IV:	Task 5:	Institutional Assessment
	Task 6:	Preliminary Economic Analysis
	Task 7:	Proposal for Further Work

ACKNOWLEDGEMENTS

The following key personnel contributed to the completion of this report:

C. R. Guerra, PSRC - Research & Development Department
M. L. Zwillenberg, PSRC - Research & Development Department
P. D. Chase, PSRC - Research & Development Department
V. Saleta, Stone & Webster Engineering Corporation
R. Ulfstam, Stone & Webster Engineering Corporation
G. S. Levitt, Stone & Webster Management Consultants
M. G. Kurz, Transflux International, Ltd.

Numerous contributions by other subcontractor personnel and members of other PSE&G departments are gratefully acknowledged.

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LIST OF EXHIBITS

Task 1. Demonstration Team

1.1 Personnel

The Phase 1 Demonstration Team consists of PSE&G Research Corporation as the prime contractor and manager for the program, its parent company, PSE&G Company, and elements of four other organizations experienced in public utility heat and power systems.

- Stone & Webster Engineering Corporation (SWEC)
- Stone & Webster Management Consultants, Inc. (SWMC)
- Transflux International, Ltd (TF)
- AB EnergiKonsult (division of Swedish Steam User's Association, Stockholm)

The manufacturers of the turbo-generator sets at the different stations and consultants also play various roles in the Demonstration Program.

Table 1.1 lists the members of the PSE&G Research Corporation and PSE&G Company Project Team. Table 1.2 lists the principal members of SWEC, SWMC, TF and EnergiKonsult. The qualifications, previous experience, and role of key members of the project team have been previously provided to DOE/ANL (Detailed Work Management Plan, January 22, 1979).

In Phase 2, it is intended to involve the steam turbine manufacturers (General Electric and Westinghouse), Consultants, potential District Heating users, the New Jersey Department of Energy, the New Jersey Board of Public Utilities, the Hackensack Meadowlands Commission, and other local and regional groups as active members of the Demonstration Team.

Table 1.1
Prime Contractor Demonstration Team

- PSE&G Research Corporation - Advanced Systems, R&D

  C. Guerra - Project Manager
  M. Zwillenberg - Assistant Project Manager, Technical Studies
  P. Chase - Coordinator, Institutional Assessment

- PSE&G Company - Project Coordination Team

Principal	Alternate(s)	Department
G. Bowdren	J. Chiappinelli	Production-Methods
H. Baranek	C. Cordeiro	Engineering-Power
G. Clarkson	F. Lark, R. Valiga	Rates & Load Mgmt.
M. Plawner	L. Oches, E. Moran	Financial Planning/Resch.
R. Girolami	P. Natale	Ind. & Comm. Mktg.
M. Hoepfner	W. Harding	Gas T&D
H. Martin	-	Residential Mktg..
T. Piascik	J. Hynds	System Planning
W. Saller	G. Brown, M. Vaskis	Governmental Affrs.
J. Shissias	S. Siebert	Environmental Affrs.
J. Lacey	R. Fryling	General Solicitor
C. Sulzberger	-	General Attorney
R. Williamson	R. Houghton	Comptroller-Income Tax
H. Umland	-	Corp. Rate Counsel
G. Heineman	-	Economic Research
C. Wood	-	Fuels
F. Riepl	-	Treasurer's
F. Cassidy	G. Schirra	Engg. Economist
J. Maddocks	-	Area Development
H. Latham	-	Contract Admin.
R. Zgorzynski	-	Computer Systems & Services - Systems Res. & Plan.

Table 1.2
Subcontractors Demonstration Teams

- Stone & Webster Engineering Corporation

  V. Saleta - Project Manager for SWEC

- Stone & Webster Management Consultants

  G. Levitt - Project Manager for SWMC

- Transflux International, Ltd.

  M. Kurz - Project Manager for TF

- AB EnergiKonsult

  G. Berg

1.2 Parties of Interest and Provisions for Involvement of Local Government and Public Interest Groups

The following actions have been taken to provide for involvement for the groups referred to above.

1. Briefing to members of the New Jersey Department of Energy (NJDOE) of the opportunity to respond to the USDOE RFP on District Heating. NJDOE issued an endorsement to the PSE&G proposal and assigned Mr. B. Patel of NJDOE as liaison to the PSE&G project.

2. Briefing to Mr. C. Sheppa of the New Jersey Board of Public Utilities (NJBPU) about the status and objectives of ongoing District Heating Project. Mr. C. Sheppa plans to act as NJBPU liaison to the PSE&G project.

3. Briefings to officials of the following New Jersey municipalities who provided endorsements to the PSE&G Phase 1 proposal: Newark, Linden, Kearny, Burlington. In addition, there have been subsequent briefings to the following municipalities and groups which might be involved in Phase 2: Newark, Jersey City, Harrison, Hoboken, Hackensack Meadowlands Development Commission (HMDC).

4. Information Circular sent by PSE&G to NJDOE and NJBPU advising of progress in project on a monthly basis.

5. Invitation to NJDOE and NJBPU representatives to attend project coordination meetings held by PSE&G with subcontractors.

6. Participation by the New Jersey Energy Research Institute (NJERI) in a meeting concerning institutional constraints.

Letters from municipalities and NJDOE indicating support of the Demonstration Program are shown on the following pages.

More extensive contacts with municipalities must await more specific site selection. Discussions with NJDOE staff and the N.J. Board of Public Utilities (NJBPU) are proceeding on a continuing basis.

When a determination has been made as to where a proposed system may or will be installed, a meeting would be held with the Mayor and other interested municipal officials to explain the project and answer questions. These installations will require street opening permits, easements, some land acquisition, building permits and possibly zoning variances or Planning Board approval. If facilities are installed within a state highway or county road, approvals of the N.J. Department of Transportation and the county will also be required.

After meeting with local officials to explain the project, it may be prudent to have a public meeting to explain the project.

The PSE&G Governmental Affairs Department will make any necessary arrangements to meet with the various government officials.

JOEL R. JACOBSON
COMMISSIONER
NEWARK, N.J.

STATE OF NEW JERSEY
DEPARTMENT OF ENERGY

May 4, 1978

Mr. Harold W. Sonn, President
PSE&G Research Corporation
80 Park Place
Newark, New Jersey 07101

Dear Mr. Sonn:

As Commissioner of the New Jersey Department of Energy, I offer my complete support to your proposed study for the U.S. Department of Energy on "District Heating and Cooling Systems for Communities through Power Plant Retrofit."

The principle of utilizing the extra energy available in the steam at an electric generating station is one which many of us who deal directly with energy conservation believe to be both feasible and necessary as an integral part of any National Energy Conservation Program.

This department stands ready to assist at any time in the development of this program, and in its implementation if technical and economic feasibility are proven.

Very truly yours,

Joel R. Jacobson

JRJ/tls

Joel R. Jacobson
Commissioner
Newark, N.J.

State of New Jersey
Department of Energy

May 26, 1978

Harold W. Sonn, President
PSE&G Research Corporation
80 Park Place
Newark, NJ 07101

Dear Mr. Sonn:

This is in response to your request for designation of a liaison officer from this Department for your application to the U.S. Department of Energy, RFP #EM-78-R-02-0008, "District Heating and Cooling Systems for Communities Through Power Plant Retrofit Distribution Network."

I am designating Bharat C. Patel, Director of our Office of Technical Assistance, as liaison officer for this Department. He stands ready to assist you at any time in the development of this program.

I hope you are successful in obtaining the contract from the federal Department of Energy. As previously indicated, I offer my complete support to your proposed study and wish you good luck in your endeavor.

Sincerely,

Joel R. Jacobson
Commissioner

JRJ:bg

PRESIDENT

MAY 11 1978

PSE&G
RESEARCH CORP.

KENNETH A. GIBSON
MAYOR
NEWARK, NEW JERSEY
07102

May 4, 1978

Mr. Harold W. Sonn
President
PSE&G Research Corporation
80 Park Place
Newark, New Jersey 07101

Dear Mr. Sonn:

It has come to our attention that the PSE&G Research Corporation is planning to participate in a United States Department of Energy-sponsored study to determine the feasibility of utilizing the steam and heated water by-product from electric generation for the purposes of heating and cooling.

It is our understanding that Public Service has an electric generating station within the City of Newark which may be suitable for inclusion within the study.

The City of Newark would be willing to cooperate in such a study by providing available development and technical data.

We look forward to completion of the study, particularly to the recommendations on the technical and economic feasibility of implementing a district heating system.

Sincerely,

Kenneth A. Gibson
Mayor

KAG:ad

KENNETH A. GIBSON
MAYOR
NEWARK, NEW JERSEY
07102

September 19, 1979

Mr. John F. McDonald
Public Service Electric
and Gas Company
80 Park Place
Newark, New Jersey 07101

Dear Mr. McDonald:

Thank you for the information you supplied on the results of the Phase 1 District Heating and Cooling study you have performed for DOE and your plans for Phase 2.

We believe that the implementation of this project could benefit our country as a whole by reducing expensive oil imports, improving our balance of payments and thus helping to moderate the inflation rate. It could benefit the citizens of Newark even more directly by providing jobs, decreasing heating and cooling costs, stimulating economic development and reducing air pollution and thermal discharges to waterways.

We warmly support your Phase 2 application to DOE and offer our cooperation in your study and in the ultimate implementation of a District Heating/Cooling system if proven feasible.

Very truly yours,

Kenneth A. Gibson

KAG:lgc

OFFICE OF THE MAYOR

STEVE CAPPIELLO — CITY OF HOBOKEN, N.J. CORPORATE SEAL — MAYOR

CITY HALL
HOBOKEN, NEW JERSEY

JOHN F. McDONALD
SENIOR VICE PRESIDENT
AUG 8 1979
GOVERNMENTAL AFFAIRS

MANAGER – CORPORATE BUDGETING
RECEIVED
AUG 9 1979
PSE&G

August 6, 1979

Mr. John F. McDonald, Senior Vice President
Governmental Affairs,
Public Service Electric and Gas Company
80 Park Place
Newark, New Jersey 07101

Re: District Heating and Cooling Systems for communities through Power Plant Retrofit Distribution Network

Dear Mr. McDonald:

We are aware of the application being made to the Department of Energy concerning the District Heating and Cooling system, which involves our community.

I strongly support your Phase Two proposal in the hope that it will be of benefit to the cities in the same financial condition as Hoboken.

Very truly yours,

Steve Cappiello

cc: Senator Harrison A. Williams
Senator Bill Bradley
Congressman Frank J. Guarini

HACKENSACK MEADOWLANDS DEVELOPMENT COMMISSION
100 Meadowland Parkway • Secaucus, N.J. 07094
Telephone: (201) 864-1220 N.J. Centrex (201) 648-2322

August 10, 1979

Harold W. Sonn, President
PSE&G Research Corporation
80 Park Place
Newark, New Jersey 07101

Re: Submission of Phase II Proposal to the U.S. Dept. of Energy on District Hearing and Cooling

Dear Mr. Sonn:

Thank you for your letter of July 1, 1979 in which you described PSE&G's efforts to date on District Heating and Cooling. The Phase I Study report that you enclosed is currently under review by my staff.

Our preliminary review of this document indicates that the potential use of thermal effluents currently discharged to the Hackensack River by PSE&G generating stations in Ridgefield, Jersey City and Kearny will have a positive and beneficial impact upon future developments in the Hackensack Meadowlands if the three schemes listed in the Phase I Report are implemented. Additionally, the conversion of these thermal effluents, which currently cause a deleterious impact to oxygen levels in the Hackensack River, into a potential solution to this State's Energy problems is one which has our whole-hearted support.

Accordingly, please advise U.S.D.O.E. of our support of your application to perform additional investigations under Phase II of this project and that we hope to see a speedy completion of the Phase II work so that we can begin investigating the implementation of District Heating and Cooling in the Hackensack Meadowlands.

We stand ready to render additional assistance during the course of the Phase II work.

Sincerely,

PATRICIA Q. SHEEHAN
EXECUTIVE DIRECTOR

JB/cv
cc: C. Guerra, PSE&G

August 28, 1979

Mr. Peter Luongo
Luongo Associates, P.A.
235 Moore Street
Hackensack, New Jersey 07601

RE: District Heating

Dear Pete:

I have had several meetings with Chet Mattson of the HMDC and Mr. M. G. Kurz, Vice President of Transflux International Limited regarding the subject of co-generation and district heating. Mr. Kurz's firm has been hired by Public Service Electric & Gas Company to study the economic and engineering feasibilities of this application in various areas including the Meadowlands.

In particular, we are interested in this possible application on the Mori site, and to that extent, we have agreed to participate, although in a limited extent, to help by providing realistic developers cost information and other developer oriented considerations.

I am enclosing a letter dated July 30, 1979 from Mr. Kurz outlining the information we agreed to provide. I would like your firm to submit a proposal to accomplish this information gathering task and to present the information in a brief but concise report. Please contact me regarding this as soon as possible. I would hope enough information is available at our offices and through our contractors and past project records that sufficient meaningful information can be compiled within 30 days. We would, of course, like a written proposal but in order to expedite this work, please contact me via telephone to discuss the project and to receive your authorization to proceed.

Very truly yours,

HARTZ MOUNTAIN INDUSTRIES, INC.

Michael B. McNally, P.E. & L.S.
Vice President
Engineering and Planning

MBMc/jb
Enclosure
cc: Chet Mattson
Mr M. G. Kurz

Task 2 - HEATING AND COOLING LOAD ESTIMATION

This task consisted of (a) estimating, from tabulated statistical data (U.S. Census, PSE&G files, other sources) the thermal load within five and ten mile radii of PSE&G steam power plants; (b) estimating, on a generalized basis, the costs of supplying thermal services to thermal loads of varying densities; (c) a "best case" economic analysis of district heating for single family homes (only cost of in-house conversion and branch distribution charged to customer) and (d) some general comments on district heating system design and development.

Task 2. HEATING AND COOLING LOAD ESTIMATION

Sub-task 2.2 Most favorable case analysis of single family house heating/cooling.

The calculations showed that without an imaginative approach to district heat single and small multi family (4 apartments) houses no economies can be found. This is a result to be expected. Even so the following summary figures suggest a number of considerations which could further the cause:

	Single Family House (60000 BTU/hr max.)		
Alt. Pipe Layout	A	B	C
Cost of distr. heating system $			
- distribution in blocks	4970	3852	3657
- " on 1 sq. mile*		710	
	5680	4562	4367
- add valves, fitt., etc.	1420	1141	1093
	7100	5703	5460
- in-house conversion		2400	
	9500	8103	7860

* 151/2 x 10^6 BTU/sq. mi.

Alt. Pipe Layout	Multi Family House (40000 BTU/hr/apt.) A	B	C
Cost of distr. heating syst. $/unit			
- distribution in blocks	1525	1138	976
- " on 1 sq. mile*		304	
	1829	1442	1280
- add valves, fitt., etc.	457	361	320
Sub-total new building	2286	1803	1600
- in-house conversion		1125	
Total - existing bldg.	3401	2928	2725

* 420 x 10^6 BTU/sq. mi.

The present annual heating bill of a house or apartment like the ones calculated is $900 and $600 respectively, obviously insufficient to finance the above indicated investments even if efficiencies of one-third better can be achieved.

There are three piping layouts referred to in the above tabulation. Each of these layouts is based on 6 blocks of houses and streets measuring 720' x 900' overall. The 3 pipe configurations are shown on Figs. 1.2-1 to 3 for the temperature differential finally selected. The difference in the pipe layouts is the amount of public v. private property utilized to run the lines. As the foregoing cost tabulation shows, there is considerable economic incentive in maximizing the use of private property (Alt. C). There is also increased institutional involvement in obtaining easements, which might or might not create undue problems dependent on the commitment the municipality makes to promote the cause of district heating.

Even with the most favorable of layouts and without changing any of the costs of the plant retrofit and the main transmission line, which are to be borne by large users, the economy of district heating cannot be shown for existing buildings. Somewhat better are the results for new buildings where the conversion costs are saved and the connection costs just about balance that of the conventional heating equipment.

There were a number of conversion schemes or connection schemes worked out and estimated for this purpose. Fig. 2.2-4 shows a hot air heating system and Fig. 2.2-5 a warm water heating system connection scheme. The costs calculated are preliminary and are based on conventional equipment not necessarily designed and made for the purpose. The effects of large quantity orders have also been neglected.

Economies of regulatory flexibility, that of quantities and possible federal tax rebates, are needed collectively to change the economic equation. It is considered discriminatory to subsidize solar heating, but not district heating. The waste heat of power generating cycles, utilized by these systems, is just as much a renewable source as the sun, as long as we keep generating electric power by conventional thermal cycles. Tax abatements of up to $2500, as available for solar installations, would definitely include small multi family housing within the target areas of otherwise large load concentrations.

The details of these investigations are shown in Appendix A.

Sub-task 2.3. Compilation of population and load data around power plants considered for retrofit

A preliminary statistical survey was made of the surrounding areas of the eight fossil-fuel-fired base and intermediate load generating stations of PSE&G. It is based on the Housing Statistics (1970) of the Bureau of Census. It covers areas within a 5 mile radius of these plants.

First a listing was made of all communities within 5 and 10 miles radii of the selected plants and within New Jersey only. A sample presentation of this listing is shown in Table 2-I--communities around the North

Bergen G.S. This and the other areas are shown in detail in Appendix B, par. 3.

The next step was a block-by-block listing of year-round housing stock in each of the communities following an arbitrary but uniform sectioning of each area into 8 directional segments. The data collection was limited to the five mile radius, with the stipulation that the broader 10 mile area will be added only if the load potential within the smaller distance is less than the heat output capability of the plant(s). This turned out not to be the case.

Table 2-II, sheet 1 of 4, is a representative sample of a data sheet and Table 2-III is a summary of all the data around the eight plants. The complete set is in Appendix B, par. 4, of this report.

Some of the data shown on these sheets are directly extracted from the statistical information available, as block number, population, number of housing units. The rest of the data is derived. Estimated heating loads are based on the indicated averages. Length of streets are measured off the maps and serve the purpose of estimating total piping length when used in conjunction with the block piping layout presented before. One can calculate the percentage of streets with and without distribution piping to achieve the generalization. In addition, a maximum pipe size was calculated for each of two temperature differentials as an upper limit on pipes used. The lower limit was set at 1" dia., sufficient to supply 4 apartments at either of the temperature differentials.

The summary of the results shows a number of important figures. First of all it pinpoints the North Bergen and Essex (Essex, Kearny and Hudson) G.S. areas as far superior to the other four. The average load densities are 2 to 4 times higher than that of the others. Even more significant, there are seven sectors around these plants with load densities 2 to 3 times higher than the average. It was also found later that these areas adjoin the one large block of land where the major housing development of the near future will take place--the Hackensack Meadowlands.

As a result, the additional investigations concentrated on these areas and on the 4 power plants within these areas.

Another step in the statistical inquiry was to look at fuel use patterns and to define the share which non-residential housing has in the heating fuel use of the area.

We found that the residential house heating fuels are overwhelmingly oil and gas, and their use breaks are approximately in the 60% to 40% ratio, respectively. Data on fuel use by the different sectors of the economy showed that in New Jersey the commercial/institutional sector uses about half as much fuel as residences do. It was then conservatively assumed that the same ratio prevails within the potential heating territory. This is a conservative estimate for two reasons: The high density areas of the cities have a higher than average commercial/institutional constituency and most of these do not operate day and night. Both tend to result in higher loads than the calculated peak loads. The total potential heating load within 5 miles of the four power plants were found to be

Essex (Kearny, Hudson)	15×10^9 BTU/hr
North Bergen	7.8×10^9 "

The two figures are not additive since some of the load can be supplied by one or the other station(s), so it is counted twice. A total of 20×10^9 BTU/hr, however, can be used as an extreme ultimate figure.

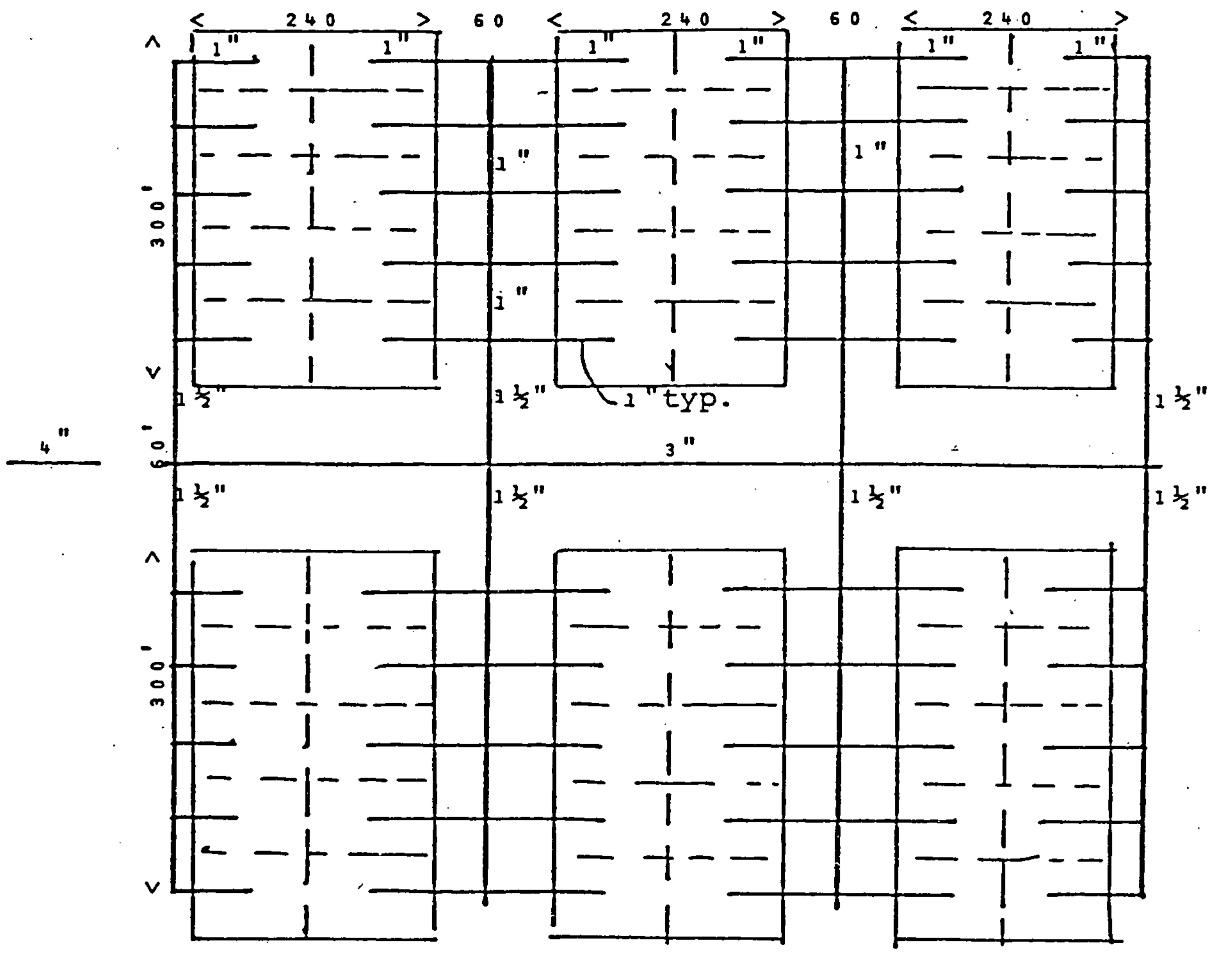
There were some more detail approaches made using Company files and other data. These and the other details are shown in Appendix B, par. 5 to 7.

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 2.2-1

40000 BTU/unit - 4 units/lot
9.6×10^6 BTU/hr

MTW @ Δ = 120°F
160 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	3240'	3000'	255000
1½"	1260'	-	63000
3"	600'	-	48000
	5100'	3000'	366000

$$\frac{366000}{240} = 1525 \text{ \$/unit}$$

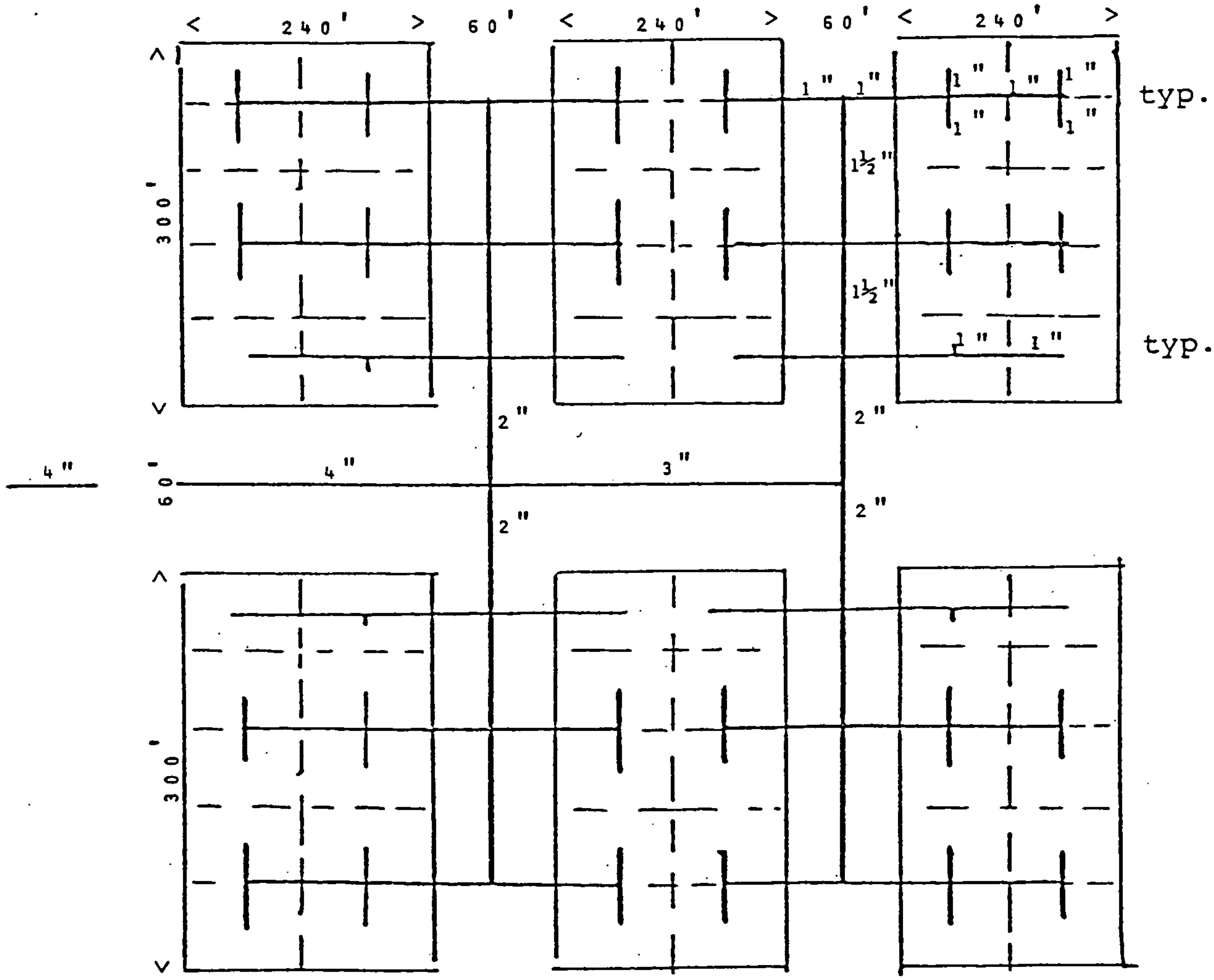
ALTERNATIVE HOUSE CONNECTION SCHEME I - MULTIPLE DWELLINGS

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 2.2-2

40000 BTU/unit - 4 units/lot
9.6 x 10^6 BTU/hr

LTHW @ Δt = 120°F
160 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	720'	4280'	168680
1½"	840'	-	42000
2"	240'	-	12960
3"	300'	-	24000
4"	300'	-	25500
	2400'	4280'	273140

$$\frac{273140}{240} = 1138 \text{ \$/unit}$$

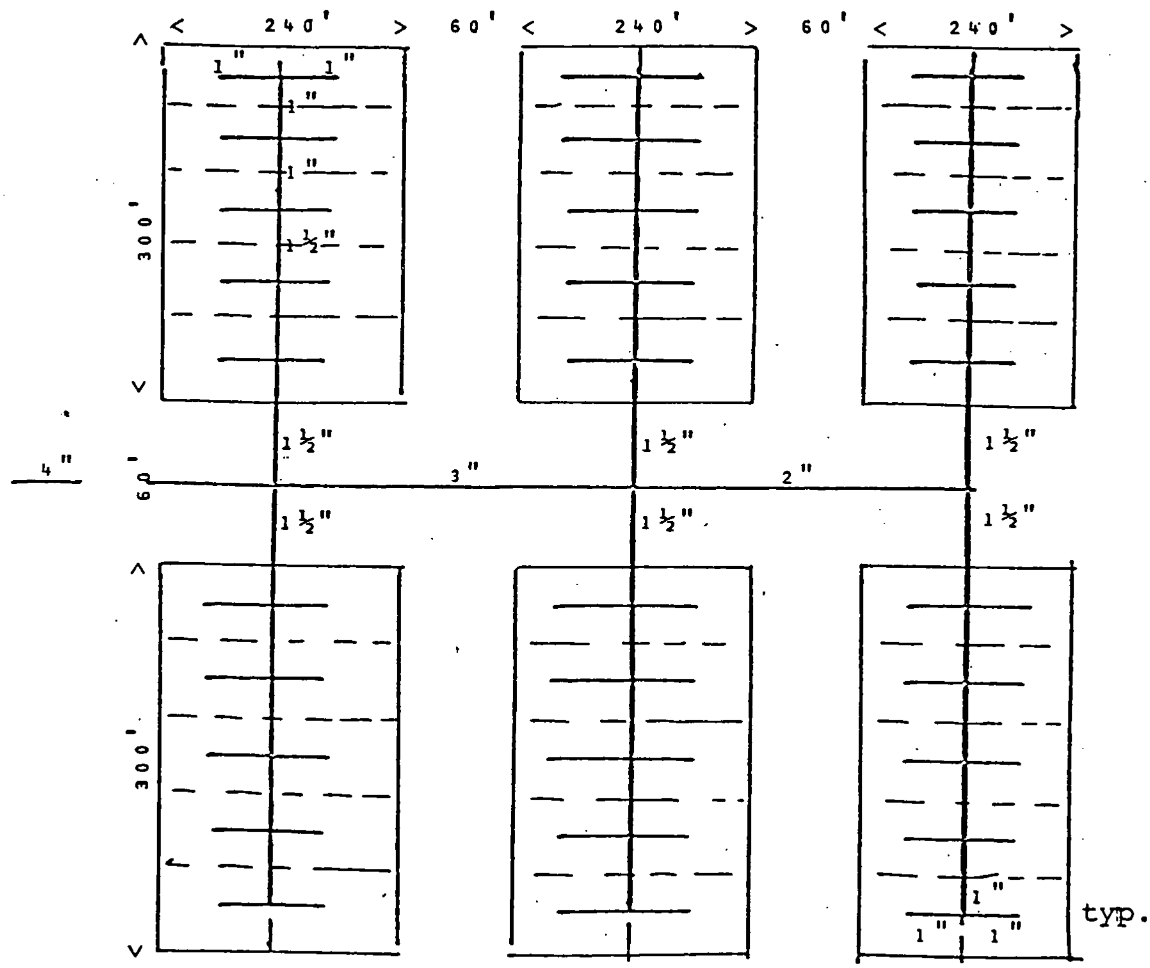
ALTERNATIVE HOUSE CONNECTION SCHEME II - MULTIPLE DWELLINGS

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 2.2-3

40000 BTU/unit - 4 units/lot
9.6 x 10^6 BTU/hr

LTHW @ Δt = 120°F
160 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

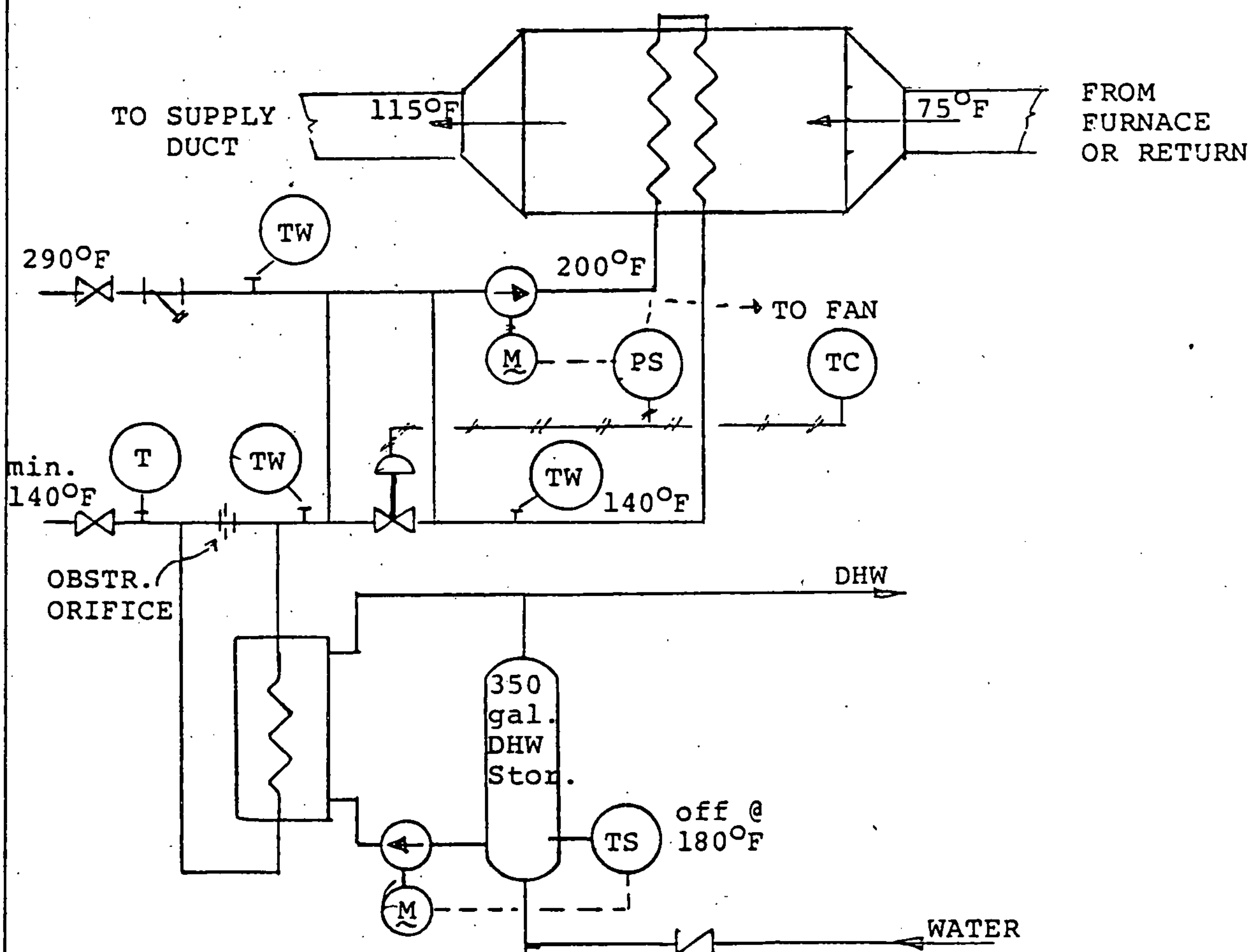
	Suburb.	Rural	$
1" ø	-	4920'	152520
1½"	180'	900'	36900
2"	300'	-	16200
3"	300'	-	24000
4"	150'	-	12750
	930'	5820'	234270

$$\frac{234270}{240} = 976 \text{ \$/unit}$$

ALTERNATIVE HOUSE CONNECTION SCHEME III - MULTIPLE DWELLINGS

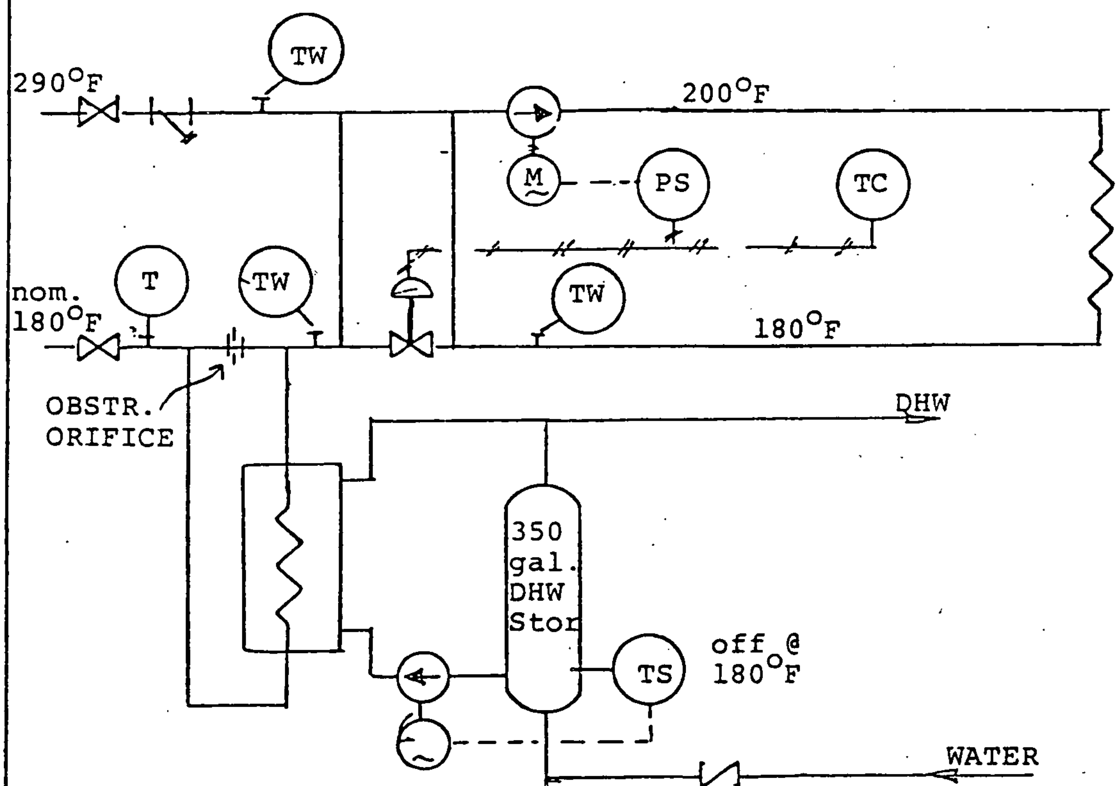
TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 2.2-4



NOTES:
1. NEW OR EXISTING HEATING SYSTEM.
2. CONSTANT FLOW, VARIABLE TEMPERATURE SYSTEMS.

MTW - SINGLE FAMILY HOUSE CONNECTION - HOT AIR HEAT



NOTES:
1. NEW OR EXISTING HEATING SYSTEM.
2. CONSTANT FLOW, VARIABLE TEMPERATURE SYSTEMS.

MTW - SINGLE FAMILY HOUSE CONNECTION - WARM WATER HEAT

LIST OF LOCALITIES WITHIN
5 MILE AND 10 MILE RADII
OF NORTH BERGEN G. S.

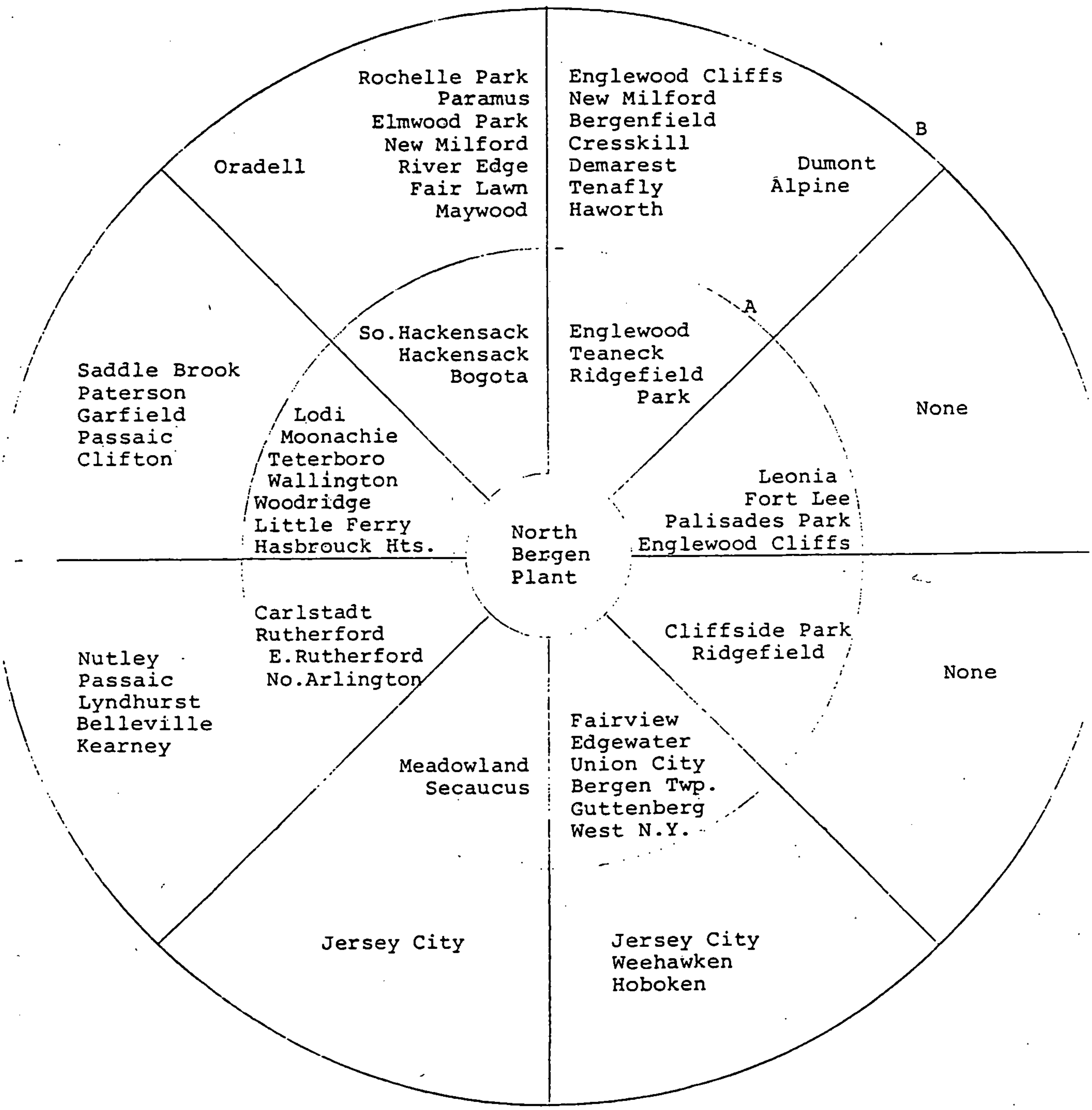


TABLE 2-I

A = 5 miles radius
B = 10 " "

TABLE 2-II

Sht. 1 of 4

GENERATING STATION: BERGEN

HOUSING HEATING LOAD ESTIMATE

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 1 (N-E)							
Ridgefield	1.0	461	3688	1244	514	257	473	30.84	29.20	60.04	28.0	14	8
Park Village, 45	1.0	463	5240	1887	597	491	799	35.82	51.60	87.42	37.5	18	8
"	1.7	462	5525	1823	856	286	681	51.36	38.68	90.04	42.0	18	8
"	2.6	546	8003	2433	1936	59	438	116.16	19.88	136.04	97.0	20	10
Teaneck Twp.	3.4	545	5703	1717	1423	41	253	85.38	11.76	97.14	71.5	18	8
Englewood, 45	4.1	154	4938	1779	488	445	846	29.28	51.64	80.92	71.0	16	8
"	4.1	155	4864	1684	974	436	1770	58.44	88.24	146.68	69.0	20	10
"	4.2	541	8855	2616	2279	51	286	136.74	13.48	150.22	126.5	20	10
"	4.5	542	4959	1707	761	282	664	45.66	37.84	83.50	46.0	16	8
"	4.5	153	5589	1741	1064	72	605	63.84	27.08	90.92	29.5	18	8
Congressional District 9, 45	4.8	543	7422	2194	2173	-	21	130.38	0.84	131.22	87.0	20	10
			64786	22321	13065	2420	6836	783.90	370.24	1154.14	705.0	54	24
						Sector No. 2 (E-N)							
Palisades Park, 45, 56	1.5	411	3830	1511	430	522	559	25.80	43.24	69.04	37.0	16	8
"	1.7	412	3052	1048	391	162	495	23.46	26.28	49.74	32.5	14	6
"	2.0	413	6469	2256	619	460	1177	37.14	65.48	102.62	81.0	18	8
Fort Lee 45,56	2.4	193	12979	4909	1619	1782	1508	97.14	131.60	228.74	123.5	24	12
"	2.5	192	7369	3064	447	1222	1395	26.82	104.68	131.50	69.0	20	10
Leonia, 45, 56	2.7	280	8847	3040	1811	334	895	108.66	49.16	157.82	87.5	20	10
Fort Lee, 45	3.1	191	10283	4605	506	3344	755	30.36	163.96	213.12	38.5	24	12
Englewood Cl.	5.0	160	5938	1612	1465	10	137	87.90	5.88	93.78	96.0	18	8
			58767	22045	7288	7836	6921	437.28	590.28	1027.56	565.0	48	24

COMPARATIVE SUMMARY
OF HOUSING HEATING LOADS WITHIN
5 MILES OF SELECTED G.S.'s

HEAT LOAD DENSITY 10^6BTU/hr/sq mi	No. Bergen	Essex	Linden	Sewaren	Mercer	Burlington
	Generating Station 5 mi. Radius					
			45° Sectors			
0		NE,SW	EN,ES,SE	ES,SE	SW,WS,WN	NE,WN,NW
0-50					EN,ES	
50-100				WN,NW		ES
100-150	NE,NW		WS,WN	WS	SE	EN
150-200	EN,ES,WN	NW	SW,NW	NE,EN	NE,NW	
200-250	SW			SW		SW
250-300	WS		NE			SE,WS
300-350		WN				
350-400		WS				
400-450	SE	ES,SE				
450-600		EN				
MEDIAN PRESENT HOUSING LOAD DENSITY	212.5	290.6	109.3	106.25	65.6	121.9
SECTOR DATA						
a) Densest Load						
-Sector	SE	EN	NE	SW	NW	EN
-Density	415	590	263	225	168	180
-Popul. Area	4.1	3.4	2.75	3.25	9.0	1.2
-Load	1701	2007	724	731	1509	217
-Major Town	Guttenberg	Jersey City Union	Elizabeth	Perth Amboy	Trenton	Burlington
b) Highest Load						
-Sector	SE	WN	NW	WN	NW	SE
-Density		305	175	96		121
-Popul.Area		8.32	7.4	8.6		3.2
-Load		2537	1298	822		387
-Major Town		Newark Harrison	Linden Elizabeth	Rahway		Willingboro

TABLE 2-III

Sub-task 2.4 Conceptual System Design

The potential load determination resulted in the definition of the suitable supply areas. The power plants located in this area are

Essex

Kearny

Hudson

North Bergen

Any or all of these plants can effectively supply the two load centers, namely

a) Downtown Newark and Harrison

b) Jersey City, Union City, West New York, Meadowlands

A preliminary, very generalized investigation of a supply system was conducted to find the feasibility of building a system.

For this preliminary step we have assumed that the plants are capable of supplying heat by retrofitting the existing turbines and by adding back pressure-turbine-generating units as needed.

The assumed maximum heating capabilities were as follows:

Essex	500×10^6 BTU/hr	
Kearny	1000×10^6	"
Hudson	1000×10^6	"
North Bergen	1000×10^6	"
	3500×10^6 BTU/hr	

Adding 1750×10^6 BTU/hr peaking capability to this in the form of fired hot water generators, boilers and/or gas turbine heat recovery units, an ultimate system of 5250×10^6 BTU/hr peak load can be based on these plants.

The plants in the final development can and should be connected to a single grid system shown in Fig. 2.4.1. This unified system allows the different plants to act as each others standby and this reduces the standby facilities required.

The statistical investigations detailed in Appendix B showed that the Newark-Harrison area within 5 miles of Essex-Hudson represents a total load potential of 3200 million BTU/hr including commerce and institutions. The Jersey City, etc., and Meadowlands area in the other direction from the plants can provide another over 3000 million BTU/hr load for a total of 6500 million BTU/hr. This is more than the ultimate supply capability of all the plants and peakers. That capability, as shown before, is about 80% of the potential. 80% is an extreme maximum coverage one can reasonably count on. So it can be said that the potential supply and the potential load are in balance.

The development of such a large system can only be achieved in stages. One such strategy has been developed in detail for the Newark area from the Essex G.S. It is visualized that the total of 5 square mile area will be successively piped up, starting one and starting another one each year for 5 years, while each area will be completed in 4 years. This is an overall development of 8 years. During the first few years a boiler plant located, say, at the Newark gas plant site, would provide heat. After that the transmission line to Essex will be built. A few years following that a connection to Kearny and/or Hudson will complete the system, adding also back pressure turbine units to these plants. In the meantime the original boiler facility will be increased so as to carry the peaks and provide standby as required. A variant to this is to use one or more of the existing gas turbines, at place or relocated, and outfit them with heat outfit them with heat recovery boilers instead of some of the peaking boilers.

Two other schemes have been developed for comparison. One is a system which uses Essex G.S. from the start of the development and so the transmission line is built at conception. The peaking boilers are located at the power plant also. The other is basically the same as the previous one except it is started with the Kearny plant where one unit can back up the other initially.

The total cost of all three schemes is the same. As Table 2-IV shows, however, the allocation of funds during the ten years of development is far more advantageous in scheme I than in the other two.

On the basis of rough cost estimates and without consideration to capacity loss, operating and maintenance and other ancillary expenses, a $220 million cost for the total system is indicated, and based on present home heating costs an annual revenue of $100 to $150 million can be expected.

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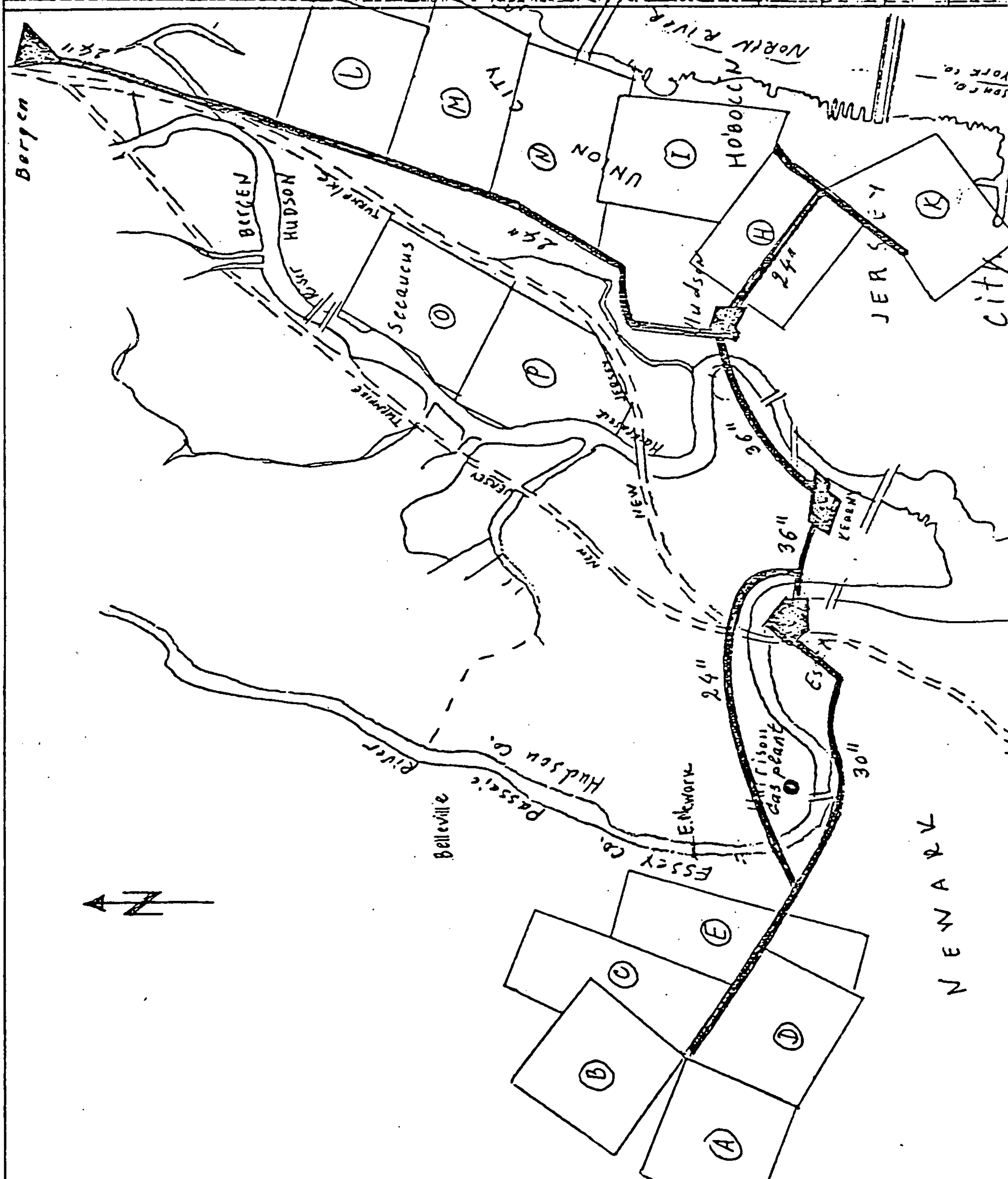
NO. 2.4-1



DISTRICT HEATING DEVELOPMENT PLAN

INVESTMENT IN LOCAL SYSTEMS

Investment Year	Distribution on 5 sq. mi. Cost	Cumul.	Distribution on 15 acres Cost	Cumul.	Total Cumul.	In-house Connection Cost	Cumul.	Total Cumul.
1st	500000	500000	140000	140000	640000	220000	220000	662000
2nd	1400000	1900000	770000	900000	2800000	880000	1100000	3900000
3rd	2000000	3900000	2100000	3000000	6900000	1980000	3080000	9980000
4th	2600000	5600000	5040000	8040000	13640000	4405000	7485000	21125000
5th	2600000	9100000	5040000	13080000	22180000	4405000	11890000	34070000
6th	2100000	11200000	4850000	17930000	29130000	4383000	16273000	45403000
7th	1200000	12400000	4265000	22195000	34595000	3525000	19798000	54393000
8th	600000	13000000	1617000	23812000	36812000	2425000	22223000	59035000

TABLE 2-IV

APPENDICES A, B AND C

to the report

on

DISTRICT HEATING AND COOLING SYSTEMS FOR COMMUNITIES THROUGH POWER PLANT RETROFIT DISTRIBUTION NETWORK

CONTRACT EM-78-R-02-0008

October 1979

TRANSFLUX International Limited

Appendix A

Generalized Investigation of District Heating Systems in Single Family and Small Multiple Dwelling Residential Districts

1. Purpose

The numerous PSE&G generating stations with a potential to serve as the basis of a District Heating System make a load survey around these stations a major task. In order to reduce this task it was decided that a generalized investigation should be made to define whether there is any possible economy in connecting single family and small multi family dwellings to a District Heating System.

2. Scope

The best possible conditions have been assumed as the basis. These assumptions are the following:

A. The incremental cost of retrofitting a power station for district heating to supply the particular residential areas investigated as a small part of a large system will be negligible.

B. The areas investigated will be adjacent to a supply main serving major loads at a point farther than those areas and, therefore, only negligible cost increment will occur in the construction of those supply mains.

C. Each of these areas will be no larger than one square mile.

The investigation will include the sub-mains within the square mile area, the distribution from these sub-mains to each lot and the equipment needed to connect a conventional heating system within the building to the district heating installation.

3. <u>Results and Recommendations</u>

The calculations showed that without an imaginative approach to district heat single and small multi family (4 apartments) houses no economies can be found. This is a result to be expected. Even so the following summary figures suggest a number of considerations which could further the cause:

Alt. Pipe Layout	Single Family House (60000 BTU/hr max.) A	B	C
Cost of Distr. heating system $			
- distribution in blocks	4970	3852	3657
- " on 1 sq.mile*		710	
	5680	4562	4367
- add valves, fitt, etc.	1420	1141	1093
Sub-Total new building	7100	5703	5460
- in-house conversion		2400	
Total-existing bldg.	9500	8103	7860

* 151.2 x 10^6BTU/sq. mi.

Alt. Pipe Layout	Multi Family House (40000 BTU/hr/apt.) A	B	C
Cost of distr. heating syst. $/unit			
- distribution in blocks	1525	1138	976
- " on 1 sq.mile*		304	
	1829	1442	1280
- add valves, fitt, etc.	457	361	320
Sub-Total new building	2286	1803	1600
- in-house conversion		1125	
Total-existing bldg.	3401	2928	2725

* 420 x 10^6BTU/sq. mi.

The present annual heating bill of a house or apartment like the one calculated is $900 and $600 respectively, obviously insufficient to finance the above indicated investment even if efficiencies of one third better can be achieved.

For a multi family building newly constructed for district heating connection the case is not so negative anymore, particularly if piping layout C is used. This layout allows nearly all the distribution pipe, with the exception of two headers, to run on private grounds along the back fence line of the plots. This as shown results in considerable savings but requires easements. This is then an institutional matter of prime importance.

Another factor to be considered is that since most of the heat supplied is energy otherwise wasted at the power plant, it is an equivalent of a renewable energy source as long as thermal power generation exists. On this basis district heating installations should not be discriminated against and should qualify for the up to $2500 federal aid solar installations are getting.

These approaches would certainly change over the economies of central heat supply to multi family dwellings and even to new single family houses.

4. Data Basis

4.1 Lot Size

The definition whereby these areas under investigation are along mains supplying densely populated areas sets the character of these communities. Mostly they are on the outskirts of large cities and, therefore, they are low- and medium-income areas. Investigating the maps of these areas, we found that the average lot size is one-quarter of an acre or less. We have selected, therefore, a quarter of an acre as an average lot size including the adjoining streets or common thoroughfares.

Therefore, 60 single family houses or 240 multi family dwellings of an average four dwellings per building are assumed to require an area of 15 acres. Dimensionally this measures 900 ft. x 720 ft. and consists of six blocks of houses as shown on Drawing Nos. 561-01 to -03 and 561-06 to -08.

Consequently, a one square mile area contains 42 of those six block units. This means that there are 2,520 single family houses or 10,080 apartments within that area. They are shown on Drawing Nos. 561-04 and -09.

4.2 Heating Load Determination

There were a number of sources used for the determination of an average heating load. The first set of data, a running survey of 200 houses of PSE&G employees conducted for the last couple of years, showed that the average house has a 100,000 BTU/hr installed capacity heating system. The average winter load was 30,000 BTU's while the calculated average peak load is 52570 BTU/hr.

Another source was a random survey of PSE&G electric and gas customers. Thirteen months billing data for the year September '77 to September '78 was used and peak heat losses on the basis of zero degrees outdoor and 70 degrees indoor temperatures were calculated. For rural houses, peak heat losses of 63,000 BTU/hr and 71,000 BTU/hr were calculated. For urban dwellings, the values varied between 33,000 and 38,000 BTU/hr.

A more generalized calculation had been run based on gas consumption data from Brown's Directory of North American Gas Companies 1977. This calculation was based on a comparison between the gas use figures of residential customers with no heating and with heating installations in their houses, and resulted in an average maximum heat demand of 47,570 BTU/hr per customer. This same calculation also showed that the average winter load for 1977 was 42% of the peak.

Based on this data, we have assigned a 60,000 BTU/hr peak load for single family housing and a 40,000 BTU/hr peak load for apartments located in small multi family dwelling units, as for example garden apartments. As mentioned in the previous section, these types of buildings are the subject of this study.

Based on the above assigned peak heating requirements, a block of single family houses will require 600,000 BTU's or six blocks of those will represent a load of 3.6 million BTU/hr. This, projected onto a square mile, gave us a 151.2 million BTU/hr heating load density. Same values for multi family dwellings are 1.6 million BTU/hr per block, 9.6 million BTU/hr for six blocks and 403 million BTU/hr for one square mile. In generalized calculations we will equate the specific loads with 160 million BTU/hr per square mile for single family and 420 million BTU/hr per square mile for multi family dwellings. This will account for the heat losses of the distribution system.

4.3 Pipe Sizing

Due to the generalized nature of the study, a general formula of economic pipe sizes has been utilized as developed by Robert Kern[1]. The basic formula has been modified somewhat in the large 14" diameter and over-size range because of the high velocities and consequent high pressure drops it resulted in. The flows, velocities and pressure drops used in our investigation are summarized in Table XXVII.

4.4 In-House Heating Systems

According to PSE&G customer surveys[2], the overwhelming majority of single family houses and garden apartments have either forced warm air or hot water or steam heating systems. Less than 4% of the single family houses and less than 10% of the garden apartments are heated by other means such as room heaters or through-the-wall heating units. While among the single family houses surveyed about half has hot water or steam heating systems and the other half forced warm air systems, two-thirds of the garden apartments are equipped with hot water or steam systems and only one-third with forced warm air heating systems.

[1] Kern, Robert, Useful Properties of Fluids Chem. Eng. Dec. 23. 74. p. 58.

[2] PSE&G Residential Electric and Gas Appliance Survey-1976, Rates Department-Load Research, Issued July 1977.

Buildings with two or more living units but excluding high rise apartments have overwhelmingly hot water or steam systems with only 10% of them on forced warm air.

There have been very few, if any, steam heating systems installed in single family houses or small apartments in the last ten years (about 16% of existing housing). It is meaningful to look at the age of the houses and the age of the heating equipment surveyed. One quarter to one fifth of the heating systems are older than 20 years. Less than 59% of the heating systems are over ten. Since systems older than twenty years can be expected to be in a condition where replacement is imminent, it is reasonable to consider that in ten years time there will be no steam heating systems in the houses. Consequently, we assumed that only hot water and forced warm air systems are to be considered for conversion to district heating. The detailed survey figures are summarized and shown on Table XXVIII.

There is no survey data available on the operating temperatures of the different systems in those buildings. We assumed that most of them are of the conventional design and will use that as a basis for further calculations. The "conventional design" means the following:

- hot water system
  200 ^{0}F supply - 180 F ^{0} return
- forced warm air system
  115 ^{0}F supply - 75 F ^{0} return

4.5 Domestic Hot Water

There is no direct survey data on the use of domestic hot water. Published figures gave us an average of 35 gallons per person of daily domestic hot water used at 140°F. Since there is an average of three people living in a single family or small multi family dwelling in the survey area, this means 105 gallons of hot water used per day per dwelling. Assuming 40°F minimum city water temperature, the heating load represented by providing domestic hot water equals approximately 100,000 BTU/day. This then equals 6½% of the peak heating load of a single family and 10% of the peak heating load of a small multi family dwelling.

The significance of supplying domestic hot water by the district heating system, however, is much greater than what those figures indicate. This load is practically constant throughout the year, while the heating or cooling load is seasonal and varies between peak and minimum averaging at less than 50% of peak. So the heat energy supplied to domestic hot water user related to heating customers is as follows:

Domestic hot water - $100000 \times 365 = 36.5\times10^6$ BTU/yr

Heating	Single family dwell.	$60000\times.5\times24\times240=172.8\times10^6$ BTU/yr
	Multi family dwell.	$40000\times.5\times24\times240=115.2\times10^6$ BTU/yr
	Apartments	$20000\times.5\times24\times240=57.6\times10^6$ BTU/yr

Consequently the heat energy delivered to households in the three categories for domestic hot water is 21.1, 31.7 and 63.4 percent respectively of the energy delivered annually for heating.

4.6 Present Fuel Use and Fuel Cost

As shown in par. 4.2 we have assigned average peak heat requirements for the types of housing investigated. On that basis one can calculate the annual fuel requirements as follows:

	Single Family dwell.			Small Multi-Family dwell.		
Peak heat load-BTU/hr		60000			40000	
Design temp. diff-^{0}F	70-10=60					
BTU/deg. day		24000			16000	
Deg. days (in 1977)	5155					
Annual net heat load- 10^6BTU		123.72			82.48	
Fuel required (@ 62.5% av. eff.)						
- 10^6BTU		197.95			131.97	
or - kWh		36250			24166	
Fuel	oil	gas	el.	oil	gas	el.
Spec. cost - $*	-.50	-.30	0.045	-.50	-.30	-.045
Annual cost - $	710	594	1631	473	396	1088

The annual "1977 Rate Statistics" of PSE&G can serve as a check on the above figures. Both electric and gas residential heating customers are covered there (RHS and HGS).

* oil-$/gal., gas-$/therm., electr.-$/kWh

The figures are as follows:

Average Revenue	RHS	HGS
Energy used for heating	9758 kWh	1294 therms
Av. annual bill - $	764.80	502.32
Av. ann. bill of nonheat customer	335.92	132.40
Appr. bill for heating-$	428.88	369.92

The 1294 therms shown above is equivalent to 928 gal. of No. 2 oil and at a price of $.50 per gallon would cost $464 annually.

One can see that the oil and gas cost figures coincide very closely with the figures of the first tabulation for a small multi-family dwelling. The electric heat figure is not representative since most of the electrically heated houses are apartments in high-rises with a heat loss of about half of that of a garden apartment. On that basis the electric energy cost figures are also in the same ballpark.

5. Calculations

5.1 Distribution Connection Schemes

The basis for the selected heat loads, lot sizes and pipe sizing have been explained in par. 4. There are three alternative piping layouts worked out to connect buildings to a heat distribution network. The difference is in the location of the lines in the immediate vicinity of the buildings, as follows:

Connection Scheme I	All distribution lines on public thoroughfares with the connecting individual branches only crossing private front or back lawns.
Connection Scheme II	All distribution lines on public thoroughfares but house connection branches extend across side fence to pick up two houses in front and two at the back of them.
Connection Scheme III	The block main is the only line on public thoroughfares. All the lines supplying individual blocks run on back fence lines and branch to each building across private back lawns.

The implications are obvious. Scheme I does not interfere with private property rights since lines on private property run only to houses actually connected to the system. This however forces all the other lines to be built under paved surfaces, and amidst traffic. Both are significant cost factors. Also it requires 20% more piping than any of the other two schemes.

Schemes II and III interfere to a differing extent with property rights and therefore involves acquisition of easements. This legal difficulty is well balanced by the considerable cost savings it facilitates. In our calculations we have assumed that all the lines are buried, but it is also technically feasible to run the lines along the fences above ground for a possible further reduction of cost.

5.2 Supply Temperature Differentials

The temperature differential of supply and return water defines the mass flow and therefore the pipe size. At a 20°F differential 10000 BTU/hr is rejected by an approximately 1 gpm flow of water. For single family houses we have investigated 20, 40, 60 and 120°F differentials, while for small multi-family dwellings we eliminated the 20°F differential and added the 200°F one.

Corresponding typical system supply and return temperatures could be as follows:

Δt = 20°F	200 - 180°F
= 40°F	210 - 170°F
= 60°F	230 - 170°F
= 120°F	290 - 170°F
= 200°F	390 - 190°F

Obviously the last one is a high pressure (>225 psig) system and raises questions of safety entering small users' premises.

5.3 Distribution System for Single Family Houses

The distribution networks developed on the previously indicated basis are shown on drawings 561-01 to 03 with subscripts A to D indicating the four temperature differentials considered. Each drawing lists also the total length of piping involved and its estimated total cost, and its cost per unit housing.

Drawing 561-4 (subscripts A to D as before) shows a distribution system for a square mile of houses, that is 42 areas of houses as shown on Dwgs. 561-01 to 03. The cost summary of these distribution networks is on Table XXVI.

5.4 Distribution System for Multi Family Dwellings

The distribution networks developed on the previously indicated basis are shown on drawings 561-06 to 08 with subscrips A to D indicating the four temperature differentials considered. Each drawing lists also the total length of piping involved and its estimated total cost, and its cost per unit housing.

Drawing 561-9 (subscripts A to D as before) shows a distribution system for a square mile of houses, that is 42 areas of houses as shown on Dwgs. 561-06 to 08. The cost summary of these distribution networks is on Table

5.5 In-House Equipment (Conversion or New Connection)

Drawings 561-11/A,B,-12/A,B and 13/A,B show some typical schemes of connection to existing or new Warm Water (WW) or Hot Air house heating systems. In all cases domestic hot water is also generated by the district heating system. The hot water generation is set up with adequate storage tank capacity. This way no heating is required at high comfort heating loads or that no more than daily average domestic hot water heat loads are to be carried by the system. The temperature differentials shown are just examples. By the modification of flows and heating surfaces any of the schemes can be applied to a number of other temperature differential systems. The only exception to this is that the high pressure (390°F supply) cannot be allowed to enter the internal heating system directly for safety reasons.

All the systems have constant flow of district heating water at temperatures variable according to outdoor temperatures with in-house thermostats to set the desired indoor temperature and to shut off the in-house system when not needed. Practically the same control arrangement operates the domestic hot water system, regulating the operation of a circulating pump in accordance with storage tank temperature.

The installed cost of these systems is estimated as follows:

In-House Heating System	Warm Water Heating	Hot Air Heating
system temp.	<290°F	<290°F
Single family house	2300	2500
Small multi family house	4000	5300
Boiler or hot air heater installation cost -		
Single family house	1100	1800
Small multi family house	1300	2500
Differential cost of new house connected to heating system -		
Single family house	1200	700
Small multi family house	2700	2800

5.6 Investment and Operating Cost

Drawings 561-17 through -20 show in graphic form the investment and pumping energy cost of the different systems.

The trend lines shown are only a rough approximation, since there are insufficient points to decide on a mathematical basis. Even so, one can arrive at the required deduction, when the cost considerations are combined with other technical ones.

First one can see that the high temperature (290< ts <390) supply systems are very expensive in first cost, give only insignificant pumping cost reduction and require a high pressure, which will make the rest of the equipment in the system also expensive. Therefore, distribution systems supplying temperatures of less than 290°F need only be considered.

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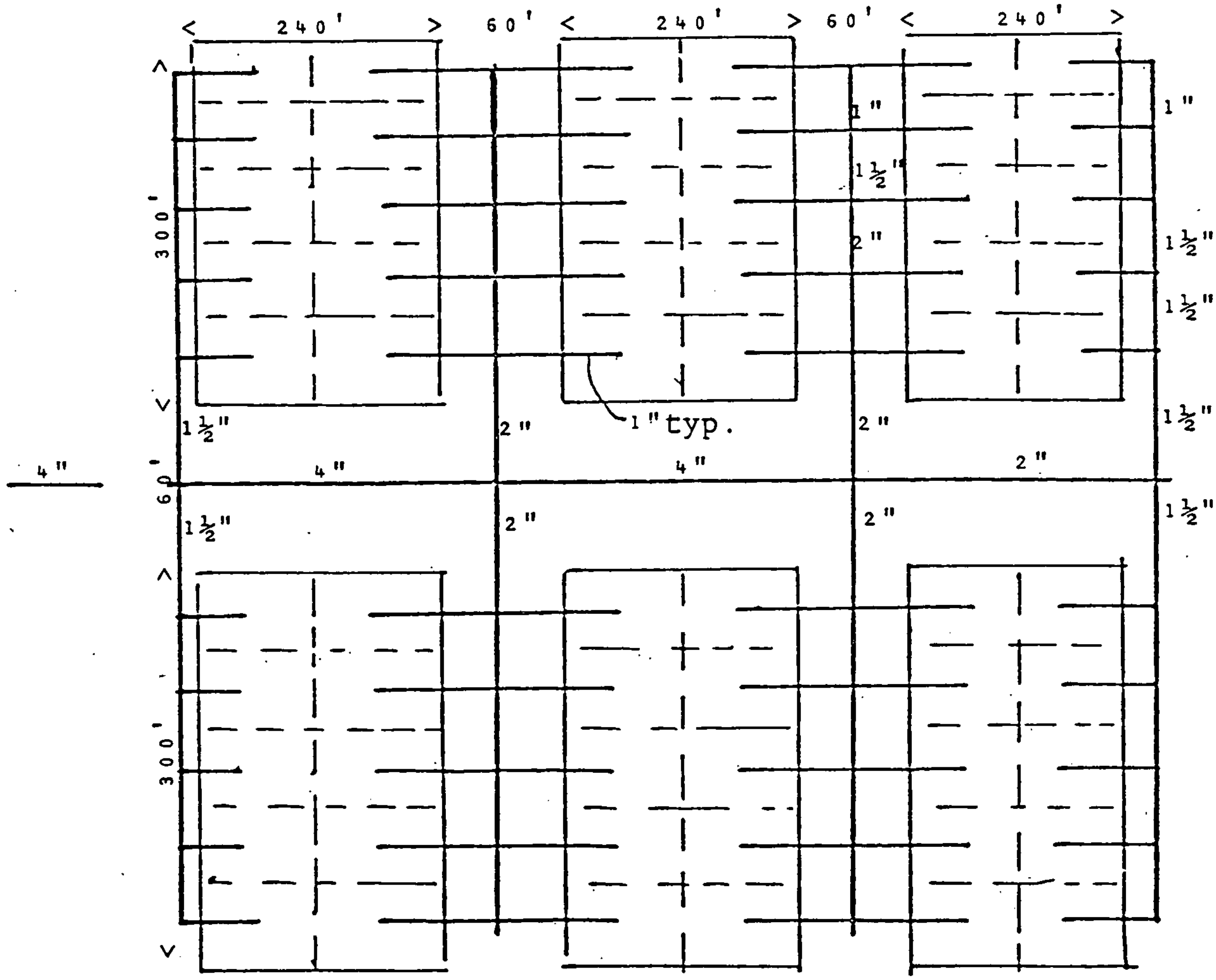
NEW JERSEY 07024

NO. 561-01/A

60000 BTU/hr/lot
3.6 x 10^6 BTU/hr total

LTHW @ $\Delta t = 20^0F$
360 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	2760'	3000'	201000
1½"	720	-	28800
2"	1020'	-	44880
4"	600'	-	41400
	5100'	3000'	316080

$\frac{316080}{60}$ = 5268 $/lot

ALTERNATIVE HOUSE CONNECTION SCHEME I - SINGLE FAMILY HOUSE

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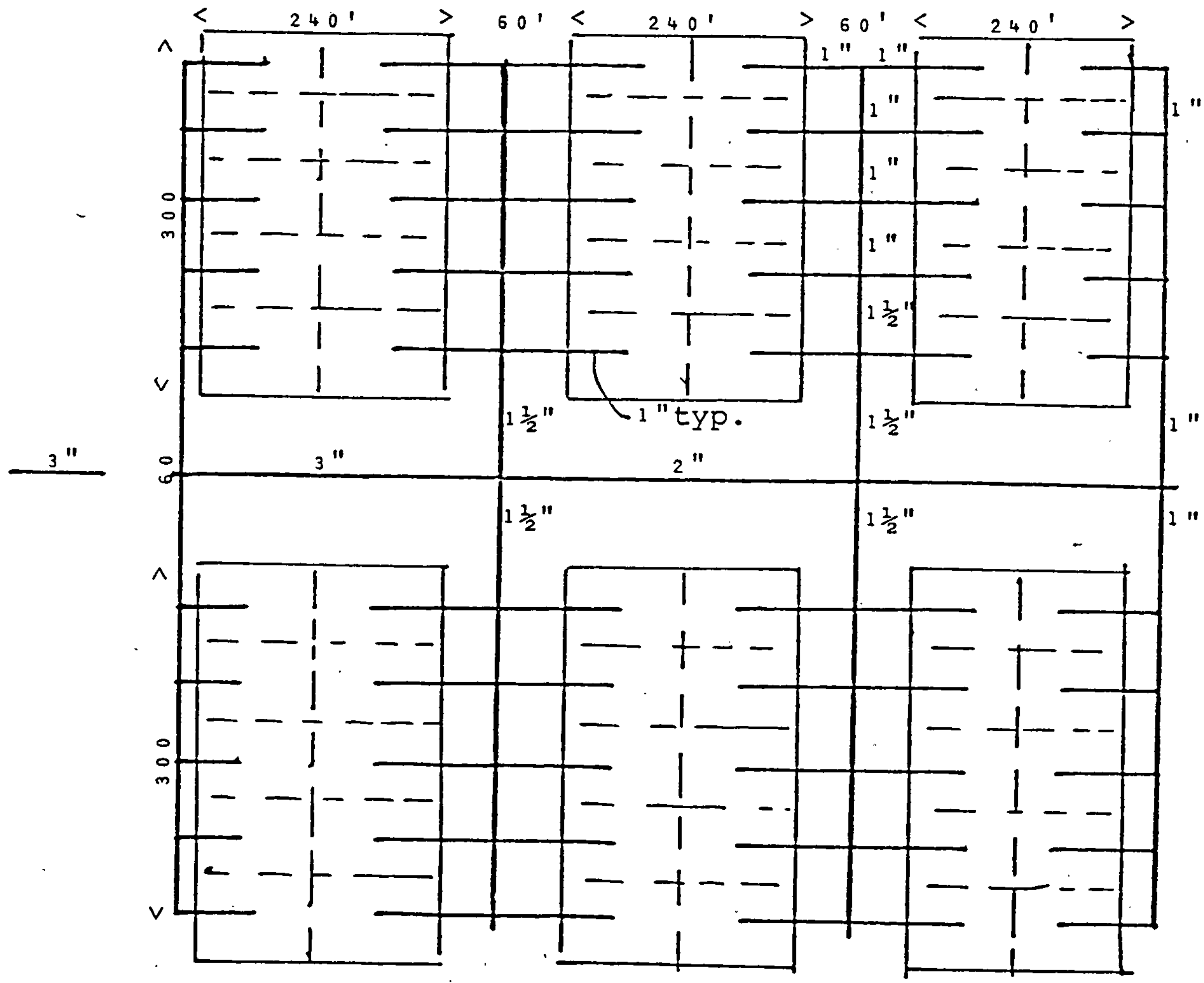
NO. 561-01/B

60000 BTU/hr/lot
3.6 x 10^6 BTU/hr total

LTHW @ $\Delta t = 60^{\circ}F$
120 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	3720'	3000'	241800
1½"	780'	-	31200
2"	300'	-	13200
3"	300'	-	15360
	5100'	3000'	297640

$$\frac{297640}{60} = 4961 \text{ \$/lot}$$

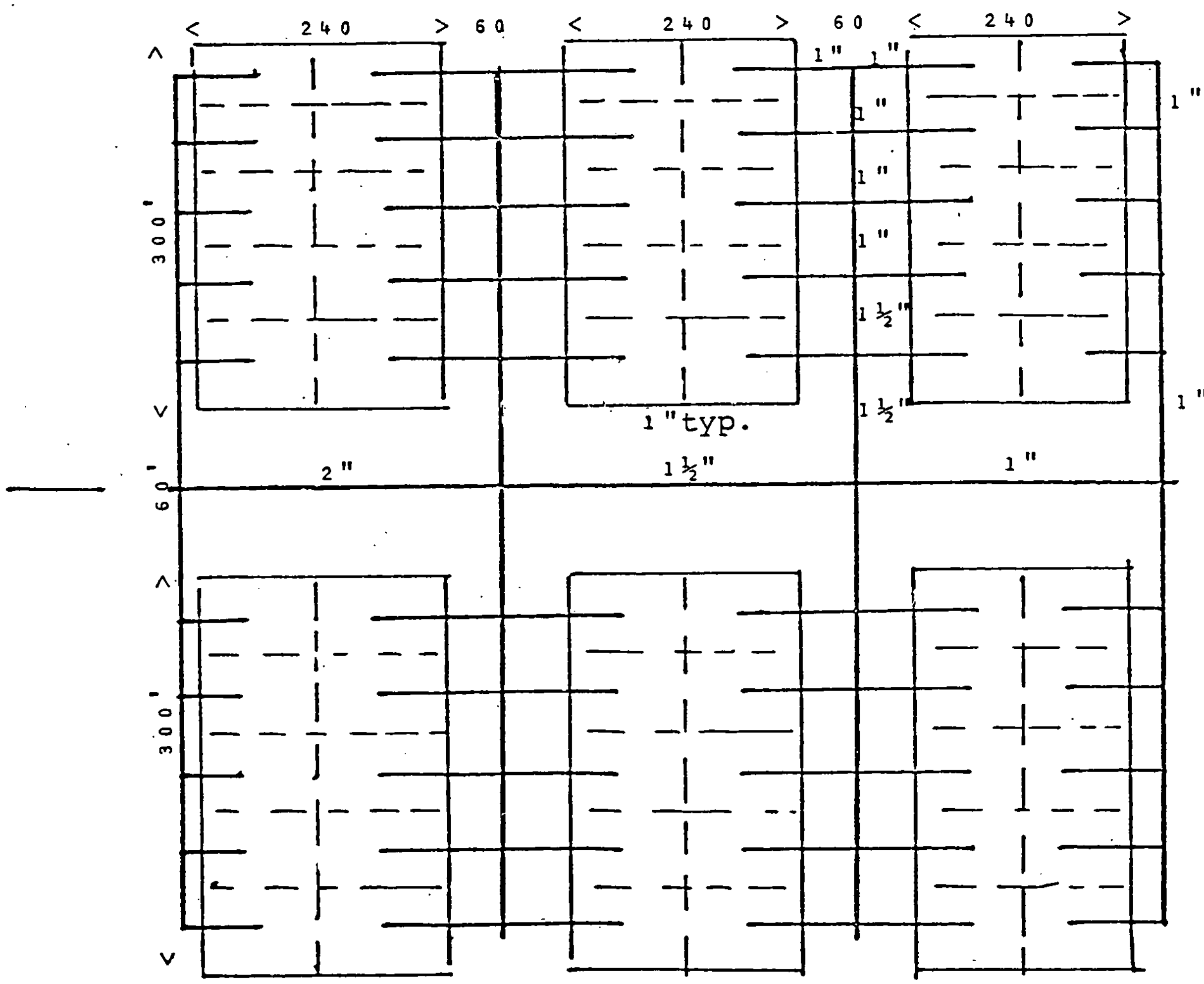
ALTERNATIVE HOUSE CONNECTION SCHEME I - SINGLE FAMILY HOUSE

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-01/C

60000 BTU/hr/lot
3.6 x 10^3 BTU/hr total

LTHW @ $\Delta t = 120^0$F
60 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	4020'	3000'	253800
1½"	780'	-	31200
2"	300'	-	13200
	5100'	3000'	298200

$$\frac{298200}{60} = 4970 \text{ \$/lot}$$

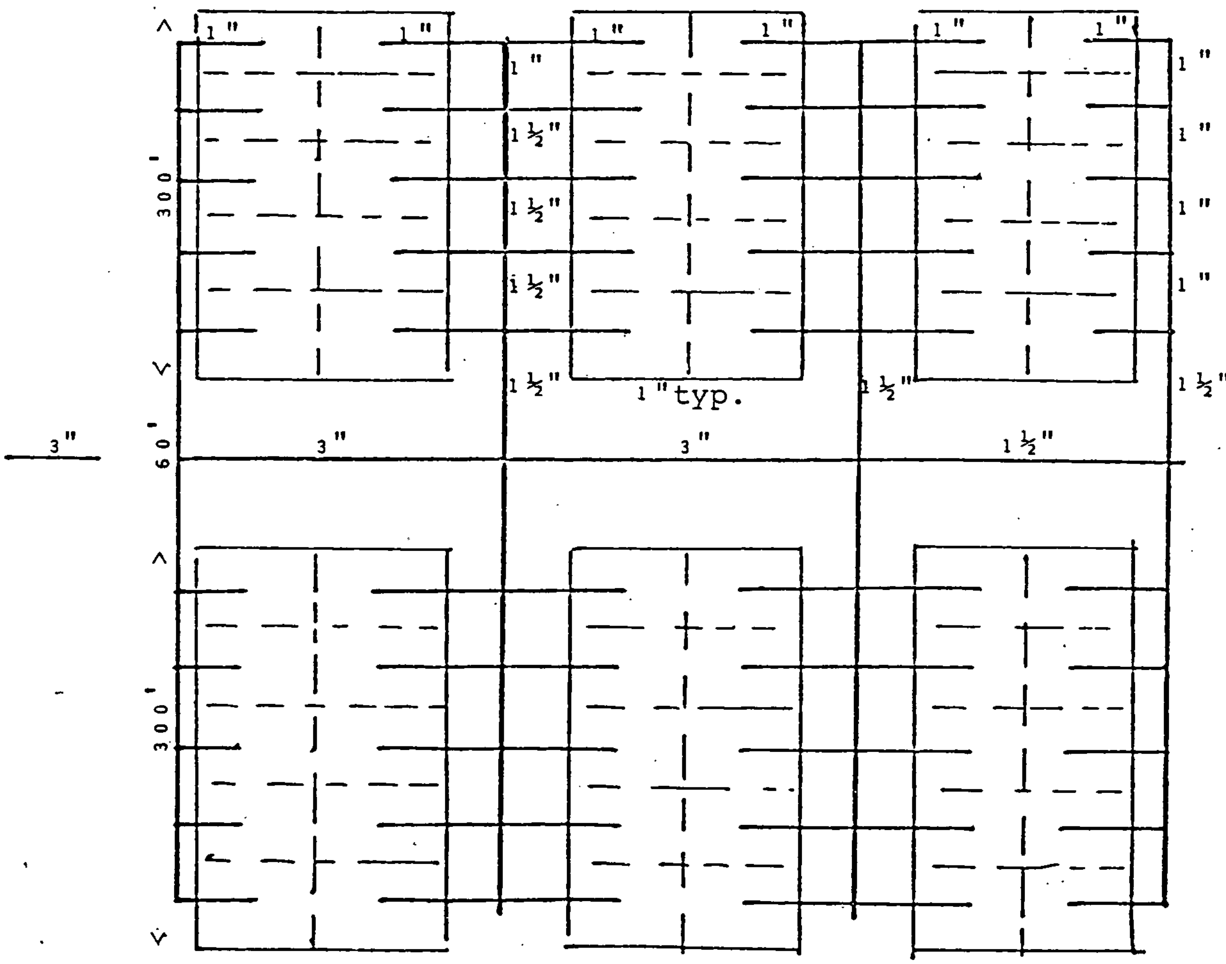
ALTERNATIVE HOUSE CONNECTION SCHEME I - SINGLE FAMILY HOUSE

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-01/D

60000 BTU/hr/lot
3.6×10^6 BTU/hr total

LTHW @ $\Delta t = 40^0F$
180 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	3240'	3000'	222600
1½"	1260'	-	50400
3"	600'	-	38400
	5100'	3000'	311400

$$\frac{311400}{60} = 5190 \text{ \$/lot}$$

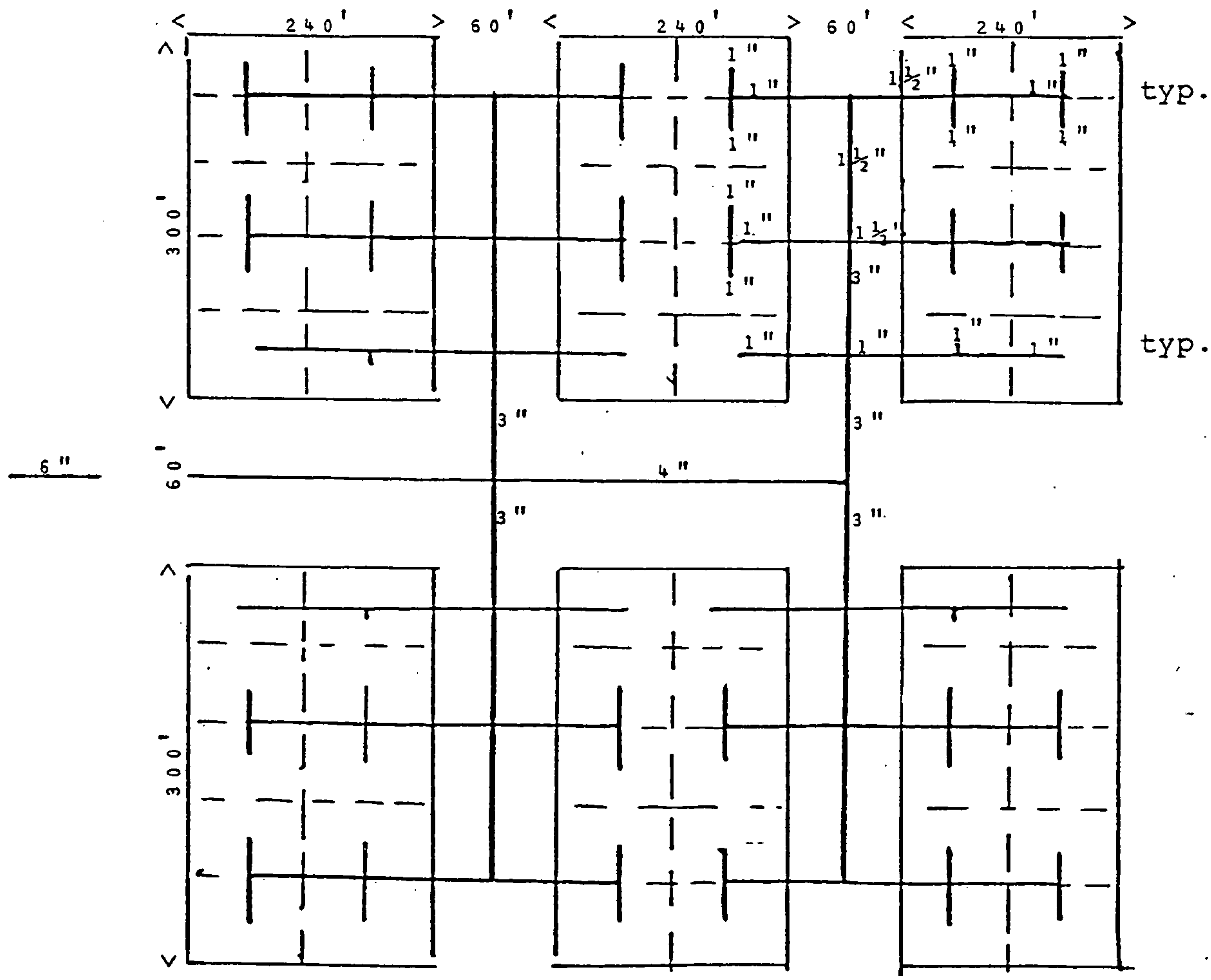
ALTERNATIVE HOUSE CONNECTION SCHEME I - SINGLE FAMILY HOUSE

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-02/A

60000 BTU/hr/lot
3.6×10^6 BTU/hr total

LTHW @ $\Delta t = 20^0F$
360 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	480'	3920'	140720
1½"	720'	400'	28800
3"	600'	-	38400
4"	300'	-	20700
6"	300'	-	26400
	2400'	4320'	255020

$\frac{255020}{60} = 4250$ $/lot

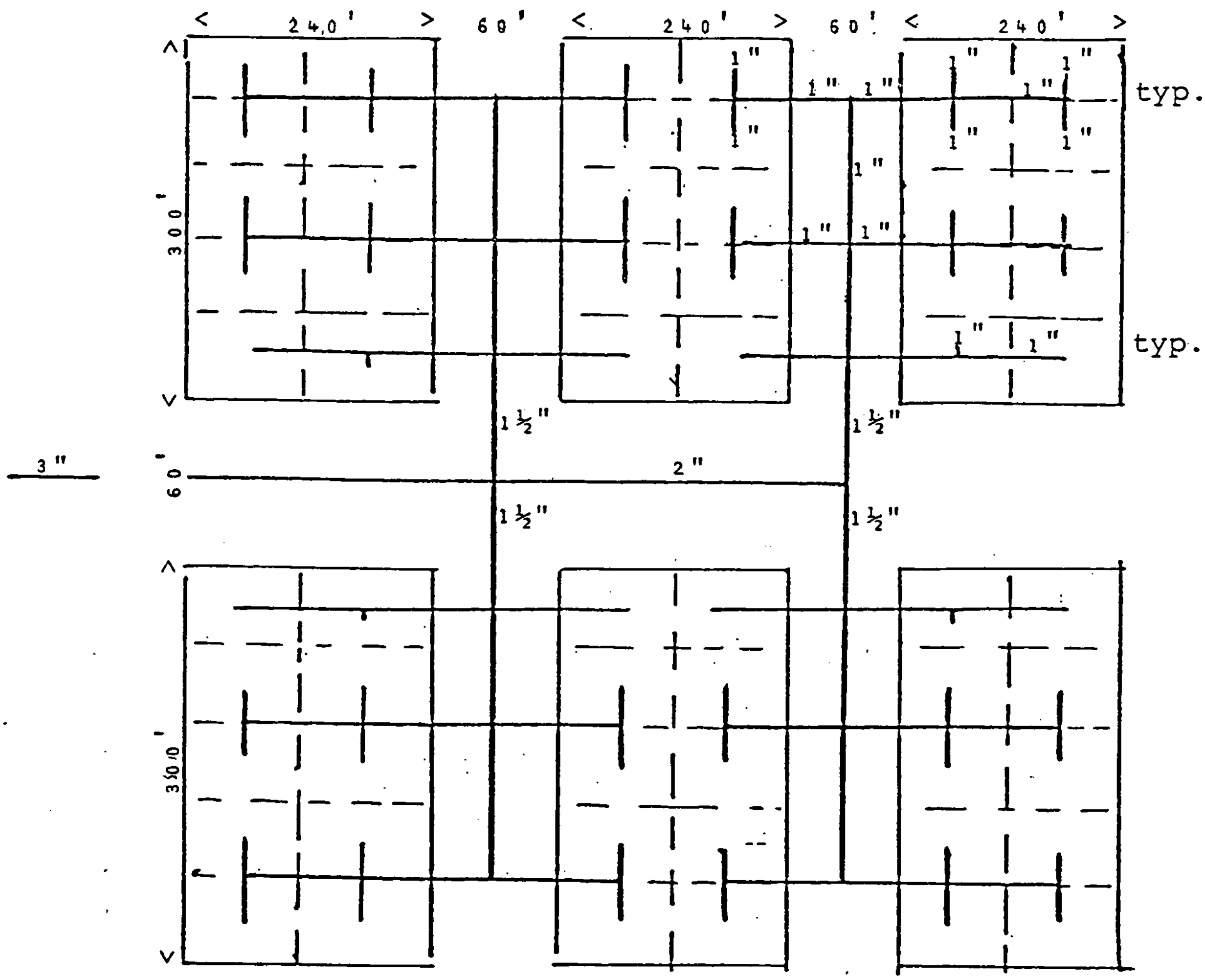
ALTERNATIVE HOUSE CONNECTION SCHEME II - SINGLE FAMILY HOUSE

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-02/B

60000 BTU/hr/lot
3.6×10^6 BTU/hr total

LTHW @ $\Delta t = 60^oF$
120 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	1200'	4320'	181320
1½"	600'	-	24000
2"	300'	-	13200
3"	300'	-	19200
	2400'	4320'	238320

$$\frac{238320}{60} = 3973 \text{ \$/lot}$$

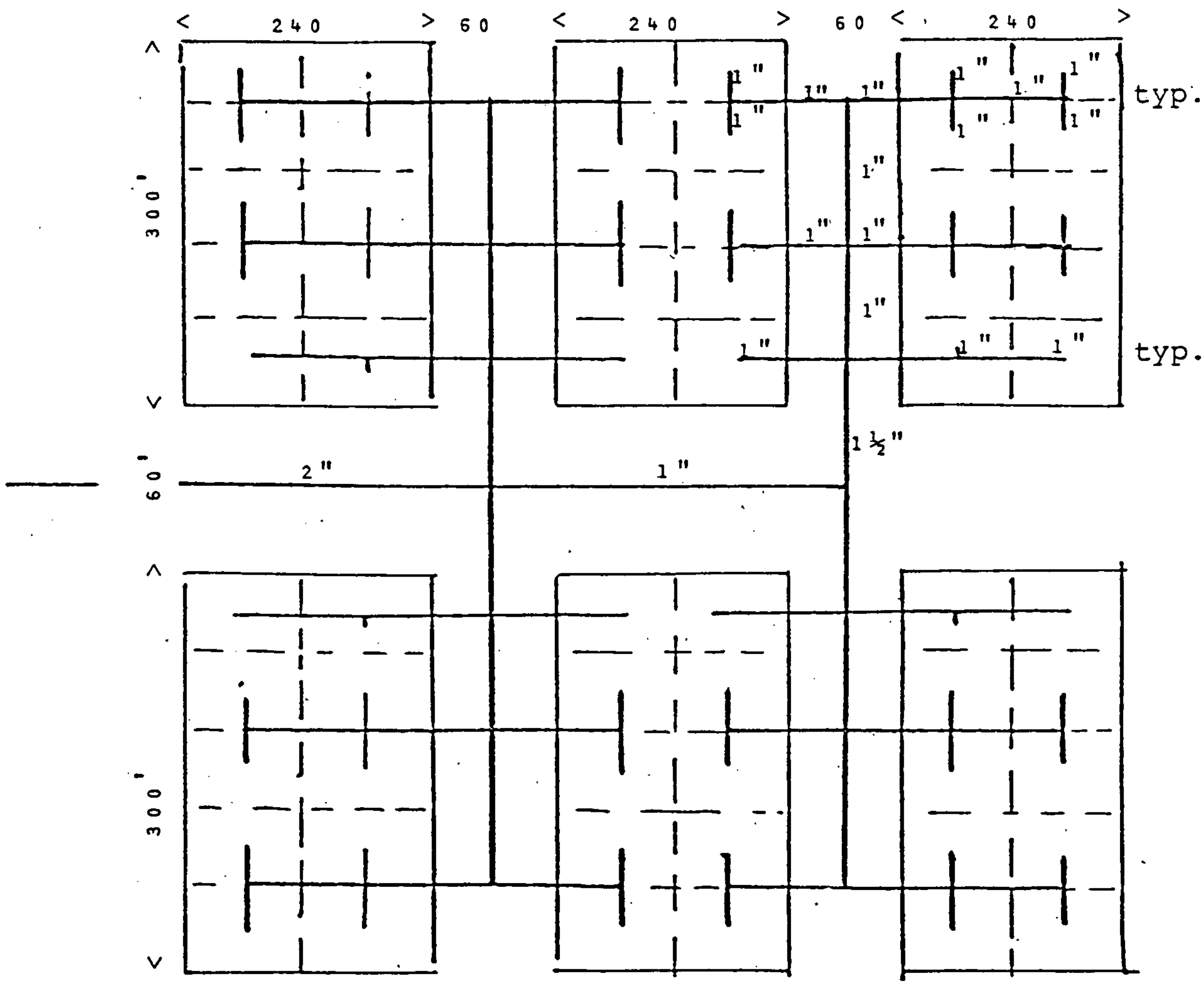
ALTERNATIVE HOUSE CONNECTION SCHEME II - SINGLE FAMILY HOUSE

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-02/C

60000 BTU/hr/lot
3.6 x 10^6 BTU/hr total

LTHW @ $\Delta t = 120^0F$
60 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	1200'	4320'	181920
1½"	900'	-	36000
2"	300'	-	13200
	2400'	4320	231120

$$\frac{231120}{60} = 3852 \text{ \$/lot}$$

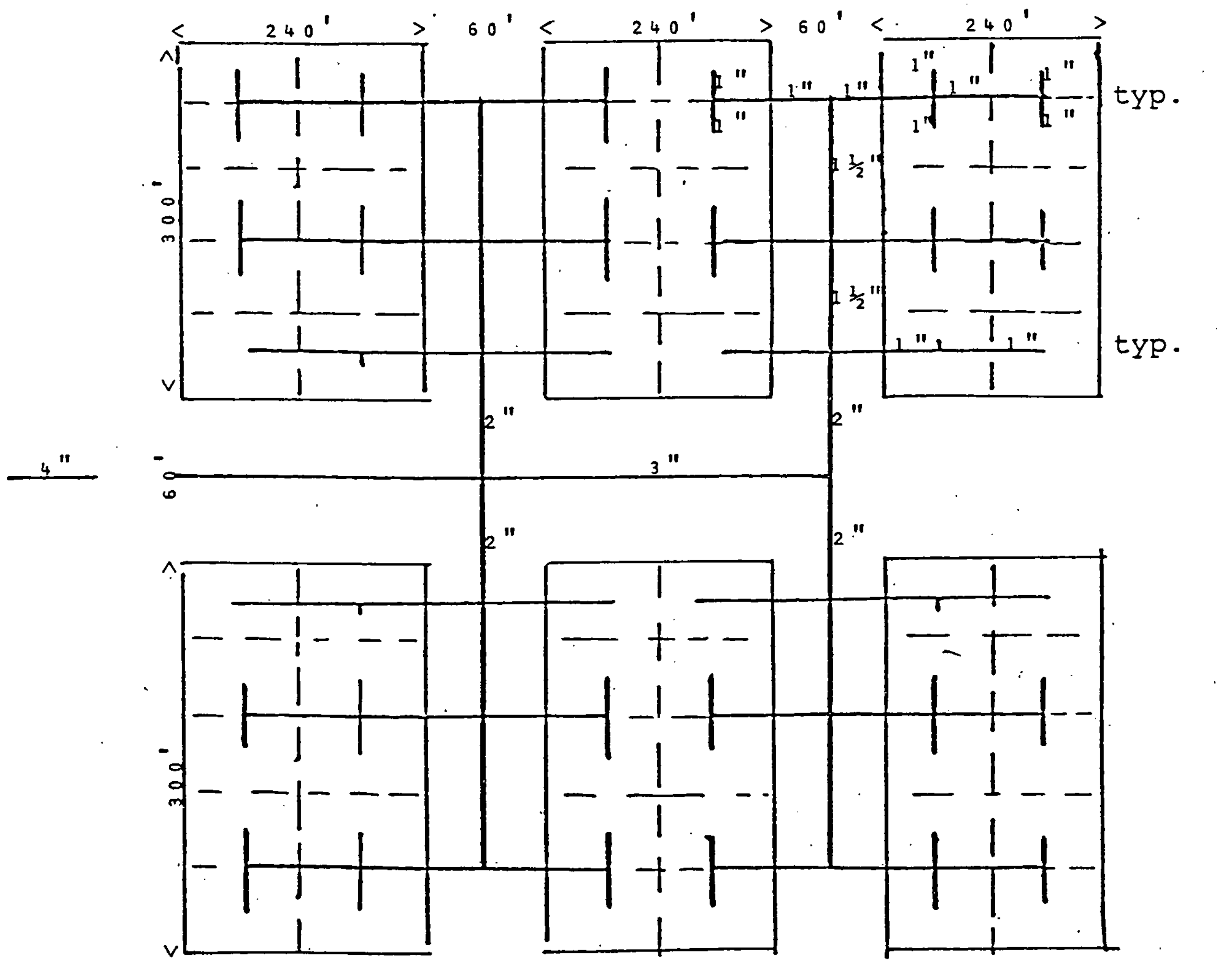
ALTERNATIVE HOUSE CONNECTION SCHEME II - SINGLE FAMILY HOUSE

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-02/D

60000 BTU/hr/lot
3.6 x 10^6 BTU/hr total

LTHW @ $\Delta t = 40^0F$
180 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	720'	4280'	161480
1½"	840'	-	33600
2"	240'	-	10560
3"	300'	-	19200
4"	300'	-	20700
	2400'	4280'	245540

$\frac{245540}{60}$ = 4092 $/lot

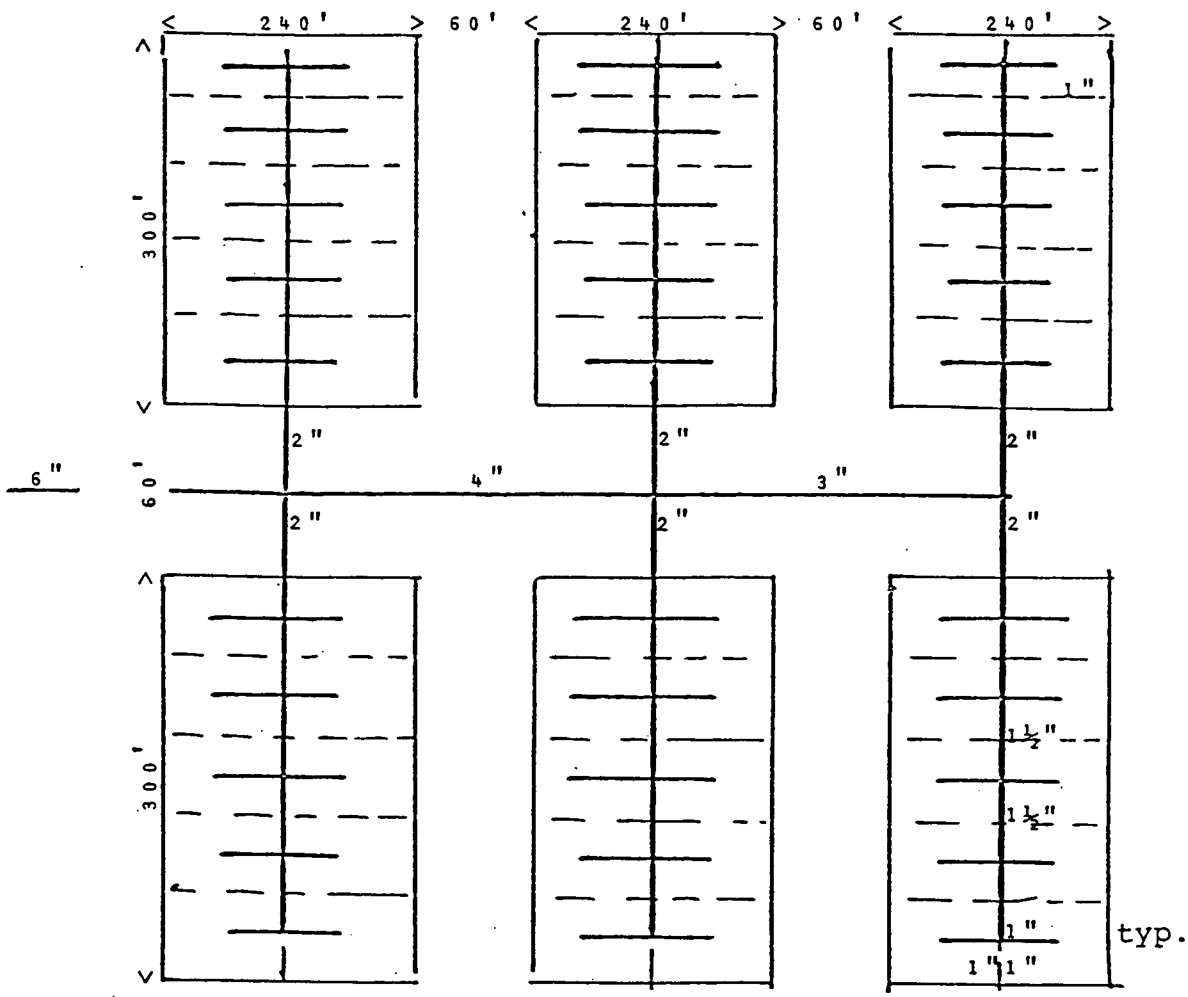
ALTERNATIVE HOUSE CONNECTION SCHEME II - SINGLE FAMILY HOUSE

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-03/A.

60000 BTU/hr/lot
3.6×10^6 BTU/hr total

LTHW @ $\Delta t = 20^0F$
360 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

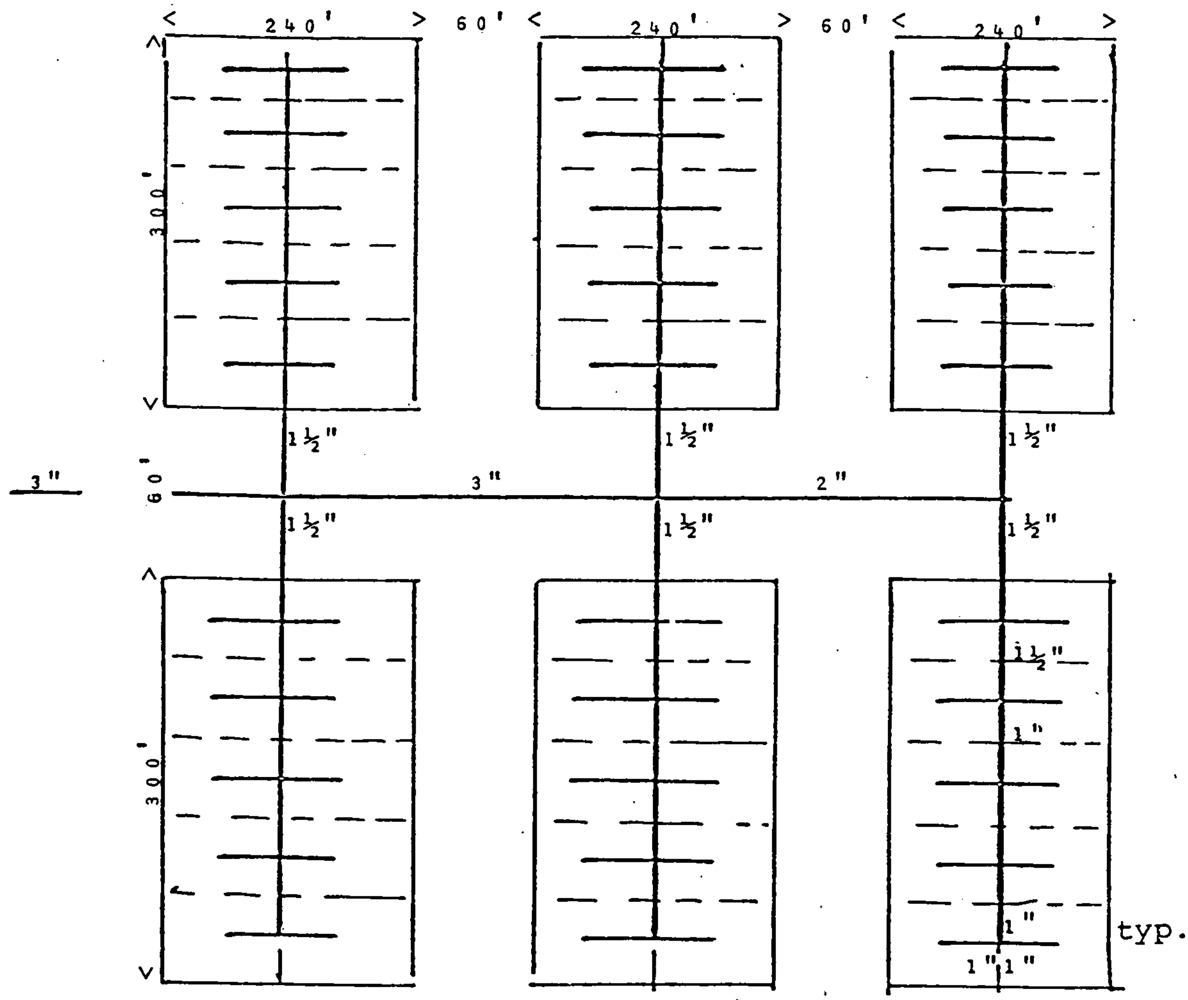
	Suburb.	Rural	$
1" ø	-	4560'	141360
1½"	-	360'	11160
2"	100'	900'	34100
3"	300'	-	19200
4"	300'	-	20700
6"	150'	-	13200
	930'	5820'	239720

$\frac{239720}{60} = 3995$ $/lot

ALTERNATIVE HOUSE CONNECTION SCHEME III - SINGLE FAMILY HOUSE

60000 BTU/hr/lot
3.6 x 10^6 BTU/hr total

LTHW @ $\Delta t = 60^0F$
120 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	-	5280'	163680
1½"	180'	540'	13940
2"	300'	-	13200
3"	450'	-	28800
	930'	5820'	229620

$$\frac{229620}{60} = 3827 \text{ \$/lot}$$

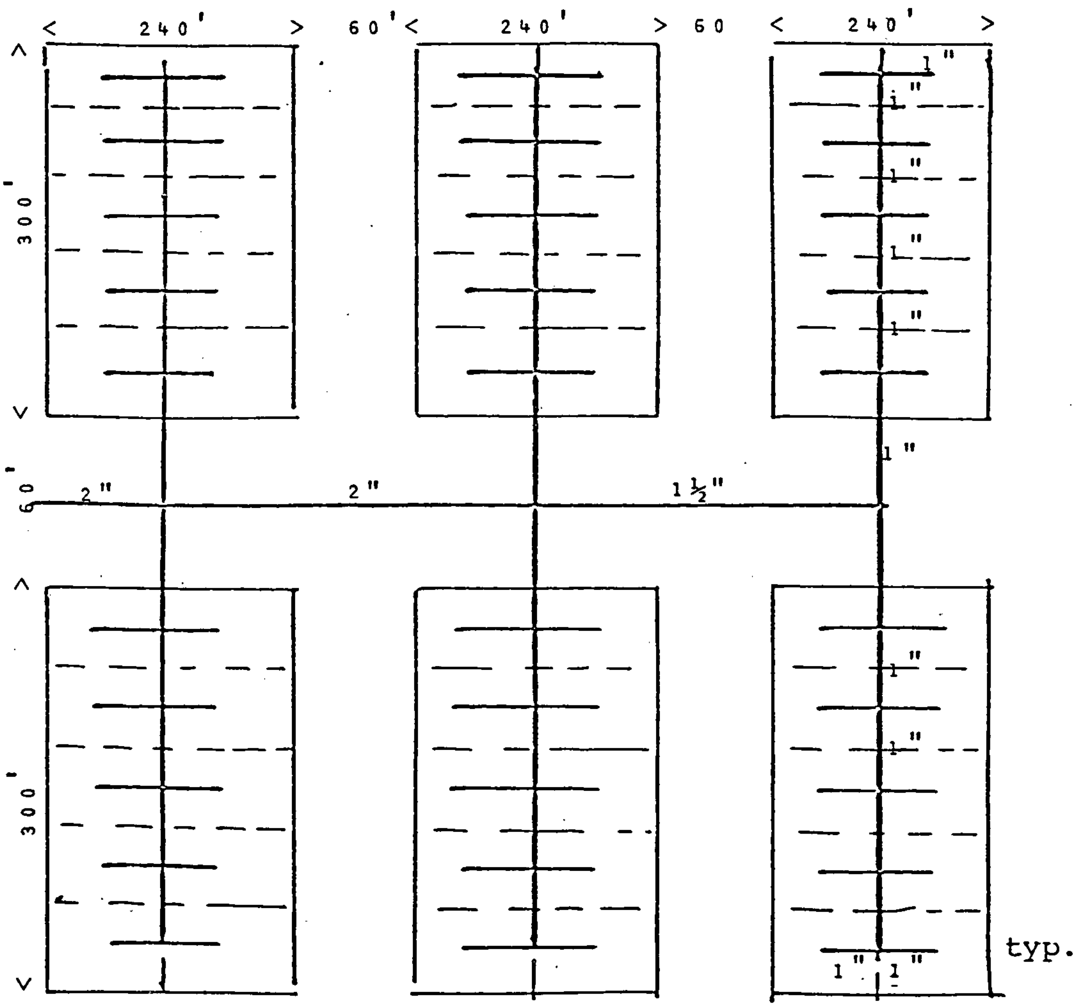
ALTERNATIVE HOUSE CONNECTION SCHEME III - SINGLE FAMILY HOUSE

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-03/C

60000 BTU/hr/lot
3.6 x 10^3 BTU/hr total

LTHW @ $\Delta t = 120^0F$
60 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

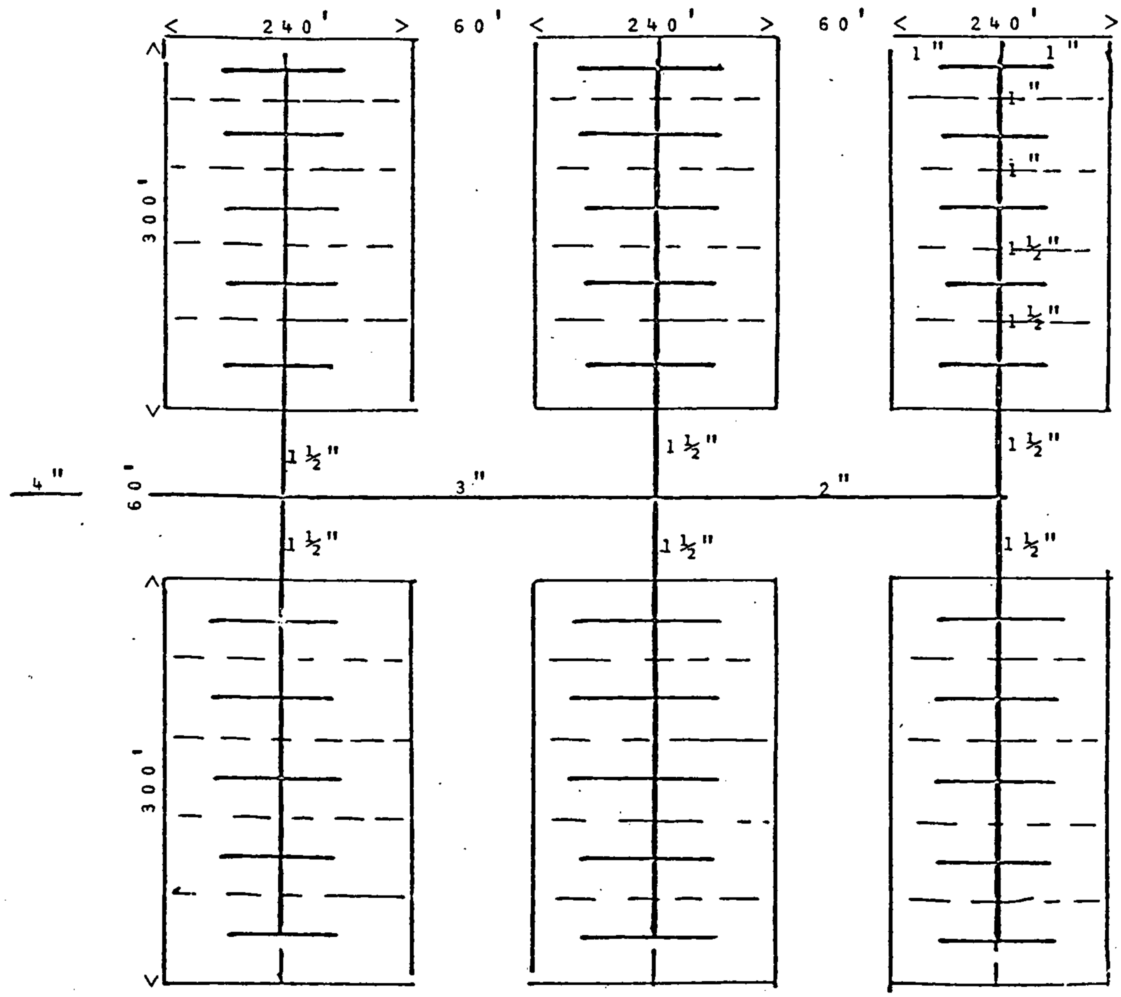
	Suburb.	Rural	$
1" ø	180'	5820'	187620
1½"	300'	-	12000
2"	450'	-	19800
	930	5820	219420

$$\frac{219420}{60} = 3657 \text{ \$/lot}$$

ALTERNATIVE HOUSE CONNECTION SCHEME III - SINGLE FAMILY HOUSE

60000 BTU/hr/lot
3.6 x 10^6 BTU/hr total

LTHW @ Δt = 40°F
180 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	-	4920	152520
1½"	180'	900	35100
2"	300'	-	13200
3"	300'	-	19200
4"	150'	-	10350
	930'	5820'	230370

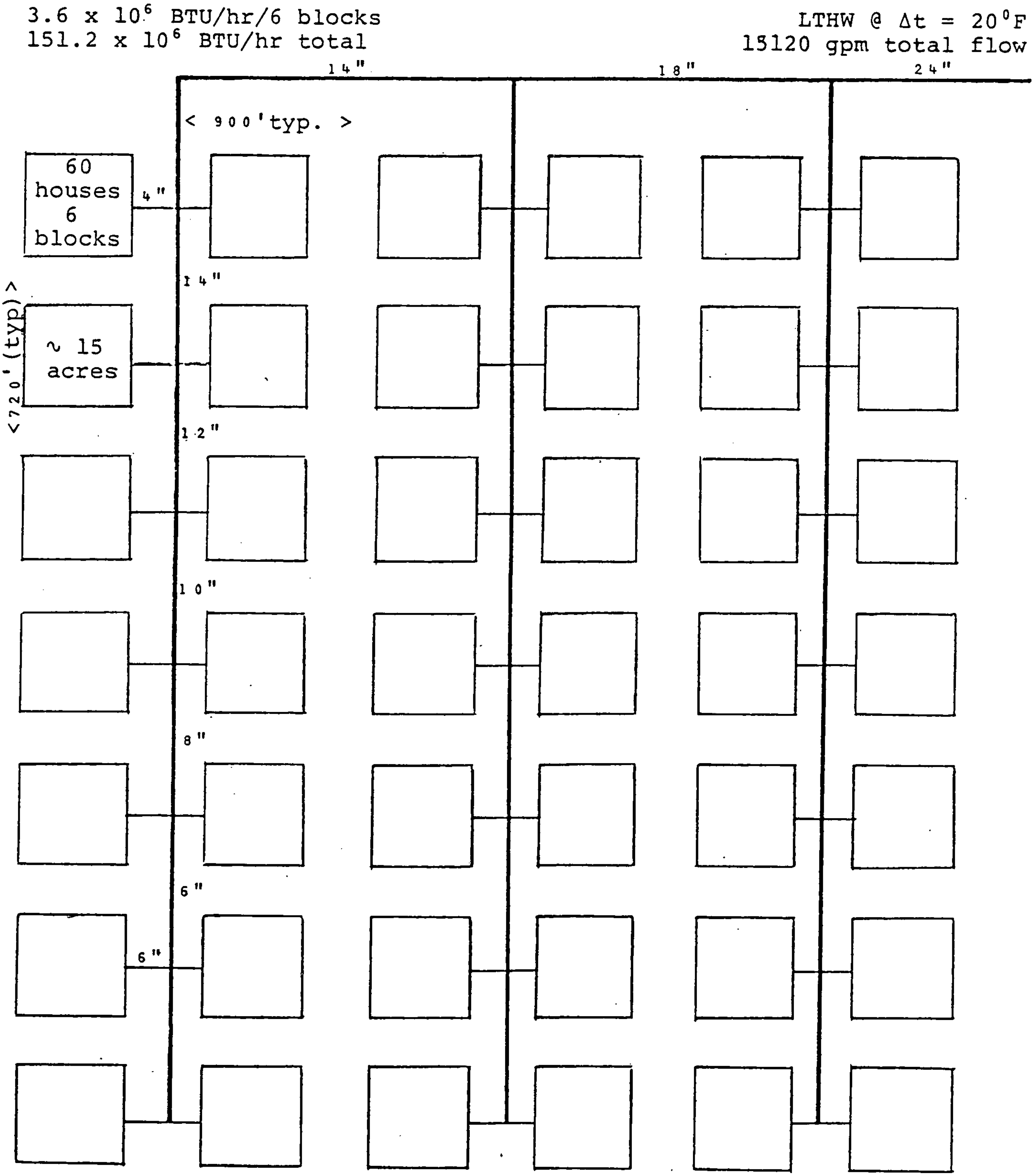
$$\frac{230370}{60} = 3839 \text{ \$/lot}$$

ALTERNATIVE HOUSE CONNECTION SCHEME III - SINGLE FAMILY HOUSE

TRANSFLUX international limited

FORT LEE, NEW JERSEY 07024

NO. 561-04/A



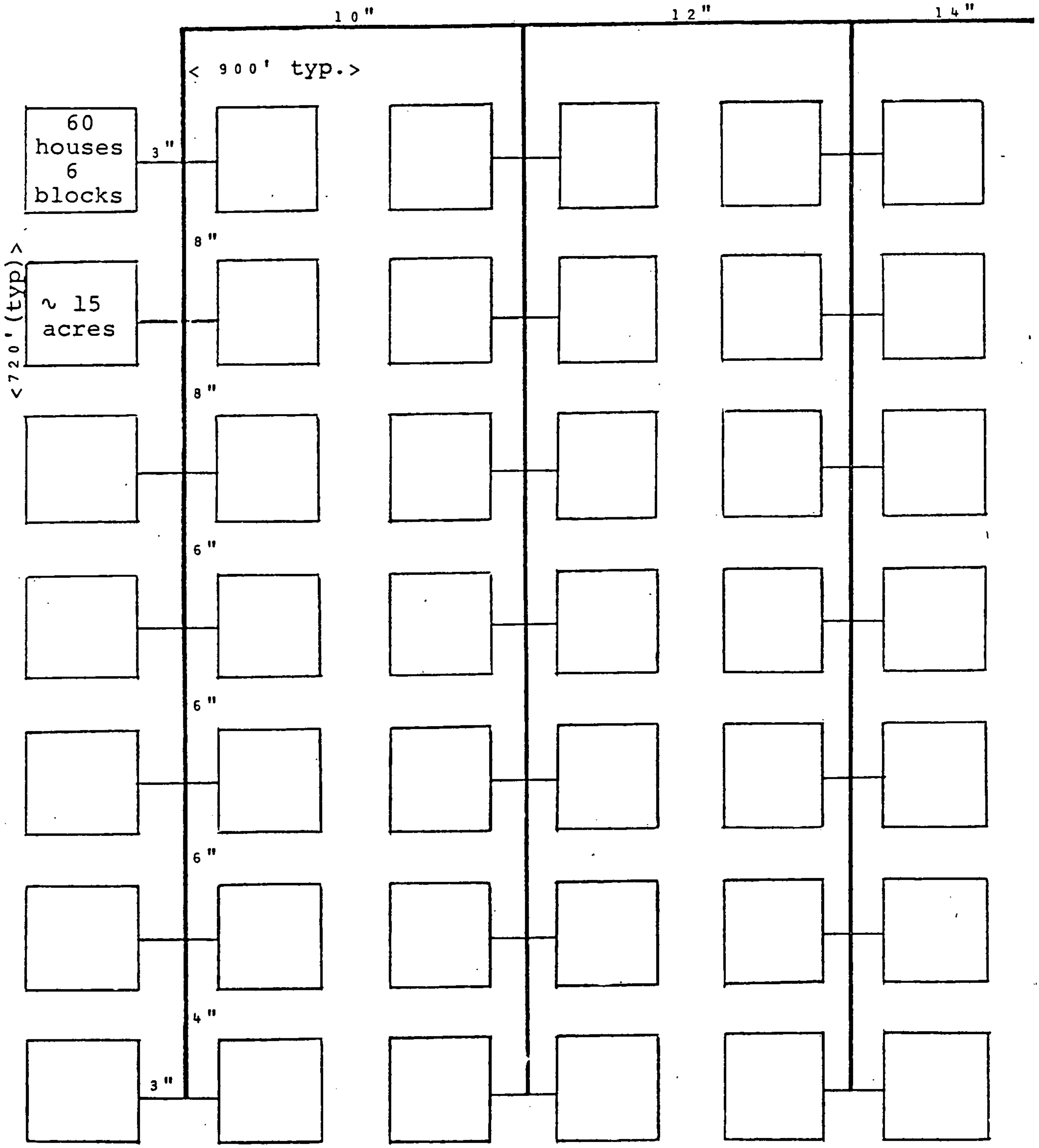
ALTERNATIVE TYPICAL 1 SQ. MI. AREA DISTRIBUTION - SINGLE FAMILY HOUSING

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-04/B

3.6×10^6 BTU/hr/6 blocks
151.2×10^6 BTU/hr total

LTHW @ $\Delta t = 60^0$F
5040 gpm total flow



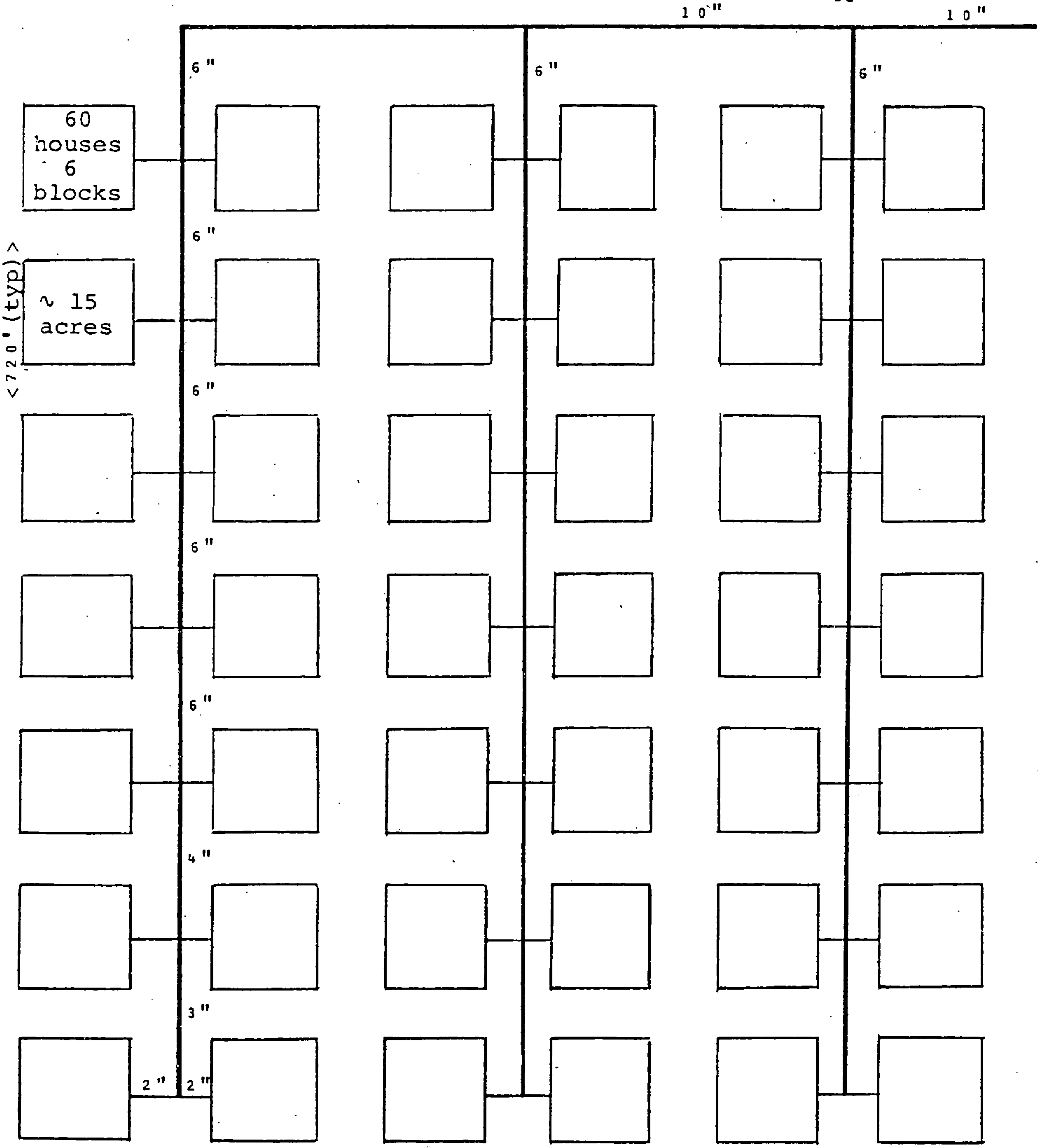
ALTERNATIVE TYPICAL 1 SQ. MI. AREA DISTRIBUTION - SINGLE FAMILY HOUSING

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-04/C

3.6 x 10^6 BTU/hr/6 blocks
151.2 x 10^6 BTU/hr total

LTHW @ Δt = 120°F
2820 gpm total flow



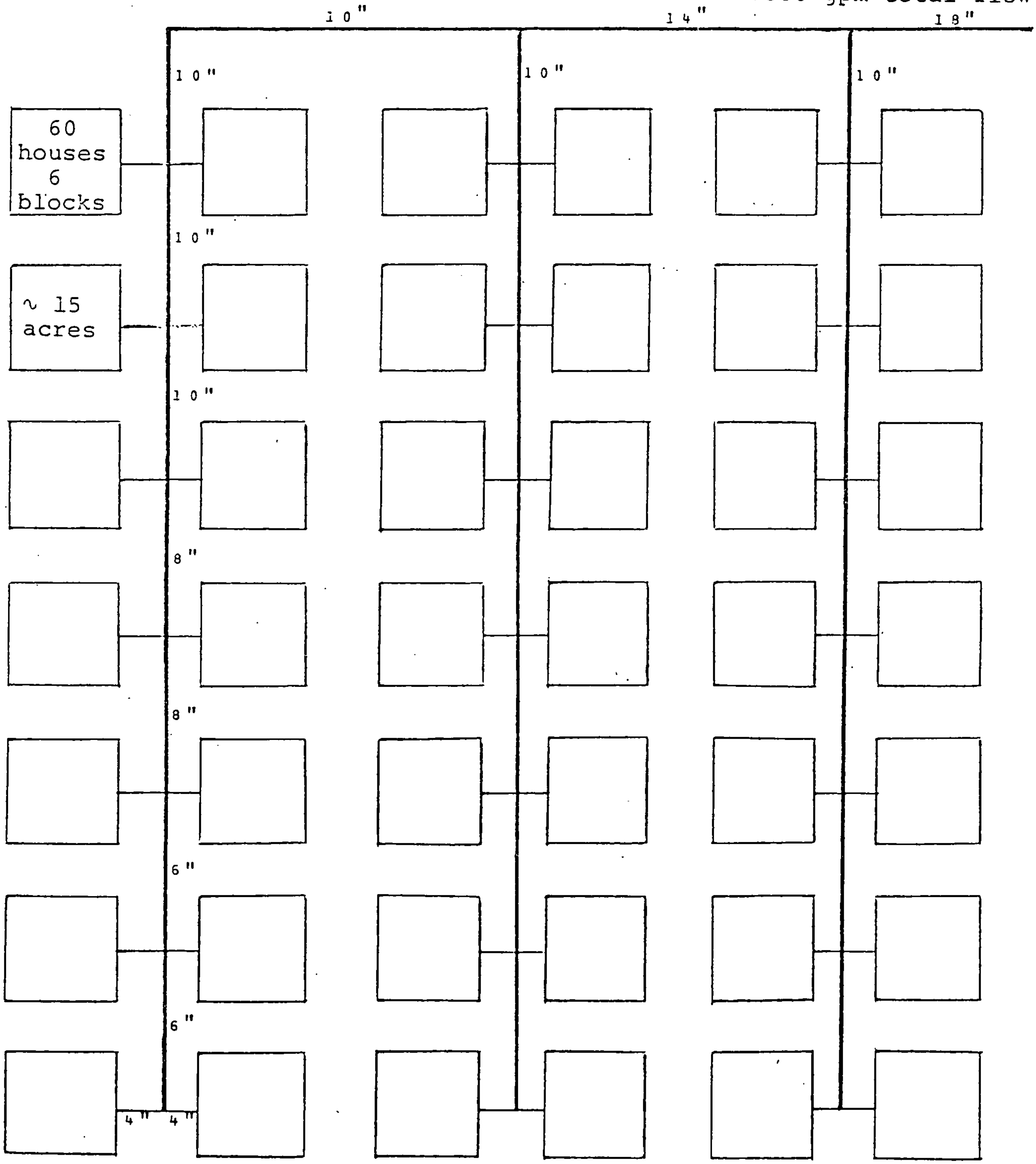
ALTERNATIVE TYPICAL 1 SQ. MI. AREA DISTRIBUTION - SINGLE FAMILY HOUSING

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-04/D

3.6×10^6 BTU/hr/6 blocks
151.2×10^6 BTU/hr total

LTHW @ $\Delta t = 40°F$
7560 gpm total flow



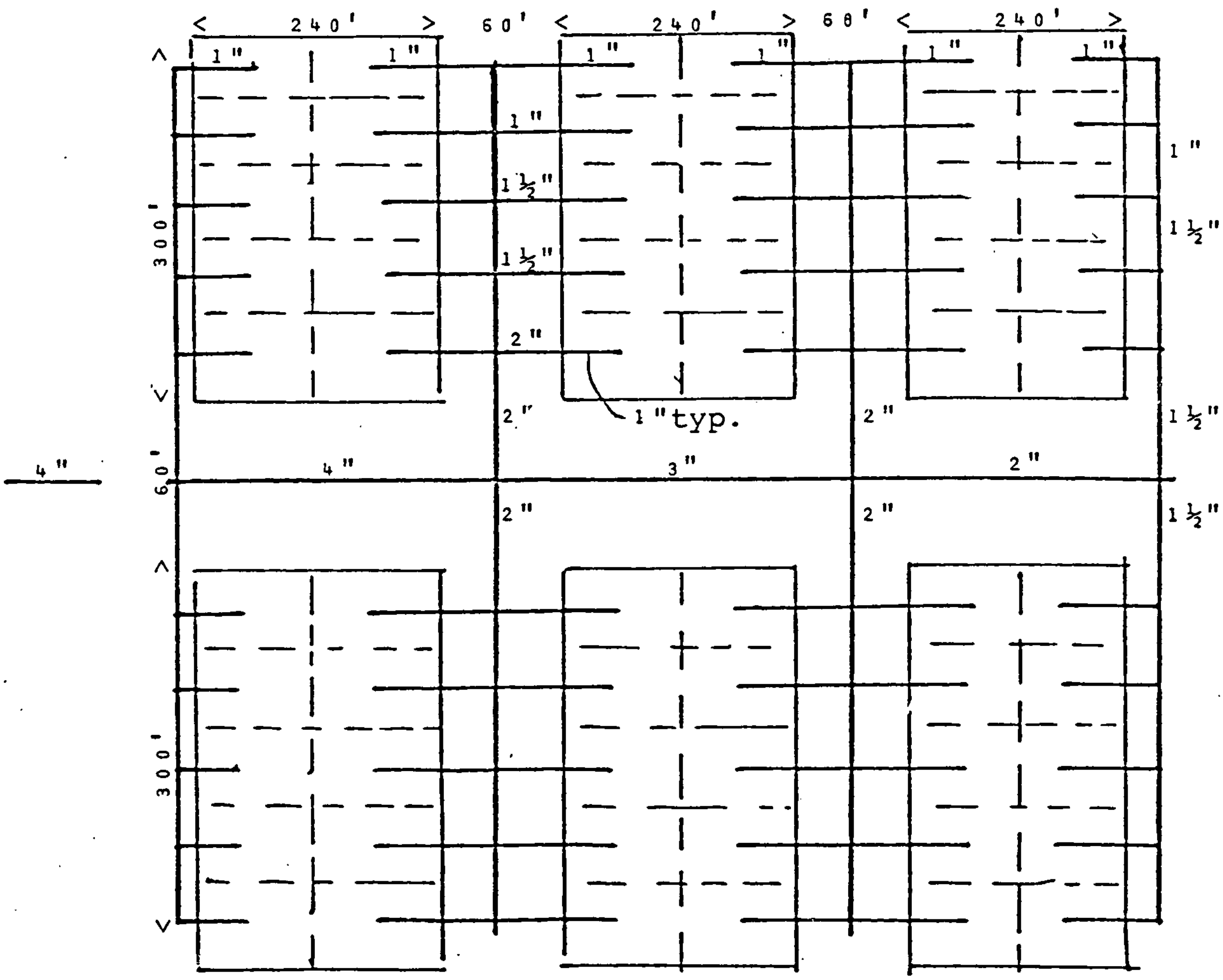
ALTERNATIVE TYPICAL 1 SQ. MI. AREA DISTRIBUTION - SINGLE FAMILY HOUSING

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-06/A

40000 BTU/unit - 4 units/lot
9.6 x 10^6 BTU/hr

LTHW @ $\Delta t = 60^\circ F$
320 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

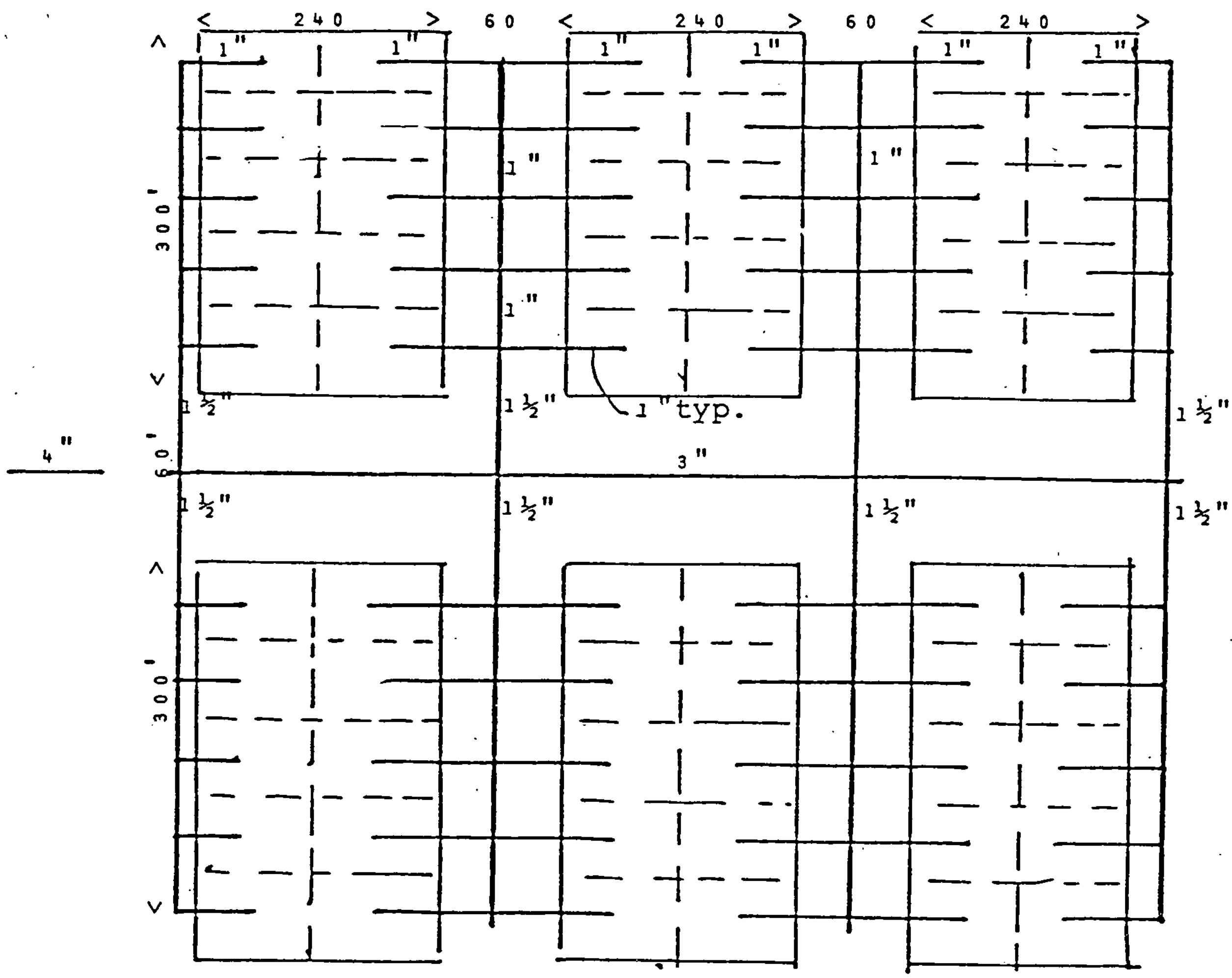
	Suburb.	Rural	$
1"	2520'	3000'	279000
1½"	1200'	-	60000
2"	780'	-	42120
3"	300'	-	24000
4"	300'	-	25500
	5100'	3000'	370620

$$\frac{370620}{240} = 1544 \text{ \$/unit}$$

ALTERNATIVE HOUSE CONNECTION SCHEME I - MULTIPLE DWELLINGS

40000 BTU/unit - 4 units/lot
9.6×10^6 BTU/hr

MTW @ Δ = 120°F
160 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

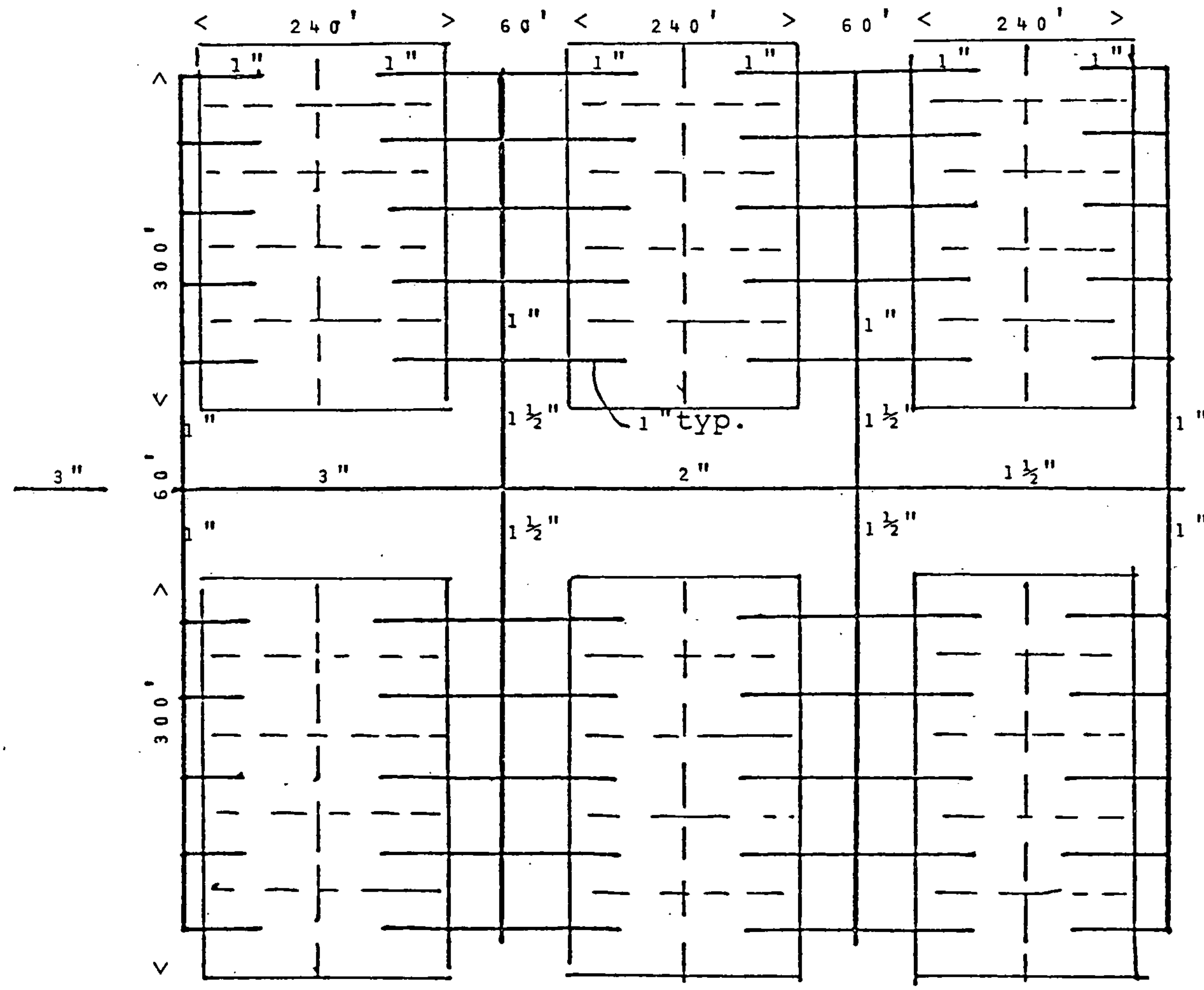
	Suburb.	Rural	$
1" ø	3240'	3000'	255000
1½"	1260'	-	63000
3"	600'	-	48000
	5100'	3000'	366000

$$\frac{366000}{240} = 1525 \text{ \$/unit}$$

ALTERNATIVE HOUSE CONNECTION SCHEME I - MULTIPLE DWELLINGS

40000 BTU/unit - 4 units/lot
9.6 x 10^6 BTU/hr

LTHW @ Δt = 200°F
96 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	3960'	3000'	799800
1½"	540'	-	75600
2"	300'	-	44865
3"	300'	-	48000
	5100'	3000'	968265

$$\frac{968265}{240} = 4034 \text{ \$/unit}$$

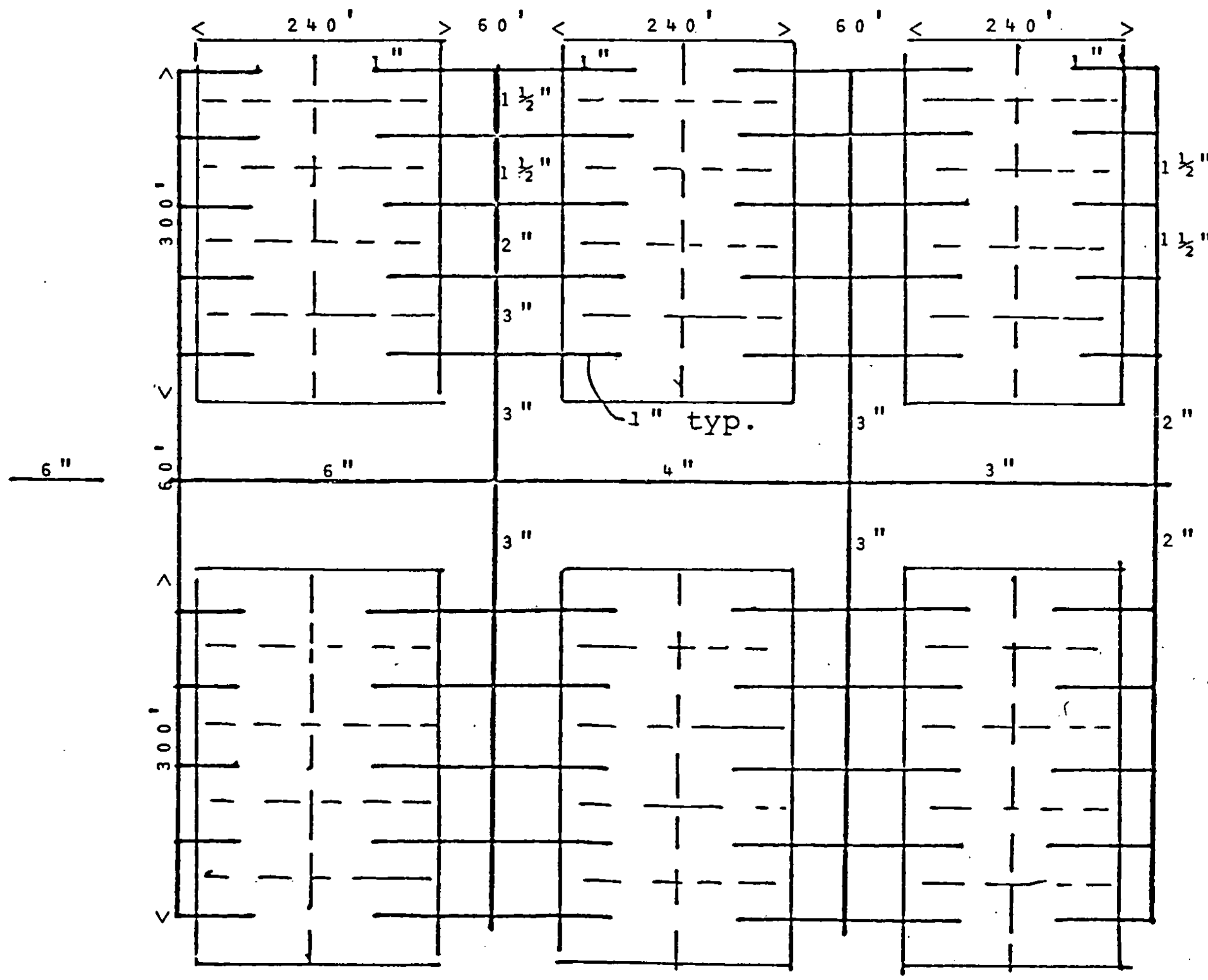
ALTERNATIVE HOUSE CONNECTION SCHEME I - MULTIPLE DWELLINGS

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-06/D

40000 BTU/unit - 4 units/lot
9.6 x 10^6 BTU/hr

LTHW @ $\Delta t = 40^0F$
480 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb	Rural	$
1" ø	2040'	3000'	195000
1½"	1200'	-	60000
2"	480	-	25920
3"	780	-	62400
4"	300'	-	25500
6"	300'	-	33000
	5100'	3000'	401820

$$\frac{401820}{240} = 1674 \text{ \$/unit}$$

ALTERNATIVE HOUSE CONNECTION SCHEME I - MULTIPLE DWELLINGS

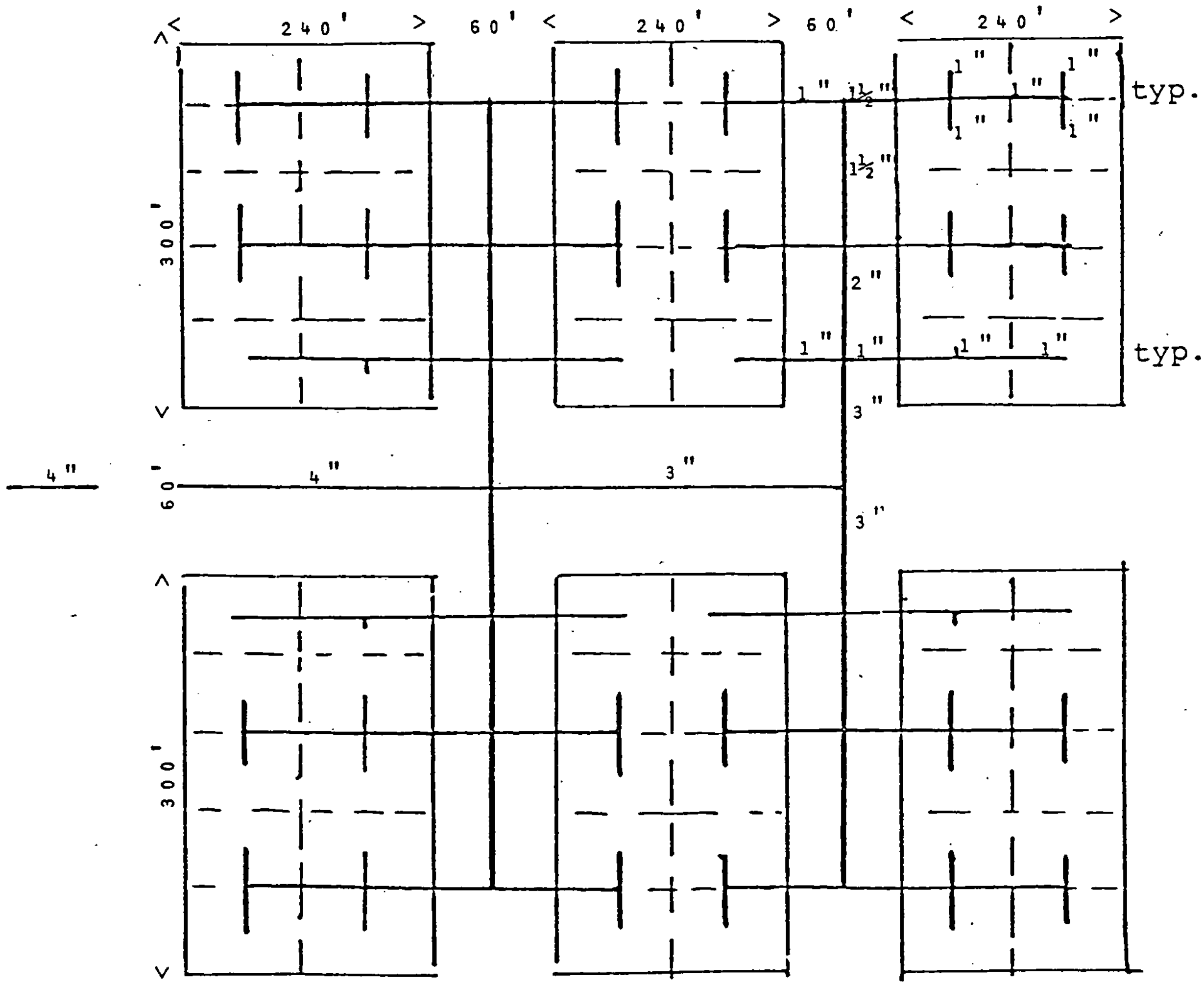
TRANSFLUX international limited

FORT LEE, NEW JERSEY 07024

NO. 561-07/A

40000 BTU/unit - 4 units/lot
9.6×10^6 BTU/hr

LTHW @ $\Delta t = 60^0F$
320 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

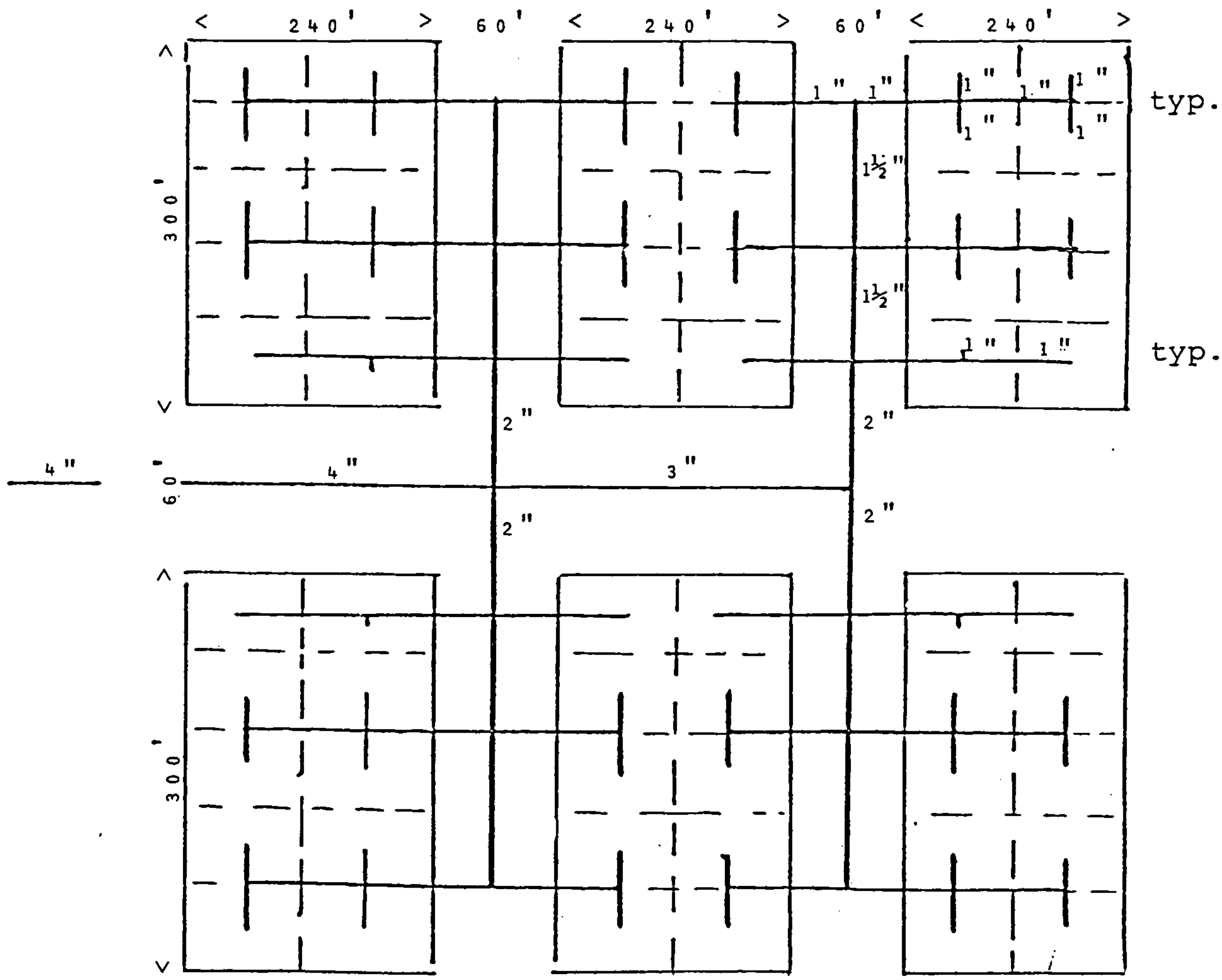
	Suburb.	Rural	$
1" ø	480'	3880'	144280
1½"	720'	400'	48400
2"	360'	-	19440
3"	540'	-	43200
4"	300'	-	25500
	2400'	4280'	280820

$$\frac{280820}{240} = 1170 \text{ \$/unit}$$

ALTERNATIVE HOUSE CONNECTION SCHEME II - MULTIPLE DWELLINGS

40000 BTU/unit - 4 units/lot
9.6 x 10^6 BTU/hr

LTHW @ $\Delta t = 120^0$F
160 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	720'	4280'	168680
1½"	840'	-	42000
2"	240'	-	12960
3"	300'	-	24000
4"	300'	-	25500
	2400'	4280'	273140

$\frac{273140}{240}$ = 1138 $/unit

ALTERNATIVE HOUSE CONNECTION SCHEME II - MULTIPLE DWELLINGS

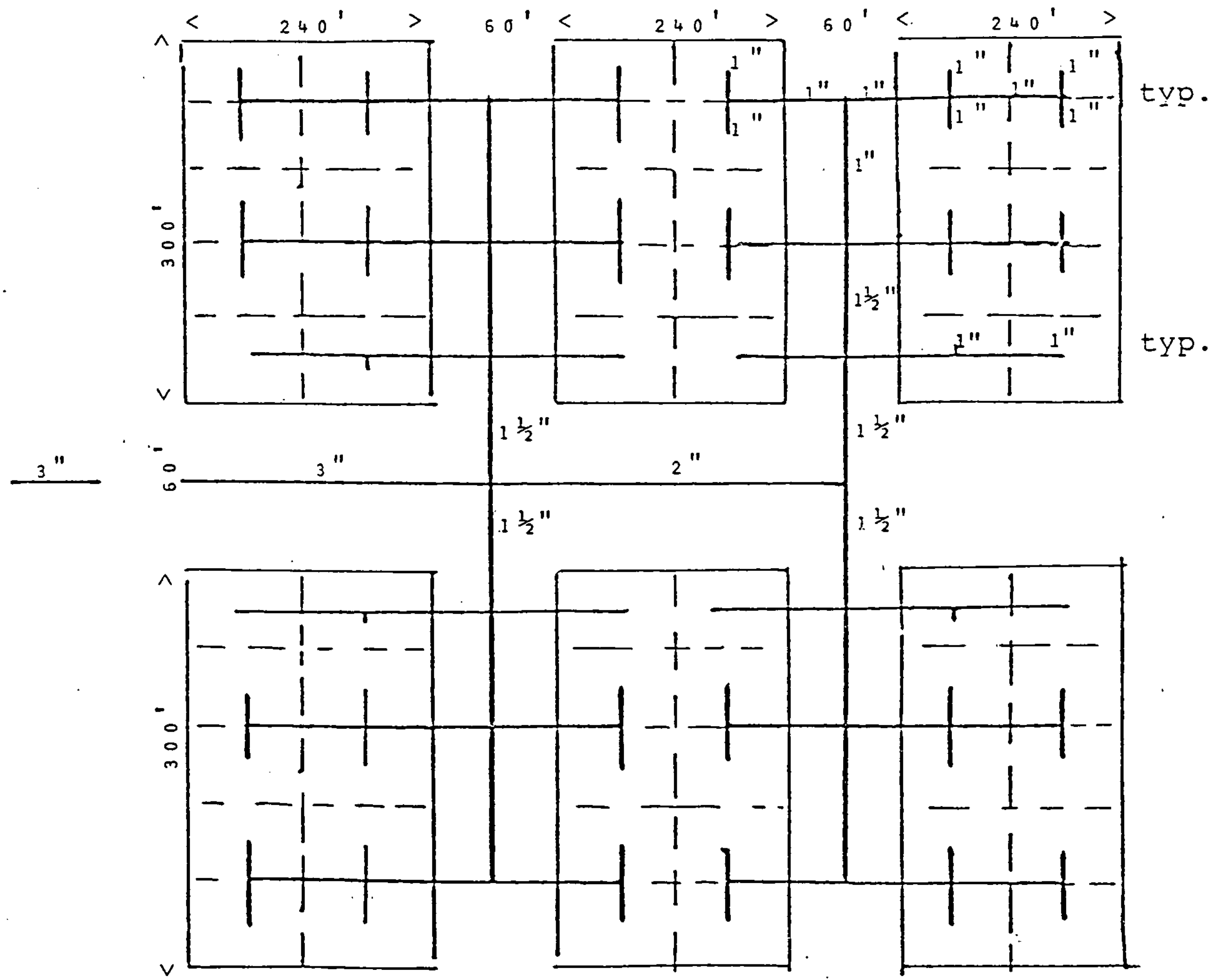
TRANSFLUX international limited

FORT LEE, NEW JERSEY 07024

NO. 561-07/C

40000 BTU/unit - 4 units/lot
9.6 x 10^6 BTU/hr

LTHW @ Δt = 200°F
96 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	1200'	4280'	562600
1½"	600'	-	84000
2"	300'	-	44865
3"	300'	-	48000
	2400'	4280'	739465

$$\frac{739465}{240} = 3081 \text{ \$/unit}$$

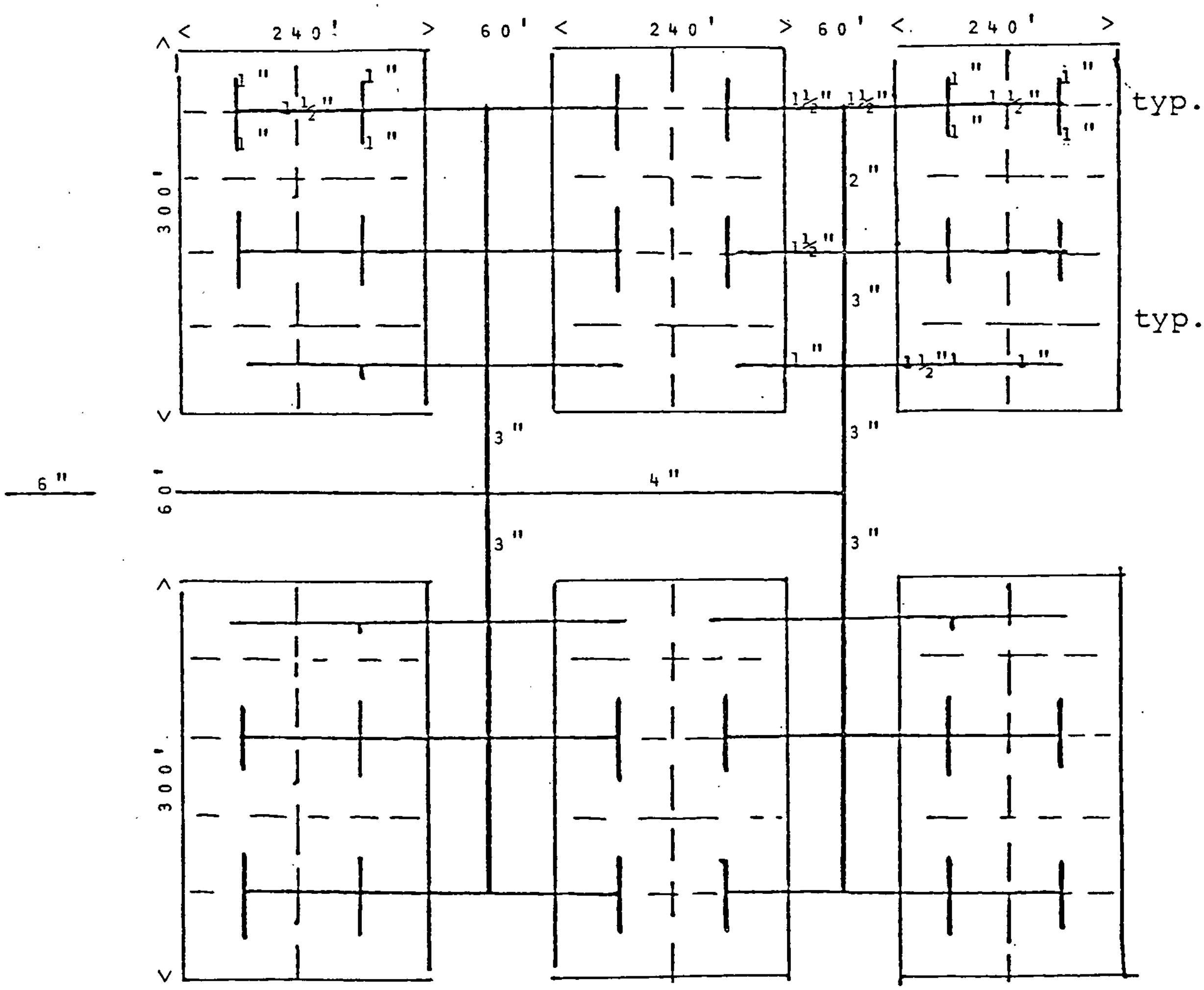
ALTERNATIVE HOUSE CONNECTION SCHEME II -MULTIPLE DWELLINGS

NO. 561-07/D

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

40000 BTU/unit - 4 units/lot
9.6×10^6 BTU/hr

LTHW @ $\Delta t = 40^0F$
480 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

	Suburb.	Rural	$
1" ø	120'	2200'	74200
1½"	600'	2120'	95720
2"	480'	-	25920
3"	600'	-	48000
4"	300'	-	25500
6"	300'	-	33000
	2400'	4320'	302340

$$\frac{302340}{240} = 1260 \text{ \$/unit}$$

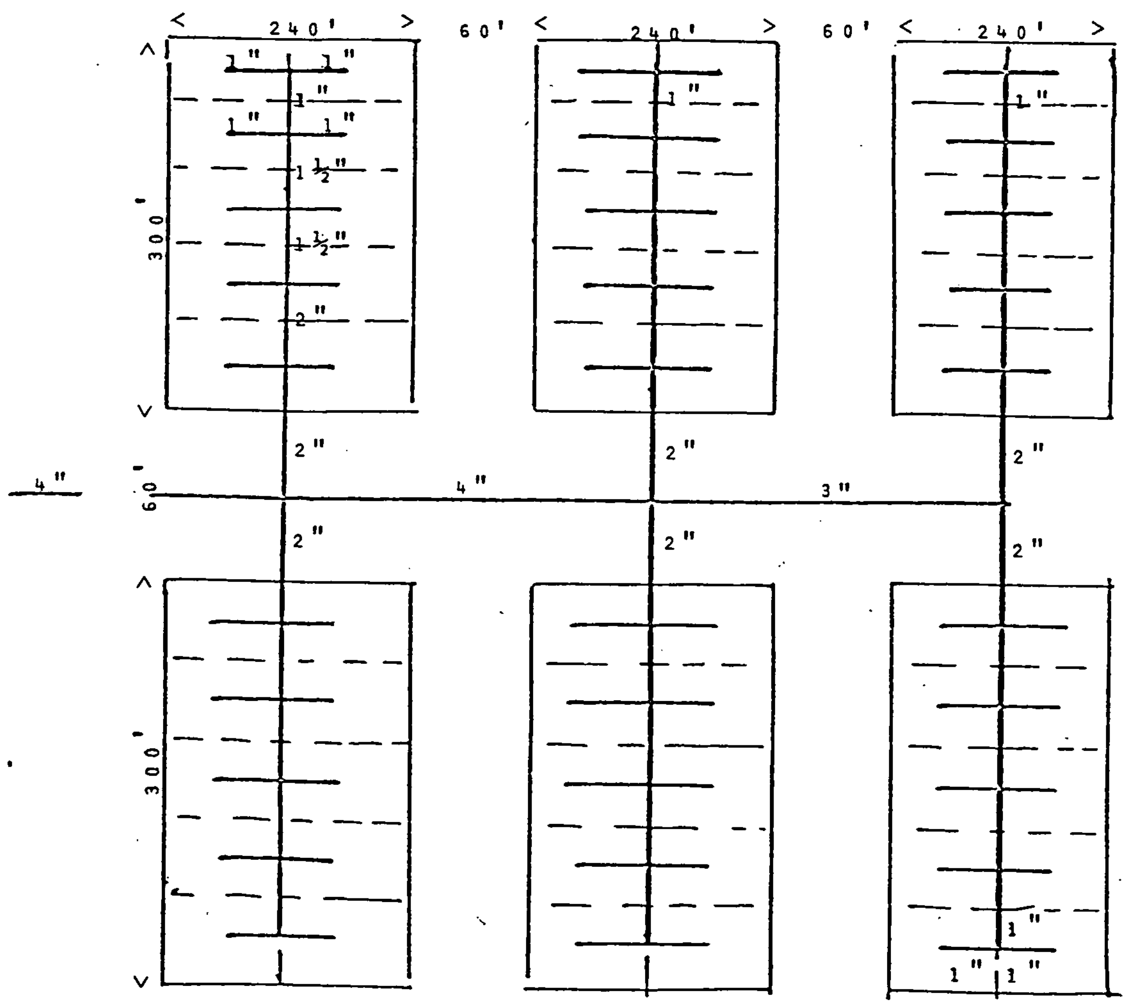
ALTERNATIVE HOUSE CONNECTION SCHEME II - MULTIPLE DWELLINGS

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-08/A

40000 BTU/unit - 4 units/lot
9.6×10^6 BTU/hr

LTHW @ $\Delta t = 60^0F$
320 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

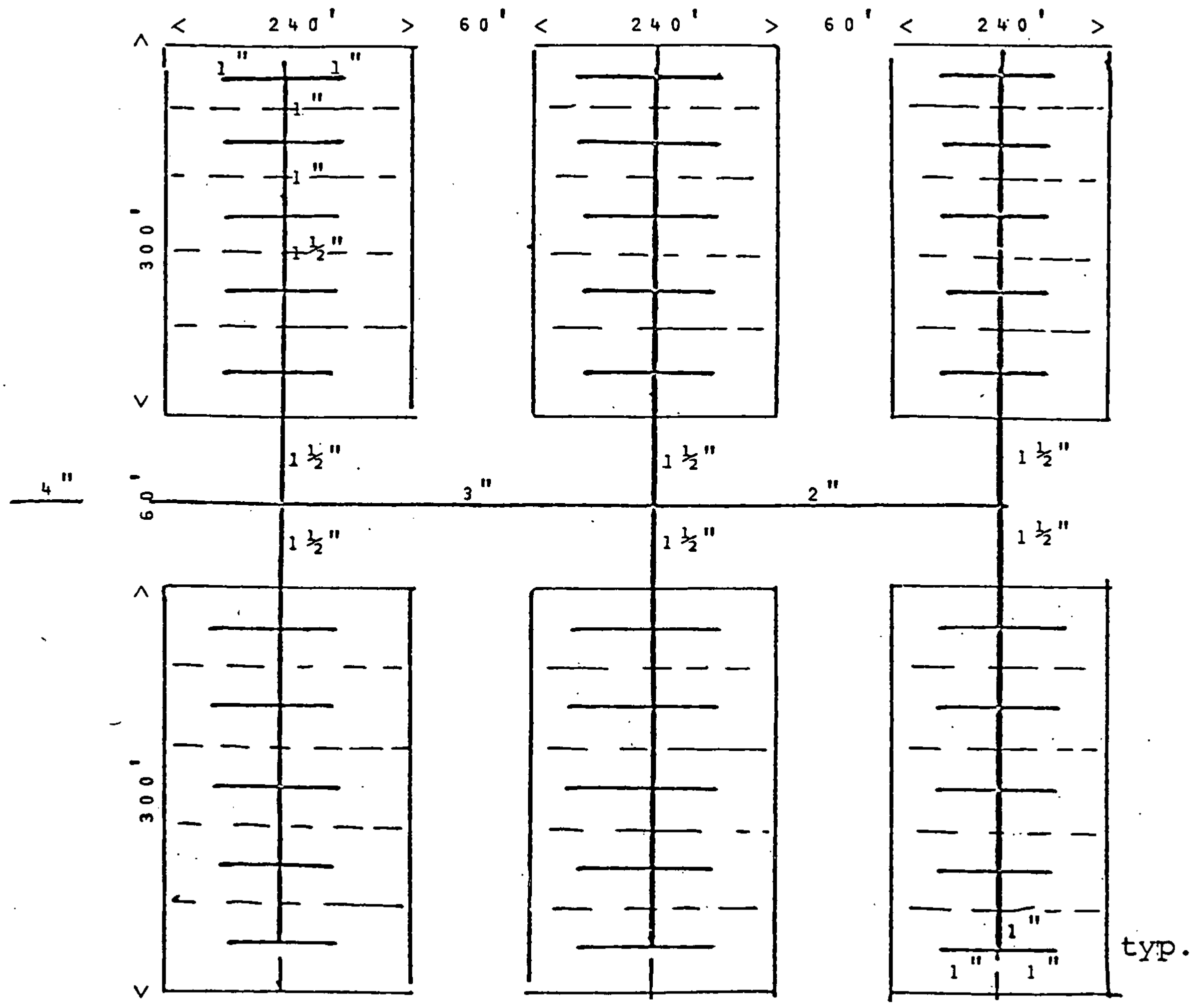
	Suburb.	Rural	$
1" ø	-	4560'	141360
1½"	-	720'	22320
2"	180'	540'	27540
3"	300'	-	24000
4"	450'	-	38250
	930'	5820'	253470

$$\frac{253470}{240} = 1056 \text{ \$/unit}$$

ALTERNATIVE HOUSE CONNECTION SCHEME III - MULTIPLE DWELLINGS

40000 BTU/unit - 4 units/lot
9.6 x 10^6 BTU/hr

LTHW @ $\Delta t = 120^0F$
160 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

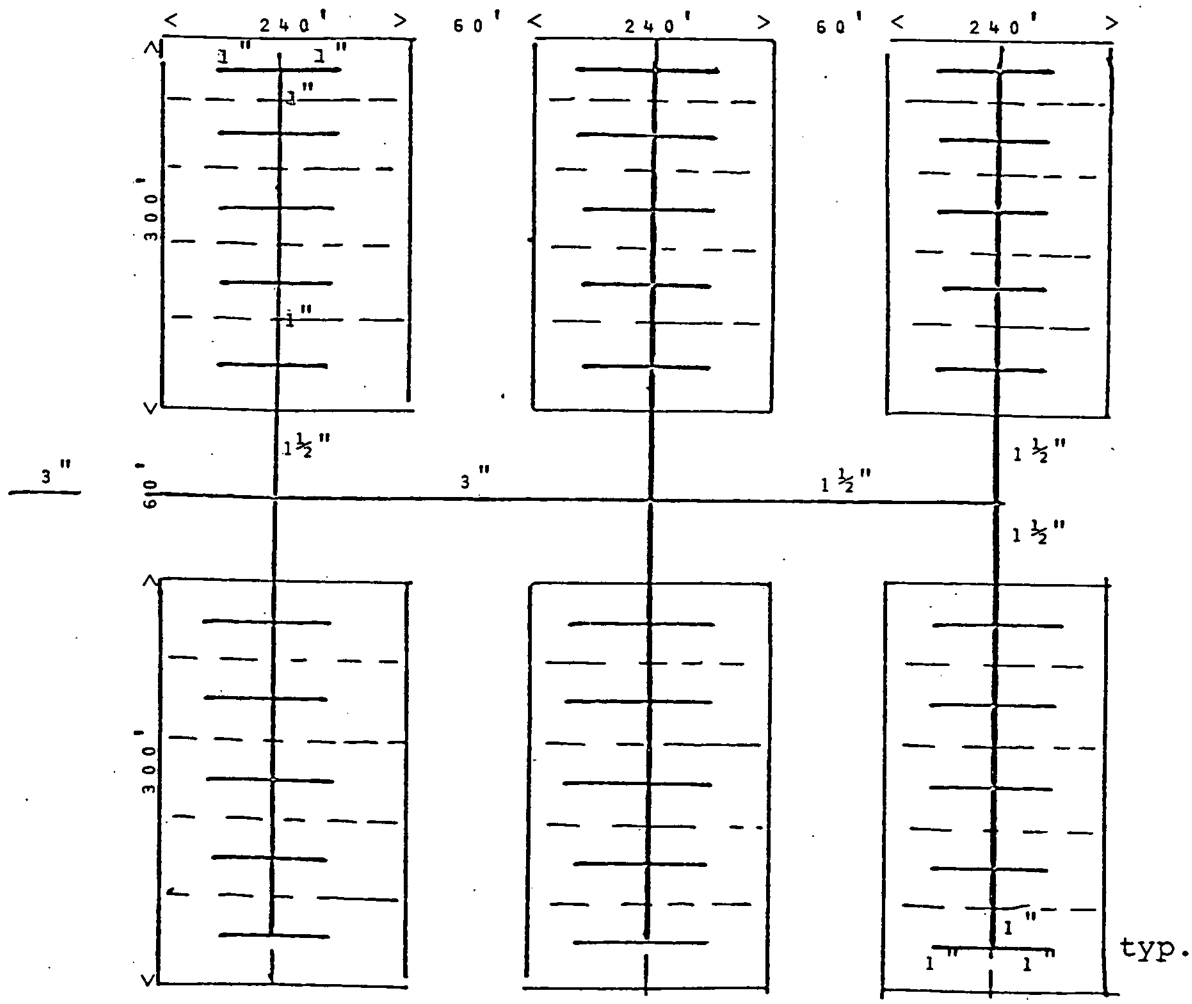
	Suburb.	Rural	$
1" ø	-	4920'	152520
1½"	180'	900'	36900
2"	300'	-	16200
3"	300'	-	24000
4"	150'	-	12750
	930'	5820'	234270

$$\frac{234270}{240} = 976 \text{ \$/unit}$$

ALTERNATIVE HOUSE CONNECTION SCHEME III - MULTIPLE DWELLINGS

40000 BTU/unit - 4 units/lot
9.6×10^6 BTU/hr

LTHW @ $\Delta t = 200°F$
.96 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

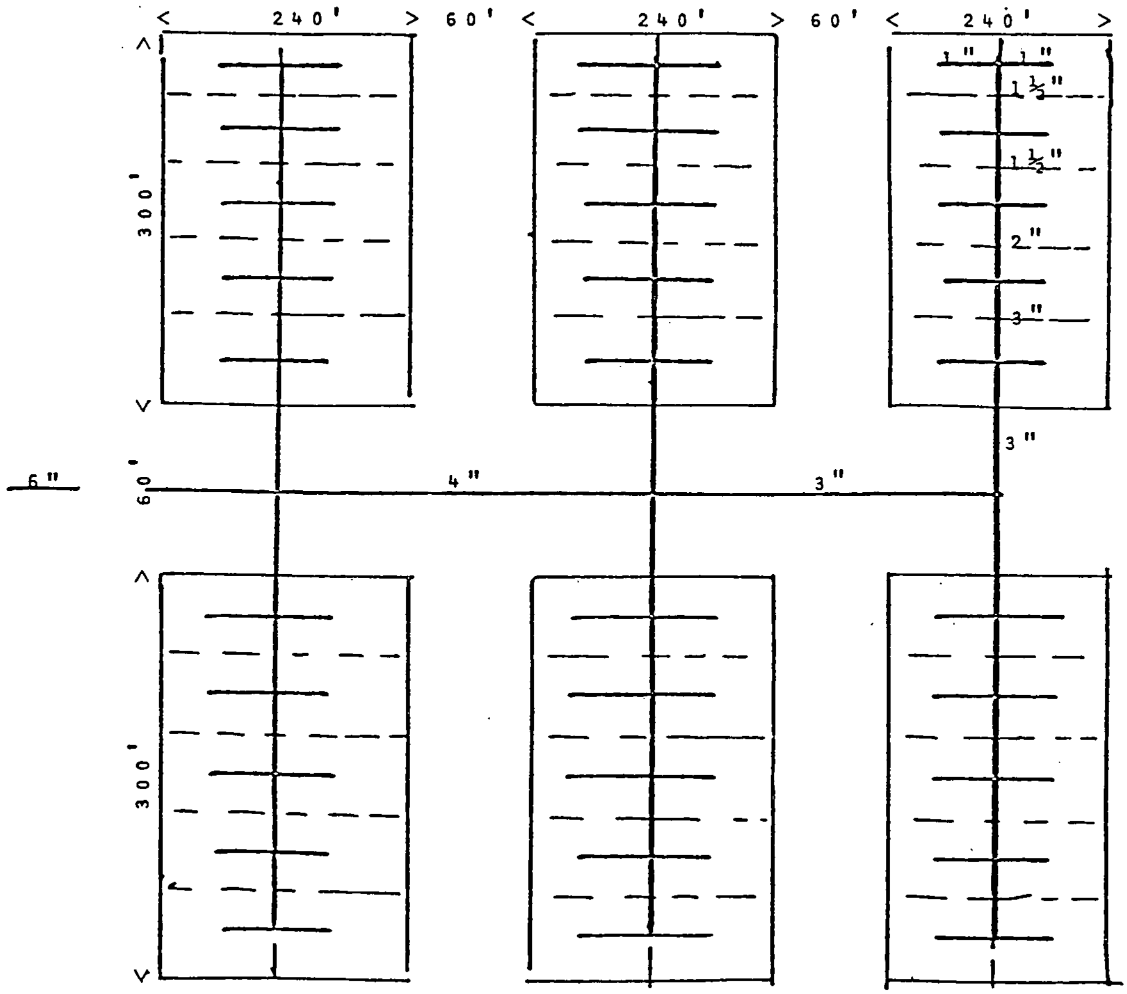
	Suburb.	Rural	$
1"	-	5640'	535800
1½"	480'	180'	85200
3"	450'	-	72000
	930'	5820'	693000

$$\frac{693000}{240} = 2888 \text{ \$/unit}$$

ALTERNATIVE HOUSE CONNECTION SCHEME III - MULTIPLE DWELLINGS

40000 BTU/unit - 4 units/lot
9.6×10^6 BTU/hr

LTHW @ $\Delta t = 40^0$F
180 gpm total flow



Area (6 blocks) = approx. 15 acres or .025 sq. mi.

DISTRIBUTION PIPING:

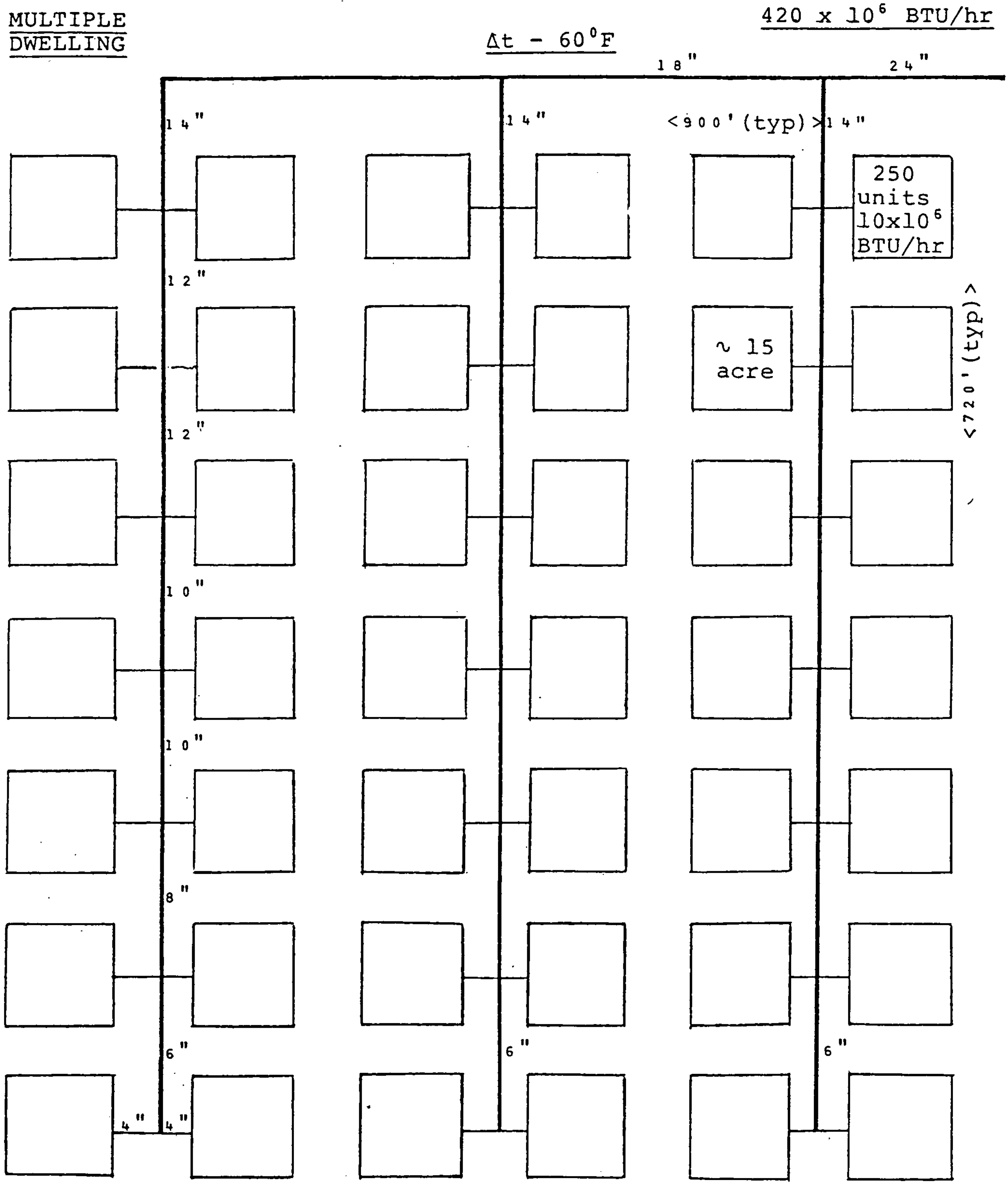
	Suburb.	Rural	$
1" ø	-	4200'	130200
1½"	-	720'	22320
2"	-	360'	11880
3"	480'	540'	64860
4"	300'	-	25500
6"	150'	-	16500
	930'	5820'	271260

$$\frac{271260}{240} = 1130 \text{ \$/unit}$$

ALTERNATIVE HOUSE CONNECTION SCHEME III - MULTIPLE DWELLINGS

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

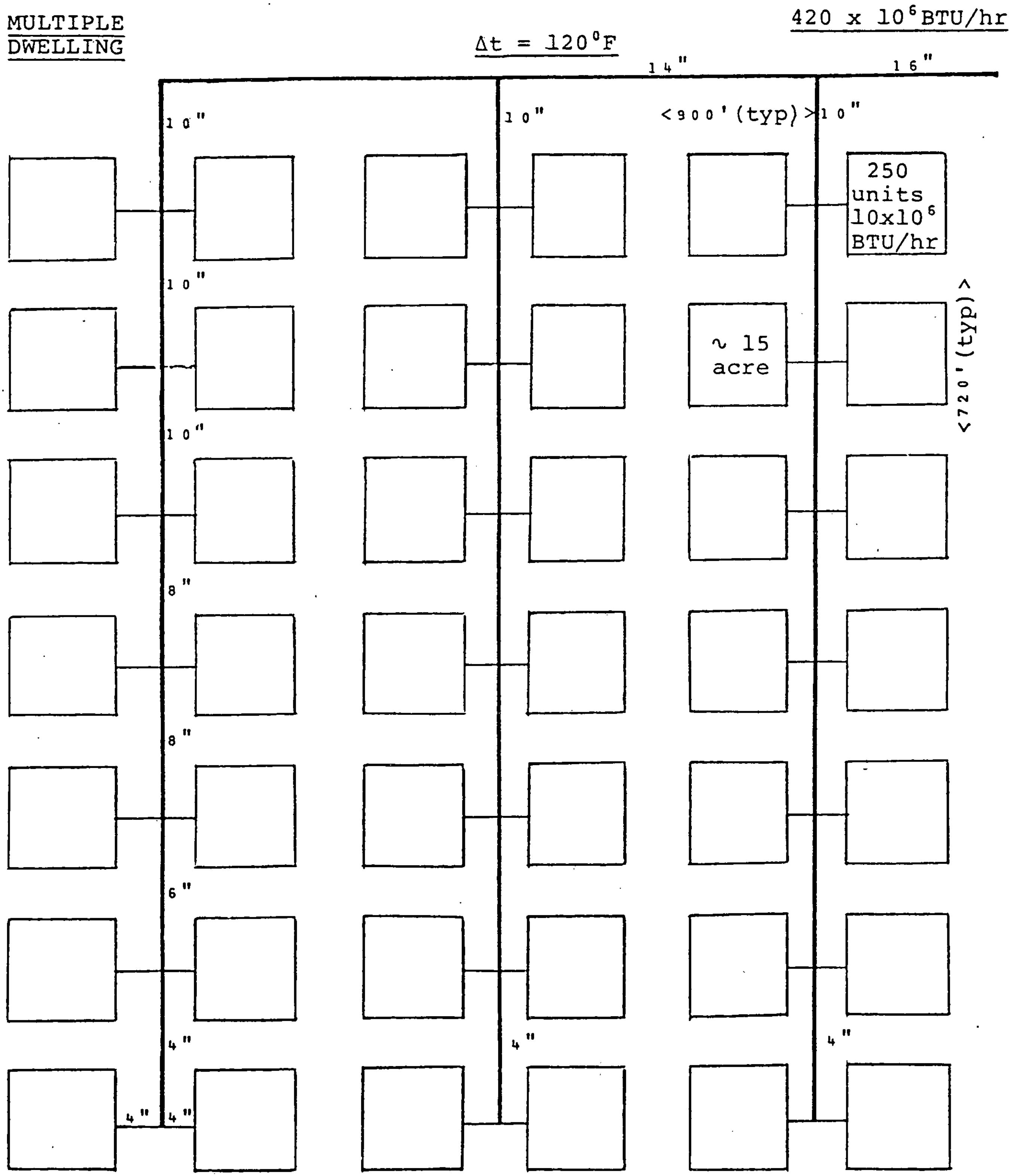
NO. 561-09/A



ALTERNATIVE TYPICAL 1 SQ. MI. AREA DISTRIBUTION

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-09/B



ALTERNATIVE TYPICAL 1 SQ. MI. AREA DISTRIBUTION

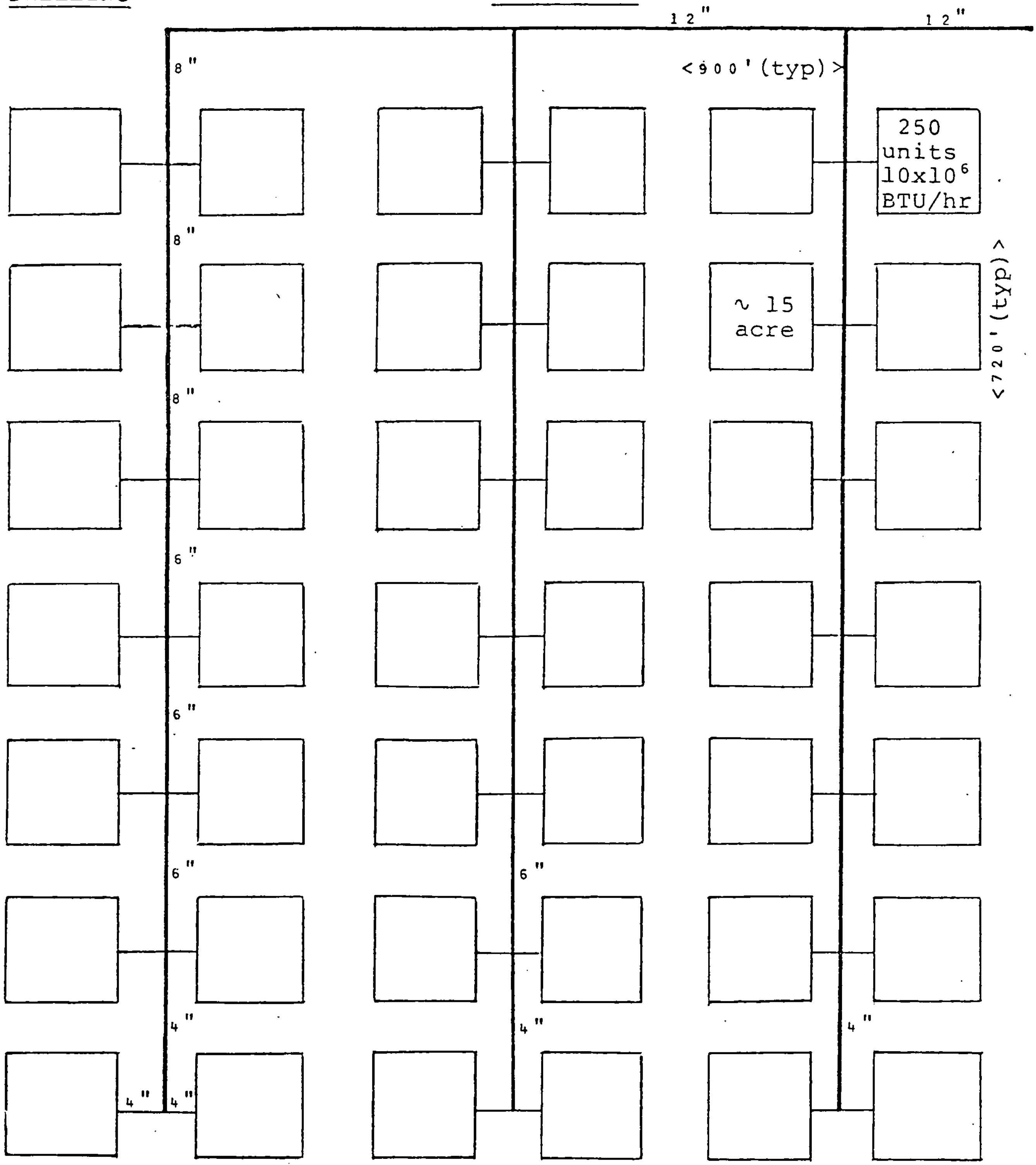
TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-09/C

MULTIPLE DWELLING

420 x 10^6 BTU/hr

$\Delta t = 200^0F$



ALTERNATIVE TYPICAL 1 SQ. MI. AREA DISTRIBUTION

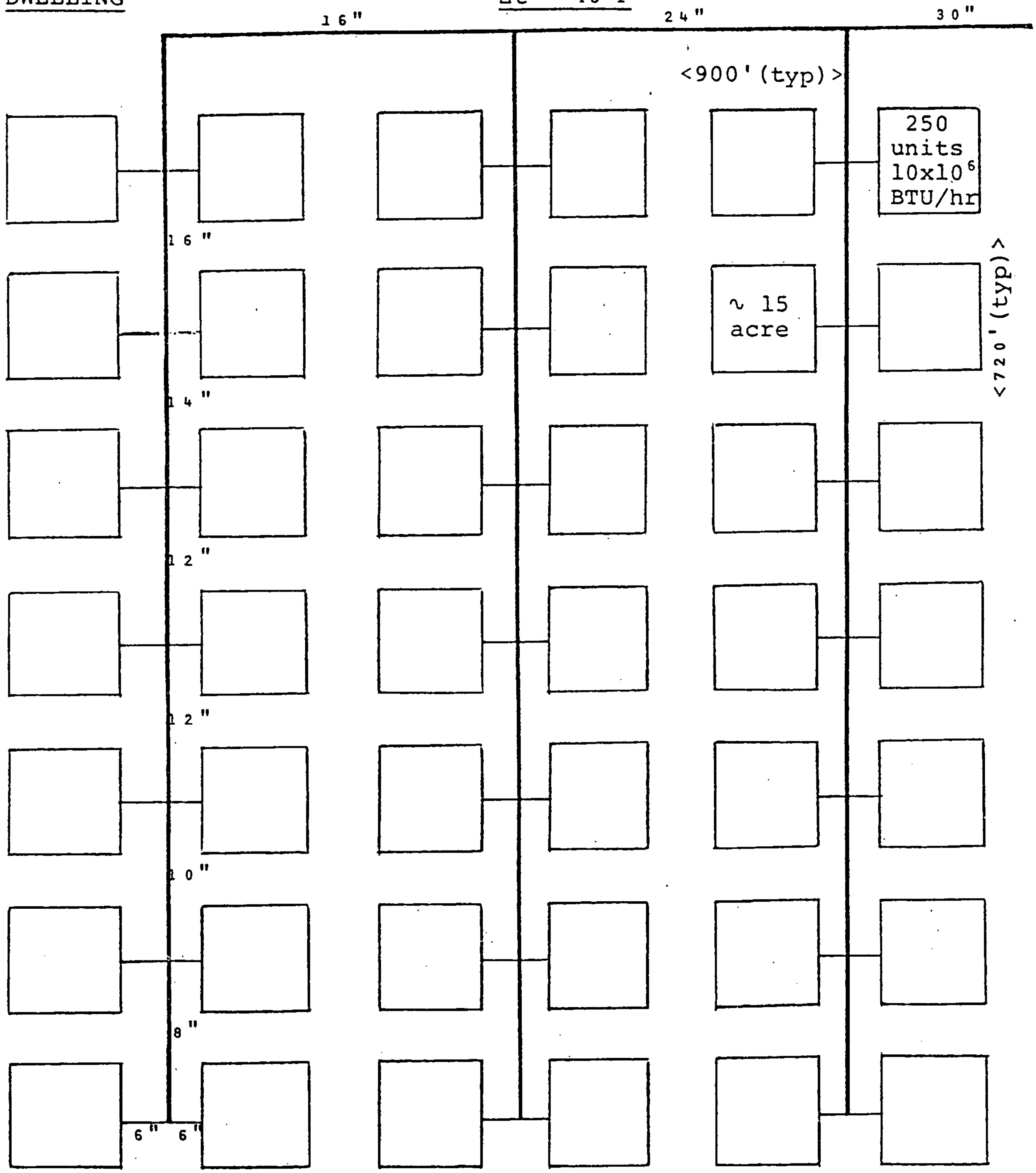
TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-09/D

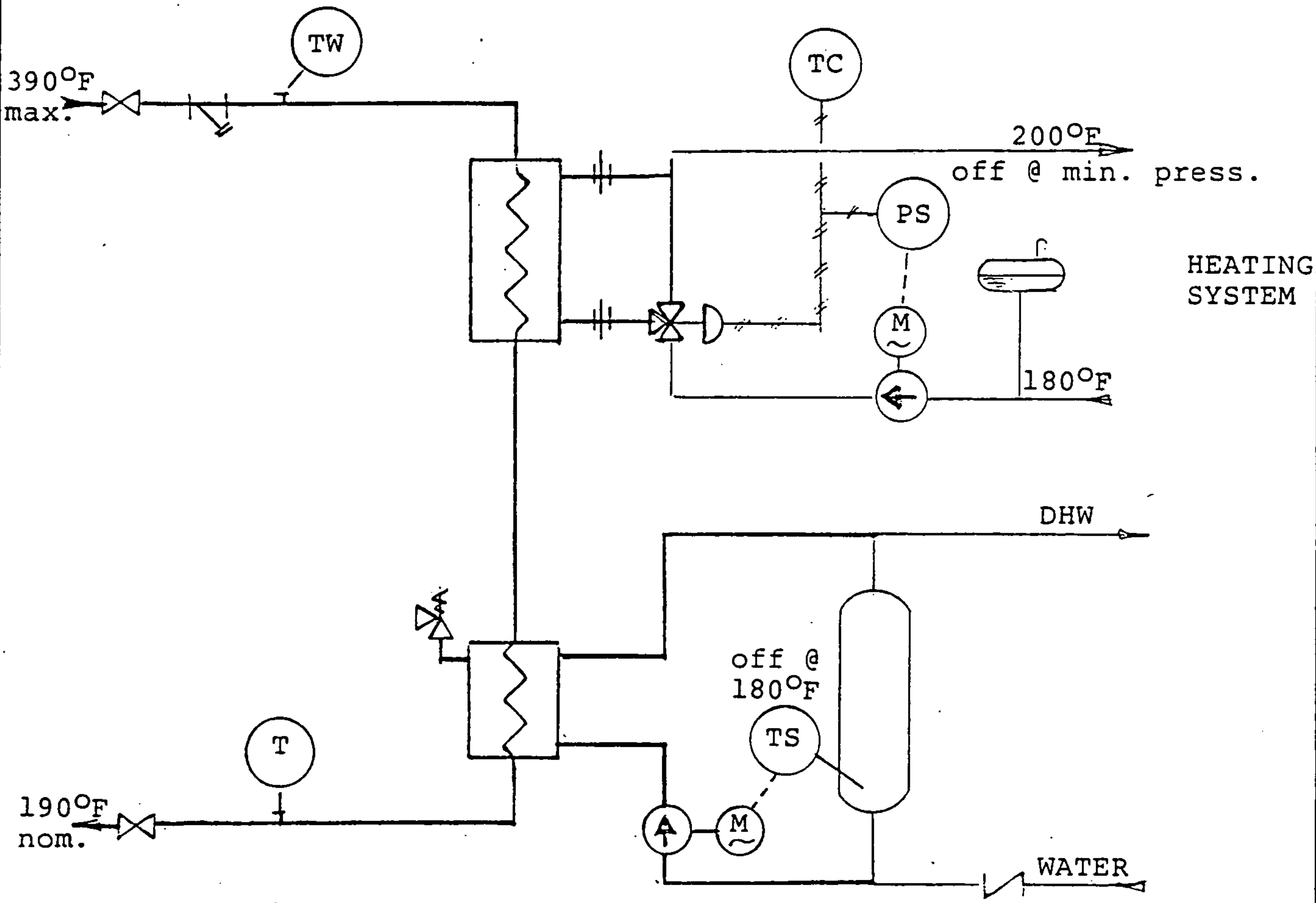
MULTIPLE DWELLING

$\Delta t = 40^0F$

420×10^6 BTU/hr



ALTERNATIVE TYPICAL 1 SQ. MI. AREA DISTRIBUTION



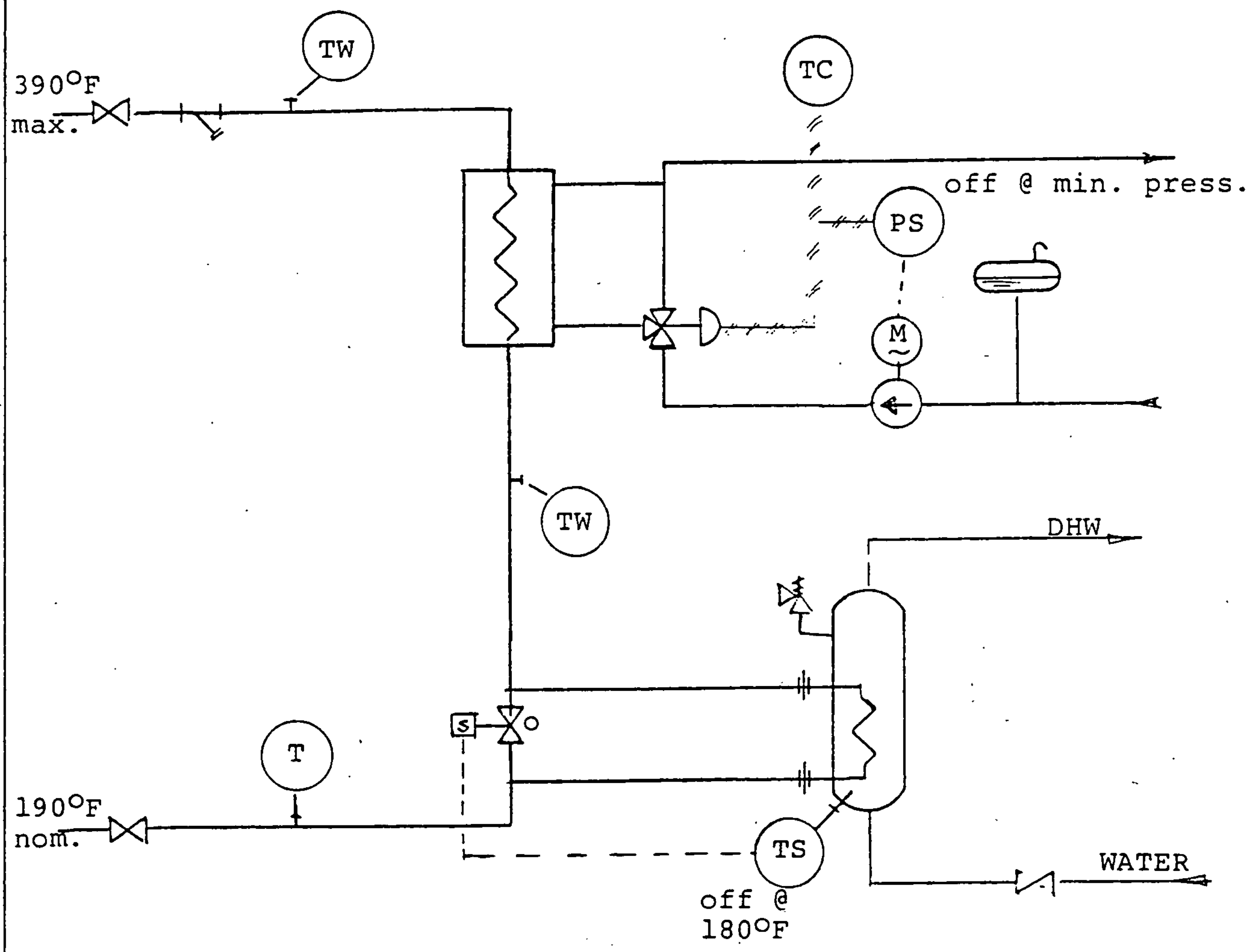
NOTES:

1. EXISTING INSTALLATION.
2. CONSTANT FLOW, VARIABLE SUPPLY TEMPERATURE SYSTEM.
3. FLOW & RETURN TEMPERATURE CAN BE METERED (NOT SHOWN).

HTW - SINGLE FAMILY HOUSE CONNECTION - WW HEAT

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-11/B

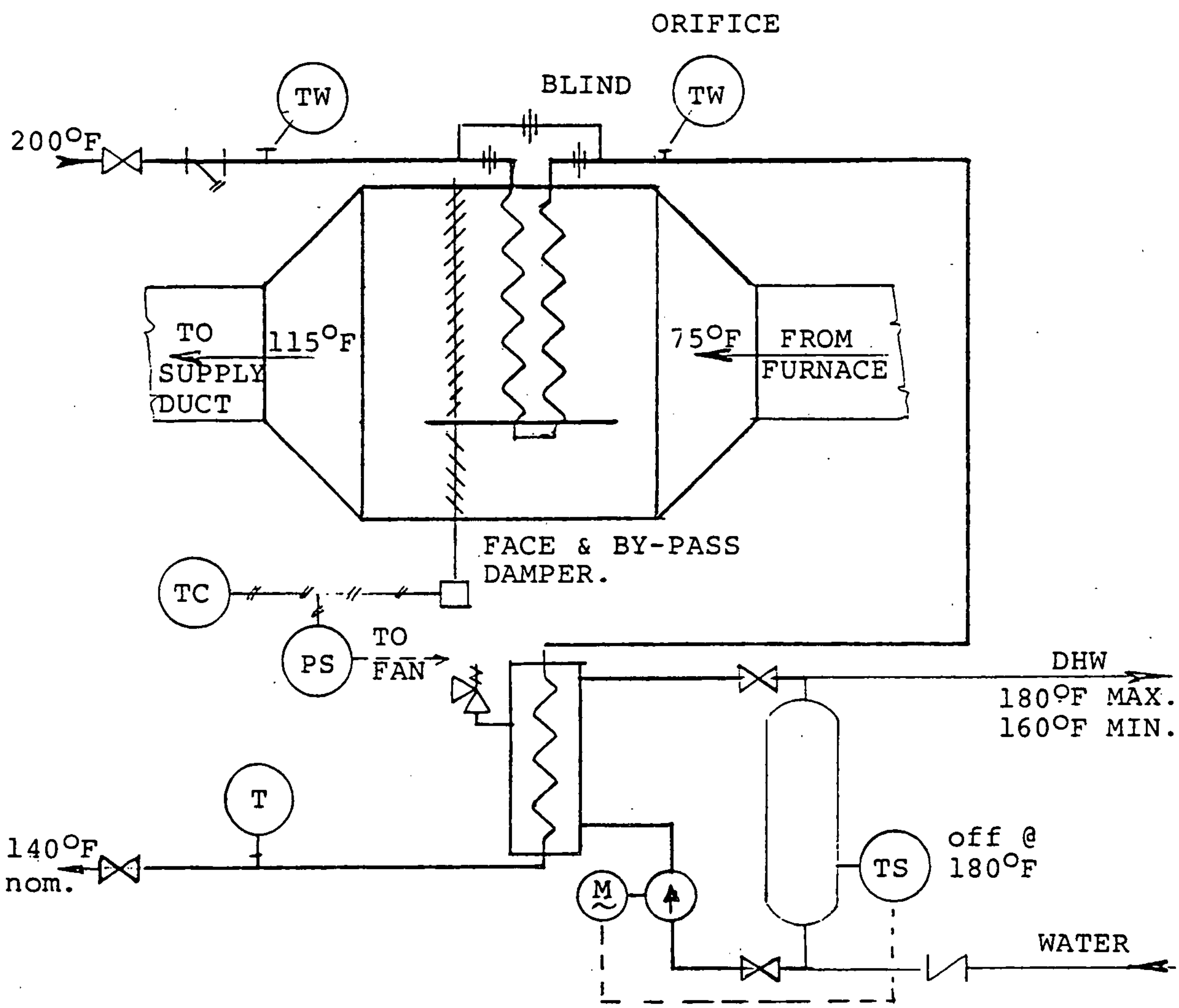


NOTES:
1. NEW INSTALLATION.
2. CONSTANT FLOW, VARIABLE SUPPLY TEMPERATURE SYSTEM.
3. FLOW & RETURN TEMPERATURE CAN BE METERED (NOT SHOWN).

HTW - SINGLE FAMILY HOUSE CONNECTION - WW HEAT

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-12/A

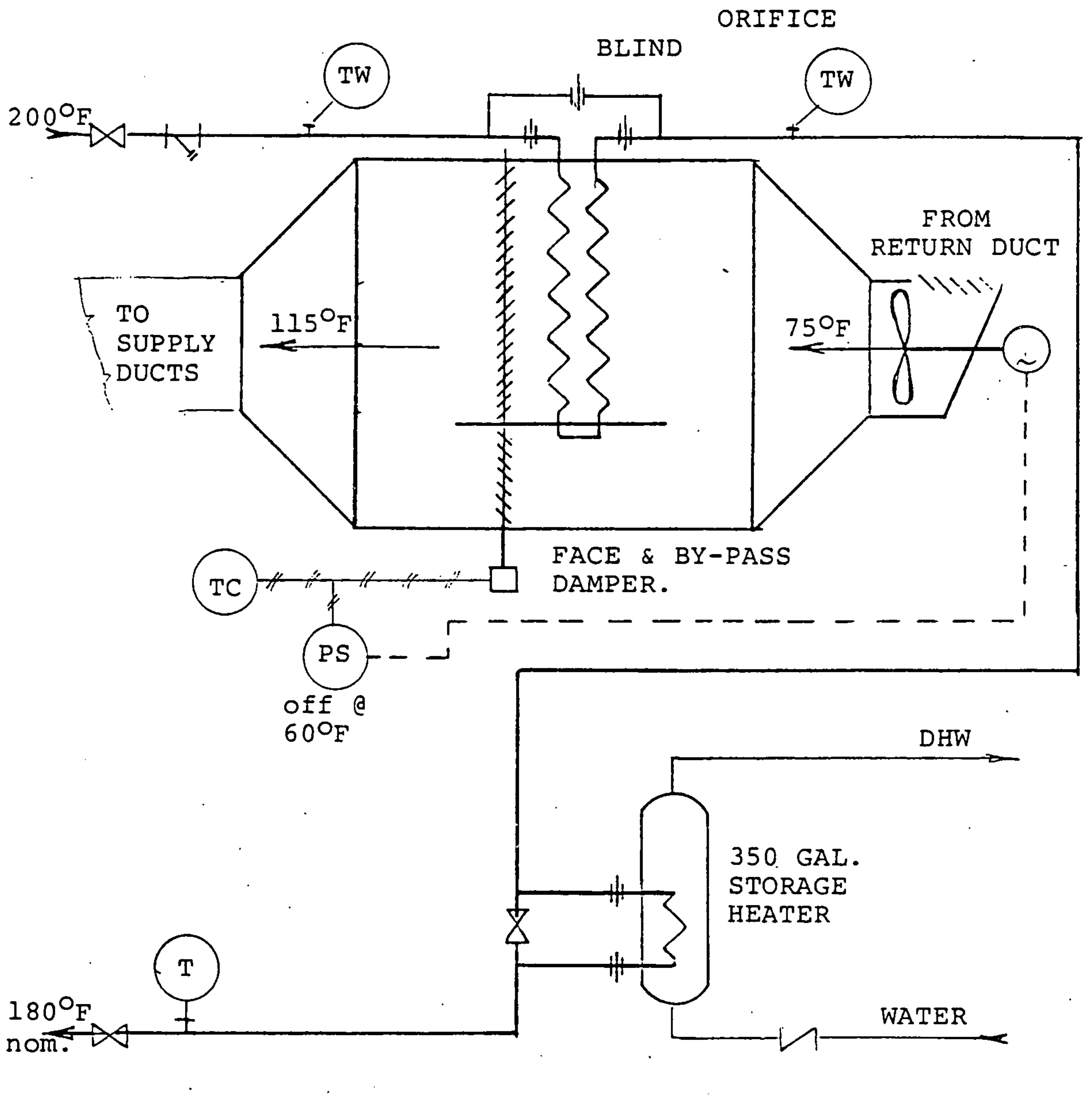


NOTES:
1. EXISTING HEATING SYSTEM.
2. CONSTANT FLOW, CONSTANT SUPPLY TEMPERATURE.
3. RETURN TEMPERATURE NEED BE METERED ONLY FOR LOAD.

LTW - SINGLE FAMILY HOUSE CONNECTION - HOT AIR HEAT

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-12/B

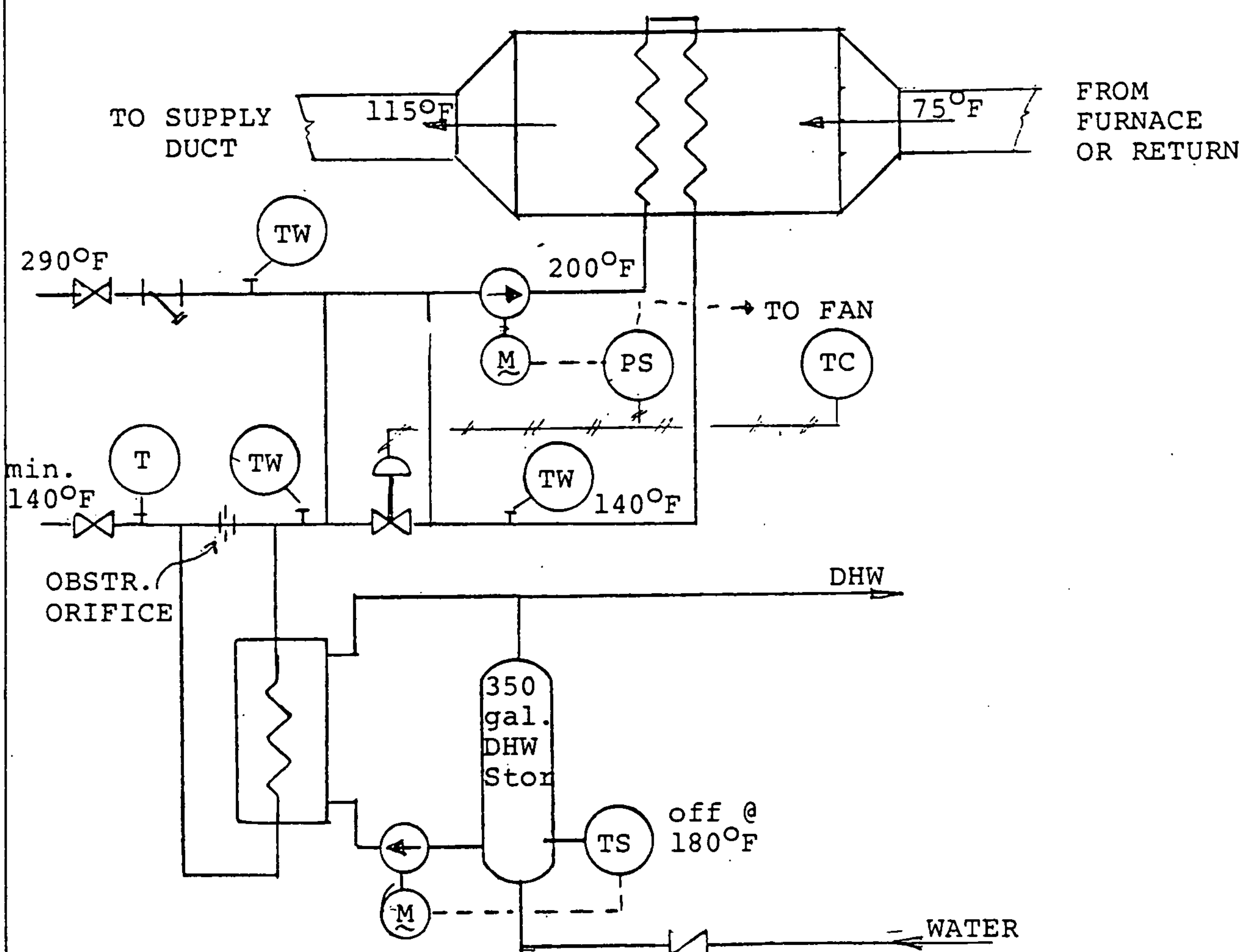


NOTES:
1. NEW INSTALLATION.
2. CONSTANT FLOW, CONSTANT SUPPLY TEMPERATURE.
3. RETURN TEMPERATURE NEED BY METERED ONLY FOR LOAD.

LTW - SINGLE FAMILY HOUSE CONNECTION - HOT AIR HEAT

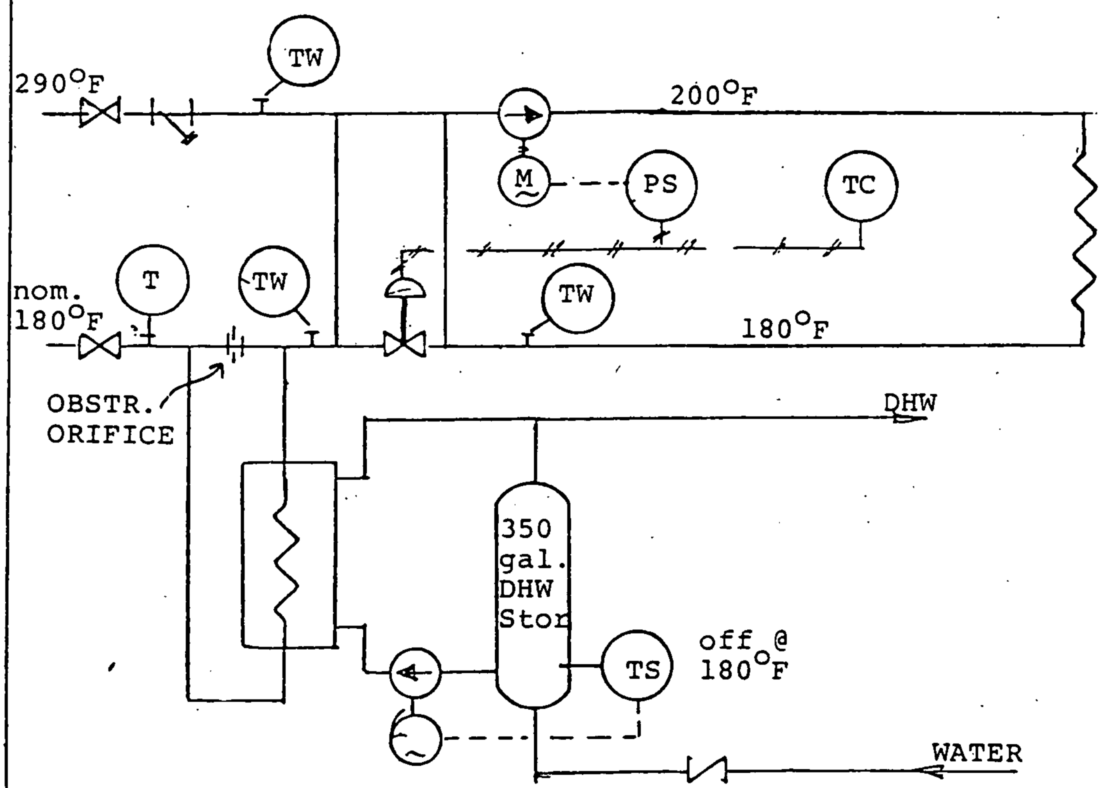
TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-13/A



NOTES:
1. NEW OR EXISTING HEATING SYSTEM.
2. CONSTANT FLOW, VARIABLE TEMPERATURE SYSTEMS.

MTW - SINGLE FAMILY HOUSE CONNECTION - HOT AIR HEAT



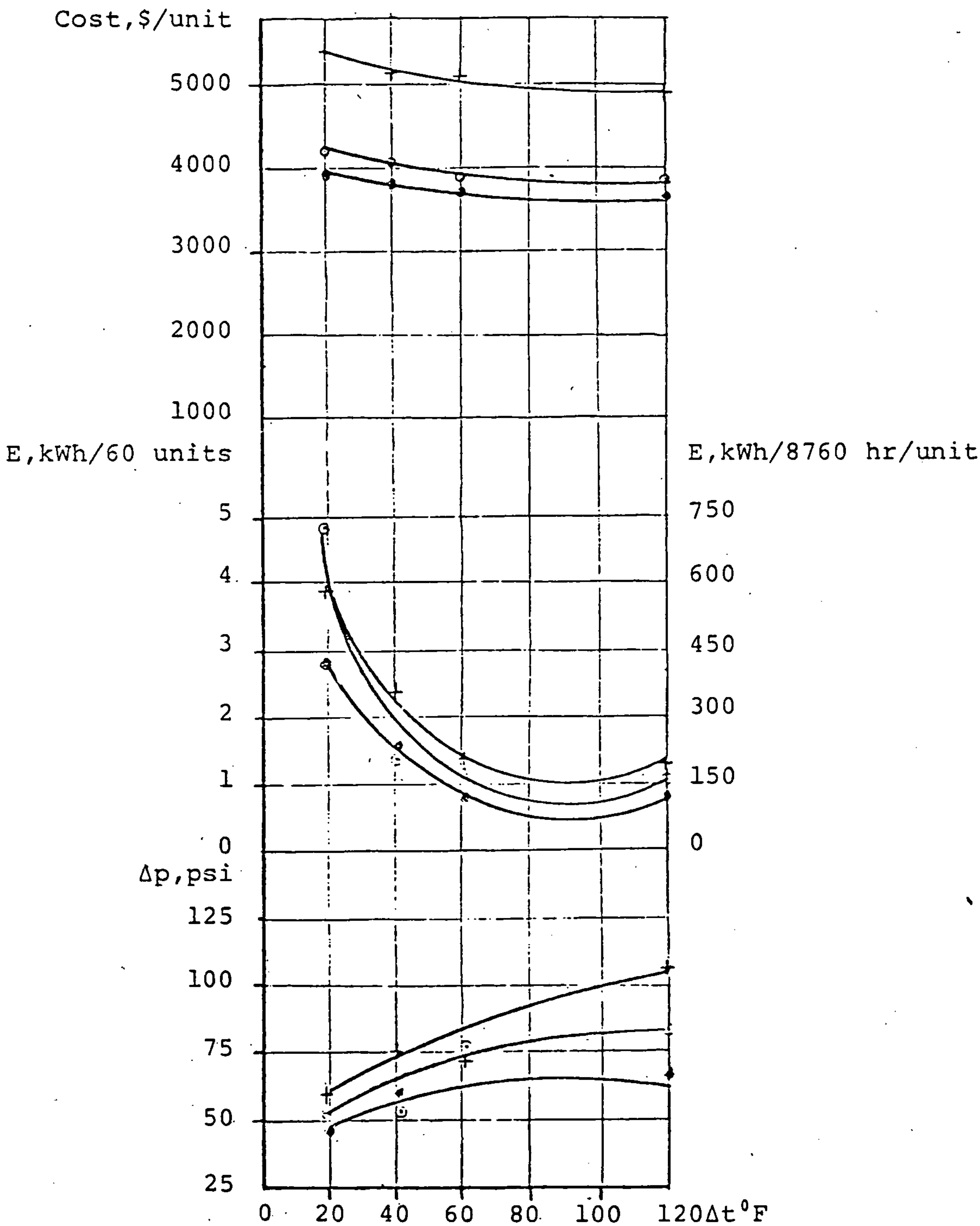
NOTES:

1. NEW OR EXISTING HEATING SYSTEM.
2. CONSTANT FLOW, VARIABLE TEMPERATURE SYSTEMS.

MTW - SINGLE FAMILY HOUSE CONNECTION - WARM WATER HEAT

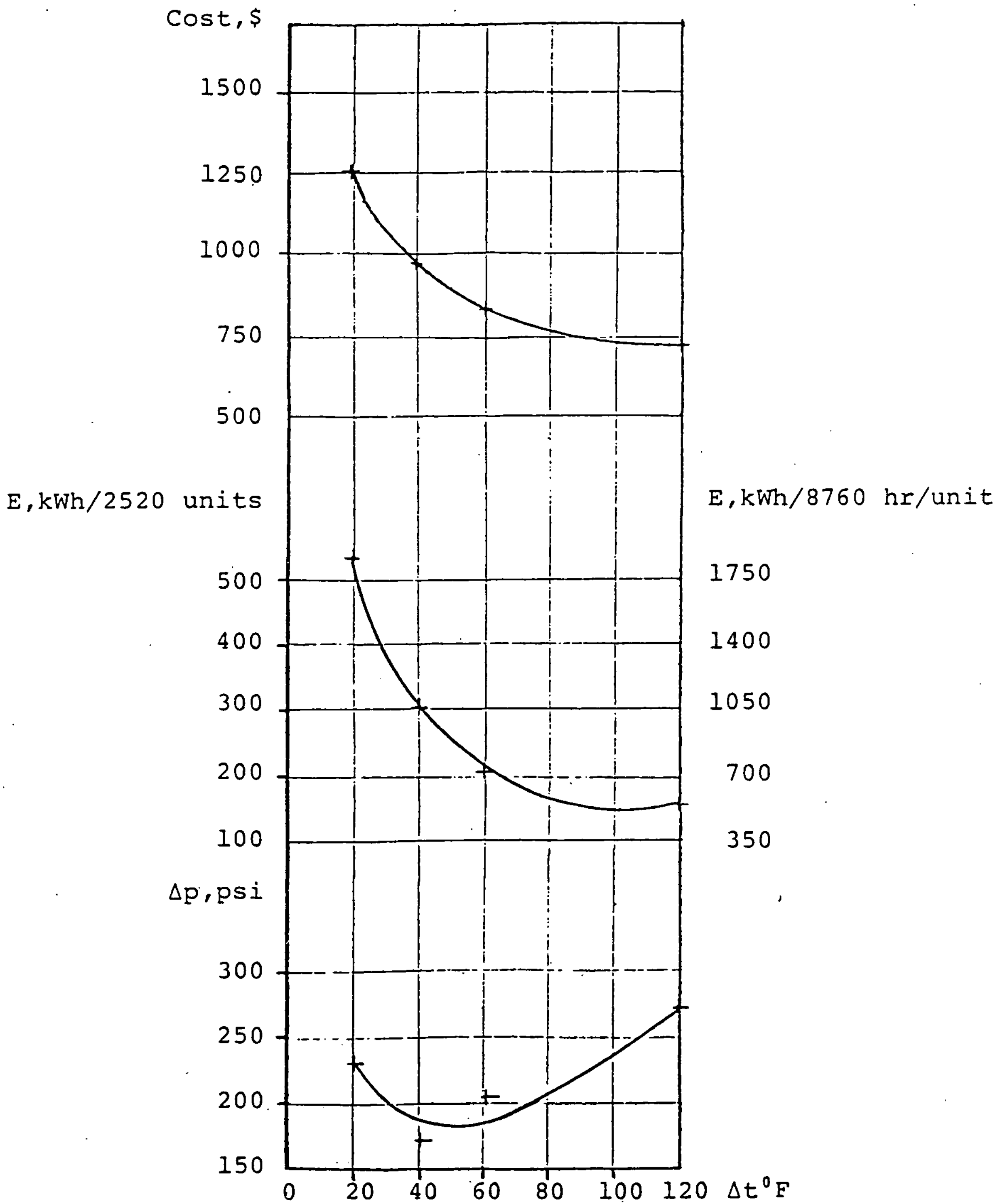
TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-17



ALTERNATIVE SCHEMES: x——x see Fig. 561-01
o——o " " 561-02
●——● " " 561-03

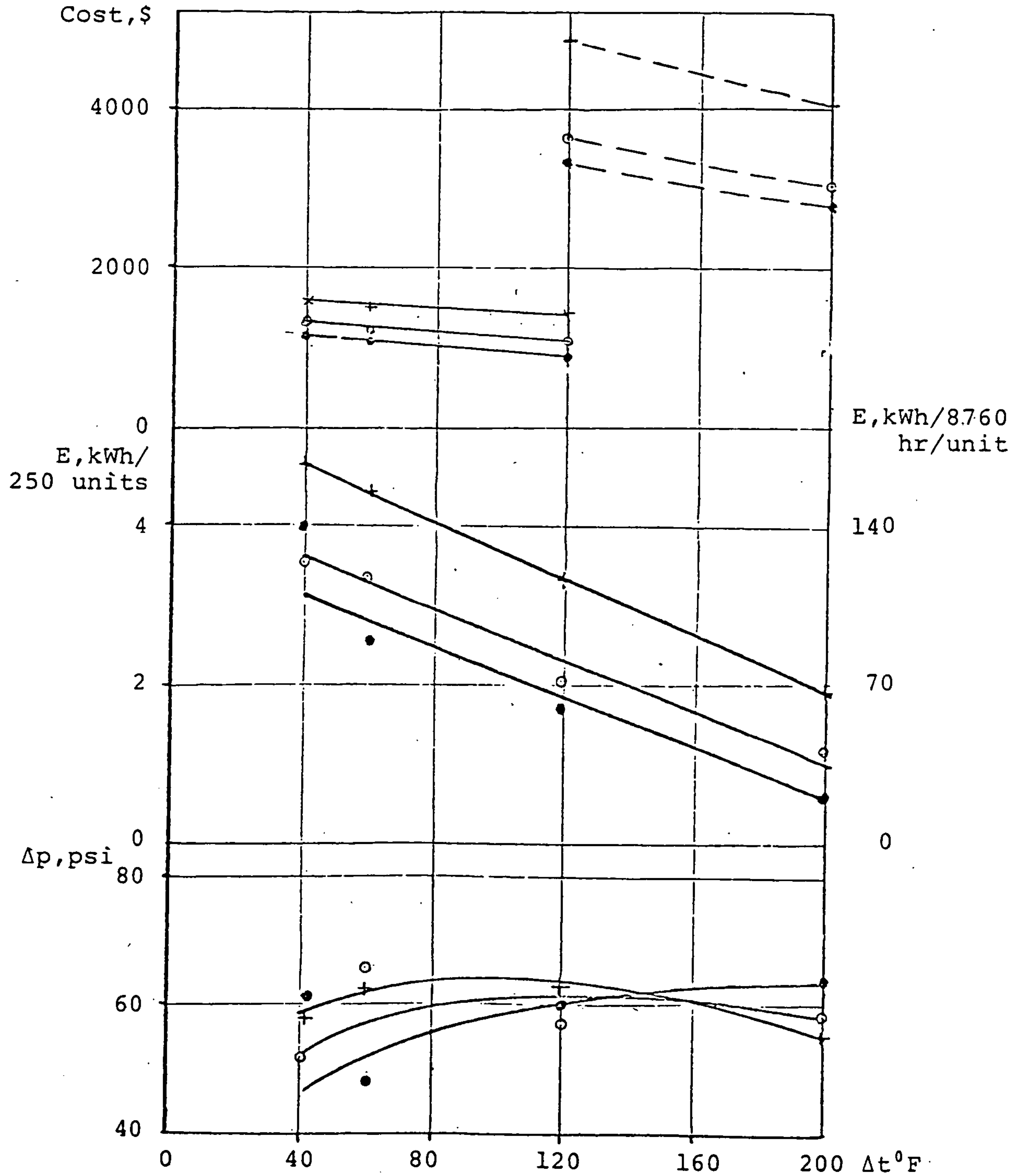
DISTRIBUTION PIPING INSTALLATION COST, PUMPING POWER & PRESSURE DROP IN 6 BLOCKS - SINGLE FAMILY HOUSES



DISTRIBUTION PIPING INSTALLATION COST, PUMPING POWER & PRESSURE DROP ON 1 SQ. MI. - SINGLE FAMILY HOUSES

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-19

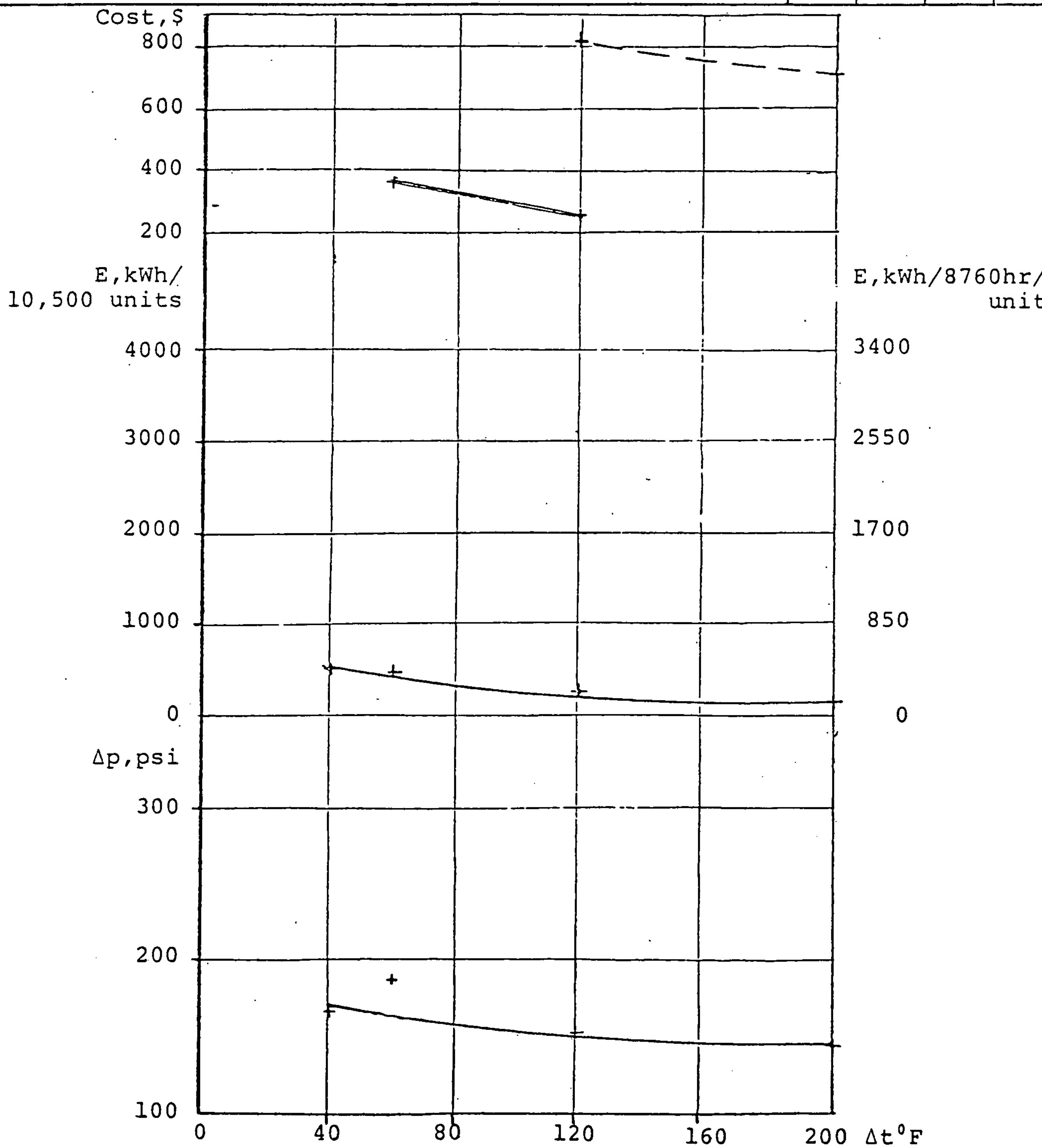


ALTERNATIVE SCHEMES: x——x see Fig. 561-06
o——o " " 561-07
●——● " " 561-08

DISTRIBUTION PIPING INSTALLATION COST, PUMPING POWER & PRESSURE DROP IN 6 BLOCKS - MULTIPLE DWELLINGS

TRANSFLUX international limited
FORT LEE, NEW JERSEY 07024

NO. 561-20



see Fig. 561-09

DISTRIBUTION PIPING INSTALLATION COST, PUMPING POWER & PRESSURE DROP ON 1 SQ. MI. - MULTIPLE DWELLINGS

COST OF DISTRIBUTION PIPING ON 1 SQUARE MILE

SINGLE FAMILY HOUSES

$\Delta t = 20^{o}F$

					Suburb./LTW		
6"ø	3 x 720'	=	2160	x	88.00	=	190,080.00
8"ø	3 x 720'	=	2160	x	114.00	=	246,240.00
10"ø	6 x 720'	=	4320	x	146.00	=	630,720.00
12"ø	3 x 720'	=	2160	x	172.00	=	371,520.00
14"ø	3 x 720'						
	3 x 360'						
	1 x 1800'	=	5040	x	201.00	=	1,013,040.00
18"ø	1 x 1800'	=	1800	x	250.00	=	450,000.00
24"ø	1 x 900'	=	900	x	312.00	=	280,800.00
			18540'				3,182,400.00

$$\frac{3182400.00}{60 \times 42} = 1261.9\$/lot$$

$\Delta t = 60^{o}F$

					Suburb./MTW		
4"ø	3 x 720'	=	2160	x	69.00	=	149,040.00
6"ø	9 x 720'	=	6480	x	88.00	=	570,240.00
8"ø	6 x 720'	=	4320	x	114.00	=	492,480.00
	3 x 360'						
	1 x 2160'	=	2160	x	146.00	=	315,360.00
12"ø	1 x 1800'	=	1800	x	172.00	=	309,600.00
14"ø	1 x 900'	=	900	x	201.00	=	180,900.00
			18540'				2,017,620.00

$$\frac{2017620.00}{60 \times 42} = 800.6\$/lot$$

$\Delta t = 120^{o}F$

					Suburb.MTW		
3"ø	3 x 720'	=	2160	x	64.00	=	138,240.00
4"ø	3 x 720'	=	2160	x	69.00	=	149,040.00
6"ø	3 x 3600'						
	1 x 1800'	=	12600	x	88.00	=	1,108,800.00
10"ø	1 x 1800'						
	1 x 900'	=	2700	x	146.00	=	394,200.00
			19620'				1,790,280.00

$$\frac{1790280.00}{60 \times 42} = 710.4\$/lot$$

Table XXIV

COST OF DISTRIBUTION PIPING ON 1 SQUARE MILE

MULTIPLE DWELLING

Δt = 60°F

						Urban/MTW		
6"ø	3 x 720'	=	2160	x	110.00	=	237,600.00
8"ø	3 x 720'	=	2160	x	141.00	=	304,560.00
10"ø	3 x 1440'	=	4320	x	182.00	=	786,240.00
12"ø	3 x 1440'	=	4320	x	213.00	=	920,160.00
14"ø	1 x 1800'						
	3 x 360'	=	2880	x	249.00	=	717,120.00
18"ø	1 x 1800'	=	1800	x	310.00	=	558,000.00
20"ø	1 x 900'	=	900	x	387.00	=	348,300.00
			18540'				3,871,980.00

$$\frac{3871980.00}{238 \times 42} = 387.35 \text{ \$/unit}$$

Δt = 120°F

						Urban/MTW		
4"ø	3 x 720'	=	2160	x	85.00	=	183,600.00
6"ø	3 x 720'	=	2160	x	110.00	=	237,600.00
8"ø	3 x 1440'	=	4320	x	141.00	=	609,120.00
10"ø	3 x 1440'						
	3 x 360'						
	1 x 1800'	=	7200	x	182.00	=	1,310,400.00
14"ø	1 x 1800'	=	1800	x	249.00	=	448,200.00
16"ø	1 x 900'	=	900	x	279.00	=	251,100.00
			18540'				3,040,020.00

$$\frac{3040020.00}{238 \times 42} = 304.12 \text{ \$/unit}$$

Δt = 200°F

						Urban/HTW		
4"ø	3 x 720'	=	2160	x	196.85	=	425,196.00
6"ø	3 x 2160'	=	6480	x	320.00	=	2,073,600.00
8"ø	3 x 1440'						
	3 x 360'						
	1 x 1800'	=	7200	x	413.00	=	2,973,600.00
12"ø	1 x 1800'						
	1 x 900'	=	2700	x	566.00	=	1,528,200.00
			18540'				7,000,596.00

$$\frac{7000596.00}{238 \times 42} = 700.34 \text{ \$/unit}$$

Table XXV

PIPING COST & PUMPING POWER
SUMMARY
FOR LOW DENSITY HOUSING

Alternative Schemes						L pipe, ft·10^{-3}			
Area		W, lb/hr/Area 10^{-3}	Δt, °F	Drawing No 561-	Pipeline Cost $/unit	D_{max} in	Rural	Sub-Urban	Pressure Drop $\Sigma(\Delta Ps+\Delta Pr)$ psi	Energy $\Sigma(Es+Er)$ kWh/hr
Single Family Housing	in an area of 6 blocks	180	20	01/A	5268.0	4	3	5.1	61.2	3.98
		90	40	01/D	5190.0	3	3	5.1	75.4	2.32
		60	60	01/B	4960.7	3	3	5.1	67.2	1.35
		30	120	01/C	4970.0	2	3	5.1	102.2	1.33
		180	20	02/A	4250.3	6	4.28	2.4	56.5	4.96
		90	40	02/D	4092.3	4	4.28	2.4	56.7	1.43
		60	60	02/B	3973.0	3	4.28	2.4	72.7	1.45
		30	120	02/C	3852.0	2	4.28	2.4	81.3	1.21
		180	20	03/A	3995.3	6	5.82	0.93	50.1	2.96
		90	40	03/D	3839.5	4	5.82	0.93	56.0	1.52
		60	60	03/B	3827.0	3	5.82	0.93	42.3	0.74
		30	120	03/C	3657.0	2	5.82	0.93	63.2	0.84
	in 1 sq. m	7560	20	04/A	1261.9	24	-	18.5	227	542
		3780	40	04/D	996.2	18	-	18.5	173	271
		2520	60	04/B	800.6	14	-	18.5	206	203
		1260	120	04/C	710.4	10	-	18.5	247	151
Small Multi Family Housing	in an area of 6 blocks	240	40	06/D	1674.25	6	3.0	5.1	57.6	3.50
		160	60	06/A	1544.3	4	3.0	5.1	68.0	3.48
		80	120	06/B	1525.0	3	3.0	5.1	67.7	1.86
		48	200	06/C	4034.5	3	3.0	5.1	45.3	1.12
		240	40	07/D	1259.75	6	4.28	2.4	53.9	4.70
		160	60	07/A	1170.0	4	4.28	2.4	74.5	4.60
		80	120	07/B	1138.0	4	4.28	2.4	58.0	3.23
		48	200	07/C	3081.1	3	4.28	2.4	51.9	1.75
		240	40	08/D	1130.25	6	5.82	0.93	63.0	4.58
		160	60	08/A	1056.1	4	5.82	0.93	50.1	2.72
		80	120	08/B	976.1	4	5.82	0.93	62.0	1.78
		48	200	08/C	2887.5	3	5.82	0.93	68.8	1.13
	in 1 sq. m	10000	40	09/D	-	30	-	18.54	166.4	470.0
		6666	60	09/A	387.35	24	-	18.54	187.6	395
		3333	120	09/B	304.12	18	-	18.54	157.0	197
		2000	200	09/C	700.3	14	-	18.54	141.0	105

Subscript s - supply
" r - return

The total cost of a unit is the distribution cost on the blocks plus the cost of sub-mains on 1 sq. mile. The cost of transmission mains is assumed to be carried by large users only.

TABLE XXVI

FLOW, VELOCITY & PRESSURE DROP
IN CARBON STEEL PIPING SYSTEMS

D_{nom} in.	D_{ins} in.	Flow Rate min/max lb/h 10^{-3}	U, fps min/max for t °F 140÷230	290	390	Pressure Drop, ΔP psi/100 ft, Temperature °F 140; Viscosity, cP 0.21; Density lb/ft³ 61.4	200; 0.134; 60.1	290; 0.095; 57.6	390; 0.04; 54.0
1	0.957	6.4	5.9	6.18	6.59	8.65	7.89	7.87	7.31
1.5	1.5	6.4	2.4	2.5	2.7	2.13	0.88	0.88	0.83
		18.5	6.9	7.3	7.8	6.90	6.30	6.30	5.90
2	2.067	18.5	3.7	3.8	4.1	1.46	1.33	1.33	1.25
		28.0	5.5	5.8	6.2	3.14	3.04	2.70	2.68
3	3.068	28.0	2.5	2.6	2.8	0.58	0.42	0.42	0.40
		78.0	6.9	7.3	7.8	2.78	2.73	2.68	2.61
4	4.026	78.0	4.1	4.3	4.6	0.83	0.77	0.77	0.71
		155.0	8.0	8.5	9.0	2.85	2.61	2.64	2.46
6	6.065	155.0	3.6	3.7	4.1	0.42	0.37	0.37	0.36
		400.0	9.2	9.6	10.3	2.27	1.66	2.06	1.95
8	7.981	400.0	5.3	5.6	5.9	0.63	0.57	0.57	0.50
		760.0	10.0	10.6	11.2	1.91	1.78	1.79	1.81
10	10.02	760.0	6.4	6.7	7.2	0.66	0.61	0.61	0.55
		1300	10.9	11.4	11.9	1.17	1.11	1.10	1.03
12	12.00	1300	7.6	8.0	8.1	0.50	0.45	0.45	0.44
		2000	11.7	12.3	13.1	1.58	1.48	1.48	1.39
14	13.25	2000	9.6	10.1	10.8	1.00	0.94	0.93	0.86
		2500	12.0	13.8	14.1	1.52	1.41	1.37	1.39
16	15.25	2500	9.1	9.2	9.5	0.78	0.72	0.66	0.58
		3700	13.5	14.1	15.1	1.60	1.49	1.44	1.35
18	17.25	3700	10.5	11.0	11.7	0.87	0.80	0.80	0.74
		4500	12.8	13.4	14.3	1.25	1.16	1.14	1.07
20	19.25	4500	10.3	10.8	11.5	0.74	0.69	0.68	0.62
		5800	13.2	13.9	14.8	1.17	1.10	1.08	1.00
24	23.25	5800	9.1	9.5	10.1	0.48	0.46	0.44	0.40
		8700	13.6	14.2	15.2	0.99	0.92	0.90	0.85
30	20.25	8700	8.6	9.0	9.6	0.33	0.31	0.30	0.28
		12400	12.3	12.8	13.7	0.63	0.59	0.57	0.53
36	35.25	12400	8.4	8.8	9.4	0.25	0.24	0.22	0.21
		21000	14.3	15.0	16.0	0.67	0.62	0.57	0.51
42	41.25	21000	10.4	10.9	11.6	0.32	0.30	0.28	0.26
		30000	14.9	15.6	16.6	0.61	0.58	0.54	0.48
48	47.25	30000	11.4	11.9	12.7	0.32	0.30	0.28	0.26
		40000	15.1	15.9	16.9	0.54	0.49	0.45	0.40
54	53.25	40000	11.9	12.5	13.3	0.30	0.28	0.27	0.25
		52000	15.5	16.2	17.3	0.49	0.45	0.44	0.42
60	59.25	52000	12.5	13.1	13.9	0.30	0.28	0.27	0.24
		67000	16.1	16.9	18.0	0.46	0.42	0.37	0.38

TABLE XXVII

EXERPTS OF PSE&G CUSTOMERS' SURVEY

(El. customers -- 18000 responses)*
(Gas customers -- 15000 responses)*

TYPE OF BLDG.	SINGLE FAMILY		GARDEN APT.		TWO OR MORE APTS.		HI-RISE	
	El.	Gas	El.	Gas	El.	Gas	El.	Gas
Age of bldg. (est)								
up to 2 yrs.	1.5	1.2	2.7	1.6	.9	.7	3.4	.7
3 to 5 yrs.	2.8	3.4	9.2	4.6	1.9	1.4	4.2	.3
6 to 10 yrs.	6.0	7.3	19.8	6.3	4.0	3.1	6.2	.9
11 to 20 yrs.	23.0	24.2	20.4	14.5	8.3	7.2	13.3	6.7
over 20 yrs.	58.5	56.0	29.2	48.3	56.1	57.5	44.5	56.4
Age of heat.syst.(est)								
up to 2 yrs.	6.4	5.8	4.2	3.4	5.0	4.2	4.6	2.9
3 to 5 yrs.	9.4	9.7	10.0	7.0	7.5	7.1	4.4	1.7
6 to 10 yrs.	15.4	16.8	16.3	7.4	12.9	13.0	6.4	2.9
11 to 20 yrs.	32.6	33.6	13.5	11.7	19.6	18.2	9.5	5.7
over 20 yrs.	26.1	24.3	9.7	17.0	16.2	16.6	14.8	19.0
Type of heat. syst.								
Forced warm air	43.4	46.0	13.0	9.5	9.9	8.7	4.4	1.9
Hot water/steam	50.8	48.8	68.9	74.4	76.1	76.8	72.8	80.6
Other	3.4	2.8	10.0	7.5	7.4	7.5	9.6	6.7
Fuel Use -								
Space heat'g-gas	56.4	67.8	25.9	23.6	38.2	39.2	9.7	10.6
-oil	41.5	31.0	53.3	64.3	55.7	55.1	71.7	77.8
-el.	1.1	.3	7.4	.7	1.4	.5	5.1	.6
Dom.water heat'g-gas	74.7	85.9	16.7	22.0	45.7	47.3	5.7	6.7
-oil	18.6	11.1	13.9	17.1	24.6	23.8	19.0	21.3
-el.	4.5	1.2	5.5	.7	1.2	.3	2.2	.2
-none	.9	.6	.6	.4	.6	.6	1.0	.7
-by-landl.	.3	.3	59.1	54.6	24.6	24.6	64.2	63.5

* Where a group does not add up to 100% data was not received from that portion of total respondents.

TABLE XXVIII

TRANSFLUX
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Appendix B

HEATING LOAD ESTIMATES

1. Purpose

There are a large number of potential generating stations in the PSE&G system which could serve as the heat supplier of a cogenerative district heating system. Selection of one or more stations as the heat supply centers depends on their relative location to present and future loads and on the practicality and cost of retrofit. This investigation addresses the question of potential load around each station.

2. Scope

This investigation is a preliminary overview of the total territory on a mostly statistical basis. Statistical data is supplemented by PSE&G in-house customer information and by other commercially available data sources. The territories investigated are limited to a radius of up to 5 miles around the stations within the state of New Jersey.

3. Towns & Localities

A set of windrose-form tables (Tables I to VI) show the towns and localities within 5 and 10 mile radii of the generating stations. Essex, Kearny and Hudson G.S.'s are so close to each other that it was found impractical to show separate supply areas for each. The 10 mile radius was included for future reference in certain cases where it might be economical to extend a supply territory beyond the 5 mile limit.

The circles are broken up into 8 segments and the detailed investigation deals with those segments.

4. <u>Statistical Population and Housing Data</u>

The basis of the investigation was the "1970 Census of Housing" (U.S. Dept. of Commerce, Bureau of the Census) - Block Statistics.

These books contain tabulations of data by census blocks and reference maps showing the location and size of each block. The relevant data extracted is shown on Tables VII to XVII.

Tables VII, IX, XI, XII, XIV and XVI are detailed data sector by sector, with reference to census block numbers. The main headings in these tables contain the following information:

<u>Area:</u> Shows the name of the political unit the block belongs to, its aerial distance to the referenced G.S. and the block number.

<u>Total Population:</u> The number of people domiciled within that block.

Housing Units in Year-Round Housing: A housing unit is a single-family house or an independent apartment in a multi-family structure. The total is a sum of all these within the block. A 1 unit structure is a single-family house. The >10 unit structures are apartment or garden apartment houses. The 2 to 9 unit structures are duplexes, triplexes, etc. or garden apartments. This last group is not listed in the census data and the figure is a simple arithmetic difference of the total minus the other two categories.

Estimate Heat Load: The estimates are based on the average peak heating requirement figures indicated. Apartments in small or larger structures were estimated at this point by using a single value.

Distribution Piping: Order of magnitude estimation was the purpose of developing these figures. The length of all streets give the most relevant idea of the size of the block and of the average size of building lots. The pipe diameters shown are the size of the pipe entering the block to supply the total heat requirements at the two different supply and return water temperature differentials.

Sector: Each sector is one-eighth of a circle, 45°. On a 5 mile radius it is an area of 9.8 sq. mi. In the two letter designation the first letter is the direction it lies closest to and the other indicates the rotation away from that line. So NE is a sector bordering on the North line and spreading East, while EN is bordering on the East line and spreads North.

Tables VIII, X, XIII, XV and XVII are summaries of data presented on the above tables. The meaning of the additional headings of these tables are as follows:

Populated Area: The actual built in area including streets within the block. Relating it to the total 9.8 sq. mi. area of each block, a good appreciation of residential density can be obtained.

Av. Population Density: This refers to the actual residential area within the block and not to the total block.

Heat Load Density: Again the reference is the built in residential area and not the total area.

Table XVIII is a summary presentation of the results. First it shows the calculated densities of all sectors around each generating station grouped in 50 million BTU/hr/sq. mi. increments and then the average load density around each station.

There is a clear indication that the majority of high load densities and the highest average densities are in the Essex (Kearny, Hudson) and No. Bergen G.S. areas.

A look at selected (by densest and by highest loads) sectors corroborates that answer, since both of those are in the Essex plant area, namely Jersey City/Union City and Newark/Harrison. The next densest load area is at the No. Bergen station, in Guttenberg.

5. <u>Statistical Data on Fuel Use</u>

There are a number of statistical sources available to check the accuracy of the estimated heating loads and to extend the estimates to cover commercial, institutional and industrial potentials. However, the accuracy of these calculations is hampered by the differences in the reference years. The data used in the following covers 1970 to 1977 period. Even so it will suffice for order of magnitude type of information.

5.1 Residential Fuel Use Patterns for Heating and Domestic Hot Water

These patterns are listed for major metropolitan areas of NE-New Jersey in the 1970 report of the Bureau of the Census. Table XXI shows the data for the entire region and for 6 selected urban areas.

One can see that the share of other than oil and gas fuels is small. One can consider that all residential, commercial and institutional heating is based on these two fuels. Taking that as 100% their respective share in the areas under investigation is as follows:

Residential fuel use:

NE-New Jersey total	gas	45.8%
	oil	54.2%
Metropolitan areas of -Jersey City, Newark Bayonne, Union City	gas	40%
	oil	60%
-Elizabeth	gas	29.5%
	oil	70.5%
-Trenton	gas	30.4%
	oil	69.6%

The New Jersey Dept. of Environmental Protection gathered fuel use data for the entire state broken down by counties. This data is shown on Table XXII for the counties of interest. The share of coal is insignificant and that leaves again oil and gas as the major fuels. The oil figures used are the totals of distillate and heavy fuel uses, for commercial and industrial users. There is no heavy fuel use listed for residential.

It is significant that on a BTU basis the total New Jersey consumption of the two fuels (oil and gas) in residential use breaks down again as

40.5% gas

59.5% oil

6. Load Potential Estimates

Table XXIX shows the total number of potential residential housing units and their estimated peak heating load within the 5 mile area of the generating stations. It also shows the housing units in multiple dwellings only, since as it was shown in Appendix A, connecting single family dwellings to a district heating system is of questionable economy.

Table XXII shows the annual fuel consumption in the relevant counties of New Jersey by major sectors of users. Using the consumption ratios of residential versus commercial/institutional fuel uses, one can obtain the potential commercial/institutional heating loads. These ratios are as follows:

	Fuel Oil	Gas	Weighted Av.
	use by commerce/institutions as % of residential		
Bergen County	49	43	46.6
Burlington "	58	51	54.4
Essex "	47	41	44.6
Hudson "	44.5	39	42.3
Mercer "	49	42.5	46.4
Middlesex "	11	46	25.0
Union	48	42	45.6

Using these averages the residential load totals of Table XXIX can be factored to include the commercial/institutional sectors to give us the following results:

Essex (Kearny, Hudson)	comm./inst.	$12077\times10^6 \times .423 =$	5108×10^6
	multiple dwell.		9800×10^6
			14908×10^6 BTU/hr.
No. Bergen	comm./inst.	$7523\times10^6 \times .466 =$	3506×10^6
	multiple dwell.		4265×10^6
			7771×10 BTU/hr.
Linden	comm./inst.	$4162\times10^6 \times .456 =$	1898×10^6
	multiple dwell.		2005×10^6
			3903×10^6 BTU/hr.
Sewaren	comm./inst.	$3468\times10^6 \times .25 =$	867×10^6
	multiple dwell.		1068×10^6
			1935×10^6 BTU/hr.
Mercer	comm./inst.	$3188\times10^6 \times .464 =$	1479×10^6
			802×10^6
			2281×10^6 BTU/hr.
Burlington	comm./inst.	$1354\times10^6 \times .544 =$	736×10^6
			144×10^6
			880×10^6 BTU/hr.

These are the load potentials around each station, still excluding industrial uses. The fuel consumption of industry is 10% to 50% higher than that of the commercial/ institutional sector, but it is impossible to quantify the types of heat users which can be supplied by a basically low temperature distribution system aimed at comfort heating.

Table XXIII shows the fuel use by industry in N. J. and it also depicts six industries which account for most of the fuel used and which are known to have considerable low level heat requirements. The table also contains data on those industries according to their location in different metropolitan areas giving their share in the total industrial fuel use in that particular area. The most concentrated load representing is in the Newark area, nearly 25% of that of the entire state.

7. Additional Data

Out of PSE&G customer records and other available data sources, an attempt was made to list and then locate high-rise or large apartment buildings and office buildings. The results are shown on Maps No. 1 to #23.

Assigning 20000 BTU/hr. for a high-rise apartment unit and 25000 BTU/hr. for a 1000 sq. ft. of office space these loads amount to the following:

Bergen G.S. (Maps No. 1-5)	6491 apts.	130.0×10^6 BTU
	1713.5×10^3 sq.ft.off.	428.4×10^6 BTU
		558.4×10^6 BTU/hr.
Essex (Hudson, Kearny) (Maps No. 6-16)	31528 apts.	636×10^6 BTU
	4077×10^3 sq.ft.off.	102×10^6 BTU
		738×10^6 BTU/hr.
Linden (Maps No. 17-18)	- apts.	
	1669×10^3 sq.ft.off.	42×10^6 BTU/hr.
Sewaren (Map No. 19)	262×10^3 sq.ft.off.	6.5×10^6 BTU
Mercer (Maps No. 20-23)	4812 apts.	96×10^6 BTU
	436×10^3 sq.ft.off.	11×10^6 BTU
		107×10^6 BTU/hr.

This can be considered as minimum data, since neither the apartment count or even less so the office count are complete. Neither is there any commercial and institutional load included. Since a large number of these are concentrated big loads it is conservative to estimate that those would at least double the above figures (meaning only 20% or so of the total potential calculated in the previous par.).

8. Conclusions

The result of the above studies is that there is considerable potential heating load within the 5 mile vicinity of any of the power plants.

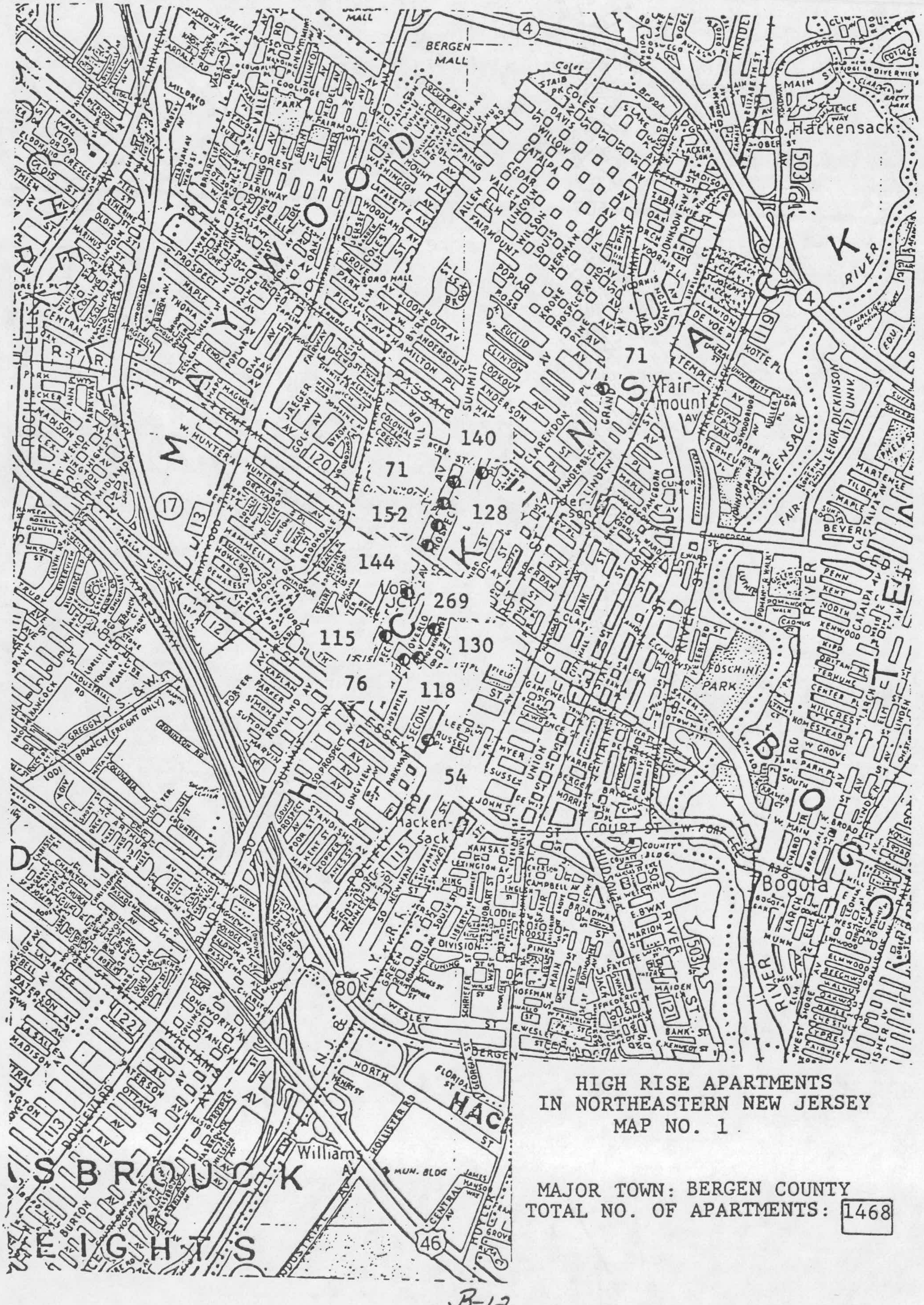
There is a marked difference in the absolute value of the potential load and in its concentration between the Bergen, Hudson, Essex, Union counties and those in Middle-Essex, Mercer and Burlington. The same applies to the number of large potential customers.

Load concentration being the key to an economical heat distribution system, the vicinity of the Essex, Kearny, Hudson and No. Bergen G.S.'s can be considered as prime supply areas.

Within this area there are three districts particularly conducive at the present and one in the future. These are:

Present	Newark downtown Jersey City, Journal Square West New York/Union City
Future	Meadowlands/Secaucus/Lyndhurst

These areas not only promise the best economy for a distribution system, but also represent total potential loads in excess of the heat supply capacity of the plants considered.

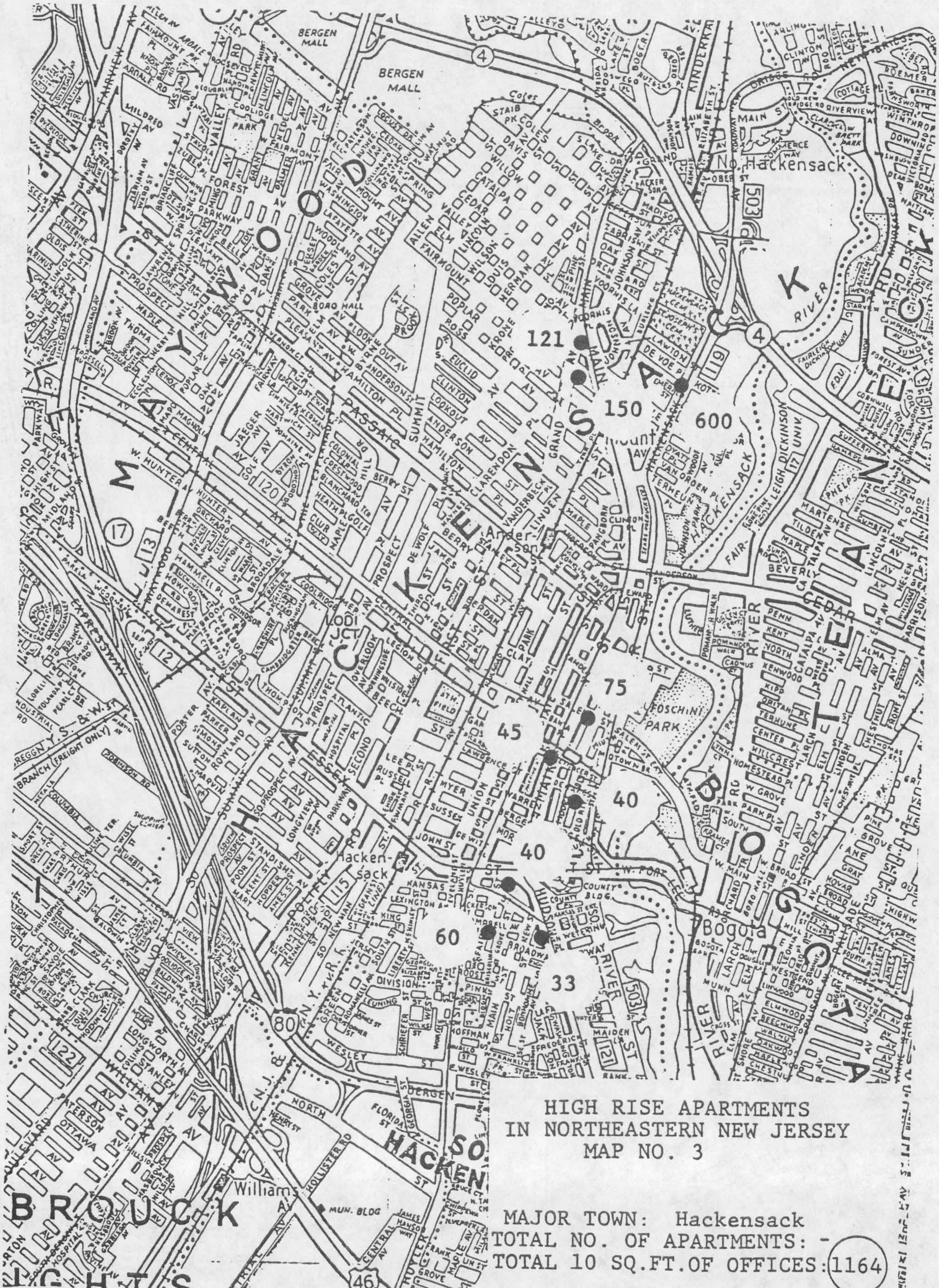


HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 1

MAJOR TOWN: BERGEN COUNTY
TOTAL NO. OF APARTMENTS: 1468

HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 2

MAJOR TOWN: Bergen County
TOTAL NO. OF APARTMENTS: 5023

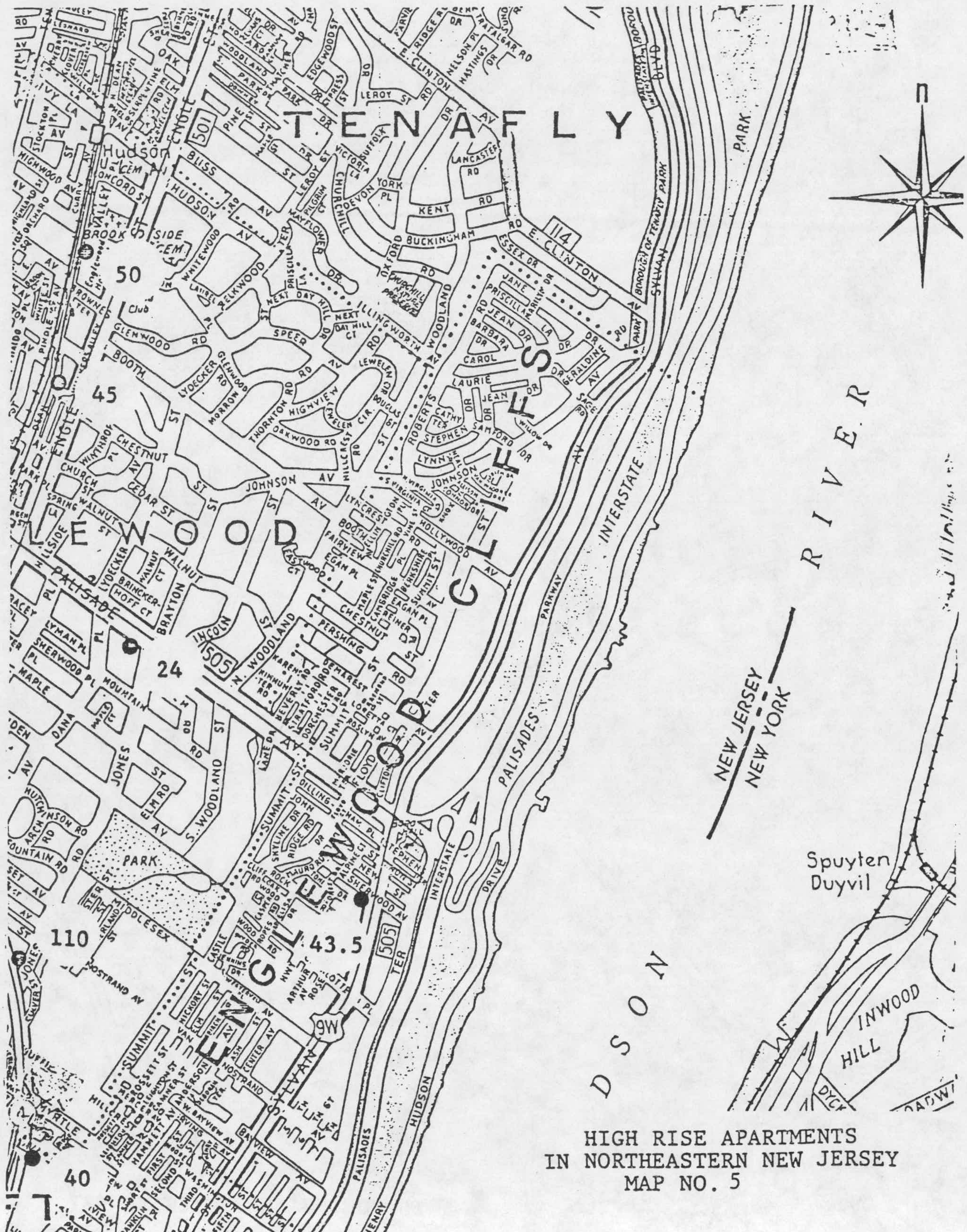


HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 3

MAJOR TOWN: Hackensack
TOTAL NO. OF APARTMENTS: -
TOTAL 10 SQ.FT.OF OFFICES: 1164

HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 4

MAJOR TOWN: Bergen County
TOTAL NO. OF APARTMENTS: -
TOTAL 10^3SQ.FT.OF OFFICES: (237)

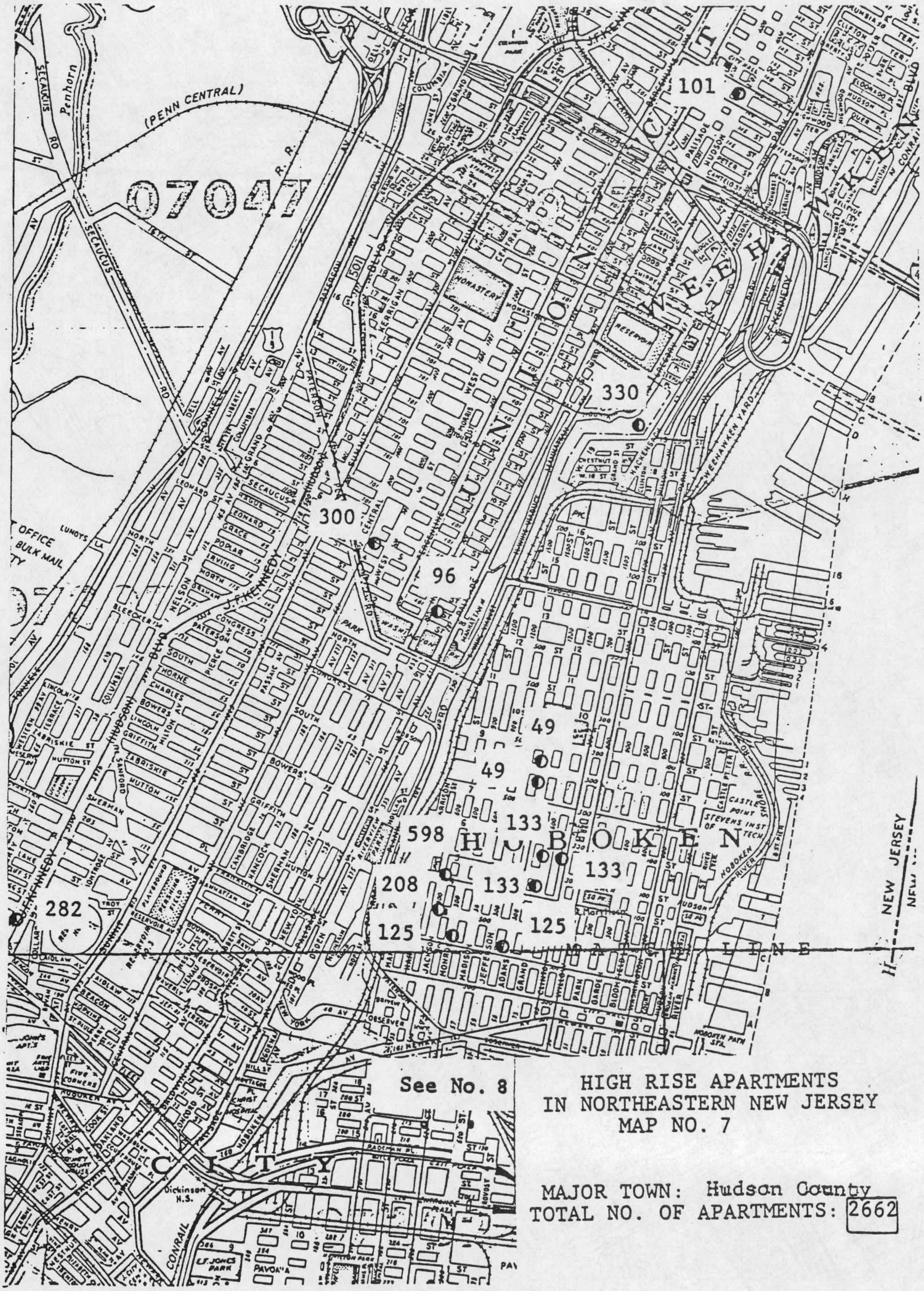


HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 5

MAJOR TOWN: Bergen County
TOTAL NO. OF APARTMENTS:
TOTAL 10^3SQ.FT.OF OFFICES: 312.5

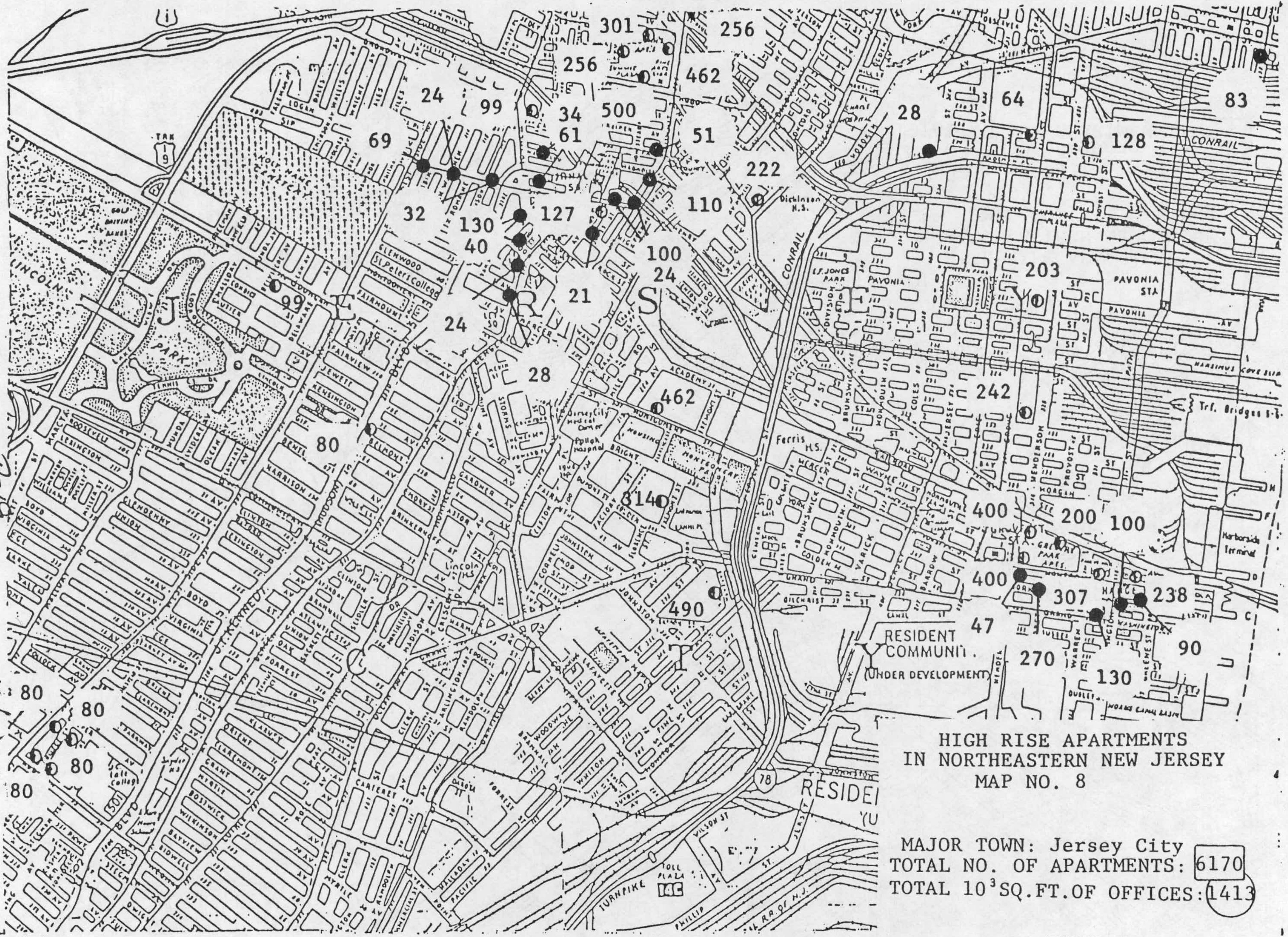
HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 6

MAJOR TOWN: Hudson County
TOTAL NO. OF APARTMENTS: 4249



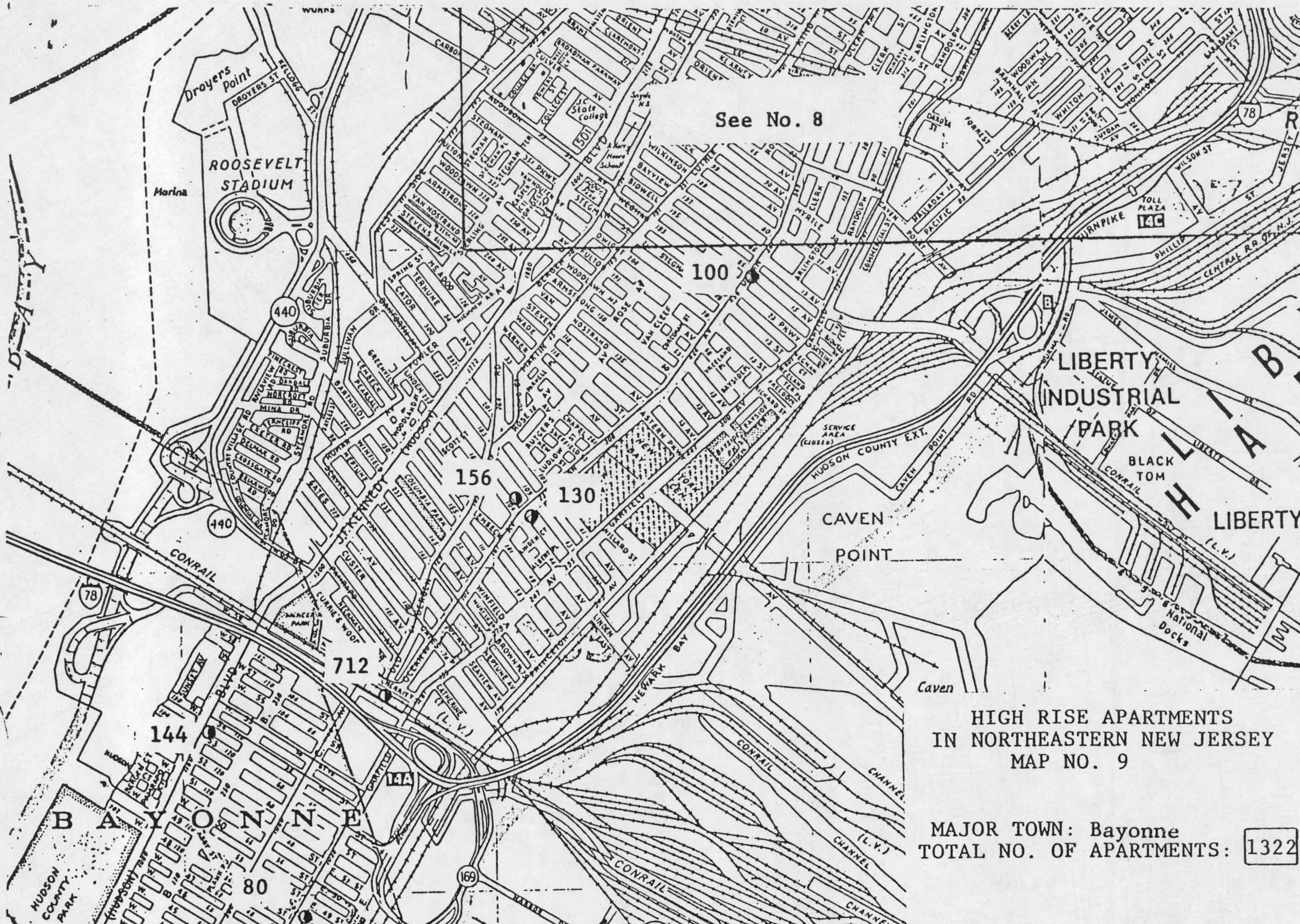
HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 7

MAJOR TOWN: Hudson County
TOTAL NO. OF APARTMENTS: 2662



HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 8

MAJOR TOWN: Jersey City
TOTAL NO. OF APARTMENTS: 6170
TOTAL 10^3 SQ.FT.OF OFFICES: 1413



HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 9

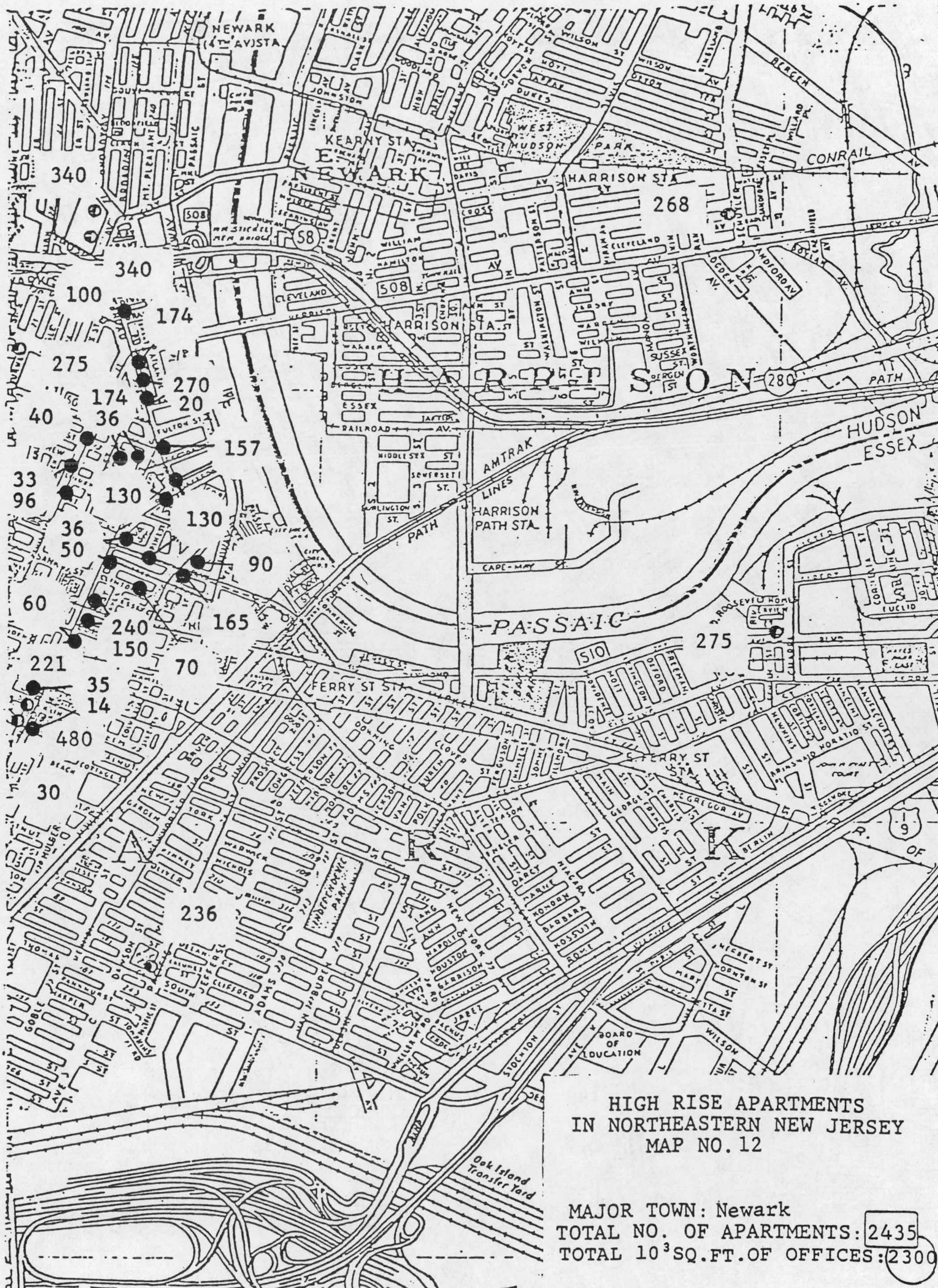
MAJOR TOWN: Bayonne
TOTAL NO. OF APARTMENTS: 1322

HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 10

MAJOR TOWN: Newark
TOTAL NO. OF APARTMENTS: 2744

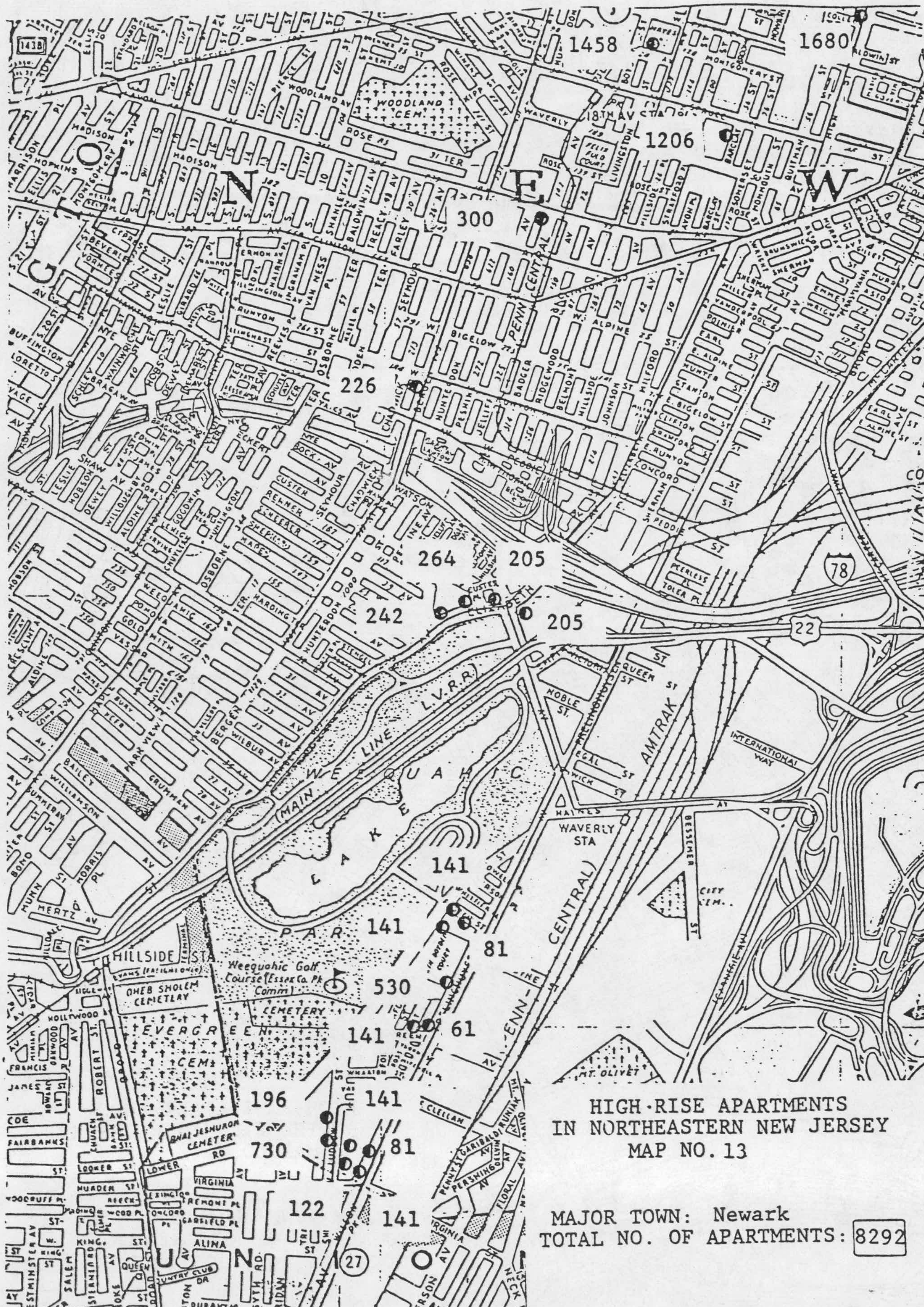
HIGH-RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 11

MAJOR TOWN: Newark
TOTAL NO. OF APARTMENTS: 3654



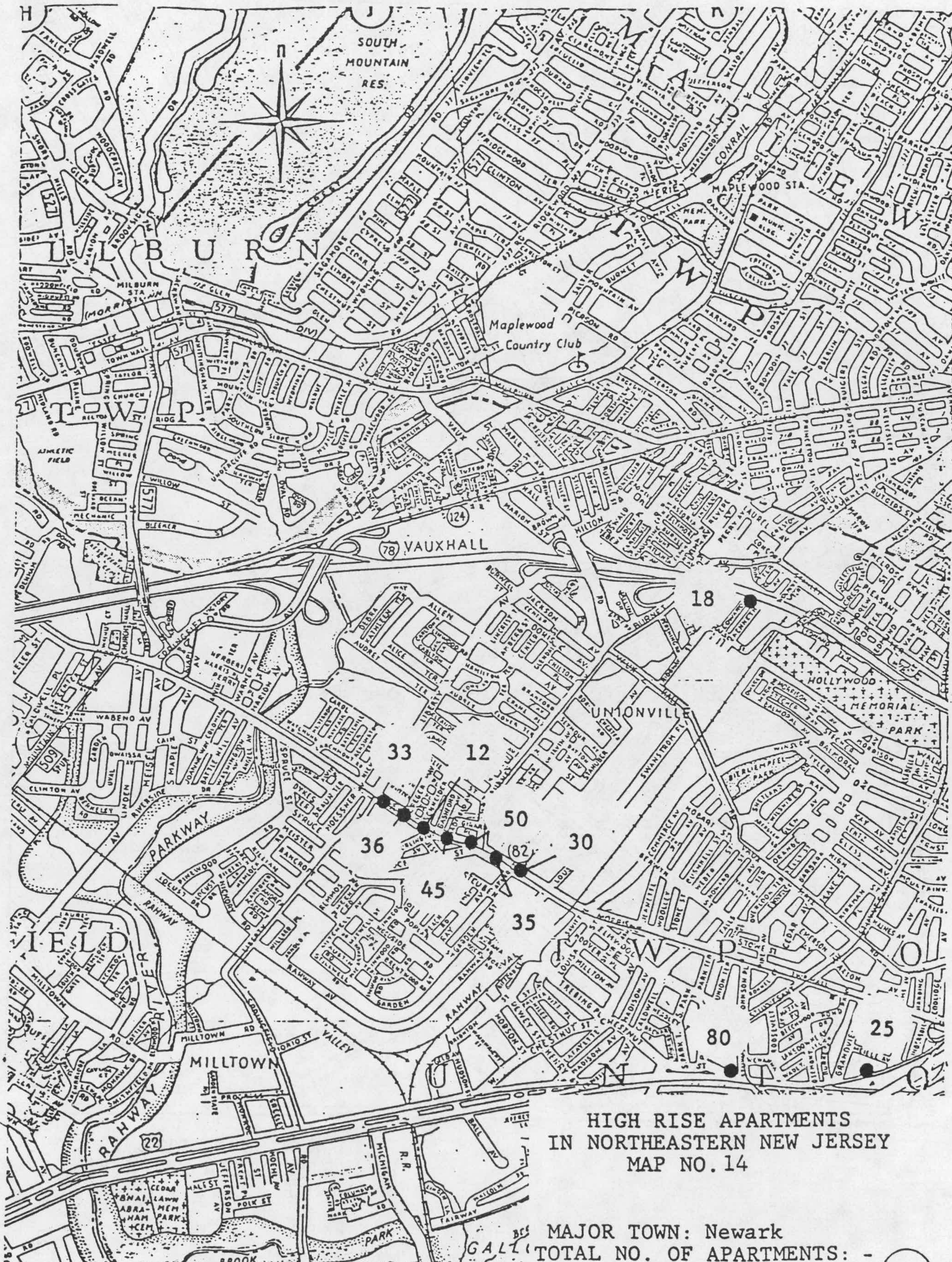
HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 12

MAJOR TOWN: Newark
TOTAL NO. OF APARTMENTS: 2435
TOTAL 10^3 SQ.FT. OF OFFICES: 2300



HIGH-RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 13

MAJOR TOWN: Newark
TOTAL NO. OF APARTMENTS: 8292



HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 14

MAJOR TOWN: Newark
TOTAL NO. OF APARTMENTS: -
TOTAL 10^3 SQ.FT.OF OFFICES: (364)

HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 15

MAJOR TOWN: Newark
TOTAL NO. OF APARTMENTS: -
TOTAL 10^3 SQ.FT.OF OFFICES: 436.5

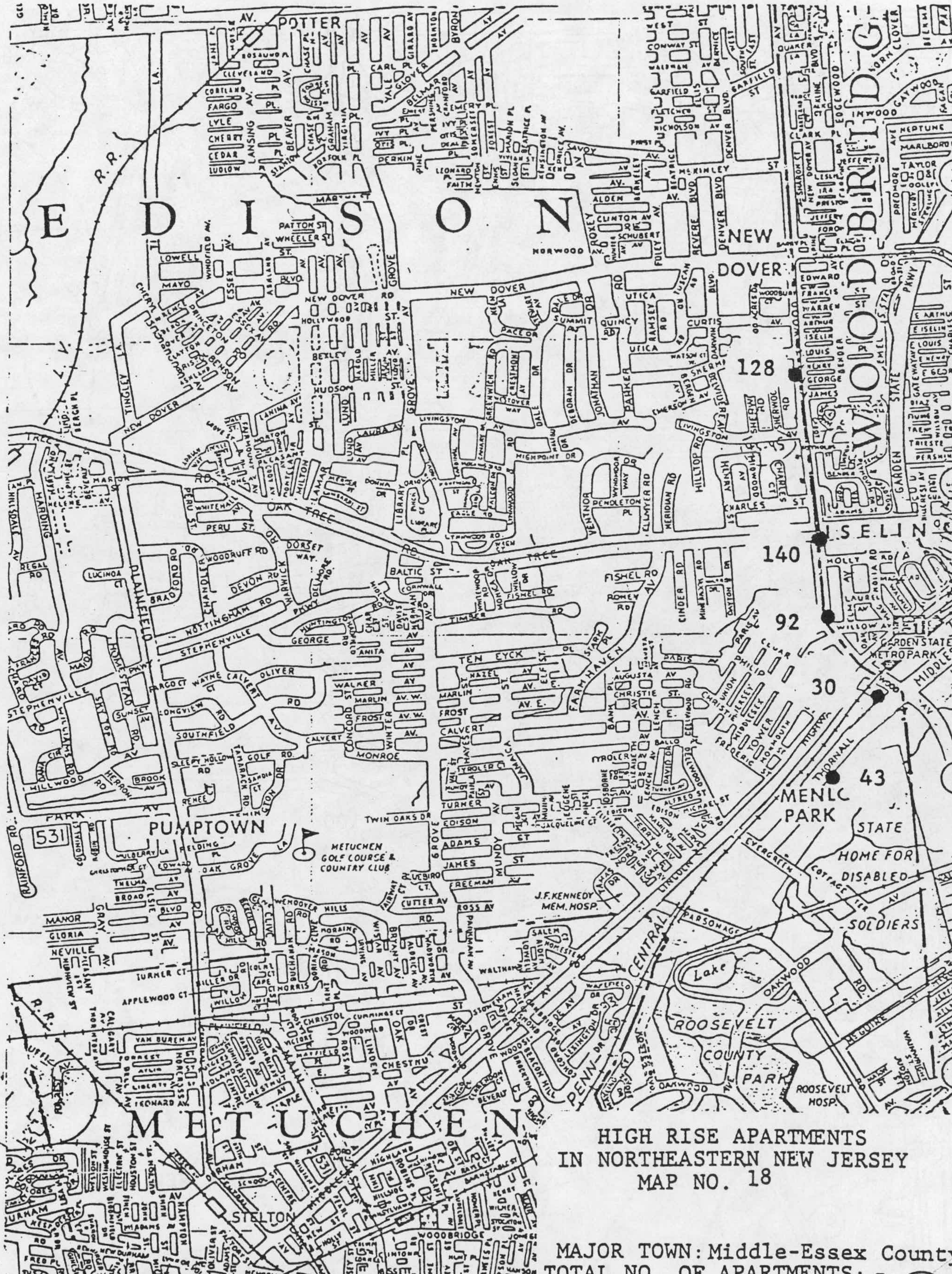
B-26

HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 16

MAJOR TOWN: Newark
TOTAL NO. OF APARTMENTS: -
TOTAL 10^3 SQ.FT.OF OFFICES: (142)

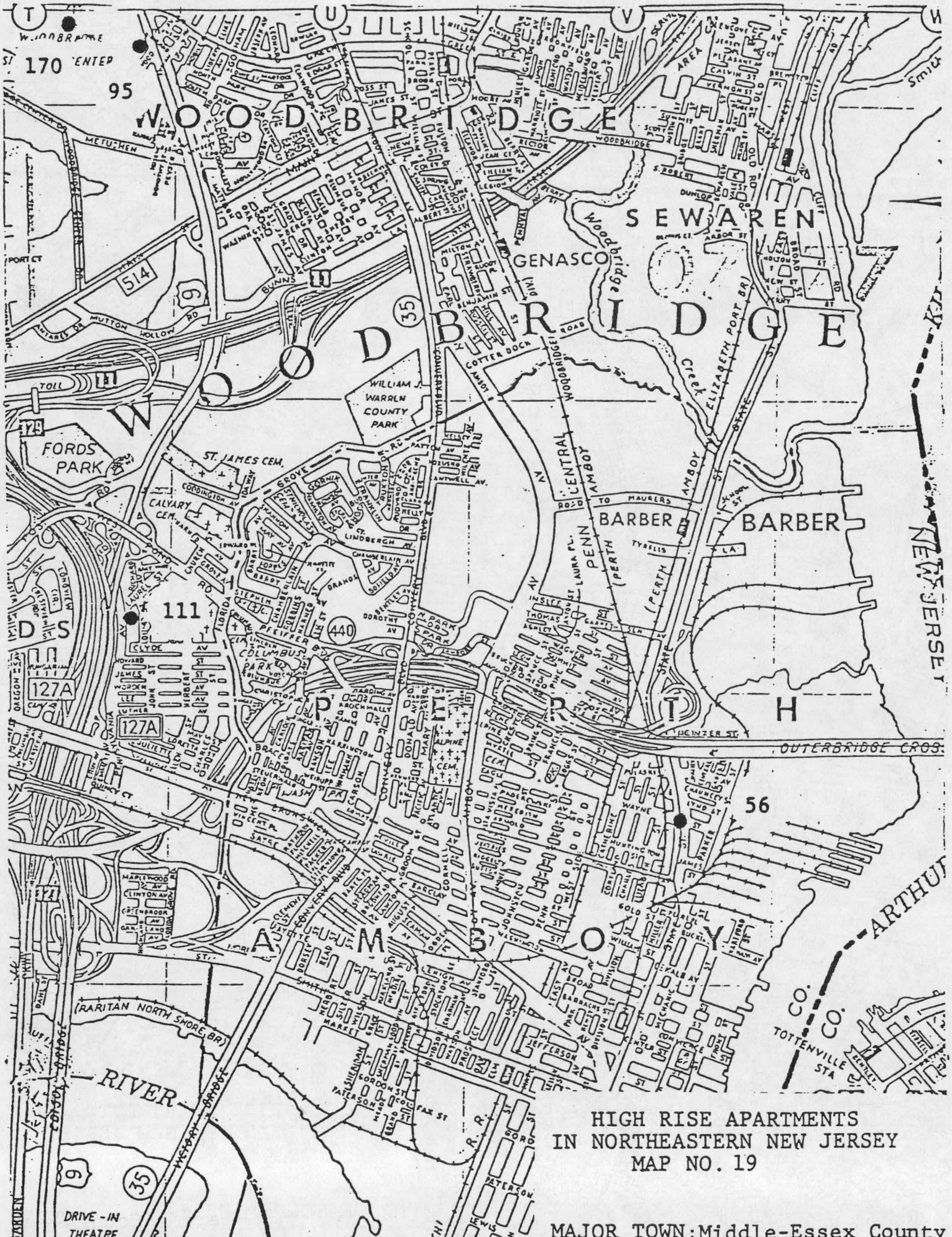
HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 17

MAJOR TOWN: Middle-Essex County
TOTAL NO. OF APARTMENTS: -
TOTAL 10^3 SQ.FT. OF OFFICES: 658



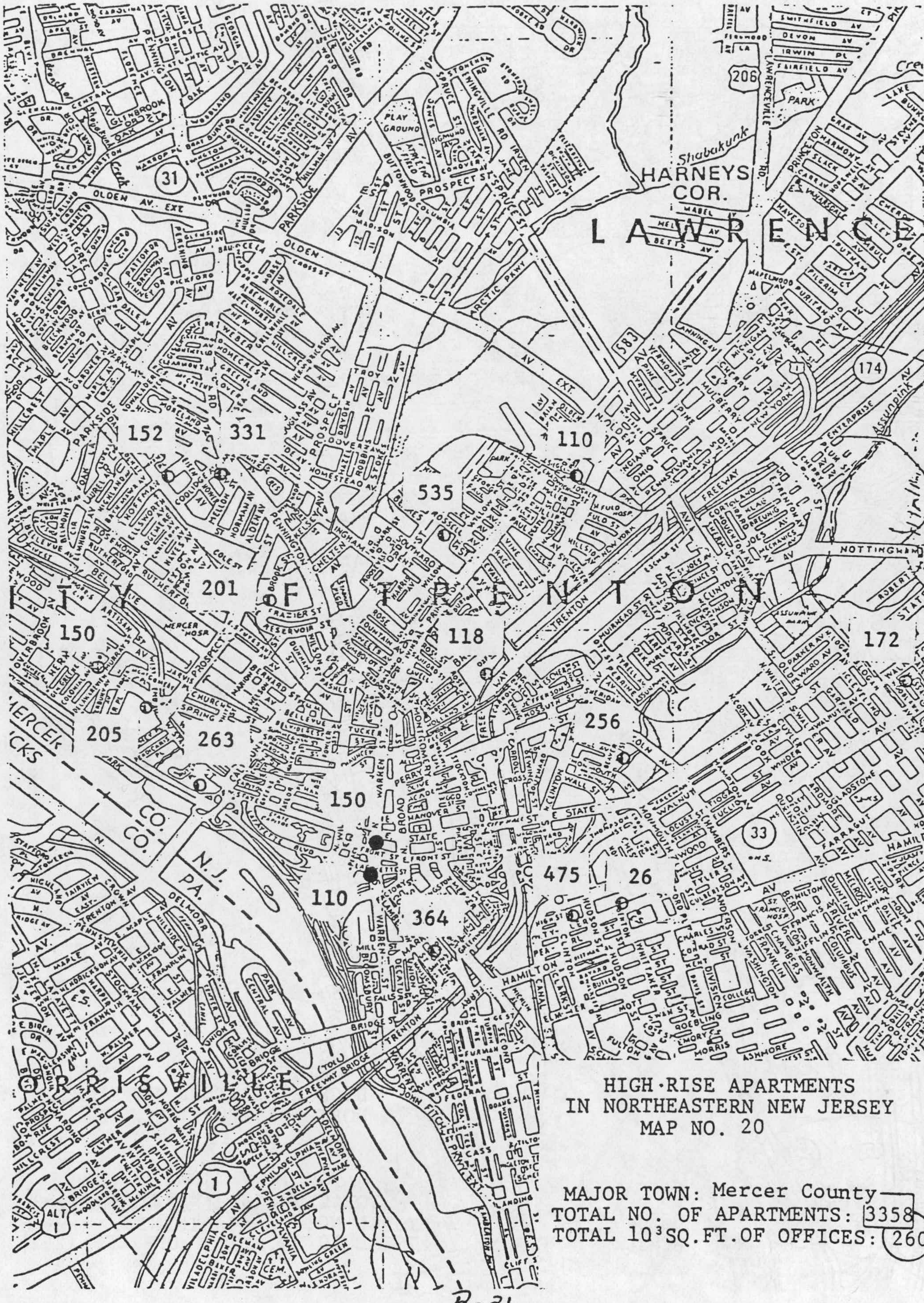
HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 18

MAJOR TOWN: Middle-Essex County
TOTAL NO. OF APARTMENTS: -
TOTAL 10^3 SQ.FT.OF OFFICES: (433)



HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 19

MAJOR TOWN: Middle-Essex County
TOTAL NO. OF APARTMENTS: -
TOTAL 10^3 SQ.FT. OF OFFICES: 262

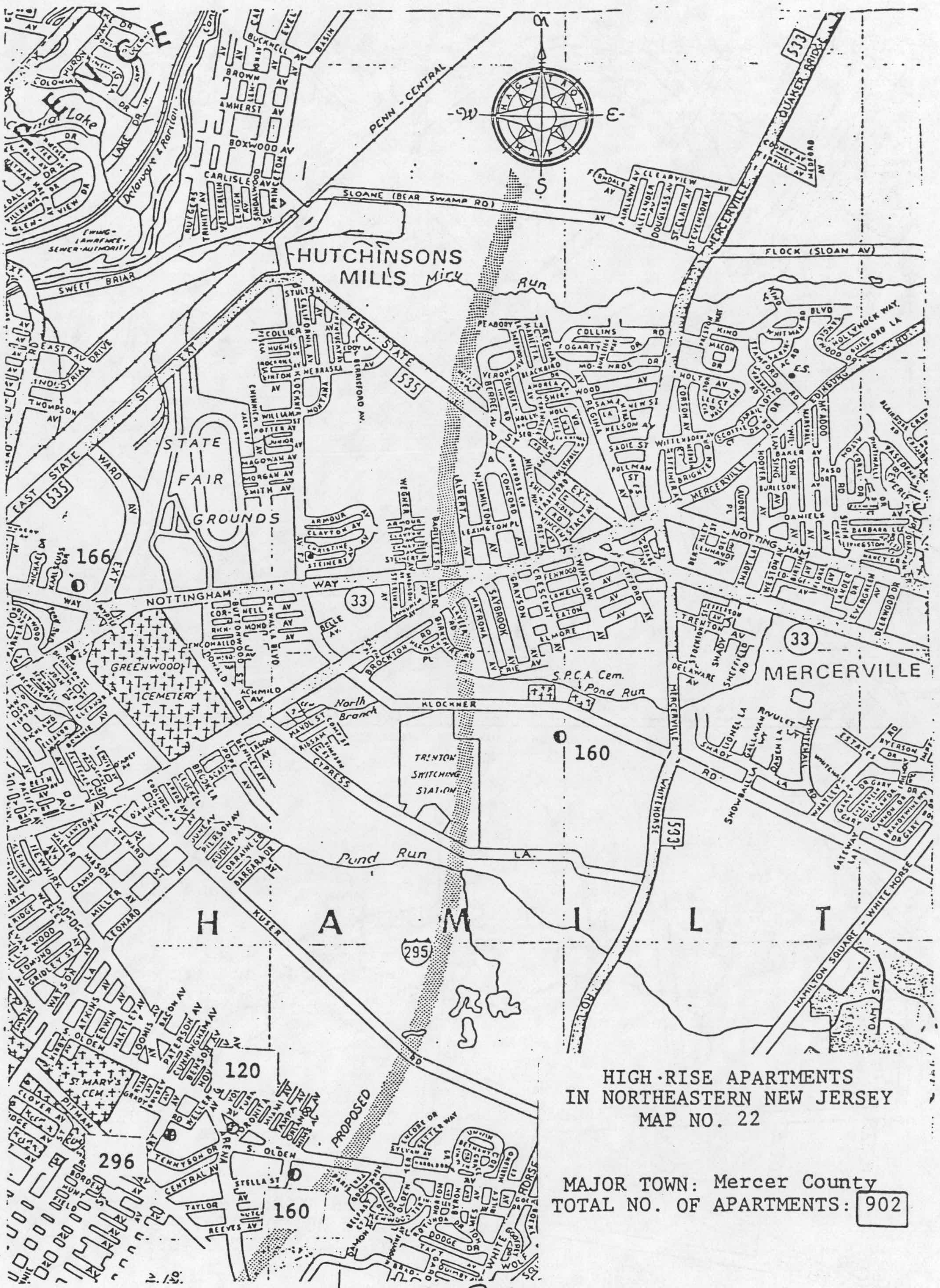


HIGH-RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 20

MAJOR TOWN: Mercer County
TOTAL NO. OF APARTMENTS: 3358
TOTAL 10³SQ.FT.OF OFFICES: 260

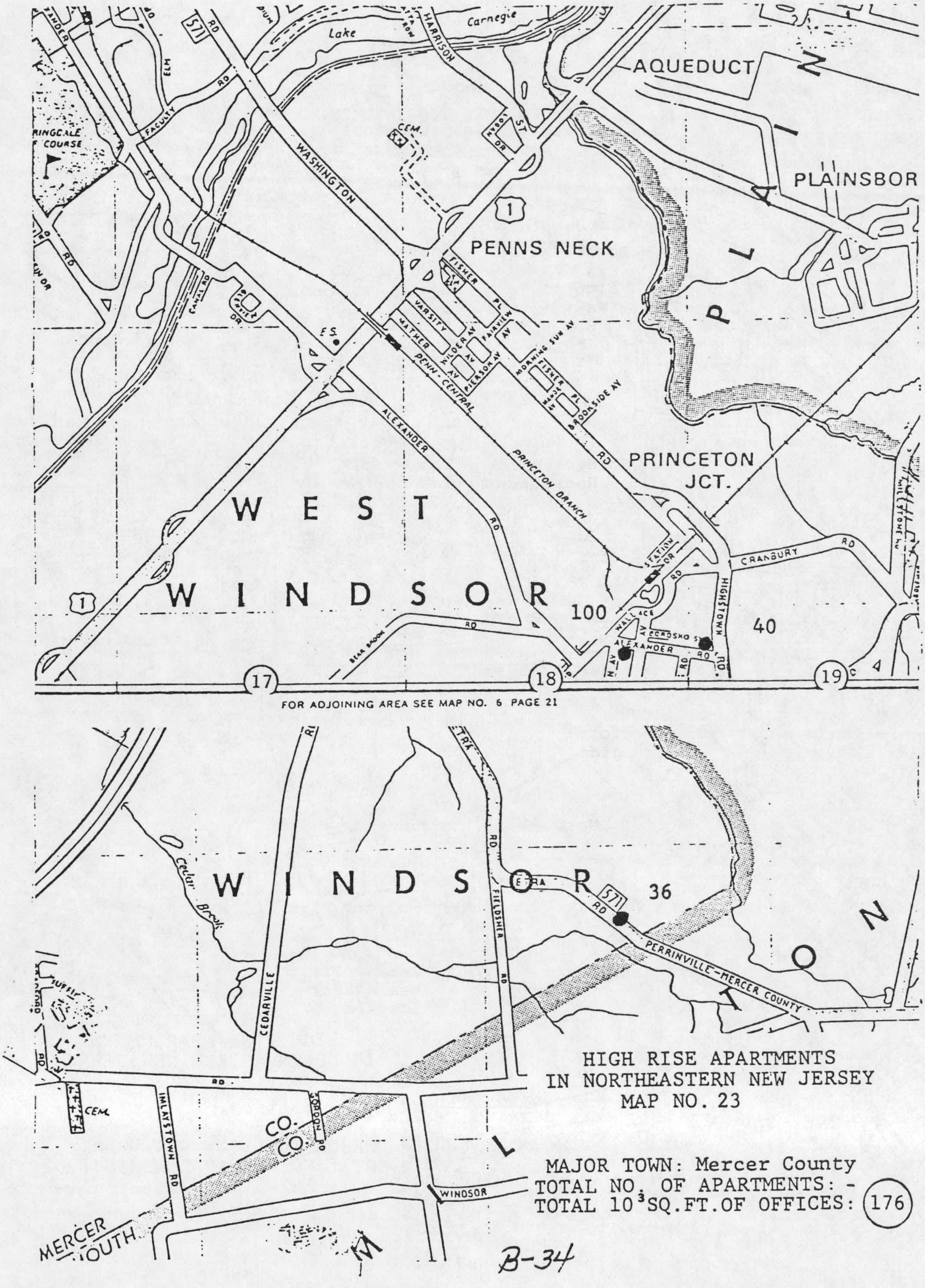
HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 21

MAJOR TOWN: Mercer County
TOTAL NO. OF APARTMENTS: 552



HIGH-RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 22

MAJOR TOWN: Mercer County
TOTAL NO. OF APARTMENTS: 902



HIGH RISE APARTMENTS
IN NORTHEASTERN NEW JERSEY
MAP NO. 23

MAJOR TOWN: Mercer County
TOTAL NO. OF APARTMENTS: -
TOTAL 10^3SQ.FT.OF OFFICES: (176)

LIST OF LOCALITIES WITHIN
5 MILE AND 10 MILE RADII
OF NORTH BERGEN G. S.

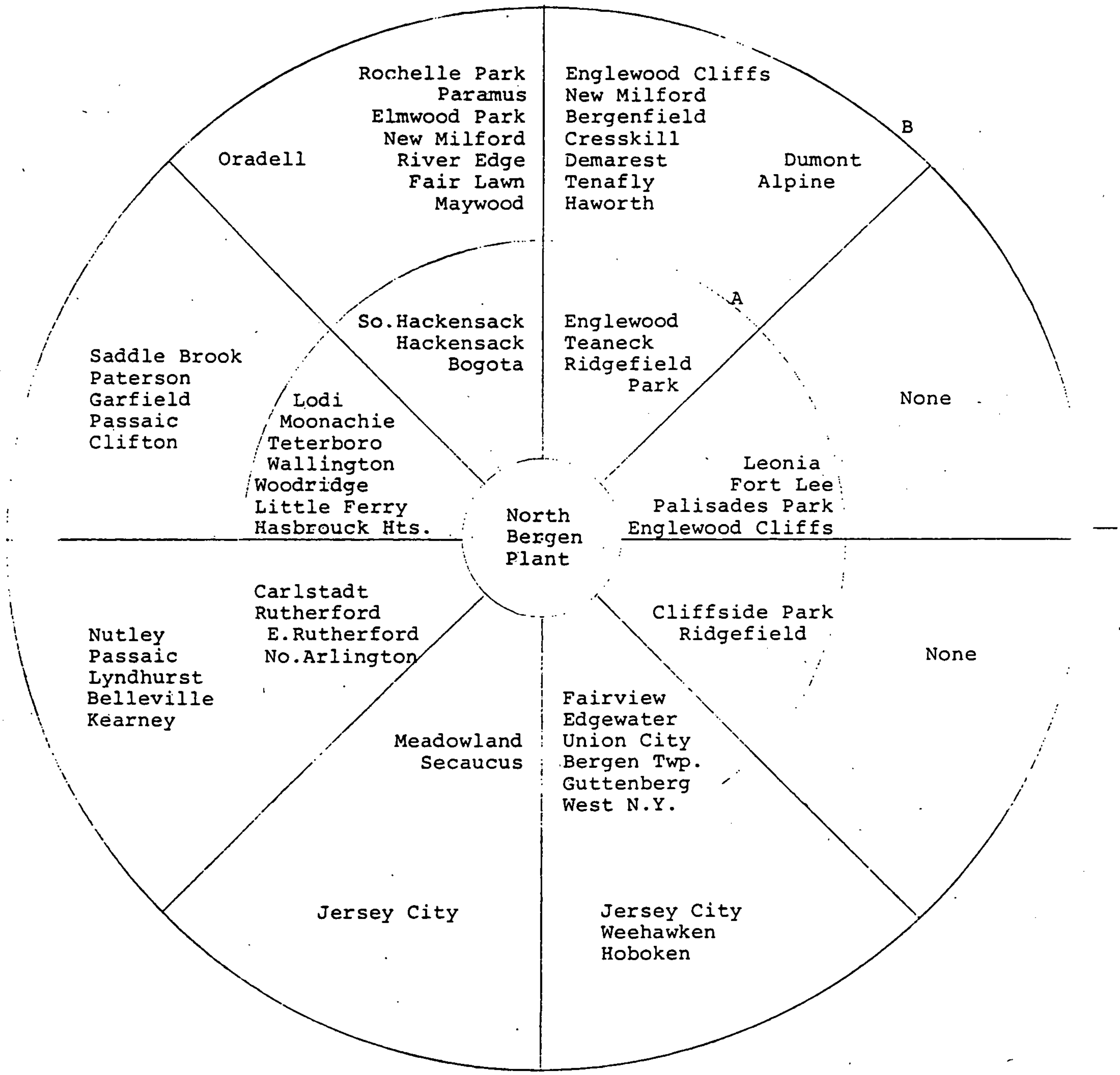


TABLE I

A = 5 miles radius
B = 10 " "

LIST OF LOCALITIES WITHIN
5 MILE AND 10 MILE RADII
OF ESSEX (KEARNY-HUDSON) G. S.

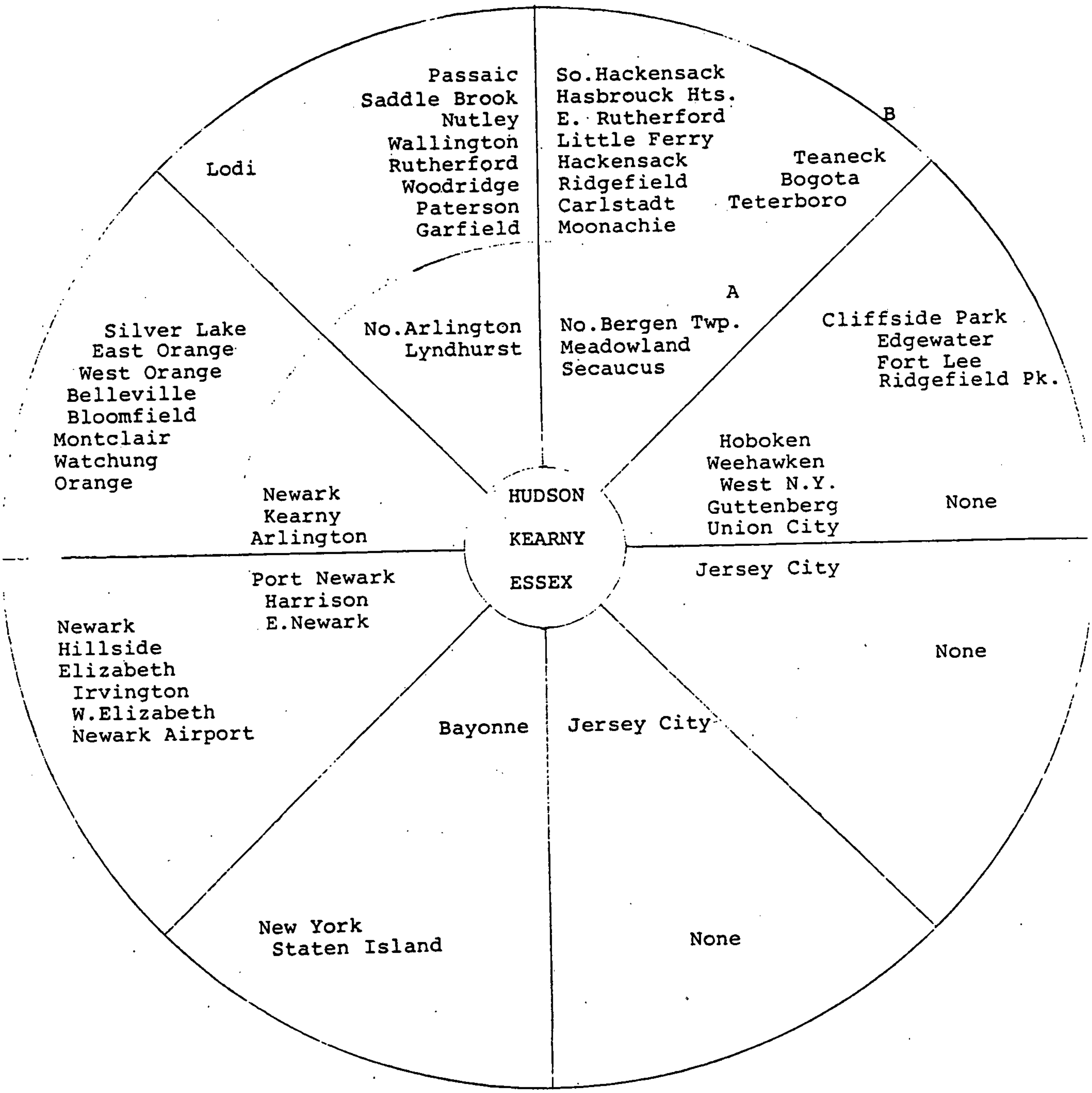


TABLE II

A = 5 miles radius
B = 10 " "

LIST OF LOCALITIES WITHIN
5 MILE AND 10 MILE RADII
OF LINDEN G. S.

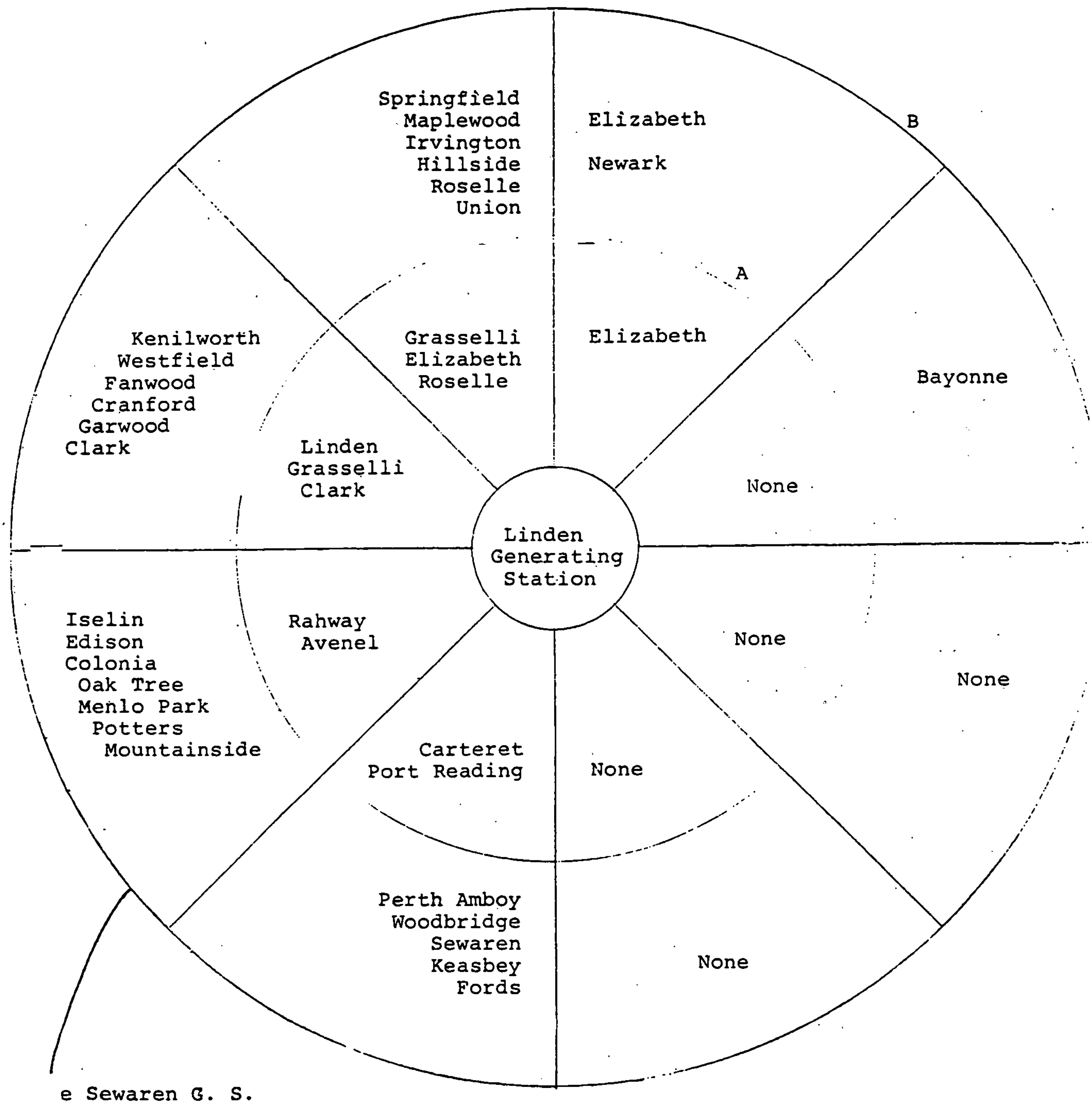


TABLE III

A = 5 miles radius
B = 10 " "

LIST OF LOCALITIES WITHIN
5 MILE AND 10 MILE RADII
OF SEWAREN G. S.

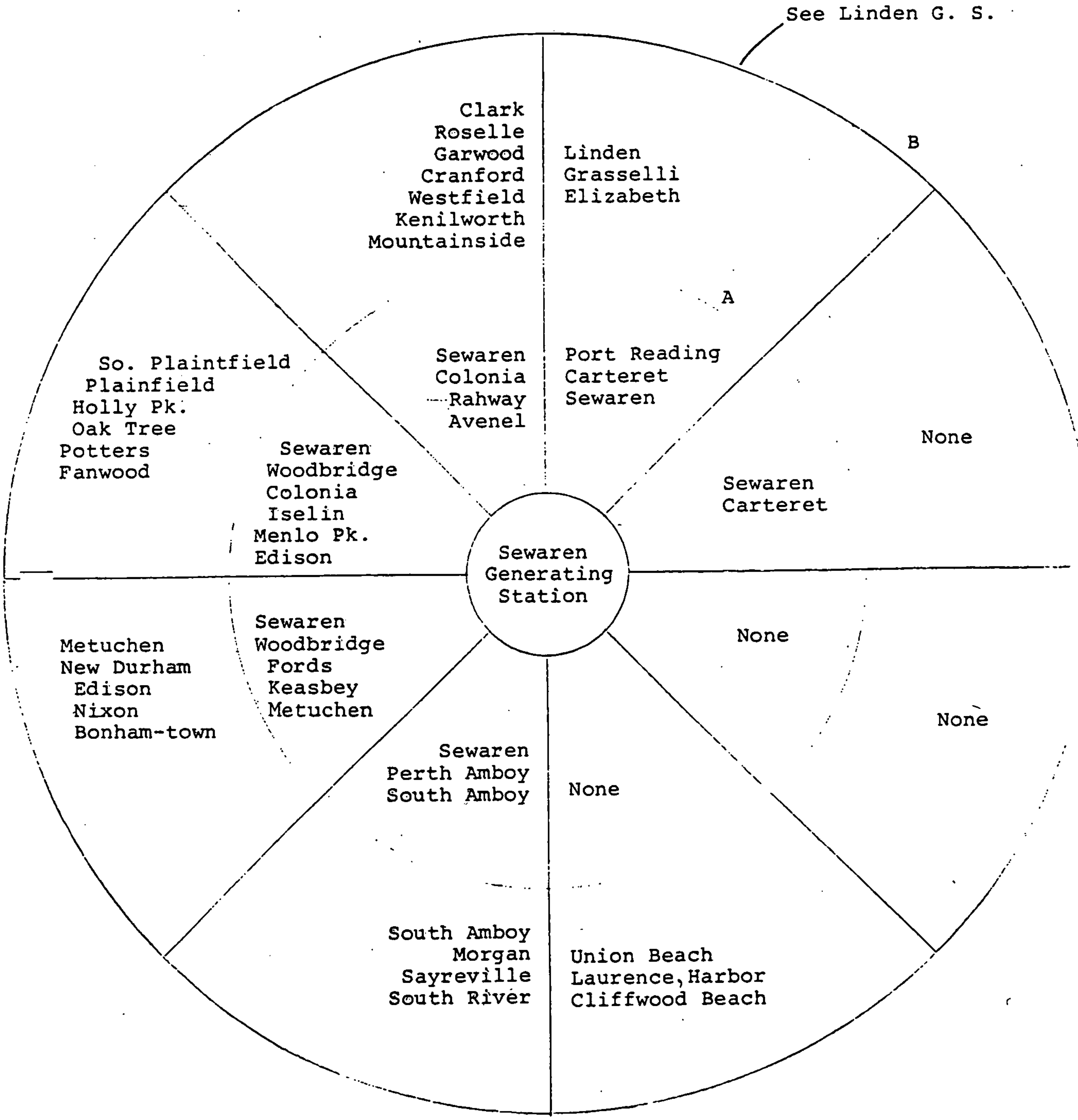


TABLE IV

A = 5 miles radius
B = 10 " "

LIST OF LOCALITIES WITHIN
5 MILE AND 10 MILE RADII
OF MERCER G. S.

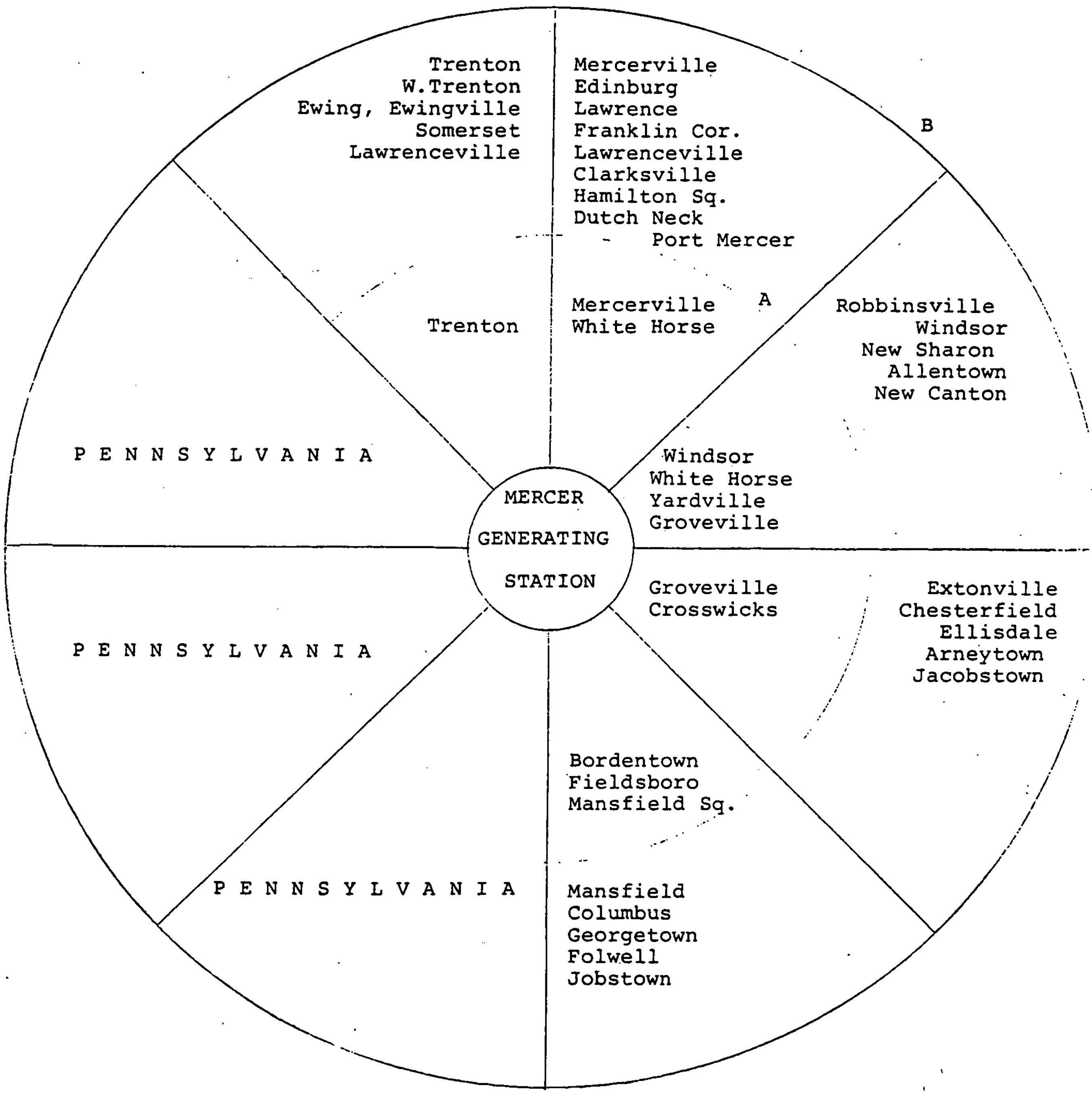
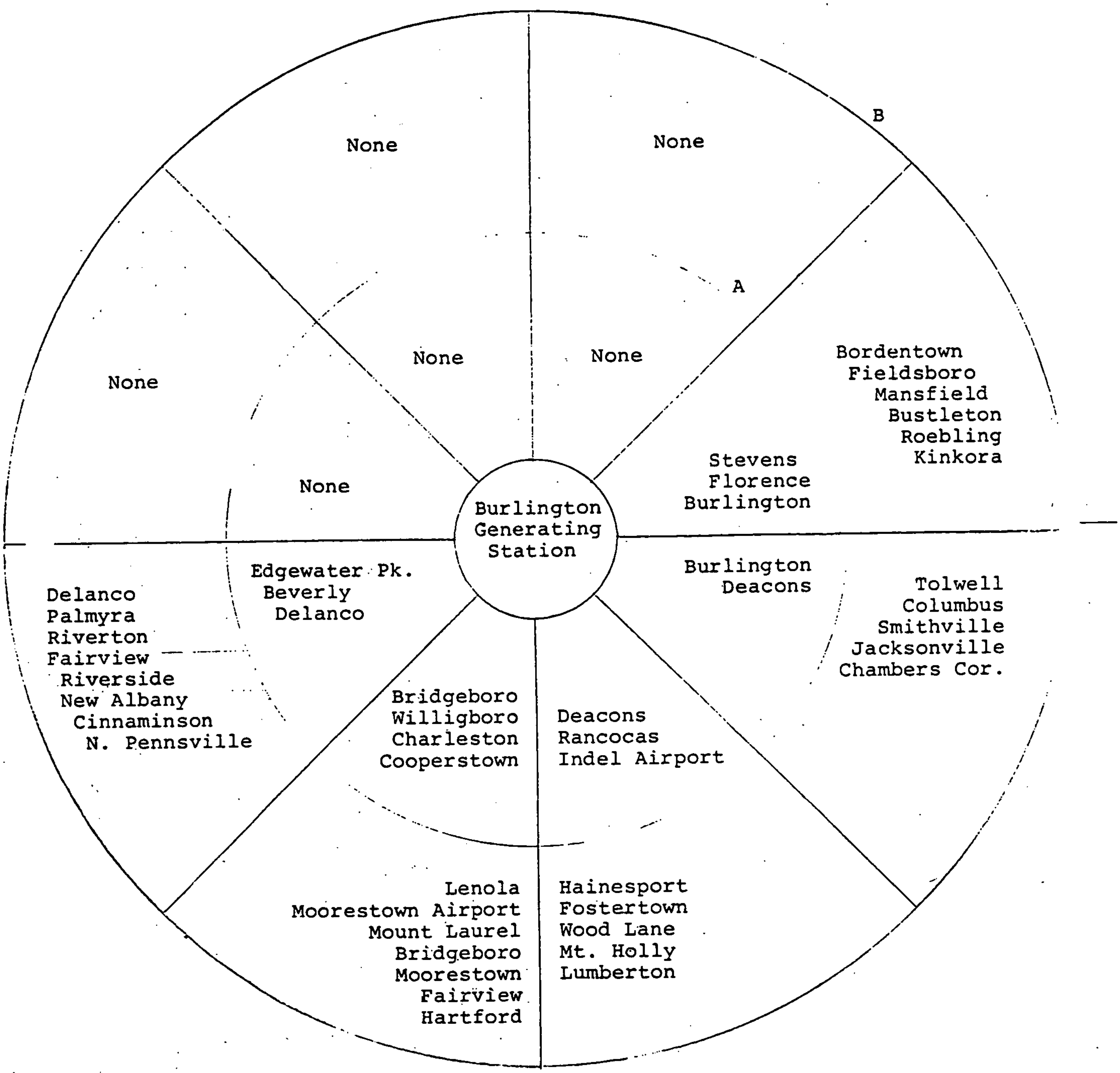


TABLE V

A = 5 miles radius
B = 10 " "

LIST OF LOCALITIES WITHIN
5 MILE AND 10 MILE RADII
OF BURLINGTON G. S.



See Mercer G. S.

TABLE VI

A = 5 miles radius
B = 10 " "

TABLE VII

HOUSING HEATING LOAD ESTIMATE

GENERATING STATION: BERGEN

AREA: Town and Map Sht. No.	AREA: Distance from Plant (mile)	AREA: Block No.	TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING: Total (n1)	in 1 Unit Structures (n2)	in >9 Unit Structures (n3)	in 2 to 9 Unit Structures (n4)	ESTIMATED HEAT LOAD (10^6 BTU/hr.): Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	DISTRIBUTION PIPING: Length of all Streets (10^3 ft)	Maximum Nom. Pipe Diameter at Δt= 20°F (in.)	120°F (in.)
						Sector No. 1 (N-E)							
Ridgefield	1.0	461	3688	1244	514	257	473	30.84	29.20	60.04	28.0	14	8
Park Village,45	1.0	463	5240	1887	597	491	799	35.82	51.60	87.42	37.5	18	8
"	1.7	462	5525	1823	856	286	681	51.36	38.68	90.04	42.0	18	8
"	2.6	546	8003	2433	1936	59	438	116.16	19.88	136.04	97.0	20	10
Teaneck Twp.	3.4	545	5703	1717	1423	41	253	85.38	11.76	97.14	71.5	18	8
Englewood, 45	4.1	154	4938	1779	488	445	846	29.28	51.64	80.92	71.0	16	8
"	4.1	155	4864	1684	974	436	1770	58.44	88.24	146.68	69.0	20	10
"	4.2	541	8855	2616	2279	51	286	136.74	13.48	150.22	126.5	20	10
"	4.5	542	4959	1707	761	282	664	45.66	37.84	83.50	46.0	16	8
"	4.5	153	5589	1741	1064	72	605	63.84	27.08	90.92	29.5	18	8
Congressional District 9, 45	4.8	543	7422	2194	2173	-	21	130.38	0.84	131.22	87.0	20	10
			64786	22321	13065	2420	6836	783.90	370.24	1154.14	705.0	54	24
						Sector No. 2 (E-N)							
Palisades Park, 45, 56	1.5	411	3830	1511	430	522	559	25.80	43.24	69.04	37.0	16	8
"	1.7	412	3052	1048	391	162	495	23.46	26.28	49.74	32.5	14	6
"	2.0	413	6469	2256	619	460	1177	37.14	65.48	102.62	81.0	18	8
Fort Lee 45,56	2.4	193	12979	4909	1619	1782	1508	97.14	131.60	228.74	123.5	24	12
"	2.5	192	7369	3064	447	1222	1395	26.82	104.68	131.50	69.0	20	10
Leonia, 45, 56	2.7	280	8847	3040	1811	334	895	108.66	49.16	157.82	87.5	20	10
Fort Lee, 45	3.1	191	10283	4605	506	3344	755	30.36	163.96	213.12	38.5	24	12
Englewood Cl.	5.0	160	5938	1612	1465	10	137	87.90	5.88	93.78	96.0	18	8
			58767	22045	7288	7836	6921	437.28	590.28	1027.56	565.0	48	24

GENERATING STATION: BERGEN

HOUSING HEATING LOAD ESTIMATE

TABLE VII

AREA: Town and Map Sht. No.	AREA: Distance from Plant	AREA: Block No.	TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING: Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	ESTIMATED HEAT LOAD: Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	DISTRIBUTION PIPING: Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	at Δt= 120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
					Sector No. 3 (E-S)								
Ridgefield, 56	0.9	452	3101	1151	470	155	526	28.20	27.24	55.44	44.0	14	8
"	1.3	451	8207	2684	1217	25	1442	73.02	58.68	131.70	64.5	20	10
"	2.0	61	3036	1151	271	264	616	16.26	35.20	51.46	38.5	14	6
"	2.4	62	6643	2382	990	458	934	59.40	55.68	115.08	46.0	20	10
"	2.4	63	4708	1745	289	148	1308	17.34	58.24	75.58	32.0	16	8
Edgewater, 56	2.9	130	4849	1845	455	420	970	27.30	55.60	82.90	41.0	16	8
			30544	10958	3692	1470	5796	221.52	290.64	512.16	266.0	36	18
					Sector No. 4 (S-E)								
Fairview, 56	1.7	182	4014	1410	418	156	836	25.08	39.68	64.76	39.0	16	8
"	2.2	181	6684	2443	497	193	1753	29.82	77.84	107.66	31.0	18	10
Guttenberg, 56	2.3	140	4271	1632	271	465	896	16.26	54.44	70.70	20.0	16	8
"	2.3	144	6468	2108	794	141	1173	47.64	52.56	100.20	47.0	18	8
"	2.6	143	4062	1475	333	192	950	19.98	45.68	65.66	23.5	16	8
"	3.0	145	5727	1995	412	322	1261	24.72	63.32	88.04	23.0	18	8
"	3.0	151	1680	663	152	92	419	9.12	20.44	29.56	10.0	12	6
"	3.1	142	5683	2100	246	780	1074	14.76	74.16	88.92	22.5	18	8
"	3.2	150	4074	1675	178	446	1051	10.68	59.88	70.56	14.0	16	8
"	3.2	154	4866	1811	170	475	1166	10.20	65.64	75.84	22.0	16	8
"	3.4	153	4161	1512	48	713	751	2.88	58.56	61.44	9.0	14	8
"	3.4	155	3737	1415	190	352	873	11.40	49.00	60.40	20.0	14	8
"	3.5	152	8322	3369	161	1816	1392	9.66	128.32	137.98	19.5	20	10

(Sector No. 4 continued next page)

HOUSING HEATING LOAD ESTIMATE

TABLE VII

GENERATING STATION: BERGEN

Sht. 3 of 4

AREA: Town and Map Sht. No.	AREA: Distance from Plant (mile)	AREA: Block No.	TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING: Total (n1)	in 1 Unit Structures (n2)	in >9 Unit Structures (n3)	in 2 to 9 Unit Structures (n4)	ESTIMATED HEAT LOAD: Single Family 60,000BTU per unit (10^6 BTU/hr.)	Multi-Family 40,000BTU per unit (10^6 BTU/hr.)	Total (10^6 BTU/hr.)	DISTRIBUTION PIPING: Length of all Streets (10^3 ft)	Maximum Nom. Pipe Diameter at Δt= 20°F (in.)	Maximum Nom. Pipe Diameter at Δt= 120°F (in.)
						Sector No. 4 (continued)							
Guttenberg, 56	3.6	156	3572	1153	79	438	636	4.74	42.96	47.70	8.0	14	6
"	3.7	157	3346	1119	43	385	691	2.58	43.04	45.62	10.5	14	6
"	3.7	160	2622	953	90	329	534	5.40	34.52	39.92	13.5	12	6
"	3.9	159	5075	1688	71	949	668	4.26	64.68	68.94	11.5	16	8
West N. Y., 56	4.1	162	5673	1958	172	446	1340	10.26	71.44	81.70	14.0	16	8
"	4.1	158	4926	1808	99	966	743	5.94	68.36	74.30	15.0	16	8
"	4.2	161	3757	1200	48	371	781	2.88	46.08	48.96	5.0	14	6
"	4.3	163	3282	1156	66	334	756	3.96	43.60	47.56	11.0	14	6
"	4.4	180	4662	1754	89	771	894	5.34	66.60	71.94	11.0	16	8
"	4.7	181	3544	1322	154	398	770	9.24	46.72	55.96	11.0	14	8
Union, 56, 73	4.7	164	3118	1114	79	214	821	4.74	41.40	46.14	13.5	14	6
"	4.9	165	3127	1251	62	536	653	3.72	47.56	51.28	11.5	14	8
			110453	40084	4922	12280	22882	295.32	1406.48	1701.78	436.0	60	30
						Sector No. 5 (S-W)							
Secaucus, 55,73	3.1	195	3975	1225	767	2	456	44.82	18.32	63.14	24.0	14	8
"	3.6	146	3250	1043	339	15	689	20.34	28.16	48.50	24.0	14	6
"	3.8	196	4005	1278	679	-	599	40.74	23.96	64.70	34.0	16	8
"	3.9	197	5248	1087	431	3	653	25.86	26.24	52.10	20.5	14	6
Union City, 73	4.2	147	3749	1261	369	39	853	22.14	35.68	57.82	28.0	14	8
"	4.5	166	3464	1175	91	401	683	5.46	43.36	48.82	13.0	14	6
"	4.8	167	-1425	536	48	120	368	2.88	19.52	22.40	10.0	10	6
"	5.0	168	3075	1088	54	110	924	3.24	41.36	44.60	10.0	14	6
			28191	8673	2758	690	5225	165.48	236.60	402.08	163.5	36	16

GENERATING STATION: BERGEN

HOUSING HEATING LOAD ESTIMATE

TABLE VII

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	Maximum Nom. Pipe Diameter at Δt= 120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 6 (W-S)							
Carlstadt, 55	3.5	50	7947	2621	1268	53	1300	76.08	54.12	130.20	76.0	20	10
Rutherford, 55	4.0	120	8536	2960	916	105	1939	54.96	81.76	136.72	83.0	20	10
"	4.4	514	5466	1816	1203	147	466	72.18	24.52	96.70	63.0	18	10
"	4.4	513	5568	1896	697	443	756	41.82	47.96	89.78	59.0	18	8
			27517	9293	4084	748	4461	245.04	208.36	453.40	281.0	36	16
						Sector No. 7 (W-N)							
Little Ferry,56	1.0	290	9042	3230	1318	768	1144	79.08	76.48	155.56	72.0	24	10
Teterboro,56,55	1.2	360	5410	1748	778	29	941	46.68	38.80	85.48	77.0	18	8
"	2.7	251	6838	2404	1266	492	646	75.96	45.52	121.38	80.5	20	10
Woodbridge, 46	3.2	600	8311	2560	1959	20	581	117.54	24.04	141.58	115.5	20	10
"	3.2	252	6813	2054	1675	10	369	100.50	15.16	115.66	83.0	20	10
Lodi, 46	3.7	304	7813	2549	721	169	1659	43.26	73.12	116.38	47.5	20	10
"	3.9	303	4908	1572	472	167	933	28.32	44.00	72.32	34.0	16	8
Wallington46,55	4.3	571	6990	2593	759	442	1392	45.54	73.36	118.90	38.0	20	10
Lodi, 46	4.4	302	6763	2271	544	68	1659	32.64	69.08	101.72	54.0	18	10
"	4.7	215	4905	1698	262	193	1243	15.72	57.44	73.16	43.0	16	8
"	4.9	214	4579	1504	411	66	1027	24.66	43.72	68.38	44.0	16	8
			72372	24183	10165	2424	11594	609.90	560.72	1170.62	688.5	54	24
						Sector No. 8 (N-W)							
Hackensack45,46	2.8	236	7470	2536	503	397	1636	30.18	81.32	111.50	67.0	18	10
Bogota, 45	2.8	40	8125	2612	1571	335	706	94.26	41.64	135.90	86.0	20	10
Hackensack, 46	3.5	234	7867	3269	754	1249	1266	45.24	100.60	145.84	61.0	20	10
Congressional District, 9, 45	3.5	544	7413	2370	1625	201	544	97.50	29.80	127.30	76.5	20	10
"	3.5	235	6578	2523	530	1115	878	31.80	78.72	110.52	51.0	18	10
"	4.0	231	2698	1311	168	587	556	10.08	45.72	55.80	46.0	14	8
Lodi, 46	4.1	301	5729	2069	642	325	1102	38.52	57.08	95.60	45.0	18	8
Maywood, 46	4.3	333	3398	1180	587	2	591	35.22	23.72	58.94	37.0	14	8
"	4.6	233	5481	1931	1149	476	306	68.94	31.28	100.22	59.0	18	10
"	5.0	232	5817	2294	809	756	729	48.54	59.40	107.94	47.0	18	10
			60576	23406	8338	6754	8314	500.28	602.72	1103.00	575.5	54	24

HOUSING HEATING
LOAD ESTIMATE
SUMMARY

Station Sector and Orientation	Populated Area	Population	Av. Popul. Density	Estimated Heat Load Single Family	Multi Family	Total Dwellings	Heat Load Density	Length of Streets
	sq.mi.	Persons	Pers/sq.mi.	10^6BTU/hr.			10^6BTU/hr/sq.mi.	10^3ft.
BERGEN								
1 - NE	8.1	64,786	7,998	784	370	1154	142	705.0
2 - EN	6.3	58,767	9,328	438	590	1028	163	565.0
3 - ES	3.0	30,544	10,181	222	290	512	171	266.0
4 - SE	4.1	110,453	20,940	295	1406	1701	415	436.0
5 - SW	1.7	28,191	16,583	165	237	402	236	163.5
6 - WS	1.7	27,517	16,186	245	208	453	266	281.0
7 - WN	7.3	72,372	9,914	609	561	1170	160	688.5
8 - NW	9.0	60,576	6,731	500	603	1103	123	575.5
Total		453,206		3258	4265	7523		3680.5

TABLE VIII

GENERATING STATION: ESSEX

HOUSING HEATING LOAD ESTIMATE

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 1 (N-E)							
						N O N E							
						Sector No. 2 (E-N)							
Jersey City, 74	2.5	17	4511	1523	153	430	940	9.18	54.80	63.98	23.25	16	8
"	3.0	9.02	4727	2235	131	1240	864	7.86	84.16	92.02	15.0	18	8
"	3.3	10	3447	1289	186	214	889	11.16	44.12	55.28	11.5	14	8
"	3.3	4	3985	1366	299	179	888	17.94	42.68	60.62	22.0	14	8
"	3.5	11	3803	1330	151	182	997	9.06	47.16	56.22	9.0	14	8
"	3.5	6	5755	2163	241	479	1443	14.46	76.88	91.34	14.5	18	8
"	3.7	5	4171	1527	199	198	1130	11.94	53.12	65.06	11.5	16	8
"	3.8	13	3508	1105	88	218	799	5.28	40.68	45.96	10.0	14	6
"	4.0	1	5756	2012	370	151	1491	22.20	65.68	67.90	23.0	16	8
"	4.0	2	4685	1705	202	244	1259	12.12	60.12	72.24	16.5	16	8
"	4.0	7	4087	1497	135	33	1329	8.10	54.48	62.58	13.5	14	8
"	4.2	3	4341	1574	220	194	1160	13.20	54.16	67.36	14.0	16	8
Union, 73	4.2	149	2680	947	118	118	711	7.08	33.16	40.24	9.5	12	6
"	4.3	177	2102	903	28	360	515	1.68	35.00	36.68	7.0	12	6
"	4.6	178	4861	1785	125	490	1170	7.50	66.40	73.90	18.0	16	8
"	4.6	176	2638	934	57	193	684	3.42	35.08	38.50	5.5	12	6
"	4.7	175	3267	1238	79	368	791	4.74	46.36	51.10	9.0	14	6
"	4.7	171	4297	1521	131	189	1201	7.86	55.60	63.46	17.0	16	8
"	4.8	148	5306	1919	218	467	1234	13.08	68.04	81.12	18.5	16	8
"	4.8	174	2161	828	62	269	497	3.72	30.64	34.36	8.0	12	6
"	5.0	173	2799	1086	112	402	572	6.72	38.96	45.68	4.5	14	6
"	5.0	172	2848	1036	56	172	808	3.36	39.20	42.56	8.5	12	6
"	5.0	170	4146	1450	46	443	961	2.76	56.16	58.92	12.5	14	8

(Sector 2 continued next page)

GENERATING STATION: ESSEX

HOUSING HEATING LOAD ESTIMATE

TABLE IX

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 2 (continued)							
Hoboken, 73	4.2	192	1580	617	28	19	570	1.68	23.56	25.24	10.0	10	6
"	4.3	190	5398	1821	27	626	1168	1.62	71.76	73.38	10.5	16	8
"	4.4	191	2651	958	14	215	729	0.84	37.76	38.60	10.5	12	6
"	4.5	189	4161	1493	122	664	707	7.32	54.84	62.16	11.0	14	8
"	4.6	185	3520	1123	24	615	484	1.44	43.96	45.40	19.0	14	6
"	4.6	188	6592	2438	126	434	1878	7.56	92.48	100.04	11.0	18	10
"	4.7	194	1626	605	21	57	527	1.26	35.04	36.30	6.0	12	6
"	4.7	186	2427	797	35	341	421	2.10	30.48	32.58	5.5	12	6
"	4.7	184	3345	1104	160	414	530	9.60	37.76	47.36	28.5	14	6
"	5.0	187	11088	3431	175	1097	2159	10.50	130.24	140.74	19.0	20	10
			126258	48090	4160	11715	32215	249.60	1757.20	2006.80	432.75	42+54	30
						Sector No. 3 (E-S)							
Jersey City, 73,74	2.2	27	7531	2306	275	859	1152	16.50	80.44	96.96	16.0	18	10
"	2.2	40	5244	1781	313	32	1436	18.78	58.72	77.50	18.0	16	8
"	2.2	48	3599	1243	217	56	970	13.02	41.04	54.06	19.0	14	8
"	2.6	18	3887	1657	62	876	719	3.72	63.80	67.52	11.5	16	8
"	2.6	28	6469	2602	201	1625	776	12.06	96.04	108.10	10.5	18	10
"	2.6	41.01	6709	2824	333	1969	522	19.98	99.64	119.62	17.0	20	10
"	2.6	42	5285	1776	324	584	868	19.44	58.08	77.52	12.5	16	8
"	2.6	49	4798	1478	239	329	910	14.34	49.56	63.90	15.5	16	8
"	2.7	29	3690	1571	192	841	538	11.52	55.16	66.68	8.5	16	8
"	2.8	20	4079	1994	136	1217	641	81.60	74.32	155.92	13.5	24	10
"	3.1	19	1890	776	126	195	455	7.56	26.00	33.56	7.5	12	6
"	3.1	51	3191	1115	85	234	796	5.10	41.20	46.30	7.5	14	6
"	3.1	50	2801	1046	124	174	748	7.44	36.88	44.32	9.5	14	6

(Sector 3 continued next page)

TABLE IX

HOUSING HEATING LOAD ESTIMATE

GENERATING STATION: ESSEX

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	Maximum Nom. Pipe Diameter at Δt= 120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 3 (continued)							
Jersey City, 73,74	3.0	44	2539	948	216	47	685	12.96	29.28	42.24	9.0	12	6
"	3.0	41.02	4100	1639	189	724	726	11.34	58.00	69.34	11.5	16	8
"	3.0	30	3338	1340	157	430	759	9.06	47.56	56.62	11.0	14	8
"	3.1	43	3913	1418	206	220	902	17.76	44.80	62.55	10.0	14	8
"	3.2	32	266	129	10	1	118	0.60	4.76	5.36	6.0	6	4
"	3.3	53	4093	1228	134	67	1027	8.04	43.76	51.80	10.5	14	6
"	3.3	45	4927	1502	333	197	972	19.98	46.76	66.74	19.5	16	8
"	3.4	46	2483	899	142	31	726	8.52	30.28	38.80	17.5	12	6
"	3.4	33	6272	1972	98	1278	596	5.88	74.96	80.84	24.5	16	8
"	3.4	31	4716	1213	70	421	722	4.20	45.72	49.22	12.75	14	6
"	3.4	21	7110	2259	767	482	1010	46.02	59.68	105.70	12.25	18	10
"	3.4	12.01	2035	740	83	68	589	4.98	26.28	31.26	6.5	12	6
"	3.4	12.02	1883	669	58	263	348	3.48	24.44	27.92	5.0	12	6
"	3.5	14	4156	1514	109	257	1148	6.54	56.20	62.74	8.75	14	8
"	3.6	22	2701	957	113	19	825	6.78	33.76	40.54	7.5	12	6
"	3.6	34	3356	1230	53	81	1096	3.18	47.08	50.26	17.0	14	6
"	3.8	15	2350	743	97	211	435	5.82	25.84	31.66	22.0	12	6
"	4.0	47	2966	981	142	25	814	8.52	33.56	42.08	20.0	12	6
"	4.0	23	3036	1077	83	100	894	4.98	39.76	44.74	6.0	14	6
"	4.0	35	3294	1060	23	182	855	1.38	41.48	43.82	5.0	14	6
"	4.1	24	3824	1254	138	229	887	8.28	44.64	52.92	9.0	14	6
"	4.1	36	2971	1099	69	193	837	4.14	41.20	45.34	8.25	14	6
"	4.2	25	2966	981	142	25	814	8.52	33.56	42.08	9.0	12	6
"	4.2	37	3085	1053	47	210	796	2.82	40.24	43.06	6.5	14	6
"	4.3	16	1613	574	37	6	471	2.22	19.08	21.30	19.75	10	6
"	4.5	38	3026	1467	32	910	525	1.92	57.40	59.32	9.5	14	8
"	4.7	39	871	345	9	53	283	0.54	13.44	13.98	6.0	8	4
"	4.8	26	1372	506	8	91	407	0.48	19.92	20.40	25.5	10	4
			148435	52886	6276	15812	30798	376.56	1864.40	2240.96	502.25	48+54	36

GENERATING STATION: ESSEX

HOUSING HEATING LOAD ESTIMATE

TABLE IX

AREA			TOTAL POPULA-TION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Struct-ures	in >9 Unit Struct-ures	in 2 to 9 Unit Struct-ures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	Maximum Nom. Pipe Diameter at Δt= 120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	In.	
						Sector No. 4 (S-E)							
Jersey City, 74,81	2.7	54	3635	1313	169	423	721	10.14	45.76	55.90	10.5	14	8
"	2.7	52	6841	2191	238	639	1314	14.28	78.12	92.40	15.0	18	8
"	2.8	56	4220	1493	158	266	1069	9.48	53.40	62.88	11.5	14	8
"	2.8	59	7674	2452	547	242	1663	32.82	76.20	109.02	24.5	18	10
"	3.1	55	4045	1319	118	157	1050	7.08	48.04	55.12	10.5	14	6
"	3.1	60	4673	1600	178	122	1300	10.68	56.88	67.56	14.5	16	8
"	3.1	61	8166	2639	385	683	1571	23.10	90.16	113.26	33.0	18	10
"	3.1	62	4089	1379	206	241	932	12.36	46.92	59.28	15.0	14	8
"	3.5	63	5175	1717	284	331	1102	17.04	57.32	74.36	17.0	16	8
"	3.5	58.01	5494	1790	186	239	1365	11.16	64.16	75.32	14.5	16	8
"	4.0	102	3572	1183	237	48	898	14.22	37.84	52.06	16.0	14	6
"	4.1	101	6302	2283	319	410	1554	19.14	78.56	97.70	22.0	18	10
"	4.1	103	3570	1209	243	184	782	14.58	38.64	53.22	13.0	14	8
"	4.2	105	5851	2205	571	665	1023	30.66	67.76	98.42	29.0	18	10
"	4.5	104	4797	1656	367	325	964	22.02	51.56	73.58	17.5	16	8
"	4.8	106	6304	2273	284	242	1747	17.04	79.56	96.60	21.25	18	10
"	5.0	107	4538	1598	269	286	1043	16.14	53.16	69.30	14.5	16	8
			89026	30300	4699	5497	20104	281.94	1024.04	1305.98	299.25	60	30
						Sector No. 5 (S-W)							
						NONE							

GENERATING STATION: ESSEX

HOUSING HEATING LOAD ESTIMATE

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	Maximum Nom. Pipe Diameter at Δt= 120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 6 (W-S)							
Newark, 74,80	1.1	75.01	4748	1527	104	587	836	6.24	56.92	63.16	34.0	14	8
"	1.1	75.02	3763	1136	123	66	947	7.38	40.52	47.90	17.5	14	6
"	1.7	74	1802	607	139	2	466	8.34	18.72	27.06	18.0	10	6
"	1.8	73	3412	1135	160	39	936	9.60	39.00	48.60	24.5	14	6
"	2.0	72	3177	1018	131	3	884	7.86	35.48	43.34	11.5	14	6
"	2.0	76	2578	865	55	141	669	3.30	32.40	35.70	10.5	12	6
"	2.2	71	2736	952	121	50	781	7.26	33.24	40.50	20.0	12	6
"	2.2	77	2940	955	66	62	827	3.96	35.56	39.52	11.0	12	6
"	2.2	79	4379	1396	71	112	1213	4.26	53.00	57.26	20.25	14	8
"	2.3	70	3546	1156	81	115	960	4.86	43.00	47.86	19.0	14	6
"	2.5	69	3423	1128	71	140	917	4.26	42.28	46.54	17.0	14	6
"	2.5	78	3089	991	62	5	924	3.72	37.16	40.88	9.5	12	6
"	2.6	80	1881	659	66	145	448	3.96	23.72	27.68	38.5	10	6
"	3.1	68	3483	1103	178	131	794	10.68	37.00	47.68	37.5	14	6
" 74,75	3.1	81	3036	1715	44	1051	620	2.64	66.84	69.49	36.0	16	8
"	3.3	64	2584	1022	66	146	810	3.96	38.24	42.20	12.5	14	6
"	3.3	65	5038	1487	21	1262	204	1.26	58.64	59.90	6.0	14	8
"	3.3	63	2133	593	9	331	253	0.54	23.36	23.90	10.5	10	6
"	3.3	67	4727	1933	86	1218	629	5.16	73.88	79.04	10.75	16	8
"	3.5	62	4819	1596	12	1221	363	0.72	63.36	64.08	11.0	16	8
"	3.5	66	4236	1514	13	1101	400	0.78	60.04	60.82	6.0	14	8
"	3.6	60	719	371	9	230	32	0.54	10.48	11.02	3.5	8	4
"	3.6	59	4296	1577	72	688	817	4.32	66.22	70.54	14.5	16	8
"	3.7	58	6183	2151	70	1109	972	4.2	83.24	87.44	14.5	18	8

(Sector 6 continued next page)

GENERATING STATION: ESSEX

HOUSING HEATING LOAD ESTIMATE

TABLE IX

Sht. 6 of 9

AREA			TOTAL POPULA-TION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Struct-ures	in >9 Unit Struct-ures	in 2 to 9 Unit Struct-ures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 6 (continued)							
Newark, 74,75	3.8	29	4010	1226	29	139	1058	1.74	47.88	49.62	9.5	14	6
"	3.8	30	2218	817	25	191	601	1.50	31.68	33.18	11.5	12	6
"	3.9	31	6397	2077	19	1551	507	1.14	82.32	83.46	12.0	16	8
"	4.0	39	1542	505	9	55	441	0.54	19.84	20.38	18.0	10	4
"	4.1	40	4807	1300	27	372	901	1.62	50.92	52.54	12.0	14	6
"	4.2	56	2558	784	14	234	536	0.84	30.80	41.64	11.0	12	6
"	4.2	57	4438	1598	152	375	1071	9.12	57.84	66.96	40.0	16	8
Newark, 74	4.3	28	5545	1571	128	102	1341	7.68	57.72	65.40	12.5	16	8
"	4.3	38	3318	996	71	57	868	4.26	37.00	41.26	15.0	12	6
"	4.4	54	6375	2032	70	523	1439	4.2	78.48	82.68	15.5	16	8
"	4.4	55	3990	1060	20	25	1015	1.2	41.60	42.80	8.5	14	6
"	4.4	50	2051	590	32	113	445	1.92	22.32	24.24	9.0	10	6
"	4.6	48.01	3270	1118	94	536	488	5.64	40.96	46.60	8.0	14	6
"	4.6	54	6375	2032	70	523	1439	4.2	78.48	82.68	12.5	16	8
"	4.7	41	5584	1692	206	311	1175	12.36	59.44	71.80	18.5	16	8
"	4.7	37	3967	1130	83	80	967	4.98	41.88	46.86	16.5	14	6
"	4.7	34	3704	1130	68	99	963	4.08	42.48	46.56	10.0	14	6
"	4.8	27	3905	1063	11	38	1014	0.66	42.08	42.74	7.5	14	6
"	4.8	26	4089	1256	72	121	1063	4.23	47.36	51.59	10.5	14	6
"	4.9	133	4941	1755	118	98	1539	7.08	65.48	72.56	20.0	16	8
"	4.9	35	5554	1568	82	64	1422	4.92	59.44	64.36	12.5	16	8
"	4.9	42	4965	1476	144	189	1143	8.64	53.28	61.92	17.0	14	8
"	4.9	53	4722	1281	143	189	949	8.58	45.52	54.10	13.5	14	8
	4.9	51	4173	1234	85	76	1073	5.1	45.96	51.06	15.5	14	6
			185226	60723	3602	16013	41108	216.12	2284.84	2500.96	682.0	2x54	36

HOUSING HEATING LOAD ESTIMATE

TABLE IX

GENERATING STATION: ESSEX

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	Maximum Nom. Pipe Diameter at Δt= 120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.	10^6 BTU/hr.	10^6 BTU/hr.	10^3 ft	in.	in.
						Sector No. 7 (W-N)							
Harrison, 74	1.6	139	2426	771	139	36	596	8.34	25.28	33.62	25.0	12	6
"	1.6	135	3657	1207	169	249	789	10.14	41.52	51.66	17.5	14	6
"	2.0	130	3110	1015	141	46	828	8.46	34.96	43.42	18.0	14	6
"	2.0	136	2268	800	78	10	712	4.68	28.88	33.56	8.0	12	6
East Newark, 74	2.0	129	3994	1307	294	33	980	17.64	40.52	58.16	13.0	14	8
"	2.0	128	4062	1414	400	77	937	24.00	40.56	64.56	27.0	16	8
Harrison, 74	2.1	138	1587	552	122	14	416	7.32	17.20	24.52	16.5	10	6
"	2.1	137	1873	715	84	27	604	5.04	25.24	30.28	8.0	12	6
East Newark, 74	2.2	134	1922	633	108	1	524	6.48	21.00	27.48	7.0	12	6
"	2.5	133	2871	1033	220	130	683	13.20	32.52	45.72	9.5	14	6
"	2.5	132	4298	1484	203	136	1145	12.18	51.24	63.42	17.5	16	8
Newark, 74	2.6	85	2832	1664	94	1081	489	5.64	62.80	68.44	33.5	16	8
"	2.7	87	5251	1829	220	483	1126	13.20	64.36	77.56	25.0	16	8
"	2.8	92	4430	1592	132	759	701	7.92	58.40	66.32	16.5	16	8
"	2.9	93	5119	1809	206	626	977	12.36	64.12	76.48	17.0	16	8
"	3.0	86	5675	1860	36	1636	188	2.16	72.96	75.12	6.0	16	8
"	3.0	88	3012	892	40	138	714	2.40	34.08	36.48	7.75	12	6
"	3.1	83	2397	601	42	29	530	2.52	22.36	24.88	10.5	10	6
"	3.1	84	4713	1618	57	707	854	3.42	15.61	18.03	9.0	10	4
"	3.1	89	2614	912	77	206	629	4.62	33.40	38.02	5.0	12	6
"	3.2	20	2820	1130	20	684	426	1.20	44.40	45.60	3.5	14	6
"	3.5	10	2198	628	55	71	502	3.30	22.92	24.22	13.0	10	6
"	3.5	11	989	260	27	21	212	1.62	9.32	10.94	8.5	8	4
"	3.5	82	1590	583	27	81	475	1.62	22.24	23.86	5.5	10	6

(Sector 7 continued next page)

HOUSING HEATING LOAD SUMMARY

GENERATING STATION: ESSEX

AREA			TOTAL POPULA-TION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Struct-ures	in >9 Unit Struct-ures	in 2 to 9 Unit Struct-ures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 7 (continued)							
Newark, 74	3.5	91	3184	1050	90	71	889	5.40	38.40	43.80	9.0	14	6
"	3.5	94	6163	2579	495	1457	627	29.70	83.36	113.06	25.0	20	10
"	3.6	95	6121	2183	365	832	986	21.90	72.72	24.62	25.25	18	10
"	3.7	9	7489	2478	234	776	1468	14.04	89.76	103.80	24.0	18	10
"	3.8	15	2347	652	30	5	617	1.80	24.88	26.68	10.0	10	6
"	3.8	13	3632	1020	96	51	873	5.76	36.96	42.72	8.5	14	6
"	3.8	8	3889	1267	179	169	919	10.74	43.52	54.26	16.0	14	8
"	4.0	3	3607	1618	210	640	768	12.60	56.32	68.92	8.5	16	8
Belleville, 54 74,75	4.0	5	1882	679	80	78	521	4.80	23.96	28.76	10.5	10	6
"	4.0	4	1920	652	72	73	507	4.32	23.20	27.52	10.0	10	6
Newark, 75	4.2	147	3153	1079	145	250	684	8.70	37.36	46.06	36.0	12	6
"	4.2	7	5577	2088	218	860	1010	13.08	74.80	87.88	21.0	16	8
"	4.2	14	4519	1337	102	49	1186	6.12	49.40	55.52	17.5	14	6
"	4.2	16	2914	919	94	218	607	5.64	33.00	38.64	12.5	12	6
"	4.3	17	5454	1557	206	56	1295	12.36	54.04	66.40	12.5	14	8
"	4.4	18	4985	1442	165	167	1110	9.90	51.08	60.98	12.5	14	6
"	4.5	108	4134	1172	177	50	945	10.62	39.80	50.42	11.75	12	6
"	4.5	109	2681	958	82	292	584	4.92	35.04	39.96	15.5	12	6
"	4.8	103	5148	1757	230	565	962	13.80	61.08	74.88	20.0	14	8
"	4.9	19	2578	843	59	281	503	3.54	31.36	34.90	14.0	12	6
"	4.9	158	4250	1575	519	488	568	31.14	42.24	73.38	24.5	12	6
"	4.9	159	5586	1861	548	23	1290	32.88	52.52	85.40	27.0	14	6
"	4.9	102	4832	1467	740	27	700	44.40	29.08	73.48	31.0	12	6
"	4.9	107	4974	1669	304	799	566	18.24	54.60	72.84	20.5	14	8
"	4.9	110	1214	416	93	144	179	5.58	12.92	18.50	8.5	8	4
			177941	60580	8524	15662	36394	511.44	2082.24	2536.80	734.25	48+60	36

HOUSING HEATING LOAD ESTIMATE

TABLE IX
Sht. 9 of 9

GENERATING STATION: ESSEX

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 8 (N-W)							
Kearny, 74,75	2.1	127	4025	1291	473	11	808	28.38	32.76	61.14	37.0	14	8
"	2.5	131	2141	720	163	55	502	9.78	22.28	32.06	11.5	12	6
"	2.6	125	3567	1208	528	73	607	31.68	27.20	58.88	27.0	14	8
"	2.6	126	3798	1333	383	148	802	22.98	38.00	60.98	22.5	14	8
"	2.6	123	2285	907	250	245	412	15.00	26.28	41.28	12.0	12	6
"	3.1	124	3434	1136	747	65	324	44.82	15.56	60.38	35.5	14	8
No. Arlington, 75	3.2	382	4878	1880	455	427	998	27.30	57.00	84.30	27.0	18	8
"	3.6	383	6889	2193	1244	13	936	74.64	37.96	112.60	61.5	18	10
"	3.8	381	6329	2263	970	347	946	58.20	51.72	109.92	38.25	18	10
"	4.5	314	6695	2162	920	110	1132	55.20	49.68	104.88	53.0	18	10
"	4.9	313	5915	1833	891	17	925	53.46	37.68	91.14	40.5	18	8
Newark, 74,75	3.2	96	6747	2022	158	825	1038	9.48	74.56	84.04	25.5	16	8
"	3.6	97	4813	1844	159	751	934	9.54	67.40	76.94	15.5	16	8
"	4.0	1	4780	1720	373	487	860	22.38	53.88	76.26	28.5	16	8
Belleville,75	4.0	145	3944	1360	300	273	787	18.00	63.60	81.60	23.5	16	8
"	4.2	144	3664	1236	394	163	679	23.64	33.68	57.32	42.5	14	8
"	4.5	146	4989	1658	730	90	838	43.80	37.12	80.92	29.5	16	8
"	4.7	143	5723	1903	864	97	942	51.84	41.56	93.40	39.5	18	8
"	4.8	142	4167	1309	879	115	315	52.74	17.20	69.94	34.0	16	8
"	4.8	141	4133	1348	747	106	495	44.82	24.04	68.86	28.5	16	8
			92916	31327	11628	4419	15280	697.68	787.96	1485.64	622.75	60	30

HOUSING HEATING
LOAD ESTIMATE
SUMMARY

Station Sector and Orientation	Populated Area	Population	Av. Popul. Density	Estimated Heat Load Single Family	Multi Family	Total Dwellings	Heat Load Density	Length of Streets
	sq.mi.	Persons	Pers/sq.mi.	10^6BTU/hr.			10^6BTU/hr/sq.mi.	10^3ft.
ESSEX								
1 - NE	-	-	-	-	-	-	-	-
2 - EN	3.4	126,258	37,135	249	1,757	2,007	590	432.75
3 - ES	5.45	148,435	27,236	377	1,864	2,241	411	502.25
4 - SE	3.0	89,026	29,675	282	1,024	1,306	435	299.25
5 - SW	-	-	-	-	-	-	-	-
6 - WS	6.67	185,226	27,770	216	2,285	2,500	375	682.00
7 - WN	8.32	177,941	21,387	511	2,082	2,537	305	734.25
8 - NW	7.8	92,916	11,912	698	788	1,486	191	623.00
Total		819,802		2,333	9,800	12,077		3,274.00

B-35

TABLE X

GENERATING STATION: LINDEN

HOUSING HEATING LOAD ESTIMATE

TABLE XI
Sht. 1 of 3

AREA			TOTAL POPULA-TION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Struct-ures	in >9 Unit Struct-ures	in 2 to 9 Unit Struct-ures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
					Sector No. 1 (N-E)								
Elizabeth, 80	2.20	306	3691	1336	218	17	1101	13.08	44.72	57.80	23.5	14	10
" 80	2.60	305	4621	1446	272	47	1127	16.32	46.96	63.28	45.3	14	10
" 80	2.80	309	4649	1508	282	41	1185	16.92	49.04	65.96	32.0	16	10
" 80,81	3.00	304	7093	1976	222	458	1298	13.32	70.24	83.56	27.0	16	10
" 80,81	3.10	310	3563	1080	145	-	935	8.70	37.40	46.10	16.25	12	8
" 80	3.25	311	4746	1716	283	226	1207	16.98	57.32	74.30	25.5	16	10
" 80	3.25	303	3282	1032	82	8	942	4.92	38.00	42.92	21.0	12	8
" 80,81	3.40	302	3279	1018	104	11	1003	6.24	40.56	46.80	24.0	12	8
" 80	3.70	312	6254	1901	329	221	1351	19.74	62.88	82.62	37.0	16	10
" 80	4.20	301	151	43	10	2	31	0.60	1.32	1.92	4.5	4	2
" 80	4.50	313	6746	1986	389	28	1569	23.34	63.88	87.22	43.0	18	10
" 80	5.00	315	5202	1678	239	110	1329	14.34	57.56	71.90	28.5	16	10
			53277	16822	2575	1169	13078	154.50	569.88	724.38	327.55	42	30
					Sector No. 2 (E-N)								
					New York	City							
					Sector No. 3 (E-S)								
					New York	City							
					Sector No. 4 (S-E)								
					New York	City							
					Sector No. 5 (S-W)								
Carteret, 94	2.2	36	4581	1748	655	12	1081	39.30	43.72	83.02	58.5	16	10
"	2.3	37	4555	1344	950	106	288	57.00	15.76	72.76	49.5	16	10
"	2.8	38	6154	1476	1211	1	264	72.66	10.60	83.26	44.5	16	10
"	2.8	39	3769	1257	316	26	815	18.96	33.64	52.60	36.5	14	8
"	3.9	28.03	4778	1223	1002	-	221	60.12	8.84	68.96	52.5	16	10
	Sub-Totals		23837	6948	4134	145	2669	248.04	112.56	360.60	241.5 (con't)		

GENERATING STATION: LINDEN

HOUSING HEATING LOAD ESTIMATE

AREA			TOTAL POPULA-TION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Struct-ures	in >9 Unit Struct-ures	in 2 to 9 Unit Struct-ures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	Maximum Nom. Pipe Diameter at Δt= 120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
	Sub-Totals		23837		4134	145		248.04	112.56	360.60	241.5		
Woodbridge Twp 94-101	5.0	34.01	2798	834	611	47	176	36.66	8.92	45.58	38.5	12	28
			26635	7782	4745	192	2845	284.70	121.48	406.18	280.0	36	20
					Sector No. 6 (W-S)								
Carteret, 94	2.25	35	4033	1274	774	6	434	46.44	20.00	66.44	37.5	16	10
Rahway, 94	3.80	28.01	1366	495	197	-	498	11.82	19.92	31.74	40.5	12	8
"	3.40	360	4139	1314	741	72	501	44.46	22.92	67.38	58.5	16	10
"	4.50	27.02	8375	1972	1249	15	708	74.94	28.92	103.86	71.0	18	12
"	4.20	358	3688	1102	693	28	381	41.58	16.36	57.94	59.5	14	10
"	4.00	359	2888	1098	456	117	525	27.36	25.68	53.04	29.5	14	10
"	4.80	27.01	3226	951	646	20	285	38.76	12.20	50.96	63.5	14	10
"	4.50	357	5816	2004	1315	219	470	78.90	27.56	106.46	54.0	18	12
"	5.00	356	4616	1303	1273	-	30	76.38	1.20	77.58	47.0	16	10
			38153	11713	7344	477	3892	440.64	174.76	615.40	461.0	42	24
					Sector No. 7 (W-N)								
Rahway, 80	2.40	353	5414	1762	475	100	1187	28.50	51.48	79.98	53.0	16	10
" 94	2.40	354	3005	924	509	-	415	30.54	16.60	47.14	22.0	14	8
"	3.25	350	3228	1089	649	-	440	38.94	17.60	56.54	37.0	14	10
"	4.00	355	7967	2677	1495	238	944	89.70	47.28	136.98	41.5	20	14
"	2.80	351	3226	1115	311	152	652	18.66	86.96	105.62	34.0	18	12
Roselle, 80,94	3.00	347	3962	1333	530	83	720	31.80	32.12	63.92	33.5	16	10
"	3.60	344	5308	1596	797	32	767	47.82	31.96	79.78	48.5	16	10
"	3.20	346	4435	1330	532	56	742	31.92	31.92	63.84	28.0	16	10
"	4.10	343	3881	1316	873	9	424	52.38	17.32	69.70	41.0	16	10
"	4.20	348	5092	1655	1585	-	70	95.10	2.80	97.90	65.5	18	12
"	3.80	349	6298	2116	1497	61	558	89.82	22.32	112.14	33.5	18	12
	Sub-Totals		51816	16903	9253	731	6919	555.18	358.36	913.54	437.5 (con't)	48	30

HOUSING HEATING LOAD ESTIMATE

GENERATING STATION: LINDEN

TABLE XI

Sht. 3 of 3

AREA			TOTAL POPULA-TION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
	Sub-Totals		51816	16903	9253	731	6919	555.18	358.36	913.54	437.5		
Rahway, 94	4.80	361	2184	217	108	1	108	6.48	4.36	10.84	14.0	8	4
"	4.80	362	8371	2231	2060	-	171	123.60	6.84	130.44	57.0	20	14
Roselle, 80	4.40	342	3901	1169	876	124	169	52.56	11.72	64.28	41.0	14	10
			66272	20520	12297	856	7367	737.82	381.28	1119.10	549.5	48	30
					Sector No. 8 (N-W)								
Linden, 80	2.50	352	2419	777	322	-	455	19.32	18.20	37.52	27.5	12	8
Elizabeth, 80	3.00	307	8116	2861	487	695	1679	29.22	94.96	124.18	35.5	20	14
"	3.20	308	3273	1149	194	234	721	11.64	38.20	49.84	35.5	14	10
Linden, 80	2.80	345	4330	1498	748	199	551	44.88	30.00	74.88	52.5	16	10
Roselle, 80	3.80	341	3876	1311	772	126	413	46.32	21.56	67.88	32.0	16	10
"	3.50	320	9230	3334	721	924	1689	43.26	104.52	147.78	46.0	20	14
Elizabeth, 80	3.70	319	7267	3205	277	1878	1050	16.62	117.12	133.74	36.5	20	14
"	4.20	314	4619	1547	212	428	907	12.72	53.40	66.12	19.5	16	10
"	4.10	318	6915	2765	621	1306	839	37.26	85.80	123.06	30.5	20	12
Hillside Twp80	4.50	317	4812	2216	323	1601	292	19.38	75.72	95.10	24.5	18	12
Roselle, 80	4.50	321	7403	2202	1822	164	216	10.93	15.20	26.13	71.5	10	6
"	4.70	340	5619	1960	829	449	682	49.74	45.24	94.98	54.5	18	12
"	4.80	337	4875	1610	1195	184	231	71.70	16.60	88.30	39.5	16	10
"	4.90	339	3159	1142	488	256	398	29.28	26.16	55.44	27.0	14	10
"	5.00	335	6574	2011	1621	79	311	97.26	15.60	112.86	47.5	18	12
			82487	29589	10632	8523	10434	539.53	758.28	1297.81	580.0	60	36

GENERATING STATION: SEWAREN

HOUSING HEATING LOAD ESTIMATE

TABLE XII

Sht. 1 of 3

AREA			TOTAL POPULA- TION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 1 (N-E)							
Carteret, 94	1.9	38	6154	1476	1211	1	264	72.66	10.60	83.26	44.5	18"	8"
"	2.5	37	4555	1344	950	106	288	57.0	15.76	72.76	49.5	18"	8"
Linden, 94	4.75	353	5414	1762	475	100	1187	28.50	51.48	79.98	55.5	18"	8"
"	4.4	354	3005	924	509	-	415	30.54	16.60	47.14	55.0	14"	6"
Carteret, 94	2.8	35	4039	1274	774	6	494	46.44	20.00	66.44	37.5	16"	8"
"	1.2	28.03	4778	1223	1002	-	221	60.12	8.84	68.96	52.5	16"	8"
				8003	4921	213	2869	295.26	123.28	418.54		36"	16"
						Sector No. 2 (E-N)							
Carteret, 94	2.0	39	3769	1257	316	26	915	18.96	33.64	52.60	36.5	16"	6"
"	2.6	36	4581	1748	655	12	1081	39.30	43.72	83.02	58.5	18"	8"
				3005	971	38	1996	58.26	77.36	135.62	95.0	20"	10"
						Sector No. 3 (E-S)							
						New York	City						
						Sector No. 4 (S-E)							
						New York	City						
						Sector No. 5 (S-W)							
Sewaren, 101	0.5	34.01	2798	834	611	47	176	36.66	8.92	45.58	38.5	14"	6"
Perth Amboy	2.5	45	3775	1208	279	91	838	16.74	37.16	53.90	17.0	14"	6"
"	2.7	33	3458	1147	739	15	393	44.34	16.32	60.66	37.0	14"	8"
"	2.3	40	4416	1287	694	167	426	41.64	23.72	65.36	35.5	16"	8"
"	2.3	43	2958	1026	566	8	452	33.96	18,40	52.36	33.0	14"	0"
"	2.8	41	2230	815	526	-	189	31.56	11.56	43.12	30.5	12"	6"
"	2.8	42	2782	992	454	1	537	27.24	21.52	48.76	26.5	14"	6"
"	2.8	44	3410	1240	419	1	820	25.14	32.84	57.98	31.0	14"	8"
				8549	4288	330	3931	257.28	170.44	427.72	638.5		

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GENERATING STATION: SEWAREN

HOUSING HEATING LOAD ESTIMATE

TABLE XII

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
Perth Amboy,101	3.25	46	4209	1488	240	211	1037	14.40	49.92	64.32	28.0	16"	8"
"	3.25	47	2403	814	237	6	571	14.22	23.08	37.30	31.5	12"	6"
"	3.50	48	4938	1650	283	269	1098	16.98	54.68	71.66	36.5	16"	8"
"	3.50	49	3411	1484	303	661	520	18.18	47.24	65.42	29.5	16"	8"
"	4.00	50	4218	1423	419	80	924	25.14	40.16	65.30	28.0	16"	8"
				15408	5770	1557	8081	346.20	385.52	731.72	790.0	42"	20"
					Sector No. 6 (W-S)								
Woodbridge Twp. 100-101	1.20	34.2	752	231	140	-	91	8.40	3.64	12.04	16.0	8"	4"
"	1.30	29.02	3056	1059	642	52	365	38.52	16.68	55.20	46.5	14"	6"
"	1.7	30	5851	1792	1425	83	284	85.50	14.68	100.18	63.0	18"	8"
"	3.7	31.01	4329	1106	820	159	127	49.20	11.44	60.64	36.5	14"	8"
"	3.7	31.02	6875	1989	1161	687	141	69.66	33.12	102.78	30.0	18"	8"
"	3.5	32.01	3291	1011	900	-	111	54.00	4.44	58.44	50.0	14"	8"
"	3.4	32.02	4235	1440	957	125	358	57.42	19.32	76.74	45.5	16"	8"
"	4.2	19.01	3775	1006	581	387	38	34.86	17.00	51.86	27.5	14"	6"
"	4.2	19.02	2640	865	561	5	300	33.66	12.20	45.86	39.5	12"	6"
"	4.8	19.03	3224	1039	719	4	316	43.14	12.80	55.94	43.0	14"	6"
				11539	7906	1502	2131	474.36	145.32	619.68		42"	18"
					Sector No. 7 (W-N)								
Woodbridge Twp. 100-101	0.75	29.01	1646	527	329	36	162	19.74	7.92	27.66	24.5	10"	6"
Rahway, 100	1.50	28.02	3583	1019	897	21	101	53.82	4.88	58.70	42.0	14"	8"
"	3.00	26.02	7196	1816	1636	94	86	98.16	7.20	105.36	67.0	18"	10"
"	3.00	26.01	3721	1088	767	239	82	46.02	12.84	58.86	40.5	14"	8"
"	3.50	26.03	3003	850	581	198	71	34.86	10.76	45.62	30.5	12"	6"
" 94	4.20	24.01	7682	1974	1761	-	213	105.66	8.52	114.18	75.5	18"	10"
" 94,95	4.00	24.02	1817	502	480	-	22	28.80	.88	29.68	57.0	10"	6"

GENERATING STATION: SEWAREN

HOUSING HEATING LOAD ESTIMATE

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	Maximum Nom. Pipe Diameter at Δt= 120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
Rahway, 100	4.90	23.01	5260	1241	1213	-	28	72.78	1.12	73.90	48.75	16"	8"
"	4.90	23.02	4495	1088	1046	-	42	62.76	1.68	64.44	48.5	14"	8"
"	4.30	25.00	8151	2176	1949	95	132	116.94	9.08	126.02	94.5	20"	10"
"	5.00	14.02	7440	2431	1079	235	1117	64.74	54.08	118.82	50.5	18"	10"
				14712	11738	918	2056	704.28	118.96	823.24		48"	20"
Sector No. 8 (N-W)													
"	1.80	28.01	1366	495	197	-	498	11.82	19.92	31.74	40.5	12"	6"
"	2.60	27.01	3226	951	646	20	285	38.76	12.20	50.96	63.5	14"	6"
"	2.10	27.02	8375	1972	1249	15	708	74.94	28.92	103.86	71.0	18"	10"
"	3.25	358	3688	1102	693	28	381	41.58	16.36	57.94	59.5	16"	8"
"	3.70	359	2888	1098	456	117	525	27.36	25.68	53.04	29.5	14"	6"
"	3.70	360	4139	1314	741	72	501	44.46	22.92	67.38	58.5	16"	8"
"	4.60	355	7967	2677	1495	238	944	89.70	47.28	136.98	41.5	20"	10"
"	4.25	356	4616	1303	1273	-	30	76.38	1.20	77.58	47.0	16"	8"
"	4.25	357	5816	2004	1315	219	470	78.90	27.56	106.46	54.0	18"	10"
"	4.80	350	3228	1089	649	-	440	38.94	17.60	56.54	37.0	14"	8"
				14205	8714	709	4782	522.84	219.64	742.48		42"	20"

HOUSING HEATING
LOAD ESTIMATE
SUMMARY

Station Sector and Orientation	Populated Area	Population	Av. Popul. Density	Estimated Heat Load Single Family	Estimated Heat Load Multi Family	Estimated Heat Load Total Dwellings	Heat Load Density	Length of Streets
	sq.mi.	Persons	Pers/sq.mi.	10^6BTU/hr.	10^6BTU/hr.	10^6BTU/hr.	10^6BTU/hr/sq.mi.	10^3ft.
SEWAREN								
1 - NE	2.1	27945	13307	295	123	418	199	244.5
2 - EN	0.7	8350	11928	58	77	135	193	95.0
3 - ES	-	-	-	-	-	-	-	-
4 - SE	-	-	-	-	-	-	-	-
5 - SW	3.25	45006	13848	346	385	731	225	790.0
6 - WS	5.60	38028	6790	474	145	619	110	403.5
7 - WN	8.60	53994	6278	704	118	822	96	579.2
8 - NW	9.00	45309	5034	523	220	743	83	502.0
Total		218632		2400	1068	3468		2614.2
LINDEN								
1 - NE	2.75	53278	19374	154	570	724	263	327.5
2 - EN	-	-	-	-	-	-	-	-
3 - ES	-	-	-	-	-	-	-	-
4 - SE	-	-	-	-	-	-	-	-
5 - SW	2.6	26635	10244	285	121	406	156	280.0
6 - WS	4.9	38153	7786	441	175	616	126	461.0
7 - WN	7.8	66272	8496	738	381	1119	143	549.5
8 - NW	7.4	82487	11147	540	758	1298	175	580.0
Total		266825		2158	2005	4163		2198.0

TABLE XIII

GENERATING STATION: MERCER

HOUSING HEATING LOAD ESTIMATE

AREA: Town and Map Sht. No.	AREA: Distance from Plant (mile)	AREA: Block No.	TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING: Total (n1)	in 1 Unit Structures (n2)	in >9 Unit Structures (n3)	in 2 to 9 Unit Structures (n4)	ESTIMATED HEAT LOAD: Single Family 60,000BTU per unit (10^6 BTU/hr.)	Multi-Family 40,000BTU per unit (10^6 BTU/hr.)	Total (10^6 BTU/hr.)	DISTRIBUTION PIPING: Length of all Streets (10^3 ft)	Maximum Nom. Pipe Diameter at Δt= 20°F (in.)	Maximum Nom. Pipe Diameter at Δt= 120°F (in.)
Sector No. 1 (N-E)													
Hamilton Twp. 15,16	1.2	25	7945	2642	2167	2	473	130.02	19.0	149.02	104.0	24	10
" 4,5,15,16	1.6	26	9701	3340	2353	170	817	141.18	39.48	180.66	152.0	24	12
Trenton, 4	1.8	5	3935	1416	1183	20	213	70.98	9.32	80.30	29.5	16	8
"	2.1	6	4611	1477	1150	-	327	69.00	13.08	82.08	46.0	16	8
"	2.8	22	6841	2152	1539	33	580	92.34	24.52	116.86	44.5	20	10
Hamilton Twp.4	2.8	27	8383	2836	2021	204	611	121.26	32.60	153.86	121.0	24	10
Trenton, 4	3.1	28	5970	2170	1426	2	742	85.56	29.76	115.32	69.5	20	10
"	3.9	18	3953	1350	1152	11	187	81.00	7.98	127.52	66.5	20	10
"	4.0	29.02	4987	1739	1074	148	517	64.44	26.60	91.04	69.0	18	8
"	4.1	30.02	5172	1366	1307	-	59	78.42	2.36	80.78	60.5	16	8
"	4.6	31	3602	1266	965	46	255	57.90	12.04	69.94	62.0	16	8
			65100	21754	16337	636	4781	980.22	216.68	1196.90	824.5	54	24
Sector No. 2 (E-N)													
White Horse-Yardville-4,16	3.0	30.04	6509	1888	1546	1	341	92.76	13.68	106.44	88.0	18	10
"	3.3	30.03	6227	1718	1493	105	120	89.58	9.00	98.58	56.0	18	10
			12736	3606	3039	106	461	182.34	22.68	205.02	144.0	24	12
Sector No. 3 (E-S)													
White Horse-Yardville-16	4.1	30.01	3904	1137	813	109	215	48.78	12.96	61.74	39.0	14	8
Bordentown Twp 16	2.3	7015.02	3231	1124	657	331	136	39.42	18.68	58.10	28.0	14	8
			7135	2261	1470	440	351	88.20	31.64	119.84	67.0	20	10
Sector No. 4 (S-E)													
Bordentown, 16	3.1	7017	4490	1582	1047	66	469	62.82	21.40	84.22	53.5	16	8
"	3.3	7016	615	199	152	31	16	9.12	1.88	11.00	21.0	8	4
"	3.7	7015.01	4072	1128	834	157	137	50.04	11.76	61.80	48.0	14	8
			9177	2909	2033	254	622	121.98	35.04	157.02	122.5	24	10

HOUSING HEATING LOAD ESTIMATE

TABLE XIV

GENERATING STATION: MERCER

Sht. 2 of 2

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
					Sector No. 5 (S-W) Pennsylvania								
					Sector No. 6 (W-S) Pennsylvania								
					Sector No. 7 (W-N) Pennsylvania								
					Sector No. 8 (N-W)								
Trenton, 5	1.2	1	2660	947	749	-	198	44.94	7.92	52.86	21.0	14	6
"	1.2	2	3536	1256	1173	-	83	70.38	3.32	73.70	21.0	16	8
"	1.6	4	4756	1804	1273	-	531	76.38	21.24	87.62	37.0	18	8
"	1.7	24	1496	1	-	-	-	-	-	30.00	1.5	12	6
"	2.0	7	3104	1056	639	11	406	38.34	16.68	55.02	16.5	14	8
"	2.0	8	2467	903	610	-	297	36.60	11.88	58.48	15.0	14	8
"	2.1	10	3162	1043	688	10	345	41.28	14.20	55.48	21.0	14	8
"	2.5	21	6685	2200	1027	283	890	61.62	46.92	108.54	41.0	18	10
"	2.6	9	7049	3241	586	506	2149	35.16	106.20	141.36	54.0	20	10
"	2.9	20	2912	863	441	165	257	26.46	16.88	43.34	18.5	14	6
"	3.0	16	1790	642	315	25	302	18.90	13.08	31.98	13.0	12	6
"	3.3	15	4907	1560	1052	32	476	63.12	20.32	83.44	27.0	16	8
"	3.4	19	3896	1163	943	-	220	56.58	8.80	65.38	19.0	16	8
"	3.5	17	6062	1895	1269	22	604	76.14	25.04	101.18	38.5	18	10
"	3.5	11	6890	2821	1038	697	1086	62.28	71.32	133.60	28.0	20	10
"	4.0	14	8861	2692	1530	190	972	91.80	46.48	138.28	28.5	20	10
"	4.3	34	3081	1018	892	10	116	53.52	5.04	58.56	50.5	14	8
"	4.8	12	4727	1779	932	274	573	55.92	33.88	89.80	38.0	18	8
"	4.8	13	3816	1336	942	181	213	56.52	15.76	72.28	34.0	16	8
"	5.0	36.01	3041	1044	806	40	198	48.36	9.52	57.88	38.0	14	8
			84898	29267	16905	2446	9916	1014.30	494.48	1508.78	561.0	60	30

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HOUSING HEATING
LOAD ESTIMATE
SUMMARY

Station Sector and Orientation	Populated Area (sq.mi.)	Population (Persons)	Av. Popul. Density (Pers/sq.mi.)	Estimated Heat Load (10^6BTU/hr.) Single Family	Multi Family	Total Dwellings	Heat Load Density (10^6BTU/hr/sq.mi.)	Length of Streets (10^3ft.)
MERCER								
1 - NE	8.0	65,100	8138	980	217	1197	150	824.5
2 - EN	5.8	12,736	2196	182	23	205	35	144.0
3 - ES	1.9	7,135	3755	88	32	120	63	67.0
4 - SE	1.1	9,177	8343	122	35	157	143	122.5
5 - SW	-	-	-	-	-	-	-	-
6 - WS	-	-	-	-	-	-	-	-
7 - WN	-	-	-	-	-	-	-	-
8 - NW	9.0	84,898	9433	1014	495	1509	168	561.0
Total		179,046		2386	802	3188		1719.0

TABLE XV

HOUSING HEATING LOAD ESTIMATE

GENERATING STATION: BURLINGTON

TABLE XVI
Sht. 1 of 2

AREA			TOTAL POPULA-TION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Struct-ures	in >9 Unit Struct-ures	in 2 to 9 Unit Struct-ures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
						Sector No. 1 (N-E) Pennsylvania							
						Sector No. 2 (E-N)							
Burlington, 19	1.1	7012.02	6471	2291	1610	77	604	96.60	27.24	123.84	69.5	20	10
"	1.8	7012.03	2339	765	541	78	146	32.46	8.96	41.42	24.0	12	6
"	2.2	7011.03	3376	938	708	12	218	42.48	9.20	51.68	24.0	14	6
			12186	3994	2859	167	968	171.54	45.40	216.94	117.5	24	12
						Sector No. 3 (E-S)							
Burlington, 32	1.2	7012.01	3181	963	896	-	67	53.76	2.68	56.44	54.5	14	8
"	1.7	70'' 02	1429	419	319	-	100	19.14	4.00	23.14	5.0	10	6
			4610	1382	1215		167	72.90	6.68	79.58	59.5	16	8
						Sector No. 4 (S-E)							
Willingboro Twp 20,31	1.2	7011.01	5807	1825	1276	408	141	76.56	21.96	98.52	88.0	18	10
"	2.8	7028.01	2928	772	772	-	-	46.32	-	46.32	19.0	14	6
"	2.8	7028.02	4964	1138	1135	-	3	68.10	0.12	68.22	53.0	16	8
"	3.7	7028.03	5491	1370	1369	-	1	82.14	0.04	82.18	59.0	16	8
"	3.8	7028.04	4202	1014	1012	-	2	60.72	0.08	61.52	52.0	14	8
"	4.3	7028.11	1898	513	513	-	-	30.78	-	30.78	10.5	12	6
			25290	6632	6077	408	147	364.62	22.20	386.82	281.5	36	16

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GENERATING STATION: BURLINGTON

HOUSING HEATING LOAD SUMMARY

AREA			TOTAL POPULATION	HOUSING UNITS IN YEAR-ROUND HOUSING				ESTIMATED HEAT LOAD			DISTRIBUTION PIPING		
Town and Map Sht. No.	Distance from Plant	Block No.		Total	in 1 Unit Structures	in >9 Unit Structures	in 2 to 9 Unit Structures	Single Family 60,000BTU per unit	Multi-Family 40,000BTU per unit	Total	Length of all Streets	Maximum Nom. Pipe Diameter at Δt= 20°F	120°F
	mile			n1	n2	n3	n4	10^6 BTU/hr.			10^3 ft	in.	
				Sector No. 5 (S-W)									
Willingboro Twp 20,31	2.4	7028.06	5947	1314	1313	-	1	78.78	0.04	78.82	61.0	16	8
"	2.4	7028.07	3248	742	735	-	7	44.10	0.28	44.32	40.0	14	6
"	3.1	7028.08	5256	1156	1156	-	-	69.36	-	69.36	49.0	16	8
"	3.1	7028.09	1693	639	625	-	14	37.50	0.56	38.06	10.5	12	6
"	3.3	7028.05	5693	1266	1265	-	1	75.90	0.04	75.94	58.0	16	8
"	4.0	7028.10	2094	480	480	-	-	28.80	-	28.80	16.0	12	6
			23931	5597	5574		23	334.44	0.92	335.36	234.5	30	14
				Sector No. 6 (W-S)									
Beverly, 20, 31	1.5	7010.02	4993	1378	1034	6	338	62.04	13.76	75.80	49.5	16	8
"	2.2	7010.01	2419	846	421	220	205	25.26	17.00	42.26	18.0	12	6
"	2.3	7009	3105	955	798	1	156	47.88	6.28	54.16	66.0	14	8
"	4.0	7008	4157	1348	1010	13	325	60.60	13.52	74.12	70.0	16	8
"	4.6	7007.03	2564	848	659	23	166	39.54	7.56	47.10	42.5	14	6
"	4.9	7007.02	2192	794	511	61	222	30.66	11.32	41.98	33.5	12	6
			19430	6169	4433	324	1412	265.98	69.44	335.42	279.5	30	14
				Sector No. 7 (W-N) Pennsylvania									
				Sector No. 8 (N-W) Pennsylvania									

HOUSING HEATING
LOAD ESTIMATE
SUMMARY

Station Sector and Orientation	Populated Area	Population	Av. Popul. Density	Estimated Heat Load Single Family	Estimated Heat Load Multi Family	Estimated Heat Load Total Dwellings	Heat Load Density	Length of Streets
	sq.mi.	Persons	Pers/sq.mi.	10^6 BTU/hr.			10^6 BTU/hr/sq.mi.	10^3 ft.
BURLINGTON								
1 - NE	-	-	-	-	-	-	-	-
2 - EN	1.2	12,186	10,155	172	45	217	180	117.5
3 - ES	0.9	4,610	5,122	73	7	80	89	59.5
4 - SE	3.2	25,290	7,903	365	22	387	121	281.5
5 - SW	3.4	23,931	7,039	334	1	335	99	234.5
6 - WS	2.9	19,430	6,700	266	69	335	116	279.5
7 - WN	-	-	-	-	-	-	-	-
8 - NW	-	-	-	-	-	-	-	-
Total		85,447		1,210	144	1,354		972.5

TABLE XVII

COMPARATIVE SUMMARY
OF HOUSING HEATING LOADS WITHIN
5 MILES OF SELECTED G.S.'s

HEAT LOAD DENSITY 10^6 BTU/hr/sq mi	No. Bergen	Essex	Linden	Sewaren	Mercer	Burlington
	Generating Station 5 mi. Radius 45° Sectors					
0		NE,SW	EN,ES,SE	ES,SE	SW,WS,WN	NE,WN,NW
0-50					EN,ES	
50-100				WN,NW		ES
100-150	NE,NW		WS,WN	WS	SE	EN
150-200	EN,ES,WN	NW	SW,NW	NE,EN	NE,NW	
200-250	SW			SW		SW
250-300	WS		NE			SE,WS
300-350		WN				
350-400		WS				
400-450	SE	ES,SE				
450-600		EN				
MEDIAN PRESENT HOUSING LOAD DENSITY	212.5	290.6	109.3	106.25	65.6	121.9
SECTOR DATA						
a) Densest Load						
-Sector	SE	EN	NE	SW	NW	EN
-Density	415	590	263	225	168	180
-Popul. Area	4.1	3.4	2.75	3.25	9.0	1.2
-Load	1701	2007	724	731	1509	217
-Major Town	Guttenberg	Jersey City Union	Elizabeth	Perth Amboy	Trenton	Burlington
b) Highest Load						
-Sector	SE	WN	NW	WN	NW	SE
-Density		305	175	96		121
-Popul.Area		8.32	7.4	8.6		3.2
-Load		2537	1298	822		387
-Major Town		Newark Harrison	Linden Elizabeth	Rahway		Willingboro

Table XVIII

FUEL USE PATTERNS FOR HEATING AND DOMESTIC HOT WATER OF SELECTED CITIES IN NEW JERSEY

Reference: Standard Metropolitan Statistical Areas
Places of 50000 Inhabitants or More
1970

	NY-NE-NJ NJ Portion		Jersey City		Newark		Bayonne		Union City		Elizabeth		Trenton	
	No. of Units	%	No. of Units	%	No. of Units	%	No. of Units	%	No. of Units	%	No. of Units	%	No. of Units	%
All Year Housing Units	1478442	100	91884	100	127314	100	25325	100	21247	100	39356	100	35240	100
Heating Fuel -														
Util. Gas	618999	41	37747	41.1	38938	30.6	9737	38.4	6631	31.2	10427	26.5	9180	26.0
Fuel Oil	755018	51.1	45650	49.7	73422	57.7	13574	53.6	13138	61.8	25034	63.6	21552	61.2
Coal	18292	1.2	1094	1.2	2909	2.3	341	1.3	106	.5	1624	4.1	1217	3.5
Electric	30576	2.1	1159	1.3	1837	1.4	398	1.6	450	2.1	1070	2.7	916	2.6
Other	20527	1.4	2152	2.3	3879	3.1	467	1.8	475	2.2	391	1.0	741	2.1
Water Heating-														
Util. Gas	804659	54.4	44564	48.5	48935	38.4	12659	50.0	8197	38.6	15216	38.7	19354	54.9
Fuel Oil	522519	35.3	36876	40.1	62974	49.5	10535	41.6	10849	51.1	20887	53.1	12068	34.2
Coal	5880	.4	689	.7	1254	1.0	63	.2	71	.3	612	1.6	3112	.3
Electric	69408	4.7	953	1.0	2567	2.0	634	2.5	620	2.9	1112	2.8	1029	2.9
Other	40986	2.8	4720	5.1	5255	4.1	626	2.5	1063	5.0	719	1.8	1033	2.9
Wash. Mech. Dishwasher	985139	66.6	46454	50.6	53648	42.1	15474	61.0	9342	44.0	21406	54.4	20361	57.8

Table XXI

ANNUAL RESIDENTIAL, COMMERCIAL/INSTITUTIONAL AND INDUSTRIAL FUEL USE (1974 data)*

	Fuel Oil 1000 barrel (1)			Coal 1000 sht. (2)			Gas 10^6 cu. ft. (3)		
	res.	comm./inst.	ind.	res.	comm./inst.	ind.	res.	comm./inst.	ind.
N. J. Total	33274	16341	27060	82.2	23.0	154	135843	58210	65419
Bergen County	4083	2006	3153	10.1	2.8	17.8	16668	7148	7621
Burlington County	1231	714	614	3.0	1.0	3.4	5026	2544	1485
Essex	4395	2062	2833	10.8	2.9	16.0	17945	7346	6849
Hudson	3027	1348	2184	7.5	1.9	12.4	12362	4802	5279
Mercer	1447	705	915	3.6	1.0	5.1	5909	2515	2211
Middlesex	12525	1338	4651	6.2	1.9	7.4	10310	4767	11246
Passaic	2163	1039	1843	5.3	1.4	10.1	8830	3702	4455
Union	2525	1214	3502	6.2	1.7	19.9	10310	4325	8465

Notes: (1) 1 barrel is approx. 6×10^6 BTU
(2) 1 sht = 2000 lb and is approx. 25×10^6 BTU
(3) 10^6 cu. ft. = 1000 x 10^6 BTU = 10000 therms.

* N. J. Dept. of Environmental Protection.

Table XXII

INDUSTRIAL FUEL USE
(1971 data)

	KWh. equiv. billion	%	Fuel Oil 1000 bar.	%	Coal 1000 sht.	%	Nat. Gas billion cu.ft.	%	Other $10^6$$	%
N. J. Total	103.7	100	28851	100	355.8	100	84.2	100	29.8	100
SIC. No. 20	8.7	8.4	2742.4	9.5	28.3	8.0	7.3	8.7	1.2	4.0
22	3.5	3.4	677.3	2.3	1.8	.5	1.2	1.4	2.2	7.4
26	9.5	9.2	4018.5	13.9	-	-	2.7	3.2	.5	1.7
28	31.3	30.2	8720.1	30.2	281.6	79.1	15.6	18.5	20.1	67.4
29	9.2	8.9	3238.8	11.2	-	-	7.1	8.4	.1	.3
30	2.3	2.2	547.7	1.9	10.6	3.0	3.1	3.7	z	-
33	8.3	8.0	1995.9	6.9	33.6	9.4	5.6	6.6	.8	2.7
		70.3		75.9		100.0		50.5		83.5
JERSEY CITY Total	9.4	9.1	2535.2	8.8	12.4	3.5	8.1	9.6	.8	2.7
SIC. No. 20	1.6	17.6	445.1	17.6	-	-	.9	11.1	-	-
22	.2	2.2	17.5	.7	1.8	14.5	.2	2.5	.3	37.5
26	.5	5.5	166.3	6.6	-	-	.1	1.2	-	-
28	2.1	22.0	555.6	21.9	10.7	85.5	2.2	27.2	.3	37.5
		47.3		46.8		100.0		42.0		75.0
NEWARK Total	25.1	24.2	7298.4	25.3	107.1	30.1	15.5	18.4	7.6	25.5
SIC. NO. 22	.2	.8	34.2	.5	-	-	.2	1.3	-	-
26	2.6	10.4	1115.6	15.3	-	-	.2	1.3	z	-
28	9.9	39.4	2986.0	40.9	82.4	76.9	2.8	18.1	6.3	82.9
30	.6	2.3	75.8	1.0	-	-	1.0	6.5	z	-
33	1.6	6.4	334.5	4.6	-	-	1.3	8.4	.4	5.3
		59.3		62.3		76.9		35.6		88.2
PATERSON-CLIFTON-PASSAIC Total	13.7	13.2	3762.9	13.0	13.8	3.9	9.2	10.9	3.0	10.1
SIC. NO. 20	1.0	7.3	160.7	4.3	3.1	22.5	.8	8.7	z	-
22	2.4	17.5	445.7	11.8	-	-	.6	6.5	1.5	50.0
26	2.8	20.4	1465.4	38.9	-	-	.6	6.5	z	-
28	2.9	21.2	774.9	20.6	-	-	.7	7.6	.7	23.3
30	.4	2.9	51.8	1.4	8.4	60.9	1.1	12.0	z	-
		69.3		77.0		83.4		41.3		73.3

Table XXIII

RESIDENTIAL HOUSING
UNIT COUNT & HEAT LOAD WITHIN
5 MILES RADIUS OF G.S.'s

Name of Generating Station	Sector	Total Housing Units No.	Total Housing Units $x10^6$ BTU/hr	Multi Family Units No.	Multi Family Units $x10^6$ BTU/hr
Essex (Kearny, Hudson)	EN	48090	2007	33930	1757
	ES	52886	2241	46610	1864
	SE	30300	1306	25601	1024
	WS	60723	2500	57121	2285
	WN	60580	2537	52056	2082
	NW	31327	1486	19699	788
		283906	12077	235017	9800
No. Bergen	NE	22321	1154	9256	370
	EN	22045	1028	13757	590
	ES	10958	512	7266	290
	SE	40084	1701	35162	1406
	SW	8673	402	5915	237
	WS	9293	453	5209	208
	WN	24183	1170	14018	561
	NW	23406	1103	15068	603
		160973	7523	105651	4265
Linden	NE	16822	724	14247	570
	SW	7782	406	3038	121
	WS	11713	615	4369	175
	WN	20520	1119	8223	381
	NW	29589	1298	18957	758
		86426	4162	48834	2005
Sewaren	NE	8003	418	3082	123
	EN	3005	135	2034	77
	SW	15408	731	9638	385
	WS	11539	619	3633	145
	WN	14712	822	2974	118
	NW	14205	743	5491	220
		66872	3468	26852	1068
Mercer	NE	21754	1197	5417	217
	EN	3606	205	567	23
	ES	2261	120	791	32
	SE	2909	157	876	35
	NW	29267	1509	12362	495
		59797	3188	20013	802
Burlington	EN	3994	217	1135	45
	ES	1382	80	167	7
	SE	6632	387	555	22
	SW	5597	335	23	1
	WS	6169	335	1736	69
		23774	1354	3616	144

TABLE XXIX

Appendix C

System Design

1. Purpose

The load potential investigations showed us that considerable load concentrations exist in the vicinity of four power plants. Independent of on what scale the development of the district heating system starts, in anticipation of its success, it has to fit into an overall development plan. These calculations are to define this plan.

2. Scope

There are two potential load centers to be investigated:

a. Downtown Newark via Kearny and Harrison

b. Northern part of Jersey City, Secaucus, Union City and West New York

The power plants to be considered as supply centers for the above loads shall be

a. Essex

b. Kearny

c. Hudson

d. North Bergen

3. Results and Recommendations

The results are shown in the main body of the report.

4. Data Basis

4.1 Heat Consumption Determination

Since the system is aimed at supplying the heating requirements of residences primarily, offices, institutions and commerce secondarily, we based our calculations on the requirements of multiple dwellings.

The design outdoor temperature in New Jersey being 0° and the indoor temperature 70°F, the peak heat requirements refer to a 70° temperature differential. Ten years of weather information (see Drawing 561-15) shows that the mean minimum temperature is 24°. This represents 65.7% of the peak load, which is therefore the limit to consider supplying heat in the cogenerative mode. The remaining 34.3% will be supplied by some peaking means. The number of days with below 70° the mean temperature is 265 annually. Heating is actually required whenever the temperature drops below 65 and that happens for 240 days per year on the average. During this number of days then, the temperature varies in a close to straight proportionate manner between 65°F and 24°F, resulting in an average of 45°F for the heating season. At this average temperature, the heating load is 35.7% of the peak design value. One arrives at a few percentage figures lower results by calculations based on published degree-day data. Another part of the heat load is that used for domestic hot water production. For the average household this is 110,000 BTU/day. Relating this to the 20,000 BTU/hr peak heating requirement of an apartment, and assuming that it is stretched evenly over the full day, domestic water heating requires 22.9% of the peak load, or 64.1% of the seasonal average load of that apartment. This amount of heat is required all through the year.

Based on these figures, the annual residential heating requirements of an apartment and its cost with our present methods of gas or oil heating are as follows:

. Heating peak - BTU/hr	20,000
. Peak design temperature differential- °F	70
. Average seasonal load - %	35.7
- BTU/hr	7,140
. Annual average heating load - 10^6BTU/yr	41.12
. Dom. water heating (365 days)-10^6BTU/yr	40.5
. Total annual average heat requirement - 10^6BTU/yr	81.27
. Fuel required at 62.5% eff.- 10^6BTU/hr	130
. No. 2 fuel oil - gal.	928
. Gas - therms	1300
. Cost: oil - $/yr	464
gas - $/yr	403

1000 sq. ft. of offices has a 25,000 BTU/hr heating peak and, dependent on the cafeteria facilities in those buildings, a similar amount or somewhat less domestic hot water is needed than in an apartment. It also usually operates for only half a day, or 12 hours. Therefore, it is reasonable to assume that the 1000 sq. ft. of office space represents a peak load equivalent to that of an apartment but that its annual heat consumption is only 50% of that.

Small multiple dwellings such as apartments in houses of not more than four to ten units usually require twice as much heating as a unit in a large apartment building but the same amount of hot water, therefore these units equal two of the other apartment units as far as peak load is concerned and only one and one-half times those with regard to annual heat consumption.

In summary, this means the following:

	Peak BTU/hr	Annual Consumption 10^6BTU/yr
Apartments in large buildings	20,000	80
Apartments in small dwellings	40,000	120
1000 sq. ft. of office space	25,000	40

4.2 Heat Supply Capability of Power Plants Considered

The heat available from the four power plants mentioned is defined by the capability of the machines to be retrofitted without affecting their normal operation. Steam will be made available by extracting it from a point between the intermediate and low pressure casings of the units installed, from pressure reducing stations and from new peaking boiler installations. The limitation is imposed by the first source of heating energy since this is the most efficient way of supplying that energy.

At this stage of the investigations there was no detailed study of what are the maximum steam flows obtainable from each machine. Safe, well-achievable figures are being used as follows:

Essex #1 Machine	- 500,000 lbs/hr	
Kearny #7 and #8 Machines	- 500,000 lbs/hr	each
Hudson #1 and #2 Machines	- 500,000 lbs/hr	each
Bergen #1 and #2 Machines	- 500,000 lbs/hr	each
Total	3,500,000	

Assuming that another 500,000 lbs/hr capacity peaking boiler plant will be added at one point of the development, the total supply of heat available from these power plants will be 4,000,000 lbs/hr which we equate for the present with 4,000 million BTU/hr.

In order to achieve this we also assume that at one point or another in the development of the total system, the plants will be connected to each other by mains and will serve the different supply areas as a single system and will provide standby capability for each other. Following the usual practice of maintaining standby for the loss of the largest single supply source, one 500,000 lbs/hr unit will have to be laid away for that purpose, allowing for a maximum peak load on the system at 3,500 million BTU/hr.

4.3 Potential Supply Territories

Based on the load estimates in Appendix B, one has to select potential supply territories in accordance with the following few, simple criteria:

a. Close proximity to the plants considered

b. High concentration of present loads

c. High concentration of developing loads

d. Minimal complications in laying out the mains

Looking at the figures in Appendix B, one can see that the Newark downtown area and the Jersey City downtown area are the ones which meet the first two criteria. The Meadowlands-Secaucus area is the one which best meets the third and fourth criteria. The Jersey City, Union City and Secaucus region also fares better with regard to the fourth criteria than does Newark. On the other hand, the Newark downtown area represents the highest concentration and the largest load potential.

In Appendix B we have presented two sets of figures, one based on an actual count of apartments in large complexes and offices in large office buildings, while the other was a statistical approach of estimating loads in the same area. The statistical approach results in load predictions of a magnitude higher than the detailed data gave us. Statistically, there are 2,200 million BTU/hr potential heating load within five miles of Essex, Kearny and Hudson in the West-South/West-North direction in the form of multi family units only. Using the ratios of commercial/institutional buildings vs. multiple dwellings, our estimate is that there is an addition 950 million BTU's potential load in those types of buildings, for a total of 3200 million BTU's. A similar amount of load exists to the East-North, East-South and North-West directions from the above mentioned power plants. The two areas then represent together a total extreme potential of over 6,500 million BTU/hr present and future, which is about twice the ultimate supply capability of the four power plants as shown in the previous paragraph. It is reasonable to assume that in the next ten years a district heating system will not achieve more than a 50% coverage of the total potential load and that mains have to be run successively to all these potential supply territories. Distribution sub-mains and house connections will be provided during that time span in each of the areas as the load develops.

5. System Development

Figure 561-23 shows all the power plants under investigation and the potential supply territories as discussed before. One can see that the Newark system covers five square miles and the Jersey City system covers three square miles. The Union City-West New York-Secaucus system will be a mix of existing and future developments on an eight square mile tract dependent on the timing of the new developments.

There are three distinct directions initial development can start. One is towards the Newark area, the other is towards Jersey City, and the third to the Union City-Meadowlands area. Each will be developed separately and finally connected into one single system.

In our previous studies we found that a square mile area built up by small multi family dwellings represents 420 million BTU/hr peak load. On the other hand, it would only take 210 apartment buildings of 100 units each to present us with the same load. 21,000 apartments in 7-story average structures give us 3000 apartments per floor, equivalent to a load use of 3 million sq. ft. or 11% of the total square mile territory. We accepted the 420 million BTU/hr specific potential and connectable load figure as the basis of our calculations. The five square mile area, therefore, has a potential for 2,100 million BTU/hr peak heating consumption.

Another assumption made was the development schedule of connecting load to a district heating system (Figure 561-24 shows this assumption graphically). It is based on the premise that one distribution system of a square mile territory will start in each one of five consecutive years and the rate of connection to that system will be increasing in a quasi-exponential manner. Each square mile will reach saturation within four years. The total development of the five square mile area in this scenario takes, then, eight years.

5.1 Newark Development

There are a number of ways to build up the system and they can be summarized in three schemes.

5.1.1 Scheme No. 1

A 500,000 to 600,000 lbs/hr boiler plant is installed at the Harrison gas plant and in each of three consecutive years one 1-square-mile areas are started to be developed and connected to this heat supply center. In the fourth year a 30"ϕ main is being built to the Essex plant and the crossover of the No. 1 Essex turbine is tapped, while the three supply areas are further developed and a new one is added. In the fifth year, a 36"ϕ connection is added from Essex to Kearny Generating Station and both Kearny No. 7 and No. 8 turbine crossovers are tapped. In the sixth year two back-pressure turbines are installed at Kearny and a 24"ϕ main is added from Essex to Newark running through Harrison. In the last two years of the development, a 36"ϕ connection between Hudson and Kearny stations could also be added dependent on the load development in these areas or in other areas, if any.

5.1.2 Scheme No. 2

It differs from Scheme No. 1 only by locating the peaking boiler plant at the Essex station. This allows the use of the Essex No. 1 boiler right from the start and therefore it allows also for the phased construction of the 600,000 lbs/hr peaking boiler plant during the first three years of development. On the other hand, one main from Essex to Newark has to be constructed during the first year of development.

5.1.3 Scheme No. 3

In this alternative the first plant supplying the system is Kearny. Since it has two units, one will provide standby capability to the other and therefore the installation of a peaking boiler plant can be delayed to take place only in the fifth year of development. On the other hand, a 36"ϕ main has to be built between Kearny and Essex and a 30" main between Essex and Newark right at the start of the development. Otherwise it will proceed as described in Scheme No. 1.

5.2 Jersey City-Meadowlands Development

The development of this system does not differ basically from that of the Newark system. It does not however lend itself to the number of variations the other one did. It is visualized that its development will go basically along the lines of Scheme 3 of the other system with the following exceptions. The first plant to supply the system would be Hudson station where there are two units and therefore no peaking boiler plant is necessary til up to the fifth year of development. The second plant to be connected in could either be Kearny, if the development at that point (years 3-4) is centered around Jersey City, or it would be North Bergen should the development be heavier in the newly developing Meadowlands district. The dollar figures shown in Table XXXI are not significantly different for this system.

5.3 Total Complex Development

It is reasonable to assume that if the economy of district heating is proven, the two previous systems will develop more or less simultaneously and probably within the decade will reach the total capacity available from the four power plants. As shown in paragraph 4.2, this capacity is 3,500 million BTU/hr available from turbine exhausts. This can be further boosted by the installation of peaker units such as steam boilers, high temperature water boilers or combustion turbine heat recovery units totalling a capacity of 1,750 million BTU/hr to meet a peak load of 5,250 million BTU/hr. On a statistical basis these peakers will operate only 700 hours annually and therefore in most cases they are the cheapest, simplest kind of installations available to provide the required service. A peaking plant like that will cost an estimated $18 million even if it is scattered over more than one site.

It is obvious from the above that a system based on the four power plants can meet the district heating needs of the densely populated areas within the five mile radius of these plants during the next ten years. It is also obvious that since four plants and different possible construction configurations out of these four plants are considered, the development can meet, quite effectively and economically, changing development patterns and development staging different from those initially assumed. It will be able to do that without incurring penalties detrimental to the momentary economy of the developing system.

6. Preliminary Cost Estimates

In order to be able to prejudge the investment requirements of the complex district heating system and get some feel of its economy, in the following we are presenting cost figures developed on a generalized basis.

6.1 Cost of Local Systems

As shown in Appendix A on Drawing 561-09/B, the piping distribution system for a square mile of four-family housing units representing a total peak heat load of 420 million BTU/hr costs $3.1 million per square mile. The district heating system proposed will aim at supplying areas where the majority of potential load is in large apartment buildings. As an extreme case the assumption was made that all 21,000 apartments representing 420 million BTU/hr/square mile load are located in the middle of the square mile territory. 16" lines will be able to supply them in a single run. The cost of that configuration is $2.1 million and it is considered as a minimum. Based on the two cost figures, we have averaged the cost at $2.6 million per square mile for the distribution system in each of the square mile areas considered. Similar assumptions were made for the distribution and building connection piping cost in the immediate vicinity of the buildings supplied and for the cost of the connection and equipment required in the buildings for conversion to district heating. All these are shown on Table XXX based on the development prediction shown on drawing 561-24. There are two cumulative totals on this table, one without and one with the cost of in-house conversion connections. This was to allow for the connections of new buildings where no additional cost is incurred. The usual boiler installation cost is replaced by the cost of heat exchangers and piping of the district heating system. Also it is a possible alternate decision that the in-house equipment cost will not be borne by the district heating system but by the building owners.

6.2 Cost of Newark System

The estimated cost and the gradual investment requirements of the three different schemes discussed in paragraph 5.1 are shown on Table XXXI. The cost of plant retrofits is based in all cases on tapping the crossover piping of the turbines and installing back-pressure turbines to expand further to the desired levels of heat rejection. The only plant where no additional turbines are planned to be installed is Essex, where the crossover pressure is too low to justify such an installation.

The distribution mains were estimated in accordance with that shown on Drawings 561-10/B and 10/C with their cost and other details shown on Table XXXII.

As one can see, the total investment is $93.2 million for a system supplying a peak of 2,100 million BTU/hr and including the conversion costs in the individual buildings. It is $71 million without the latter.

This system would supply 8,400,000 million BTU's annually if all the connected loads are apartments (105,000 units). As also shown before, 1,000 sq. ft. of office space equals the peak load of an apartment but it uses only half the heat on an annual basis. This heat, however, is used mainly during the daylight hours. The annual heat consumption of apartments in small buildings, on the other hand, can be as much as twice that of the high-rise apartment. Not being able to predict at this point the actual mix of different uses, the tabulated figure seems to be a good average.

The No. 2 oil used in most apartment houses in the area sells today at around 50¢ per gallon, or $3.60 per million BTU's. At 62½% average annual boiler efficiency, 1 million BTU net comparable to the heat supplied by a district heating system cost $5.76 in fuel. Adding maintenance, replacement and operating personnel costs to these, a $6-$8 per million BTU present cost can reasonably be assumed. On this basis the present heating bill of the number of users considered runs \$50-\$65 million per year. The expected revenue from the district heating system one can assume to be in the same order of magnitude.

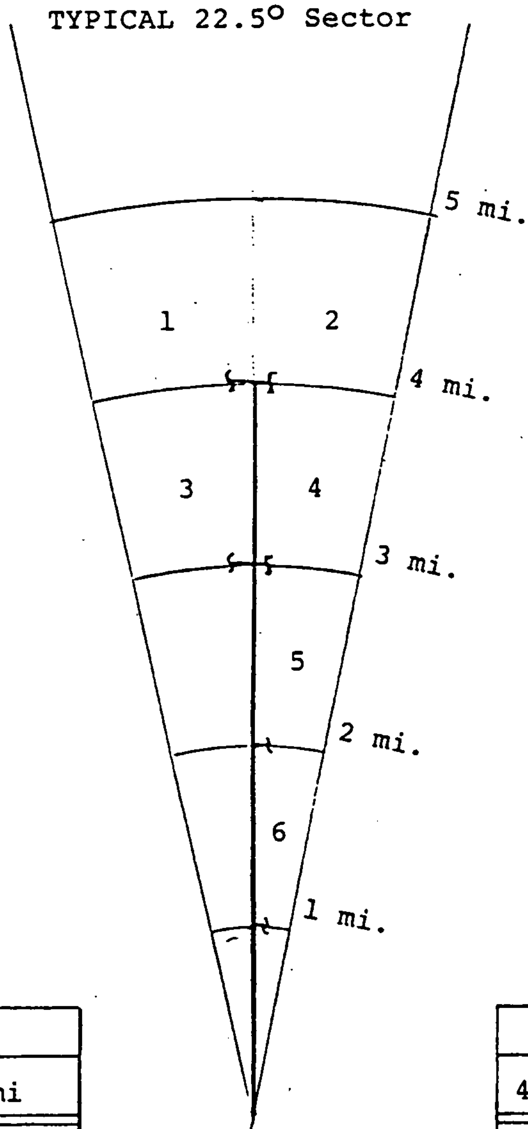
6.3 Ultimate System Cost

As also shown before, the ultimate system capacity is 5,200 million BTU/hr including additional peaking facilities. The cost of such a system can be estimated in round figures at around \$220 million with expected revenues from the sale of heat at \$100-\$150 million annually.

TRANSFLUX international limited
1275 FIFTEENTH STREET, FORT LEE, NEW JERSEY 07024

NO. 561-10/B

TYPICAL 22.5° Sector



LOAD DENSITY				
840×10^6 BTU/hr/sq mi				
Sect.	Pipe Size @ Δt			
Miles	40	60	120	200
0-1	(72)	60	48	42
1-2	(72)	60	42	36
2-3	60	54	42	36
3-4	48	42	30	24

LOAD DENSITY				
420×10^6 BTU/hr/sq mi				
Sect.	Pipe Size @ Δt			
Miles	40	60	120	200
0-1	54"	48"	36"	30"
1-2	54"	42"	36"	24"
2-3	48"	42"	30"	24"
3-4	36"	30"	24"	16"

? ? 13.3 < Investment Cost-10^6\$ > 16.3 13.3 10.3 18.0

TYPICAL 5 MI. RADIUS DISTRIBUTION MAIN LAYOUT - 22.5°

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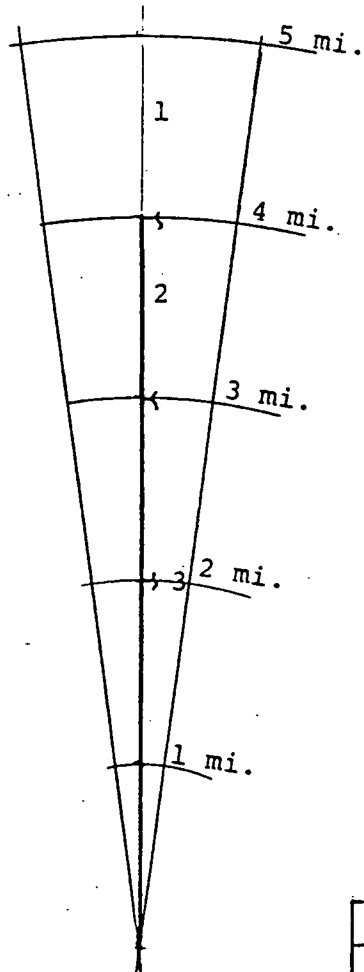
NO. 561-10/C

Typical 15° Sector



LOAD DENSITY				
840x10⁶BTU/hr/sq mi				
Sect.	Pipe Size @ Δt			
Miles	40	60	120	200
0-1	60	54	42	36
1-2	60	48	36	30
2-3	54	42	36	30
3-4	42	36	24	20

133 113 111 24.8

$ x 10⁶

LOAD DENSITY				
420x10⁶BTU/hr/sq mi				
Sect.	Pipe Size @ Δt			
Miles	40	60	120	200
0-1	48"	42"	30"	24"
1-2	42"	36"	30"	24"
2-3	42"	36"	24"	18"
3-4	30"	24"	18"	14"

11.1 8.2 15.0

TYPICAL 5 MI. RADIUS DISTRIBUTION MAIN LAYOUT - 15°

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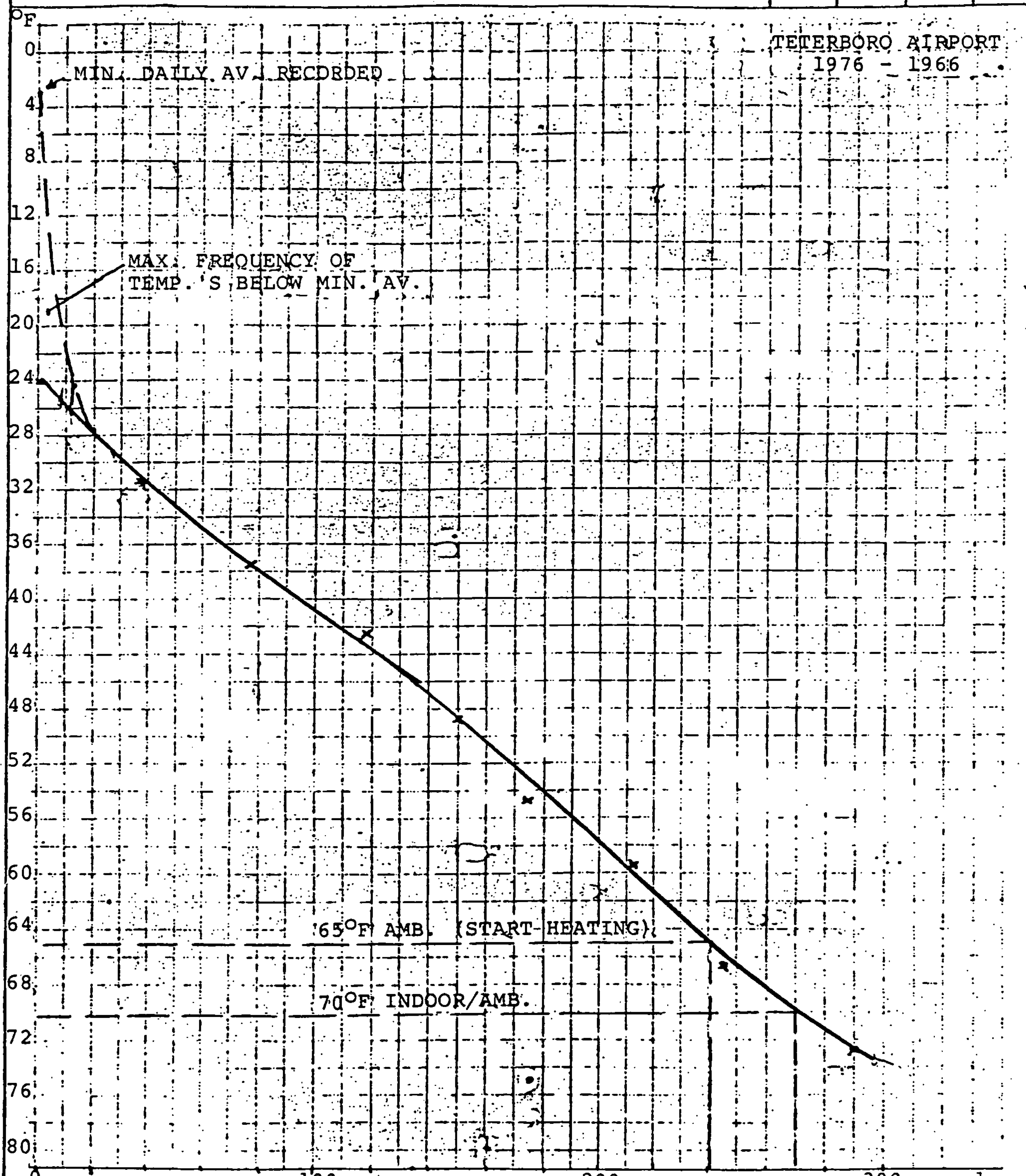
NO. 561-15



NEW JERSEY 10 YR. AVERAGE DAILY TEMP.'S

TRANSFLUX international limited

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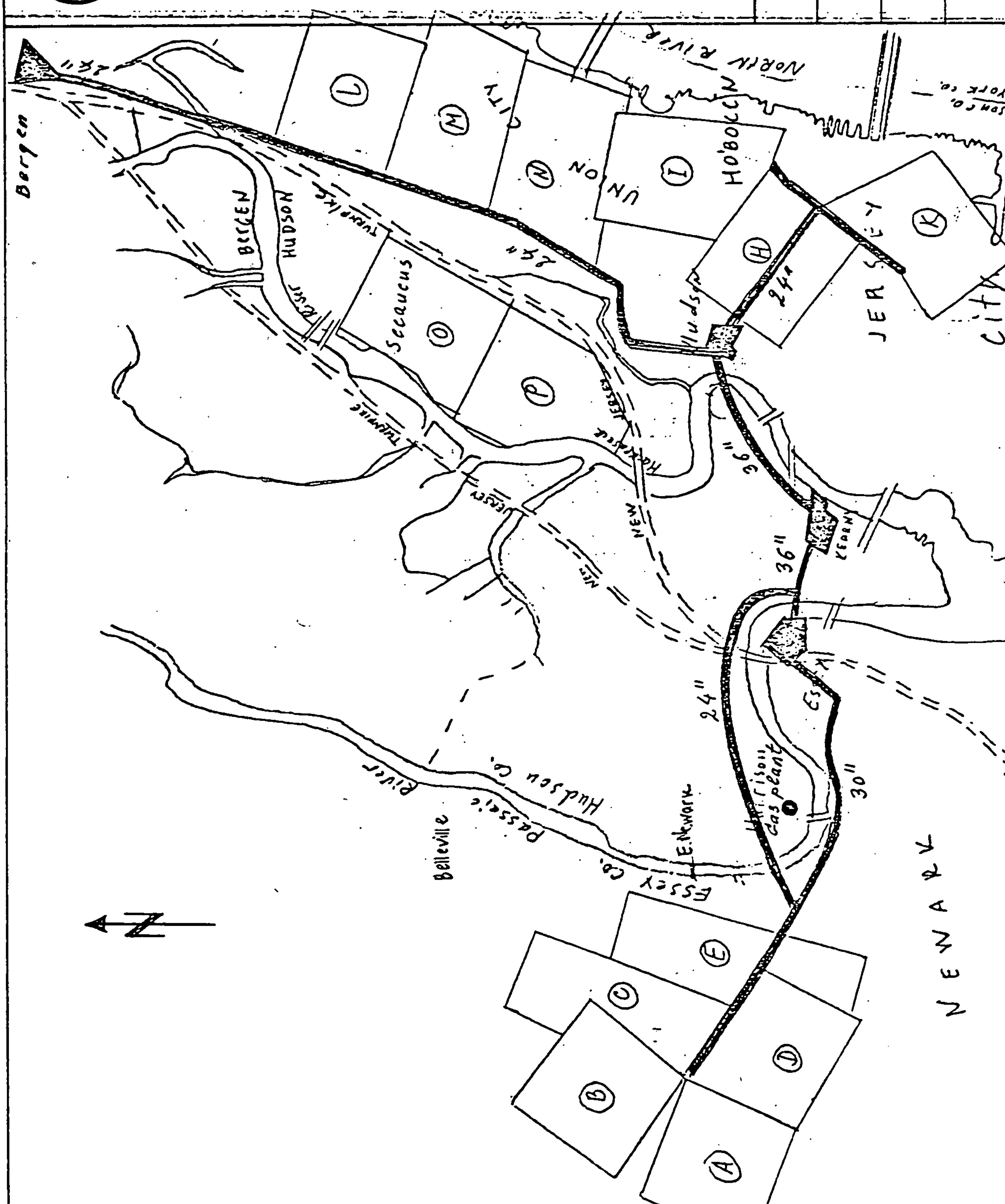
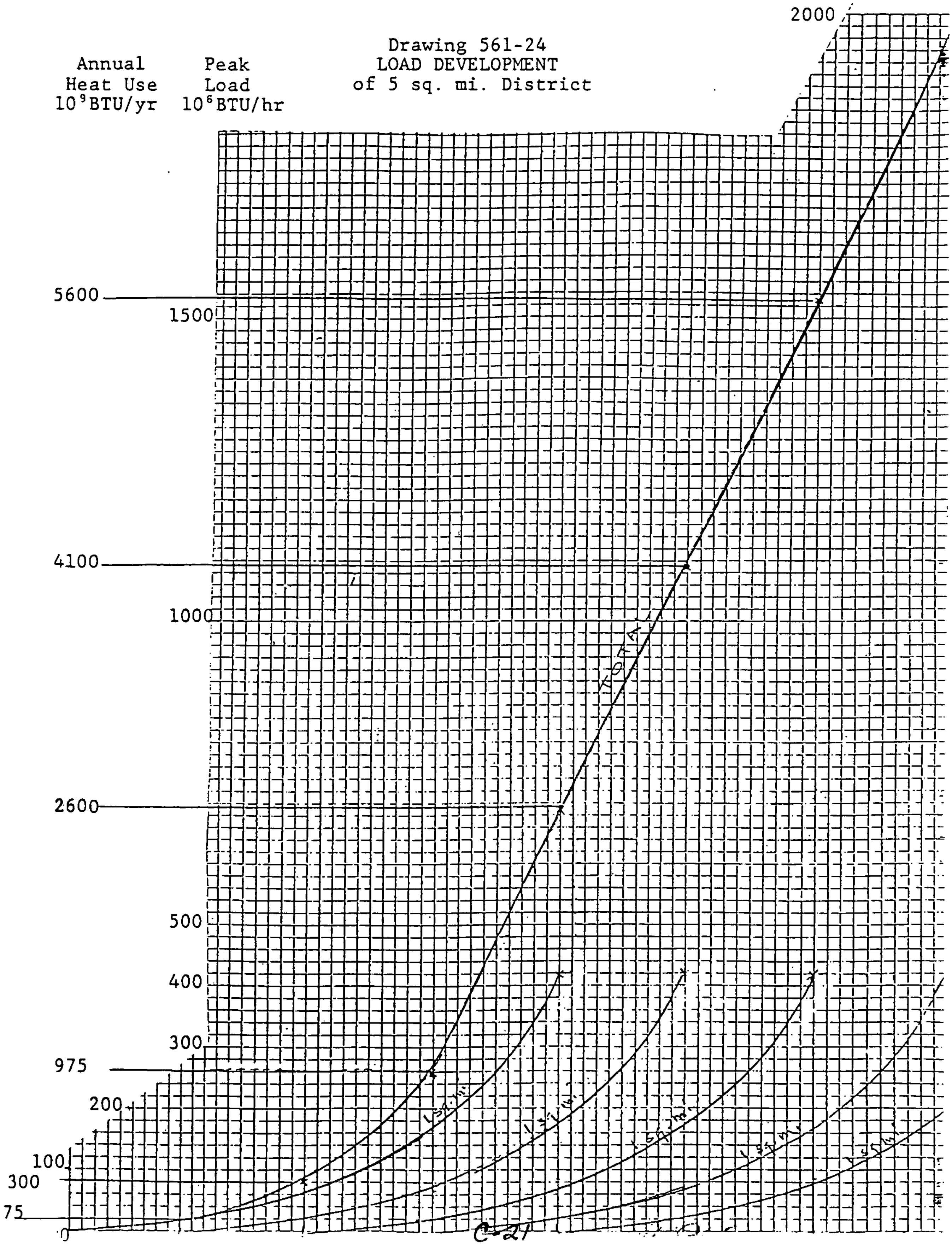
NO. 561-23



DISTRICT HEATING DEVELOPMENT PLAN

Drawing 561-24
LOAD DEVELOPMENT
of 5 sq. mi. District



INVESTMENT IN LOCAL SYSTEMS

Investment Year	Distribution on 5 sq. mi. Cost	Distribution on 5 sq. mi. Cumul.	Distribution on 15 acres Cost	Distribution on 15 acres Cumul.	Total Cumul.	In-house Connection Cost	In-house Connection Cumul.	Total Cumul.
1st	500000	500000	140000	140000	640000	220000	220000	662000
2nd	1400000	1900000	770000	900000	2800000	880000	1100000	3900000
3rd	2000000	3900000	2100000	3000000	6900000	1980000	3080000	9980000
4th	2600000	5600000	5040000	8040000	13640000	4405000	7485000	21125000
5th	2600000	9100000	5040000	13080000	22180000	4405000	11890000	34070000
6th	2100000	11200000	4850000	17930000	29130000	4383000	16273000	45403000
7th	1200000	12400000	4265000	22195000	34595000	3525000	19798000	54393000
8th	600000	13000000	1617000	23812000	36812000	2425000	22223000	59035000

C-22

TABLE XXX

NEWARK - DISTRICT INVESTMENT STRATEGIES
(in millions of $)

SCHEME	Plant Retrofit $	Plant Retrofit Cumul.	Distribution Mains $	Distribution Mains Cumul.	Local Systems Cumul.	Total Investment Cumul.	Total w/o in-house Cumul.	Connected Peak 10^6 BTU/hr	Heat Supplied 10^9 BTU/yr
SCHEME I									
1st year	4.0	4.0	1.0	1.0	.86	5.86	5.64	20	80
2nd year	-	4.0	-	1.0	3.9	8.9	7.8	80	320
3rd year	-	4.0	-	1.0	10.0	15.0	11.92	280	1120
4th year	2.0	6.0	7.0	8.0	21.1	35.1	27.62	700	2800
5th year	1.5	7.5	3.5	11.5	34.1	53.1	41.2	1100	4400
6th year	4.0	11.5	4.2	15.7	45.4	72.6	56.3	1500	6000
7th year	2.0	13.5	5.0	20.7	54.4	88.6	68.8	1800	7200
8th year	-	13.5	-	20.7	59.0	93.2	71.0	2100	8400
SCHEME II									
1st year	3.0	3.0	5.2	5.2	.86	9.06	8.84	same as above	same as above
2nd year	-	3.0	-	5.2	3.90	12.1	11.0		
3rd year	1.0	4.0	-	5.2	10.0	19.2	16.12		
4th year	2.0	6.0	-	5.2	21.1	32.3	24.8		
5th year	1.5	7.5	10.5	15.7	34.1	57.3	44.5		
6th year	4.0	11.5	-	15.7	45.4	72.6	56.3		
7th year	2.0	13.5	5.0	20.7	54.4	88.6	68.8		
8th year	-	13.5	-	20.7	59.0	93.2	71.0		
SCHEME III									
1st year	1.5	1.5	10.5	10.5	.86	12.86	12.64	same as above	same as above
2nd year	-	1.5	-	10.5	3.90	15.90	14.80		
3rd year	-	1.5	-	10.5	10.0	22.00	18.92		
4th year	2.0	3.5	-	10.5	21.0	35.0	27.5		
5th year	1.6	5.1	-	10.5	34.1	49.7	37.8		
6th year	6.4	11.5	5.2	15.7	45.4	72.6	56.3		
7th year	2.0	13.5	5.0	20.7	54.4	88.6	68.8		
8th year	-	13.5	-	20.7	59.0	93.2	71.0		

TABLE XXXI

PIPING COST & PUMPING POWER SUMMARY
FOR MAINS

Alternative Schemes					Pipeline Cost $/unit	L pipe, ft·10^{-3}			Σ(ΔPs+ΔPr) psi	Σ(Es+Er) kWh/hr
Area		W, lb/hr/Area 10^{-3}	Δt, °F	Drawing No 561-		D_{max} in	Rural	Sub-Urban		
for sector 15°	420·10^6 BTU/sq.m	32700	40	10/C	404.16	48	10.55	10.55	875.1	3767
		22870	60		337.58	42	10.55	10.55	193.2	2776
		11440	120		251.78	30	10.55	10.55	251.2	1728
		6860	200		455.25	24	10.55	10.55	346.0	1451
	840·10^6 BTU/sq.m	66000	40	10/C	-	60	10.55	10.55	115.0	4973
		45740	60		454.26	54	10.55	10.55	135.7	3984
		22870	120		337.58	42	10.55	10.55	193.2	2776
		43720	200		751.4	36	10.55	10.55	168.8	1281
for sector 22.5°	420·10^6 BTU/sq.m	49000	40	10/B	330.07	54	10.55	10.55	161.5	5056
		34300	60		269.72	48	10.55	10.55	186.0	4030
		17150	120		209.58	36	10.55	10.55	184.6	2005
		10300	200		364.50	30	10.55	10.55	338.0	2067
	840·10^6 BTU/sq.m	98600	40	10/B	-	(72)	10.55	10.55	-	-
		68600	60		-	60	10.55	10.55	148.8	6340
		34400	120		269.72	48	10.55	10.55	186.0	4030
		20600	200		-	42	10.55	10.55	128.8	1593

Table XXXII

District Heating and Cooling Systems for Communities Through Power Plant Retrofit Distribution Network

Task 3 - ENERGY MARKET ANALYSIS

2.2.2 Define the boundary of the proposed service area and the location relative to the selected Power Plants. Describe in detail the mix of End Users in the Service Area.

2.2.3 Conduct a survey of the building types within the proposed service areas and other data on utility use levels to assist in establishing projected load requirements for heating and cooling.

2.3.1 Conduct a complete survey of the current and forecasted user loads for each proposed potential service area. Categorize the present and potential future customers into residential, commercial, industrial, etc. Prepare a complete inventory of the type of system, quality and age of the customers equipment. This data shall be used for developing the load demand profile in Phase II analysis.

2.3.3 Examine and evaluate the different factors that will induce the End Users to switch from traditional energy supply sources to a centrally generated thermal energy. These should include cost, reliability, level of maintenance required by the End-Users, disruption of current pattern of use and safety. An analysis of the cost of heat and the cost of changes required in the End User's equipment should be based on customer data collected in Item 2.3.1

2.3.4 Identify the generic nature of the market, characteristics and problems as they relate to other urban industrial areas.

2.4.7 Determine and assess the scarce fuel saving potential of each retrofit scheme relative to the generation of thermal and electric energy.

2.2.2 Boundary of Proposed Service Areas

As the result of preliminary quantitative and qualitative analysis three possible service areas have been defined for the purpose of this analysis. All three areas are located in the northern New Jersey area which has been found to have both the greatest density of existing thermal loads and in the Hackensack Meadowlands, the greatest potential residential, commercial and industrial growth in a relatively concentrated geographic location. The three schemes analyzed include:

1. Scheme 1 - Serving potential new loads in the Hackensack Meadowlands and the existing thermal market in the Jersey City area. These loads will be served by retrofitting the PSE&G Hudson generating station.
2. Scheme 2 - Serving the existing thermal market in the Newark area. These loads will be served by retrofitting the PSE&G Essex generating station.
3. Scheme 3 - Serving potential new loads in the Hackensack Meadowlands and the existing thermal market in both Jersey City and Newark. These loads will be served by retrofitting the PSE&G Hudson, Bergen and Essex generating stations.

The specific timing, loads to be served and associated captial and operating costs for these three schemes are discussed elsewhere in this report.

2.2.3 Survey of Proposed Service Areas

Introduction

In order to establish the potential market for district heating which exists within a five (5) mile radius of the selected generating stations a field survey of each location was conducted. To accomplish this, three basic goals were set forth:

1) Design a questionnaire which would supply all the information needed for the analysis.
2) Administer the questionnaire to a selected sample of customers.
3) Analyze the resulting data and draw conclusions as to the potential district heating load.

The results of the questionnaires along with a detailed computation of existing structures by type (residential and non-residential) will be used to determine the detailed load estimates at the selected sites. Details of the methodology used for each step is found in the subsequent sections.

Questionnaire Design

The questionnaire used for the field survey was developed by SWMCI in conjunction with the other participants in this project. In addition input was received from various operating departments of PSE&G.

The final questionnaire shown in Exhibit 2.2.3-I is divided into two parts. The first part consists of the front cover marked CONFIDENTIAL which identified the customer, the interviewer and interviewee, and establishes a code for the customer class, general location within a grid and questionnaire number. The interviewees were advised that this information would be kept by Public Service Electric and Gas and would remain confidential.

The second part of the survey form contains specific questions, which cover the following areas:

1) Customer characteristics including square footage of building, type of operation (i.e., residential-retail sales, manufacturing), hours of operation, number of employees, age of building, change in amount of usable space in the last five years, etc.
2) Fuel consumption and annual bills by type of fuel and any change in the last 12 months.
3) Heating equipment, type (steam, hot water, air), input output and quantities of steam used at less than 50 psig or hot water below 290°F.
4) Cooling equipment by type, tonnage and average age.
5) Process steam of hot water equipment.
6) Domestic hot water equipment.
7) Future expansion plans short-term (6 months to 1 year) and long-term including additional fuel requirements by type.
8) Payback period or return on investment required for new fuel and energy related investments.

The information obtained from the questionnaire enables us to determine the heating and process load requirements of the five classes of customers (residential, small commercial, large commercial, small industrial and large industrial) as well as the price of fuel currently used and their future plans. The size of the building was also obtained to allow for loads to be expressed on a per square foot basis. Other questions pertaining to the specific equipment and the temperature and pressure of operation allowed us to determine those loads which represent potential customers of the proposed hot water district heating system.

The questionnaire was designed to be analyzed by existing computer programs. The results of each questionnaire were key punched and entered into a data base for analysis. The forms were also designed for ease of administration and to avoid undue burden to the customer selected for interview.

In order to select a representative sample of customers to interview the following procedure was followed:

The PSE&G service area is served by commercial offices. Each office has been assigned a given geographic service area. Computerized listings of all electric customers within each commercial area are available. The listing contains such information as name, address, rate class, consumption and bill. Electric customers from the commercial offices which serve areas within a 5 mile radius of the selected generating stations were chosen as the population of customers to be surveyed.

By choosing the electric customers it was assured that all customers (including those who had gas provided by sources other than PSE&G) were included in the areas to be surveyed. It is assumed that everyone has electric service.

The sample was selected using standard statistical sampling techniques to assure confidence at the 5% level. The sample was taken from a population containing multifamily residential buildings, and commercial and industrial customers. In addition, all gas customers with interruptible service (rate

ISG) and all large C&I customers (rate HL) were included in the sample. The original population served by the selected commercial officer included some 3,300 such customers, however, parts of several towns fell outside of the 5 mile radius and were eliminated. Therefore the target population was reduced to 3,000 and the sample required was 340 in addition 104 large customers were added for a total of 444 customers originally chosen for survey. Each of the customers surveyed was located on a grid map and the grid number was used as part of the customer code, this system allows the location of load concentration or load density of an area. In addition, a separate list of all multifamily residential buildings (high rise and large apartment complexes) within the five mile radius of each of the plants was compiled by PSE&G. The list also included the type of fuel used and the type of heating system. Finally, the location of these buildings and the number of dwelling units at each location was plotted on maps for easy location. Over all, 444 customers were included in the survey.

Personal interviews were conducted by employees of PSE&G employed at each of the 5 commercial offices. These people were familiar with the territory to be surveyed and in many cases with the customers to be surveyed (particularly large industrial and commercial customers). In cases where customers initially selected could not be surveyed others were substituted, large C&I customers who could not be reached or could not answer the questions at the local office were dropped from the survey. This action did not effect the sample since those customers dropped (without being replaced) were from ISG and HL rates which were not part of the original sample. Ultimately

384 questionnaires were received and analyzed. The results of the surveys are discussed and tabulated in the following paragraphs.

Survey Results

The survey data gathered during interviews with the selected customers was compiled and stored on magnetic tape to facilitate analysis and for possible future use.

The total number of the survey respondents was 384 and is comprised of various customers classes, including small and large commercial; small and large industrials; residential and multi-use customers. Exhibit 2.2.3-II shows the breakdown of the surveyed sample. Small industrial and commercial represent the majority of the sample customers, with 38 and 30 percent of the total, respectively. Large industrial represent 21 percent, large commercial 9 percent, and residential and multi-use customers represent only 2 percent of the total customers. In addition information on the location, type of heating system, fuel use and number of units was obtained for all residential high rise apartments in the study area by PSE&G.

It should be pointed out that the data used in the analysis has been scanned and filtered so that unreasonable or erroneous data was eliminated in the analysis.

The first area analyzed was floor areas to determine the size of the establishments to be heated, in total as well as per customer, and by customer class. It is shown in Exhibit 2.2.3-III that on a per customer basis, large commercial has the most floor area 506,000 square feet, and small commercial has the least 75,000 square feet. For all customers classes the average floor area is 151,700 square feet per customer excluding residential customers.

Presented in Exhibits 2.2.3-IV, V and VI are the average use and cost statistics for heating fuels for each of the four classes of customers. Exhibit 2.2.3-IV shows by class of customers the average bill (thousands of dollars) for the last 12 months. The type of fuels as well as the average for all fuels is presented. Exhibit 2.2.3-V shows the average annual fuel use per customer for each type of fuel and each class of customers. The high and low and mean values are shown to provide information on the large range of customer sizes in the sample. Exhibit 2.2.3-VI tabulates for each customer class the average per unit fuel cost by fuel type. The standard deviation is shown to provide information on the variability of fuel cost. The data for these exhibits is compiled from those customers indicating the use of fuel for heating only.

The large commercial class consumes more fuel than other classes on a per customer basis and large industrial class pays the lowest unit fuel cost per customer.

As summarized in Exhibit 2.2.3-VII the survey showed that 46.3% of the customers interviewed are equipped with steam heating systems and 17.5% of the total customers have steam heating systems of which the major portions are operated below 50 psig. The survey also indicated that 27.8% of the customers have process loads and 16.1% of the customers have process loads that are below 50 psig.

Exhibit 2.2.3-VIII shows that overwhelming majority of the total sample are equipped with electric motor driven cooling units of a total tonnage of 57,381. Other customers are equipped with steam absorption cooling units of 17,754 tons and others steam driven cooling units of 8,380 tons.

The survey shows that 36% of the total customers are equipped with central domestic water heating systems, 43% with individual type, and 21% did not indicate if they were equipped with domestic water heating systems.

52% of those surveyed indicated fuel-fired boilers for the water heating system; 14% indicated steam from other systems as the source for heating domestic hot water; 22% with electric boilers; and 12% did not provide an indication as to what type of boiler they had. This information is summarized in Exhibit 2.2.3-VIII.

Exhibit 2.2.3-IX indicates that, on a short-term basis, 16% of the customers have firm plans for new equipment installation in the next six months to a year, 80% have no such plans, and 4% did not state their intentions. On a long-term basis, that is for the next five to ten years, 11% of the customers expected increases in building floor space, only 1% expected a decrease, and 88% did not expect any change in floor space. When asked about anticipated changes in heating, cooling or process equipment, 12% answered they expected some change, 65% answered no changes and 23% did not provide definite answers.

Exhibit 2.2.3-X shows the payback period as return on investment for the various customer classes. The longest payback period of 4.6 years is tolerated by small commercial customers, the shortest of 3.2 years, is required by large industrial establishments, the average payback period for energy related investments for all customers is 3.7 years.

The consumption of fuels have been translated into a common base of gross Btu content. The conversion factors used are as follows:

No. 2 oil	- 137,000 Btu/gal.
Nos. 4 and 5 oil	- 143,000 Btu/gal.
No. 6 oil	- 145,500 Btu/gal.
Natural Gas	- 100,000 Btu/therm

We have calculated the annual average load per square foot and the standard deviations for each customer class. Exhibit 2.2.3-XI shows these results ranging from a low 58,020 Btu/ft.^{2} for large commercial to a high of 96,080 Btu/ft.^{2} for small commercial establishments. The average values for small and large industrial are 81,867 and 85,175 Btu/ft.^{2} respectively. The heating loads were weather normalized to 5,034 average annual heating degree days (HDD) per year for Newark. This compares to 5,317 HDD for 1978. The rather large standard deviation in the usage for these 4 types of customers is due to the large diversity in usage patterns as well as size among the customers surveyed. For example the heating requirements of a warehouse are quite different than those of an office building. The average Btu per square foot requirements for each customer type (resulting from the survey) was compared to those from an existing district heating system and they showed no major distortions.

These average loads per square foot will be used in other parts of the study to project the future loads for each customer class in the PSE&G service area.

Exhibit 2.2.3-I

CONFIDENTIAL

HEATING, COOLING, DISTRICT HEATING

QUESTIONNAIRE

Name of Firm ____________________ Person Interviewed ______________________

Address ________________________ Interviewer ____________________________

____

________________________ Date ______________________

Customer Class

Large Industrial (A) ☐ Small Commercial (D) ☐

Small Industrial (B) ☐ Residential (E) ☐

Large Commercial (C) ☐ Multiuse (F) ☐

Customer Account # ____________________ Questionnaire # __________________

Rate Class ____________________________

Location: Plate # ______________ Grid # ______________ Code ______________

Code # [ ] 1–9

1. Customer Information

Manufacturing (M) Apartments (A)

Product Manufactured ________ No. of Dwelling Units _____ 10 [ ]

____

Office (F) Warehouse (W) Retail Establishment (R) ________ 11 [ ]

Other including multiuse, specify ________ (X)

Building Floor Area (1000 Sq. Ft.) ________ 12 [ ] 16

* SIC Number ________ 17 [ ] 20

Number of Employees ________ 21 [ ] 23

Daily Occupancy hours 8 16 24 ________ 24 [ ] 25

Weekly 10-40 (A) 41-80 (B) 81-120 (C) 121-168 (D) ________ 26 [ ]

Seasonal Operation Summer (S) Winter (W) Year Round (R) ________ 27 [ ]

Age of Building ________ 28 [ ] 29

No. of years present Operation in effect ________ 30 [ ] 31

Usable space in Past 5 years Increased (I) Decreased (D) Same (S) ________ 32 [ ]

Amount of change (1000 sq. ft.) ________

No. of Boiler and Cooling Plant Operators ________

2. Fuel Consumption for the 12 months ending Dec. 1978

H = space heating P = Process G = General

	Amount	Annual Bill	Used For
Natural Gas (M Therms) ________	33 [ ] 36	[ ] 40	[ ] 41
Fuel Oil (1000 Gal) #2 ________	42 [ ] 45	[ ] 49	[ ] 50
#4 or #5 ________	51 [ ] 54	[ ] 58	[ ] 59
#6 ________	60 [ ] 63	[ ] 67	[ ] 68
Electricity (1000's Kwh) ________	69 [ ] 74	[ ] 78	[ ] 79

Other (Specify) ________

Has this consumption changed over the previous 80 [1]

12 months No Yes % Change _____

Reason for Change ________

____

* Filled out by General Office Staff

Comments: ________

____

____

____

Code # 1 [ ] 9

3. **Heating Equipment**

Type of System

Steam (S) Hot Water (W) Hot Air (A) ____ 11 [ ]

Size of System

Input (Million Btu) ____ 12 [ ] 16

Output (Million Btu) ____ 17 [ ] 21

% Above 50 PSIG ____ 22 [ ] 23

% Below 50 PSIG ____ 24 [ ] 25

Comments: ____

4. **Cooling Equipment**

Types of Use (Check all applicable)

Comfort (A) [ ] Computer (C) [ ] Process (P) [ ] Refrigeration (R) [ ]

Absorption (A) [ ]

Tonnage ____ 28 [ ] 31

Average Age of Equipment ____ 32 [ ] 33

Steam Driven (S) [ ]

Tonnage ____ 35 [ ] 38

Steam Inlet Pressure (PSIG) ____ 39 [ ] 41

Average Age of Equipment ____ 42 [ ] 43

Electric Motor Driven (E) [ ]

Central (C) [ ] Package Unit (including window) (P) [ ] ____ 45 [ ]

Combination (B) [ ]

Tonnage ____ 46 [ ] 49

Average Age of Equipment ____ 50 [ ] 51

Comments: ____

5. **Process Steam or Hot Water**

	Amount	Units
Annual usage 1000 lbs (L) or MMBTUS (B)	52 [ ] 56	[ ] 57

Any end use with Design Pressure at 50 PSIG
or 290°F and below Yes (Y) No (N) ____ [ ] 58

If yes, supply total maximum capacity in (1000's Lbs/Hrs)(L) or MMBTU/Hrs (B) 59 [ ] 62 [ ] 63

Type of Operation Seasonal (S) Year Round (R) ____ [ ] 64

Type of Steam End Use, describe ____

6. **Domestic Water Heating**

Type of System: Central (C) Individual (I) ____ [ ] 65

Boiler (Heater): Fuel Fired (F) Steam from other System(S) ____ [ ] 66

Electric (E)

Water Temperature ____ 67 [ ] 69

Annual Use (1000's Gal) ____ 70 [ ] 74

Maximum Hourly Use (Gal) ____ 75 [ ] 79

Comments: [2] 80

7a. **Future Plans**

Short Term

Code [ ][ ][ ][ ][ ][ ][ ][ ][ ] 9

Based on current operation and knowledge, are there any firm plans for new equipment Installation in the next 6 months to a year? Yes (Y) No (N) ________ [ ] 11

If yes, will it change the amount and Type of Fuel used Yes (Y) No (N) ________ [ ] 12

Quantify below

Fuel Consumption for new equipment

H = space heating P = Process G = General

	Amount	Estimated Additional Cost $(1000)	Used For H-P-G
Natural Gas (M Therms) ________	13 [ ][ ][ ][ ] 16	[ ][ ][ ][ ] 20	[ ] 21
Fuel Oil (1000's Gal) #2 ________	22 [ ][ ][ ][ ] 25	[ ][ ][ ][ ] 29	[ ] 30
#4 or #5 ________	31 [ ][ ][ ][ ] 34	[ ][ ][ ][ ] 38	[ ] 39
#6 ________	40 [ ][ ][ ][ ] 43	[ ][ ][ ][ ] 47	[ ] 48
Electricity (1000's Kwh) ________	49 [ ][ ][ ][ ][ ][ ] 54	[ ][ ][ ][ ] 58	[ ] 59
Other (Specify)			

Comments:

7b.

Long Term

On a longer term basis, what increase (decrease) do you expect in the next 5 to 10 years.

	Amount	Units (P-F)
Building Floor Space % Growth (P) or 1000's of Sq. Ft. (F) ________	60 [ ][ ][ ][ ] 63	[ ] 64
Increase (I) Decrease (D) ________		[ ] 65

Do you anticipate any changes in the heating, cooling or process equipment? Yes (Y) No (N) ________ [ ] 66

If yes, describe below

Type (Heating, Cooling process) (H) (C) (P)	Equipment Added (Removed)	Approximate Annual Energy Requirements (Specify Units)	Year of Change
________	________	________	________
________	________	________	________

8. What is the payback period or return on investment required for fuel and energy related investments? ________ Years 67 [ ][ ] 68 ________ % 69 [ ][ ] 70

____

9. Can you provide your daily or annual thermal energy consumption curves for your building? Yes____ No____ Information Attached_____, Will Follow_____ ________ [3] 80

10. Other Comments________

________ ________

* 11. Do you presently generate electricity? Yes No

if yes, describe equipment used

	Engine	Gas Turbine	Steam Turbine
Maximum hourly Kw	________		
Annual (Mwh)	________		

* 12. Estimate your annual usage of energy for the next ten years (or annual growth rate (decline) in energy usage).

____

* Filled out by PSE&G

SURVEY SAMPLE SIZE

Customer	Sample Size Number	Sample Size Percent of Total
Commercial - Small	115	30
Commercial - Large	36	9
Industrial - Small	145	38
Industrial - Large	82	21
Residential	4	1
Multiuse	2	1
Total	384	100

BUILDING FLOOR AREA

Customer	Size of Floor Area: Total	Size of Floor Area: Per Customer
	(1,000 ft^2)	
Commercial - Small	4,998	75
Commercial - Large	9,627	506
Industrial - Small	4,968	87
Industrial - Large	4,222	302
All Customers	23,815	152

ANNUAL AVERAGE HEATING FUEL BILL PER CUSTOMER
($000)

	Oil			Natural	
	#2	#4 & #5	#6	Gas	Average
Commercial - Small	16.0	36.6	56.3	18.3	23.6
Commercial - Large	40.7	95.7	-	73.2	66.5
Industrial - Small	16.3	43.1	16.5	24.2	24.6
Industrial - Large	79.0	110.3	37.5	72.3	77.9

Exhibit 2.2.3 -V

ANNUAL AVERAGE HEATING FUEL USE PER CUSTOMER

	No. 2			No. 4 or 5			No. 6			Natural Gas		
	(1,000 Gal)									(1,000 Therm)		
	High	Medium	Low	High	Medium	Low	High	Medium	Low	High	Medium	Low
Commercial - Small	195	36	1	500	87	13	200	145	110	303	54	2
Commercial - Large	400	128	42	300	211	132	-	-	-	1,597	262	4
Industrial - Small	150	35	4	200	65	20	70	40	10	284	75	3
Industrial - Large	258	186	11	500	248	40	203	105	7	558	227	43

Exhibit 2.2.3 - VI

AVERAGE PER UNIT FUEL COST

	OIL							
	No. 2		No. 4 or 5		No. 6		Natural Gas	
	(¢/Gal)						(C/Therm)	
Customer	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Commercial - Small	47.0	5.3	44.0	5.4	38.8	2.6	36.2	4.8
Commercial - Large	39.0	7.3	46.1	3.5	-	-	32.9	6.2
Industrial - Small	47.6	6.5	44.6	3.5	45.0	5.0	34.6	3.7
Industrial - Large	43.3	4.1	42.9	6.6	37.7	3.6	31.9	1.2

SD - Standard Deviation

STEAM CUSTOMERS AS PERCENT OF TOTAL CUSTOMERS SURVEYED*

Type of use	Total	Below 50 PSIG
Heating Load	46.3 %	17.5 %
Process Load	27.8 %	16.1 %

Note:

* Excluding Residential

TYPES OF COOLING EQUIPMENTS

Type	Number	%	Total Capacity (Tonnage)
Steam Absorption Units	47		17,754
Steam Driven Units	11		8,380
Electric Motor Driven Units	320		57,381

DOMESTIC WATER HEATING SYSTEMS

Type of System	Number	%
Central	138	36
Individual	164	43
N/A	82	21
Boiler Type		
Fuel-Fired	200	52
Steam	53	14
Electric	83	22
N/A	48	12

FUTURE EQUIPMENT INSTALLATION AND FLOOR SPACE EXPANSION PLANS

Short Term (6 Months to 1 Year)

Equipment Installation	No.	%
Yes	63	16
No	306	80
Not Definite	15	4

Long Term (5 to 10 Years)

Floor Space Change	No.	%
Increase	43	11
Decrease	5	1
Not Definite	336	88

Change in Equipment		
Yes	46	12
No	248	65
Not Definite	90	23

PAYBACK PERIOD OR RETURN ON INVESTMENT

Customer	Period (Yrs)
Small Commercial	4.6
Large Commercial	3.6
Small Industrial	3.4
Large Industrial	3.2
Residential	3.7
Total	3.7

ANNUAL AVERAGE LOAD PER SQUARE FOOTAGE*

(Btu/ft^2)

Customer	Mean	Std. Deviation
Commercial - Small	96,080	43,500
Commercial - Large	58,020	27,332
Industrial - Small	81,867	56,086
Industrial - Large	85,175	43,656

Note

* The conversion factors used are:

No. 2 Oil	- 137,000 Btu/gal.
Nos. 4 and 5 oil	- 143,200 Btu/gal.
No. 6 oil	- 145,500 Btu/gal.
Natural Gas	- 100,000 Btu/therm

2.3.1 Current and Forecasted Thermal Load

Introduction

The purpose of this section is to develop estimates of the existing and potential heating load for five-mile radii around four Public Service Electric and Gas (PSE&G) generating stations of interest in this study. The determination of square footage of existing and future commercial, industrial and high-rise residential structures serves as a prerequisite to the prediction of thermal loads.

Discussions with PSE&G personnel as well as with members of the Tri-State Regional Planning Commission have confirmed the fact that the service area in question represents a mature urban area and therefore exhibits only a very low growth potential. The notable exception is the Meadowlands area which consists of portions of fourteen New Jersey boroughs and townships. An extensive development master plan has been established by the Hackensack Meadowlands Development Commission (HMDC) and serves as the basis for the square footage projections for the area included in this study. Overall square footage projections for the relevant service territory are obtained by summing the estimates of natural growth and those from the Meadowlands less a provision to avoid double counting.

Square Footage Projections

A. Estimates from the Meadowlands

The map in Exhibit 2.3.1-I represents the areas within a five-mile radius of the North Bergen, Essex, Linden and Sewaren generating stations. (Note the Sewaren and Linden areas have been eliminated from consideration). The map in Exhibit 2.3.1-II presents a more detailed view of the thirty-two square mile Meadowlands district comprised of portions of fourteen municipalities. The map indicates that the entire Meadowlands area falls within a five-mile radius of either the North Bergen or Essex area generating stations.[1]

The HMDC master plan has been developed on a square footage basis for nine zonal types. The Commission has designated certain areas as: research parks, research distribution parks, light industrial and distribution (types A and B), heavy industry, highway commercial, service highway commercial, waterfront recreation and low density residential. The precise definitions of these zones is found in Appendix A. In addition, the HMDC has established Specifically Planned Areas (SPAs). The general purpose of these SPAs is stated in the Commission's zoning rules outlined in July of 1978.

> "The strategic location of large parcels of largely - undeveloped land in the heart of an intensely - developed metropolitan area gives the public the opportunity to require that development be undertaken on a large scale in order that available land be used in the most efficient manner possible and in accordance with the most comprehensive and far sighted planning techniques which will be of substantial benefit to both developers and landowners and to the public."[2]

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[1]For simplification the Essex area is assumed to consist of the region within five-mile radii of the Essex, Hudson and Kearny generating stations.

[2]Hackensack Meadowlands Development Commission Zoning Rules, Division of Administrative Procedure, Department of State (July 24, 1978), p. 111.

An SPA may be termed Island Residential or Parkside Residential the precise definitions of which are found in Appendix 2.3.1. Berry's Creek Center is also considered a SPA and according to the Commission:

> "... is intended to be the focal point of the Meadowlands District. It shall be a business, shopping, civic, cultural and transportation center, built along parks and plazas, pedestrian ways and the restored Berry's Creek Center and containing at its peripheries park-like open spaces and marshland preserves."[1]

The Specifically Planned Areas represent the only locations in the approximately 19,750 acres which comprise the Meadowlands where high-rise residential units are planned.

The fully developed master plan calls for the construction of residential*, commercial, and industrial structures totaling approximately 138 million square feet sometime between 1995 and 2000. A precise time-table for development is extremely difficult to establish, a land use specialist at the Commission noted, but a tentative plan was proposed in the Commission's recent transportation study. According to that study the following schedule outlining the various stages of development was prepared. Percentages for the 1975, 1985 and the year of full development (set at 2000 by SWMCI) were taken from the study for the Commercial, Office and Industrial groupings. Figures for the residential sector were derived by comparing a Commission's building permit report covering the 1970-1978 period with full-development estimates and furnished estimates for 1975 and 1980. Estimates for the remaining years were obtained by interpolation.

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[1]Ibid., p. 128.

*Only residential units in high-rise structures are included in the figure. An additional 34.4 million square feet are attributed to low density housing units.

Table 1
Development Plan for the Meadowlands
Percent of Full Development by Five-Year Intervals

%

Development Type	1975	1980	1985	1990	1995	2000
Residential	1.4	6.7	25.0	50.0	75.0	100.0
Commercial	14.4	23.6	32.8	55.2	77.6	100.0
Office	5.2	12.6	20.1	46.2	73.4	100.0
Industrial	41.0	44.9	48.8	60.0	80.0	100.0

Exhibit 2.3.1-III presents the master development plan for the Meadowlands based on the percentages assumed in Table 1. The data provided by the HMDC listed the various development types which were planned for each of the fourteen municipalities. As a consequence, a breakdown of potential square footage for the North Bergen and Essex generating stations was possible and is included in the table below.

B. Estimates of the Region's Natural Growth

As emphasized earlier, the major portion of the growth in the relevant region is expected to eminate from the Meadowlands. Some growth, however, is expected to take place in the relevant region lying outside of the Meadowlands. In order to produce estimates of the expected growth in square footage several data sources were examined as discussed in the following paragraphs.

Primary among the additional data sources was the 1970 Land Use Estimate summary compiled by the Tri-State Regional Planning Commission. Using 1970 census tract data the Commission compiled estimates of: (a) the number of housing units, (b) the square footage of non-residential structures, and (c) the square footage of "other" units for each square mile of land within the tri-state planning area. Exhibit 2.3.1-I shows the one-square mile tracts, while the circles (as noted earlier) enclose the area within a five-mile radius of the given generating station.

Table 2 summarizes these estimates for square mile blocks falling within 5-mile radii of the North Bergen, Essex, Linden, and Sewaren generating stations.

Table 2
Tri-State Regional Planning Commission
1970 Housing Units and Square Footage Estimates Within Five-Mile Radii of Given Generating Station

		Floor Area (00 sq. ft.)			
Generation Station (1)	Housing Units (2)	Non-Residential (3)	Residential (4)	Other (5)	Total (6)
North Bergen	195,898	1,838,640	2,077,707	23,309	3,939,726
Essex	326,617	3,849,661	3,468,107	149,970	7,467,738
Linden	166,568	1,922,154	1,759,807	37,514	3,719,475
Sewaren	83,803	1,001,039	880,531	15,634	1,897,204
Total*	772,886	8,611,494	8,181,952	226,427	17,024,143
Total#	649,927	6,815,001	6,753,044	192,095	13,730,733

* Includes area of double counting.
\# Avoids double counting.

1. Non-Residential and "Other"

PSE&G has furnished Stone & Webster with floor area estimates for office buildings, commercial establishments and other miscellaneous structures within its entire service area. These estimates are available for 1970 and 1975 and appear in Exhibit 2.3.1-IV. From that exhibit it is determined that the combined annual growth rate was 1.89% in the floor areas of office buildings, commercial establishments and warehouses and was .43% in square footage for the "other"[1] category. Given that the 1970-1975 period included the worst recession since 1929, the growth figures are quite conservative, but appear to reflect adequately the expected growth in the mature urban territory served by PSE&G. In an effort to avoid double counting of the area already considered in the Meadowlands the rates were reduced by 30%. Growth rates of 1.323% and .301% were therefore applied to the totals in Table 2 in order to generate floor area estimates out to the year 2000. The results are summarized in Table 3 below.

Table 3
Floor Area Projections For Non-Residential and "Other" Structures (000,000 sq. ft.)

Development Type	Year 1975	1980	1985	1990	1995	2000
Non-Residential*	727.8	777.2	830.0	886.4	946.6	1010.9
"Other" #	19.5	19.8	20.1	20.4	20.7	21.0
Total	747.3	797.0	850.1	906.8	967.3	1031.9

* Assumes growth rate of 1.323% annually.

\# Assumes growth rate of 0.301% annually.

2. High Rise Residential

No information was supplied regarding the existing square footage in high-rise apartments and so this figure had to be derived using a less direct approach. The 1970 Census of Housing provides estimates of the number of dwelling units in buildings housing fifty or more units for all places containing a population of 2,500 or more.[2]

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[1]Note: "Other" includes schools, colleges and universities, hospitals, and other public institutions.

[2]United States Department of Commerce, Bureau of the Census, 1970 Census of Housing, vol. 1. part 32 (August 1972).

Places falling within a five-mile radius of the four stations were considered, and were found to include about 47,700 housing units. This figure, however, includes high-rise structures within the boundaries of a given city, not simply that portion of the city falling within the five-mile limit and so provides an exaggerated estimate. Comparing the number of housing units in Exhibit 2.3.1-III reveals that only about 6% of the total housing units in the relevant area are located in high-rise structures.

A check on the above estimate was made possible through a recent effort by the staff at PSE&G. The number of units as of 1978 in high-rise structures was determined to be approximately 37,500 and so the 1970 base estimate appears reasonable. A simple division of column (4) by column (2) in Table 2 reveals furthermore, that a typical housing unit contains approximately 1,040 square feet of floor space, and this fact is utilized below.

A final statistic required to generate a housing units projection is the anticipated growth rate in housing units out to 2000. This problem was tracked from two perspectives, and therefore provided an internal accuracy check. The first involved an examination of trends in building permits from the 1970 to 1978 period, while the second focused on the natural growth in population, and the number of new housing units necessary to accommodate that growth.

A. Building Permit Approach

A summary of privately owned housing units authorized by building permits was compiled for the 1970 to 1976 period for places within a five-mile radius of the relevant generating stations. Records show that 31,666 new housing units were authorized over the period, and this represents an average annual growth rate over the 1970 base of about 0.85%. This relatively modest growth rate is consistent with earlier discussions relating to the nature of the service area in question.

If the growth trend were to persist approximately 176,278 new housing units could be expected by 2000. Earlier it was established that about 6% of the units were housed in high-rise structures so about 10,577 new units with approximately 11,000,000 square feet of floor area are anticipated by the end of the century.

B. Cohort Component Population Model

The Cohort Component Population Model is employed as an alternate method for predicting the number of new housing units.

Public Service has provided SMWCI with population estimates by county, as derived from its in-house population projection models. The estimates are presented in Table A of Exhibit 2.3.1-V and illustrate a declining population trend out to the year 2000. The table reveals that the five-county area is expected to experience a decline in population by about 0.45% annually when compared with the 1975 base. The population decline is attributed primarily to the net out-migration of people from the area, with the decline in fertility rates serving as a force moderating general population growth.

The <u>1970 Census of Population</u> for New Jersey was referenced and provided estimates of the population of those cities falling within the relevant five-mile radii. The percentage of total county population living with the relevant PSE&G service territory was calculated and was applied to the first portion of Exhibit 2.3.1-V. The results presented in the second portion of the exhibit reveal an average compound annual decline in population of approximately 0.56% for the area under consideration.

The decline in population is consistent with the trend noted in recent government publications.[1]

Finally, the expected number of households in the relevant service area can be calculated if some estimate of persons per household is available. Demographers have noted a declining trend in persons per household for the last several years. The trend is most often attributed to the increasing numbers of divorces, the postponement of marriages, and the accelerating rate of young people leaving their families and forming their own households. The Wharton Econometric Forecasting Associates predict that the trend will continue at least out to 2000 and provide the following estimates in one of their recent forecasts.

Table 4
People Per Household Estimates

Year	People Per Household
1970	3.23
1975	3.00
1980	2.84
1985	2.75
1990	2.70
1995	2.64
2000	2.58

When the figures in Table 4 are applied to part B in Exhibit 2.3.1-V, the projected number of housing units falling within the relevant five-mile radii are determined. These are presented in Exhibit 2.3.1-VI. The exhibit reveals that the total number of housing units increases from 560,118 in 1975 to 566,047 by 2000 or by about .04% annually. Therefore, the apparently

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[1]See for example, "Estimates of Population of Counties and Metropolitan Areas," July 1, 1975 and 1976. Also, Series P-25, No. 739 (November 1978), No. 769 (January 1979), and No. 709 (September 1977).

paradoxical phenomenon of a decreasing population (as shown in Exhibit 2.3.1-V accompanied by an increase in households (Exhibit 2.3.1-VI) is explained.

The results translate into 5,929 new housing units by 2000. Even if 50% of these units are assumed to be located in high rises, the annual compound growth rate would amount to only 0.3%. In other words, the growth in relevant residential units resulting solely from natural forces is expected to be virtually zero!

This result is in apparent conflict with those derived using the building permit approach above. Further investigation reveals, however, that the majority of those permits were issued in the Meadowlands district and therefore tend to over-estimate the growth in high-rise residential units for the entire relevant area. The results of zero growth outside of the Meadowlands appear most feasible and will be employed in the analysis below.

C. Floor Area Estimate - Meadowlands and Natural Growth

Section A provided square footage estimates for the developing Meadowlands area and section B estimated the floor space anticipated as a result of natural growth forces in relevant area apart from the Meadowlands. Table 5 on the following page combines the previously derived statistics and provides estimates of the potential floor area for the five-mile radii around the four relevant generating stations.

Table 5
Total Projected Floor Space Within
Five-Mile Radii of Relevant Generating Stations
(000 sq. ft.)

Development Type	Year 1975	1980	1985	1990	1995	2000
Residential*						
Natural Forces	36,888.4	36,888.4	36,888.4	36,888.4	36,888.4	36,888.4
Meadowlands	251.0	1,201.5	4,483.2	8,966.4	13,449.6	17,932.8
Total	37,139.4	38,089.9	41,371.6	45,854.8	50,338.0	54,821.2
Non-Residential						
Natural Forces	727,790.1	777,224.2	830,016.1	886,393.8	946,660.9	1,010,897.5
Other	19,550.3	19,795.6	20,095.3	20,399.6	20,708.5	21,022.0
Commercial #	3,619.6	5,976.3	8,306.1	13,978.5	19,651.0	25,323.5
Office #	995.8	2,412.9	3,849.1	8,942.9	14,055.9	19,149.7
Light Indust. #	29,341.2	32,132.2	34,923.2	42,938.3	57,251.1	71,563.9
Heavy Indust. #	1,838.6	2,013.5	2,188.4	2.690.7	3,587.6	4,484.5
Total	786,705.2	839,554.7	899,378.2	975,343.8	1,061,855.0	1,152,441.1
Overall Total	823,844.6	877,644.6	940,749.8	1,021,198.6	1,112,193.0	1,207,262.3

*Units in high-rise structures only.
#Contribution from Meadowlands.

By the year 2000, the area within the relevant five-mile sector is expected to contain over 1.2 billion square feet of floor area. This represents an annual growth rate of about 1.65%. The Meadowlands district accounts for the only growth in high-rise residential units. The area outside of the Meadowlands is expected to provide substantial growth of the non-residential type. A significant contribution to floor space is also expecting to flow from the Meadowlands and from all development types: residential, commercial, office and industrial.

Potential Heating Load Projections

The potential heating load projection can be made based on the floor space projection given in Table 5 in conjunction with the annual average load per square feet - shown in Exhibit 2.2.3-XI for each customer class. Notice that, however, the floor space projection for the non-residential excluding Meadowlands is given as natural forces and others. In order to forecast the load for each customer class, some "breakdown" factors are to be devised. This was accomplished by taking the numbers of customers surveyed and properly ratioing them. Of the total non-residential customers, 60% are industrial and 40% are commercial, which are then each further subdivided into 12% large and 88% small customers.

Using the "breakdown" factors, the floor space and the heating load for each customer class exclusive of Meadowlands, are projected out to the year 2000 at a five-year interval, as shown in Exhibit 2.3.1-VII and 2.3.1-VIII. In deriving the annual load, a 65% efficiency factor was used and the heating degree days of 5,317 in 1978 has been normalized to reflect the historical value of 5,034. A load factor of 27.7% was used in deriving the peak load which is representative of a space heating utilization rate. An annual load growth of 1.3% is observed over the 25-year period.

Exhibit 2.3.1-IX illustrates the projections of floor space, annual heating load and peak load for the future Meadowlands development. A 6.4% annual load growth rate is observed in the Meadowlands area over the period from 1985 through 2000.

Under the assumption that much of the energy used for space heating purposes typical daily monthly and yearly use patterns can be constructed. By using data from existing district heating systems which serve some process loads, small amounts of air conditioning loads, domestic hot water loads as well as heating loads curves which should be typical to a system in the area under study are derived. Exhibit 2.3.1-X and 2.31.-XI present the annual load duration curve and the typical hourly loads for the highest and lowest day.

Exhibit 2.3.1-XII presents the annual and monthly peak hourly demand as a percent of the highest peak. Also shown in this exhibit is the monthly and annual load factors and the monthly energy as a percent of the annual energy.

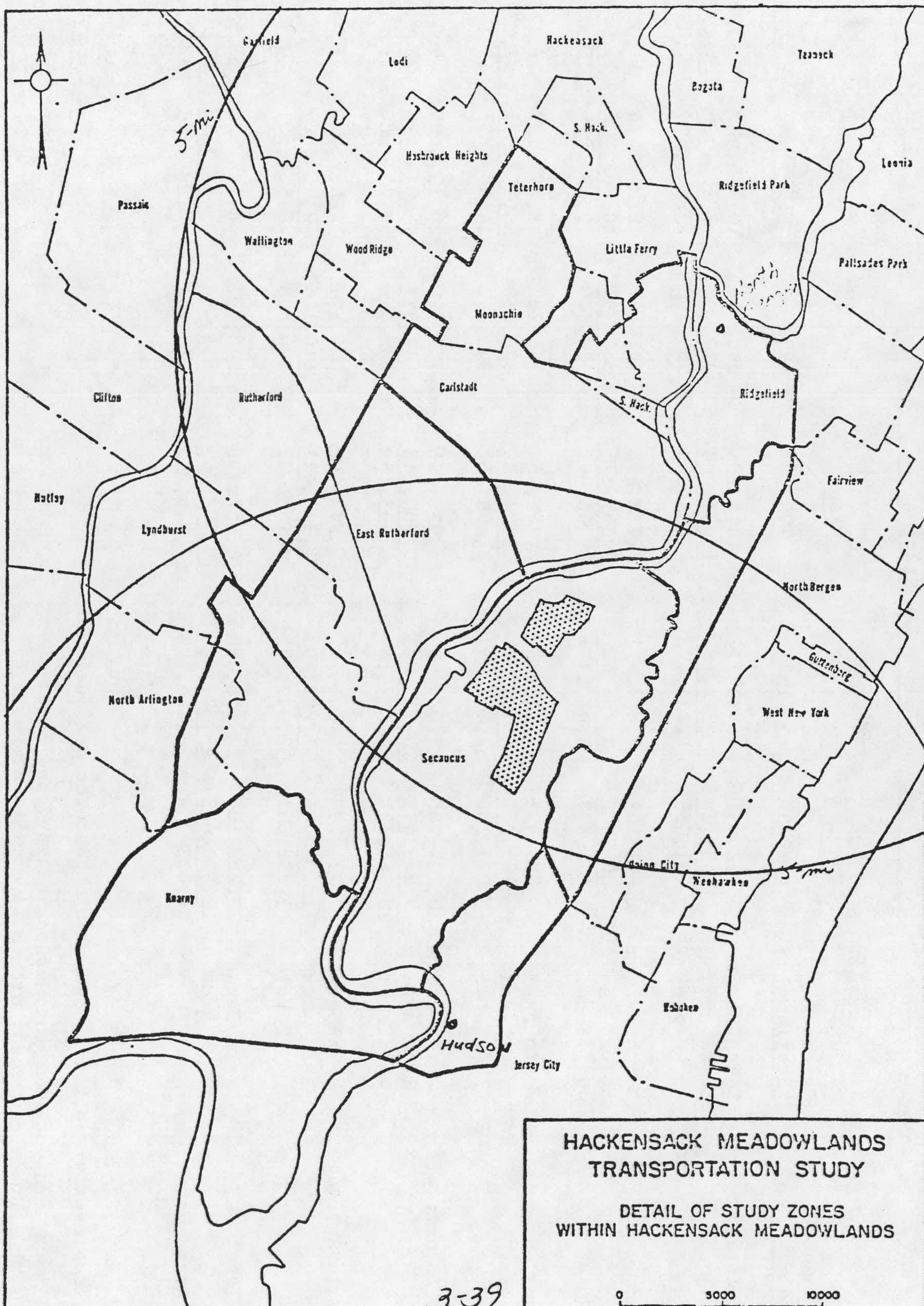
The results of this analysis were discussed with a Swedish consultant in order to gain the experience of the Swedish findings. It was found that these curves were typical of those experienced in Sweden.

Finally the projected monthly peak energy requirements were plotted against PSE&G's gas send out as shown in Exhibit 2.3.1-XIII. This graph suggests that the expected district heating loads are in line with gas energy consumption and should have similar characteristics.

Based on a maximum generating capacity of 3.6×10^9 Btu/Hr. (asssuming Hudson, Bergen and Essex plants are retrofitted as in scheme 3). the maximum annual energy generated would be $9{,}000 \times 10^9$ Btu, assuming a 27% load factor. From Exhibit 2.3.1-VIII the potential heating in the year 2000 load is $55{,}720 \times 10^9$ Btu per year (excluding the Meadowlands). Thus, the energy generated represents less than 20% of the potential market around the generating stations studied. Indicating that a market penetration of less than 20% is required to achieve the desired loads. In other words, the market potential is limited by the generating capacity.

Exhibit 2.3.1-1

Generating Stations and Areas within Five-Mile Radius


Garfield
Lodi
Hackensack
Teaneck
Bogota
S. Hack.
Hasbrouck Heights
Teterboro
Ridgefield Park
Leonia
Passaic
Wallington
Wood Ridge
Little Ferry
Palisades Park
Moonachie
Carlstadt
Clifton
Rutherford
S. Hack.
Ridgefield
Fairview
Nutley
Lyndhurst
East Rutherford
North Bergen
Guttenberg
North Arlington
West New York
Secaucus
Union City
Weehawken
Kearny
Hoboken
Hudson
Jersey City
5-mi
HACKENSACK MEADOWLANDS
TRANSPORTATION STUDY
DETAIL OF STUDY ZONES
WITHIN HACKENSACK MEADOWLANDS
0
5000
10000

Development Plan for the Meadowlands
Estimated Square Footage by Development Type
and by Generating Station

Development Type	Generating Station	1975	1980	1985	1990	1995	2000
Residential*	North Bergen	192,931	923,314	3,445,200	6,890,400	10,335,600	13,780,800
	Essex Area#	58,128	278,184	1,038,000	2,076,000	3,114,000	4,152,000
	Total	251,059	1,201,498	4,483,200	8,966,400	13,449,600	17,932,800
Commercial	North Bergen	1,641,169	2,689,693	3,738,218	6,291,147	8,844,076	11,397,005
	Essex Area	2,005,408	3,286,641	4,567,875	7,687,399	10,806,923	13,926,447
	Total	3,646,577	5,976,334	8,306,093	13,978,546	19,650,999	25,323,452
Office	North Bergen	586,395	1,420,881	2,266,664	5,266,282	8,277,197	11,276,835
	Essex Area	409,387	991,976	1,582,438	3,676,610	5,778,654	7,872,826
	Total	995,782	2,412,857	3,849,102	8,942,892	14,055,851	19,149,661
Light Industrial	North Bergen	20,107,766	22,020,456	23,933,146	29,425,999	39,234,665	49,043,331
	Essex Area	9,233,413	10,111,713	10,990,013	13,512,311	18,016,415	22,520,519
	Total	29,341,179	32,132,169	34,923,159	42,938,310	57,251,080	71,563,850
Heavy Industrial	North Bergen	734,295	804,142	873,990	1,074,577	1,432,770	1,790,963
	Essex Area	1,104,346	1,209,393	1,314,441	1,616,116	2,154,821	2,693,526
	Total	1,838,641	2,013,535	2,188,431	2,690,693	3,587,591	4,484,489
Total	North Bergen	23,262,566	27,858,486	34,257,198	48,948,405	68,124,308	87,288,934
	Essex Area	12,810,682	15,877,907	19,492,767	28,568,436	39,870,813	51,165,318
Grand Total		36,073,248	43,746,393	53,749,965	77,516,841	107,995,121	138,454,252

*Only residential units in high-rise structures are included.

#The Essex Area includes the Hudson, Kearny, and Essex generating stations and the sum of all loads within five miles of each.

Exhibit 2.3.1-III

Public Service Electric & Gas
DOE/District Heating

Total Floor Area Non-Residential Structures

	Structure Type	Floor Area (000,000 sq. ft.) 1970	1975	Annual % Change
A.	Office Buildings (private)	66.0	80.0	3.92
	(public)	21.7	27.0	4.47
B.	Commercial (stores)	228.0	224.0	1.37
	(other)	47.0	50.0	1.25
C.	Warehouse	99.0	106.0	1.38
D.	School	95.0	92.0	1.38
E.	College/Universities	12.6	12.9	.47
F.	Hospital	18.0	19.0	1.09
G.	Other Public Institutions	71.0	77.0	8.45
	Total	658.3	707.9	1.46

Exhibit 2.3.1-V

Public Service Electric & Gas
DOE/District Heating

Table A
PSE&G's Population Projections By County

County	1970	1975	1980	1985	1990	1995	2000
				Year			
Bergen	898,012	879,100	851,500	839,600	835,900	827,700	816,700
Essex	929,986	881,600	825,000	778,550	741,050	714,650	688,000
Hudson	609,266	577,600	546,650	524,750	510,450	492,200	478,650
Middlesex	683,813	594,000	592,600	602,200	622,650	644,400	659,500
Union	543,116	520,500	496,450	481,050	469,100	455,350	441,650
Total	3,564,193	3,452,800	3,312,220	3,226,150	3,179,150	3,136,300	3,084,500

Table B
Population Projections by County for Areas
Within A Five-Mile Radius of Generating Stations

County	1970	1975	1980	1985	1990	1995	2000
Bergen	375,818	367,903	356,353	351,373	349,842	346,392	341,789
Essex	382,410	363,514	339,240	320,140	304,720	293,864	282,906
Hudson	609,266	577,600	546,650	524,750	510,450	494,200	478,650
Middlesex	154,419	157,113	156,743	159,282	164,691	170,444	174,438
Union	224,578	215,227	205,282	198,914	193,973	188,287	182,622
Total	1,746,491	1,680,357	1,604,268	1,554,459	1,523,676	1,493,187	1,460,405

Public Service Electric & Gas
DOE/District Heating

Projected Housing Units by County for All Cities
Falling Within a Five-Mile Radius of
Relevant Generating Stations

	Year						
County	1970	1975	1980	1985	1990	1995	2000
Bergen	118,555	122,634	125,476	127,772	128,294	131,209	132,476
Essex	128,326	120,838	119,451	116,414	112,859	111,312	109,653
Hudson	214,530	192,533	192,484	190,818	187,056	187,197	185,523
Middlesex	45,417	52,371	55,191	57,921	60,997	64,562	67,611
Union	72,212	71,742	72,282	72,332	71,842	71,321	70,784
Total	579,040	560,118	564,882	565,257	563,048	565,601	566,047

FLOOR SPACE PROJECTIONS
EXCLUDING MEADOWLANDS

Customer	1975	1980	1985	1990	1995	2000
	($000 \times ft^2$)					
Commercial - Small	263,064	280,551	299,239	319,191	340,514	363,236
Commercial - Large	35,872	38,257	40,805	43,526	46,434	49,532
Industrial - Small	394,596	420,827	448,859	478,787	510,771	544,854
Industrial - Large	53,809	57,385	61,208	65,289	66,051	74,398
Residential	36,888	36,888	36,888	36,888	36,888	36,888
Total	784,229	833,908	886,999	943,681	1,004,258	1,068,808

ANNUAL HEATING LOAD PROJECTIONS(1)

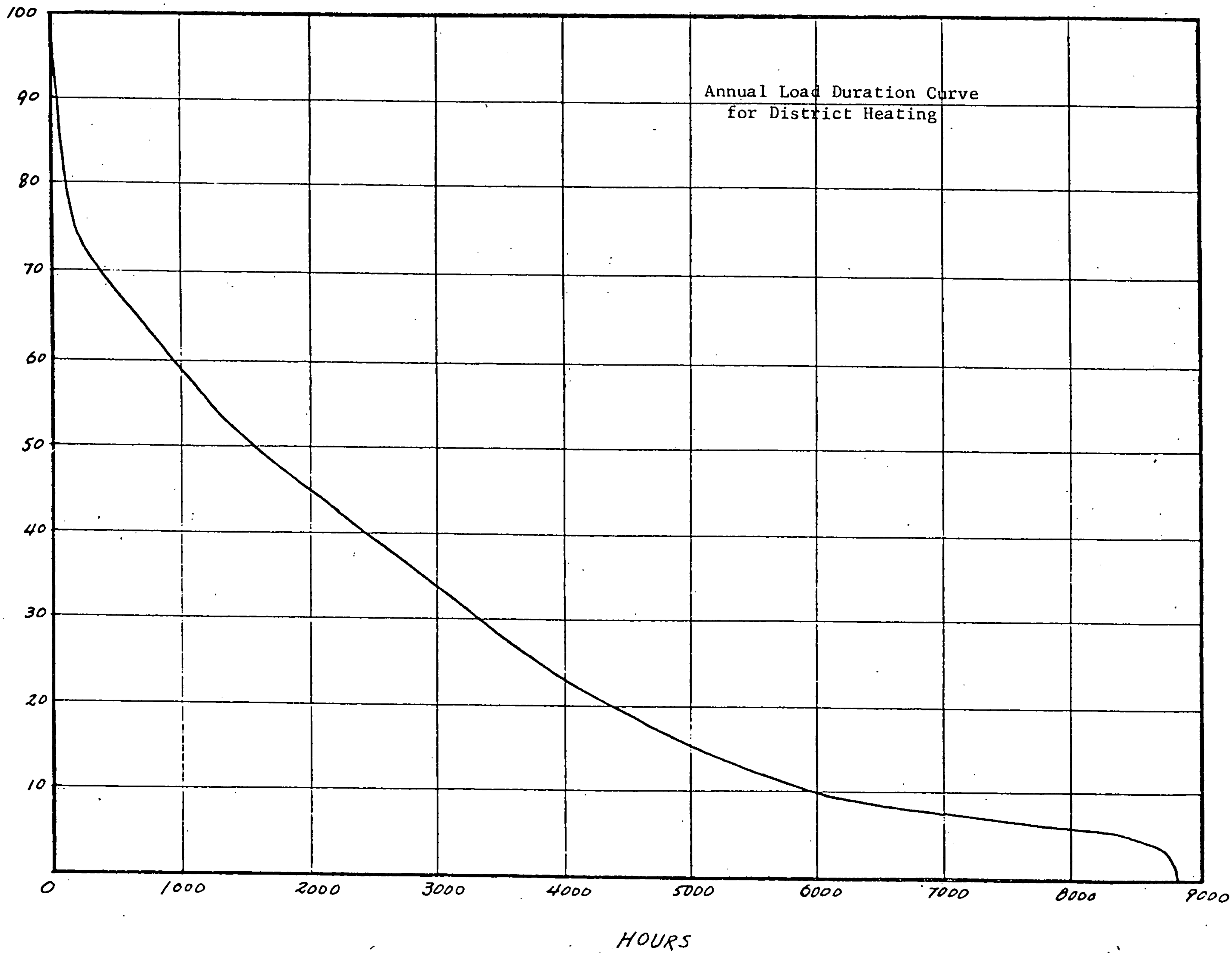
EXCLUDING MEADOWLANDS

Customer	1975	1980	1985	1990	1995	2000
	(10^{12} x Btu)					
Commercial - Small	15.56	16.59	17.70	18.67	20.14	21.47
Commercial - Large	1.28	1.36	1.46	1.55	1.66	1.77
Industrial - Small	19.87	21.19	22.62	24.12	25.73	27.45
Industrial - Large	2.82	3.01	3.21	3.42	3.65	3.89
Residential(2)	1.14	1.14	1.14	1.14	1.14	1.14
Total	40.67	43.29	46.13	48.90	52.32	55.72
Peak Load (10^9 x Btu/hr)(3)	16.76	17.84	19.01	20.15	21.56	22.96

Notes:
(1) Weather normalized and based on 65% efficiency factor.
(2) 50,000 Btu/ft^2 is used.
(3) Using 27.7% Load Factor.

MEADOWLANDS FLOOR SPACE
ANNUAL HEATING LOAD AND PEAK LOAD PROJECTIONS

	1985	1990	1995	2000
Floor Space (1,000 ft^2)				
Residential	4,483	8,966	13,450	17,933
Commercial and Office	12,155	22,921	33,707	44,473
Industrial - Small	34,923	42,938	57,251	71,564
Industrial - Large	2,188	2,691	3,588	4,485
Total	53,749	77,516	107,996	138,455
Annual Heating Load (10^{12} x Btu)				
Residential	0.14	0.28	0.41	0.55
Commercial and Office	0.69	1.29	1.90	2.51
Industrial Small	1.76	2.16	2.88	3.61
Industrial Large	0.12	0.14	0.19	0.24
Total	2.71	3.87	5.38	6.91
Peak (10^6 x Btu/hr)	1,112	1,595	2,220	2,842



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Exhib. ...5.1-X

HOURLY SENDOUT FOR HIGHEST AND LOWEST DAYS AS A PERCENT OF HIGHEST PEAK

Hour	Highest Day % of Peak	Lowest Day % of Peak
1	69	4.6
2	70	4.1
3	74	3.7
4	75	3.7
5	76	3.7
6	86	3.7
7	100	3.7
8	88	3.7
9	86	4.1
10	84	4.1
11	81	4.6
12	80	4.6
13	82	4.6
14	77	4.6
15	76	4.6
16	76	4.6
17	74	4.6
18	74	4.6
19	72	4.6
20	71	4.6
21	69	4.6
22	70	4.6
23	71	4.6
24	70	4.6

ANNUAL AND MONTHLY PEAKS, ENERGY AND LOAD FACTOR
FOR THE PROJECTED DISTRICT HEATING SYSTEM

Month	Peaks as a Percent of Annual Peak	Energy as a Percent of Annual Energy	Load Factor
	%	%	%
Jan	100	20.86	66.2
Feb	88	14.45	57.8
Mar	67	11.27	53.4
Apr	58	7.68	43.6
May	40	3.68	28.9
Jun	15	2.40	52.2
Jul	15	1.93	41.7
Aug	13	2.40	59.2
Sep	15	2.65	59.1
Oct	39	6.35	51.3
Nov	75	10.21	44.7
Dec	87	16.12	59.0
Annual	100	100	27

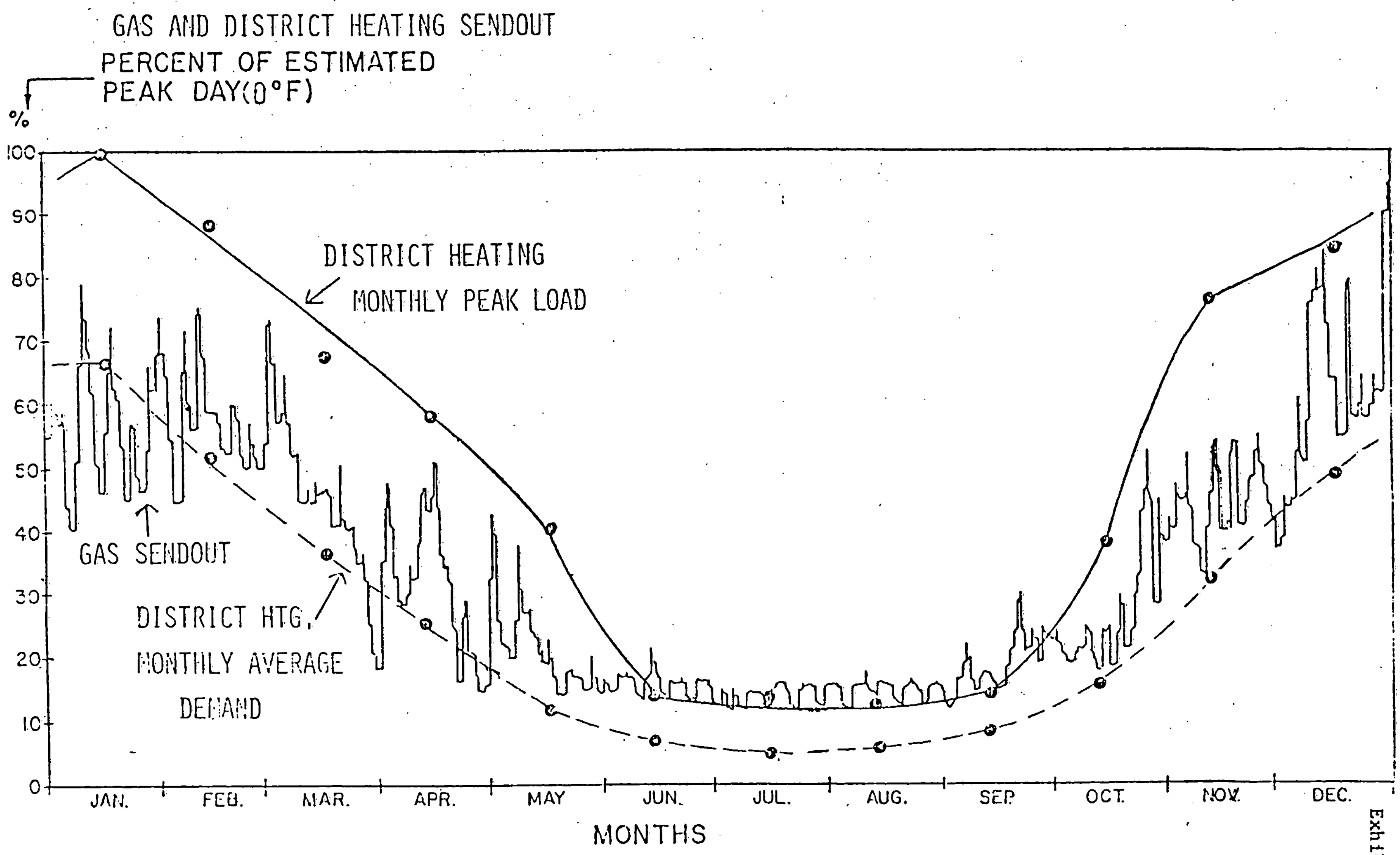


Exhibit 2.3.1-XIII

2.3.3 Analysis of Factors Influencing Fuel and Energy Source Selection

In order to identify the factors which will induce end users to switch from traditional energy supply sources to a centrally generated thermal energy system the fuel and energy source selection decision making process must be reviewed. An initial factor which must be recognized is that as with any other decision made in a free enterprise market the ultimate purchasers biases as well as social pressure can have major influences on selection decisions, as irrational as they may appear to the analyst. In this district heating project it is assumed that the decisions on fuel and energy source selection will be made on a rational economic basis. This is an acceptable premise as individual residential customers have not been included in the potential market. The business and engineering judgement which would be applied by the owners and managers of businesses as large apartment buildings would be expected to be generally more rational.

The fuel and energy source selection process can be divided into two distinct segments. The first involves preliminary screening and the second comparison and ultimate selection. This is illustrated in Exhibit 2.3.3-I.

In the preliminary screening process determination as to the acceptability of each fuel or energy source in terms of compatability with the intended end use, environmental requirements and security of supply are made. Once the universe of acceptable alternatives have been isolated a comparison of various utilization characteristics is made, in terms of dollars from which the least cost alternative is selected. This process applies to the analysis of purchasing thermal service from a central district heating system.

The end uses for which the thermal service from the proposed retrofitted plants would apply include

1. Space heating
2. Domestic hot water heating
3. Low temperature process water heating needs

In the majority of space heating and domestic water heating applications low pressure steam (less than 15 psig) or low temperature hot water (less than 200°F) is required which is compatable with the operating conditions of the hot water distribution systems being considered by PSE&G. The use of purchased thermal service should be considered at least as secure a source of energy as natural gas and somewhat more secure than fuel oil. This conclusion is based on the modes of delivery, pipeline for natural gas and hot water versus trucks or barges for fuel oil.

The table below shows by customer classification and type of fuel the distribution of fuel and energy utilization for space heating on a net basis as determined by the field survey described in section 2.2.3. This data will serve as the basis of the competitive fuel analysis which follows.

Net Thermal Energy Consumption by Fuel Type and Consuming Customer Classification

Customer Classification	Natural Gas	Fuel Oil No. 2	Fuel Oil No. 4 & 5	Fuel Oil No. 6	Total
Large Industrial	5	7	6	2	20
Small Industrial	11	6	5	1	23
Large Commercial	16	6	5	-	27
Small Commercial	8	7	11	4	30
	40	26	27	7	100

The table on the preceding page was derived by taking the reported annual consumption of the surveyed establishments and converting them to net Btu's using the following representative fuel heat contents and seasonal utilization efficiencies.

	Fuel Heat Content	Seasonal Utilization Efficiency
Natural Gas	100,000 Btu's/therm	65%
No. 2 Fuel Oil	137,000 Btu's/gallon	65%
No. 4 & 5 Fuel Oil	143,200 Btu's/gallon	62%
No. 6 Fuel Oil	145,500 Btu's/gallon	60%

During the field survey the current costs of each fuel, in each customer group, was also determined. Exhibit 2.3.3-II contains the current and escalated fuel prices as delivered. The escalated costs were constructed using the prescribed low (3%) and high (10%) differential escalation rates. These are intended to be rates in excess of general inflation. Exhibit 2.3.3-III contains the same data converted to cost per net million Btu's. The same fuel heat contents and seasonal utilization efficiencies shown earlier were used as the basis of this conversion. This is the cost of usable thermal energy with which the proposed district heating system must compete.

Shown on Exhibits 2.3.3-IV, V, VI, and VII are graphic representations of the data tabulated in Exhibit 2.3.3-III for each customer classification. The cost per net million Btu's of thermal energy is an important factor in estimating the market penetration achievable by the proposed district heating system. As can be seen however, from the current fuel market price structure this cost is not the only basis of fuel selection. Various operating and logistics considerations are also important. These include storage facilities for fuel oil, preheating requirements for the heavier grade fuel oils, the cost of burners, controls and stacks and environmental considerations. The characteristics of a purchased thermal service for space are most comparable to those of natural gas. Both are delivered by pipeline, require no storage facilities or investment in fuel inventory. Purchased thermal service has the additional advantages of no emission to the environment, no need for stacks and for new installations a lower first cost investment. On this basis the value of thermal service from a central district heating plant would exceed the value, in terms of dollars per net million Btu's, of natural gas for space heating applications. In an attempt to quantify this incremental value of thermal service to new establishments an estimate was made of the annualized value, in dollars per million Btu's to the average customer in each market sector being studied. This calculation is shown as Exhibit 2.3.3-VIII. In this Exhibit the first column contains the use of the average natural gas customer in each sector in therms. On the assumption of a 27% annual load factor and installed boiler capacity of 150% of the calculated peak. Column 2 shows the peak hourly installed capacity in therms and column 3 in MBtu's. At an average cost of $6.50 per MBtu the investment required for each boiler plant is then shown in column 4. Column 5 contains the payback period data collected in the field survey and shown on Exhibit 2.2.3-X plus one year. This approach has been taken so that when a potential user compares his cost of fuel using natural gas versus purchasing thermal service from the proposed central plants his calculation of the annual savings realizable if he elected to use natural gas over district heating would not meet his payback criteria for the investment in boilers he would need to make. As the cost of thermal service exceeds that of natural gas by more than the amount being calculated here, the greater the likelihood that the potential user would not opt for thermal service. Column 6 is then the investment in Column 4 divided by the payback periods in column 5, and column 7 is the annual savings in column 6 divided by the average use in column 1. Column 8 takes the ¢/therm of column 6 and adjusts this cost to $/MMBTU of net energy using conversion factors of a 65% seasonal efficiency and 10 therms per MMBTU.

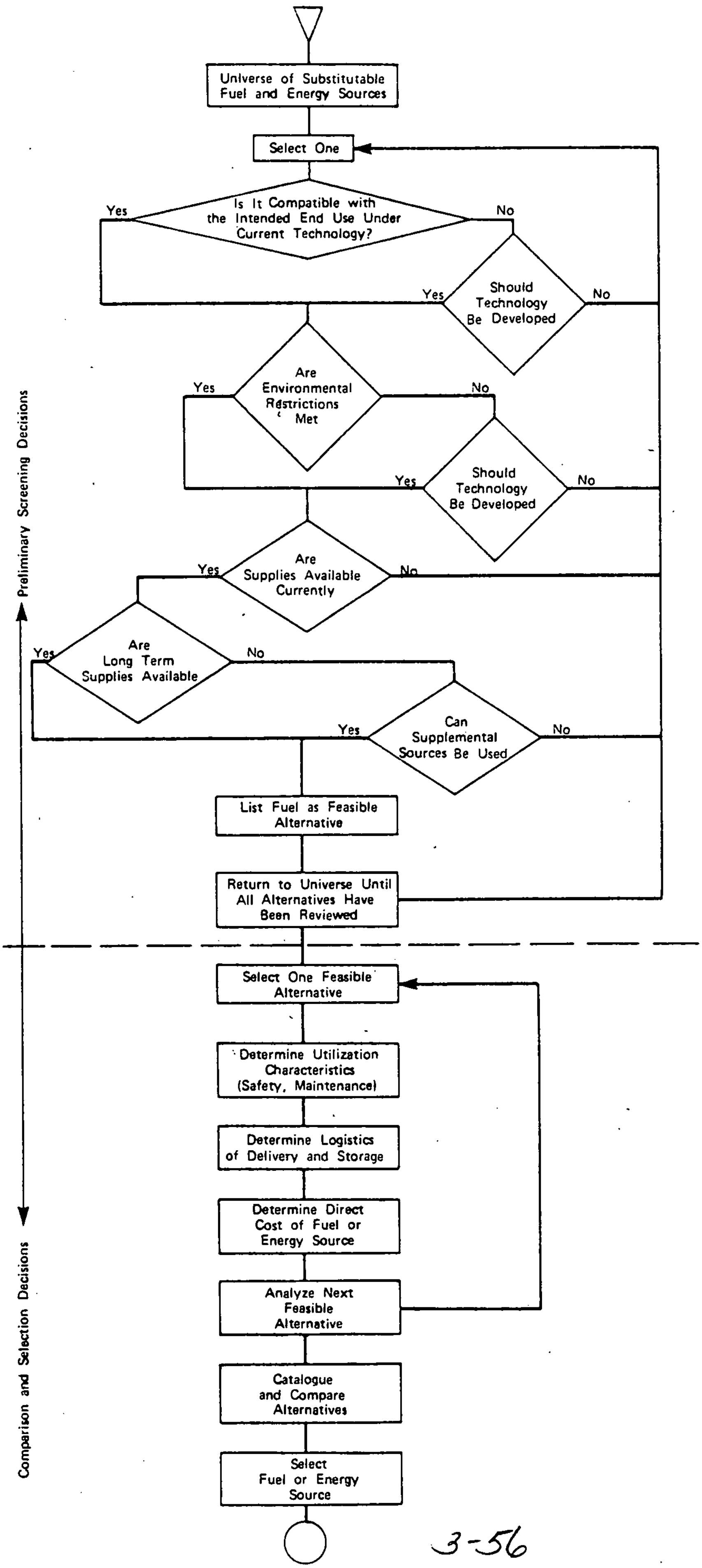
The impact of these incremental costs above natural gas have been included in Exhibits 2.3.3-IV, V, VI, and VII and are labeled as breakeven lines. These graphs will be used in section 2.6 as a basis to determine the economic viability of the proposed projects.

From the standpoint of fuel usage the entire area surrounding the four power plants being considered in this study is homogeneous. The Meadowlands as described in a previous section and the remainder of the area exhibit significant differences in projected development. Essentially, the Meadowlands has, if developed as currently conceived, the potential to increase in residential, commercial and light industrial establishments. The remaining area has a large established market but minimal prospects for growth. This situation leads to the general conclusion that the sale of thermal service in the Meadowlands will be in a more favorable competitive situation. The new structures expected in the Meadowlands will be saved the investment required for natural gas or fuel oil burning and delivery systems if they elect to take the thermal service.

In existing structures which already have operating fuel systems such as is found in the remaining areas the economics of purchased thermal service would be measured against only existing operating costs. In these existing establishments purchased thermal service would be in the best competitive position in those cases where equipment age or condition requires major maintenance expenses or even replacement.

FUEL AND ENERGY SOURCE SELECTION DECISION TREE

Exhibit 2.3.3–1



PUBLIC SERVICE ELECTRIC & GAS
DEPARTMENT OF ENERGY DISTRICT HEATING STUDY
CURRENT AND ESCALATED FUEL COSTS BY CUSTOMER CLASSIFICATION

(¢/delivered unit)

Customer Classification	Units	Current Fuel Costs (1)	Future Fuel Costs: Low (3% Per Year Escalation)					Future Fuel Costs: High (10% Per Year Escalation)				
			1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
Large Industrial												
Natural Gas	¢/therm	31.9	32.9	38.1	44.2	51.3	59.4	35.1	56.5	91.0	146.6	236.1
No. 2 Fuel Oil	¢/gallon	43.3	44.6	51.7	59.9	69.5	80.6	47.6	76.7	123.5	198.8	320.2
No. 4 and 5 Fuel Oil	¢/gallon	42.9	44.2	51.2	59.4	68.9	79.8	47.2	76.0	122.4	197.2	317.5
No. 6 Fuel Oil	¢/gallon	37.7	38.8	45.0	52.1	60.4	70.1	41.5	66.8	107.6	173.4	279.2
Small Industrial												
Natural Gas	¢/therm	34.6	35.6	41.3	47.8	55.5	64.3	38.1	61.4	98.9	159.2	256.3
No. 2 Fuel Oil	¢/gallon	47.6	49.0	56.8	65.9	76.3	88.5	52.4	84.3	135.9	218.9	352.5
No. 4 and 5 Fuel Oil	¢/gallon	44.6	45.9	53.2	61.7	71.5	82.9	49.1	79.1	127.4	205.1	330.3
No. 6 Fuel Oil	¢/gallon	45.0	46.4	53.8	62.4	72.3	83.8	49.5	79.7	128.4	206.8	333.0
Large Commercial												
Natural Gas	¢/therm	32.9	33.9	39.3	45.6	52.8	61.2	36.2	58.3	93.9	151.2	243.5
No. 2 Fuel Oil	¢/gallon	39.0	40.2	46.6	54.0	62.6	72.6	42.9	69.1	111.3	179.2	288.6
No. 4 and 5 Fuel Oil	¢/gallon	46.1	47.5	55.1	63.8	74.0	85.8	50.7	81.7	131.5	211.8	341.1
No. 6 Fuel Oil	-	-	-	-	-	-	-	-	-	-	-	-
Small Commercial												
Natural Gas	¢/therm	36.2	37.3	43.2	50.1	58.1	67.4	39.8	64.1	103.2	166.3	267.8
No. 2 Fuel Oil	¢/gallon	47.0	48.4	56.1	65.0	75.4	87.4	51.7	83.3	134.1	216.0	347.8
No. 4 and 5 Fuel Oil	¢/gallon	44.0	45.3	52.5	60.9	70.6	81.8	48.4	77.9	125.5	202.2	325.6
No. 6 Fuel Oil	¢/gallon	38.8	40.0	46.4	53.8	62.3	72.2	42.7	68.8	110.8	178.4	287.3

Note:
(1) Based on first quarter 1979 survey data.

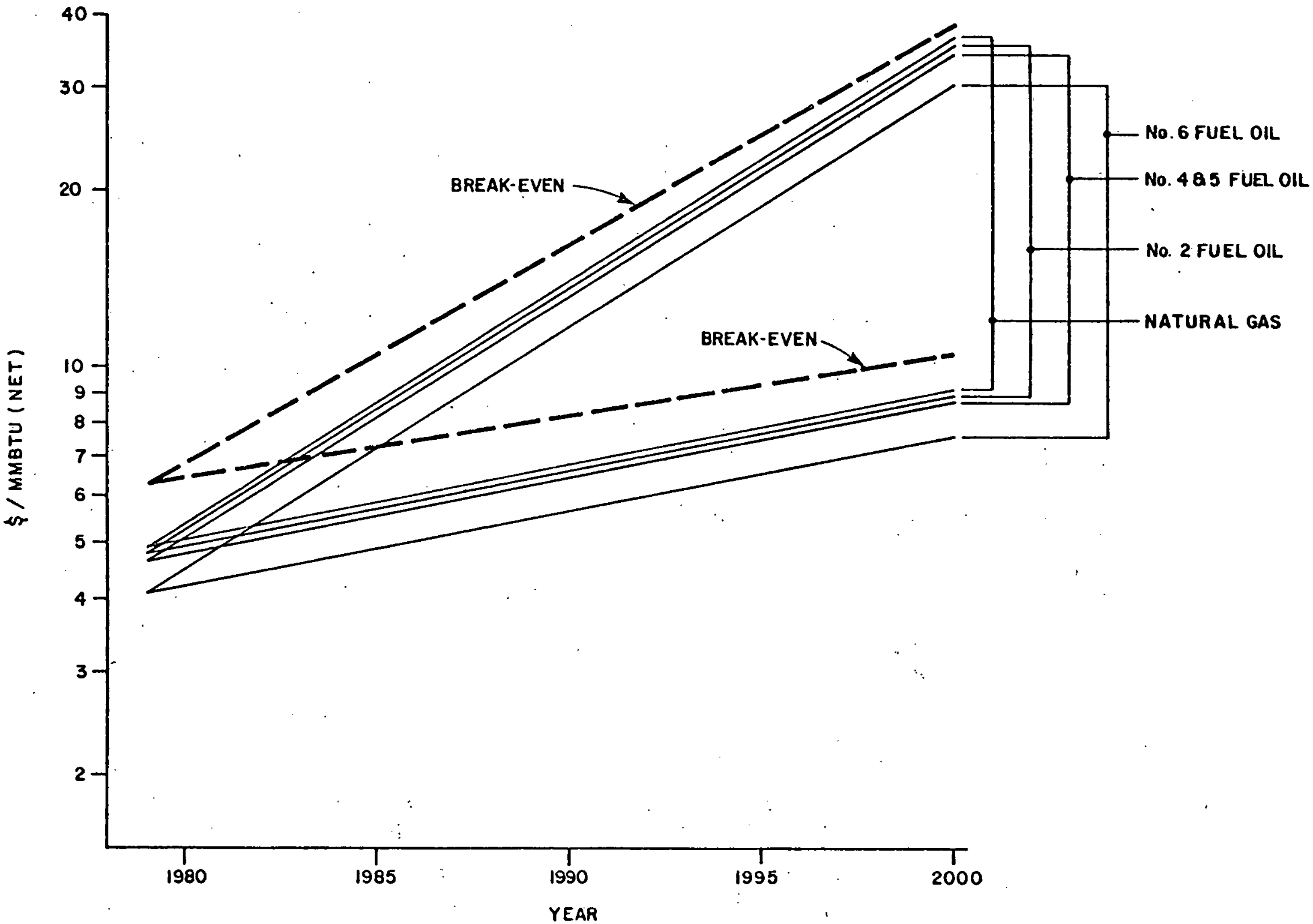
Public Service Electric & Gas
Department of Energy District Heating Study
Current and Escalated Fuel Costs by Customer Classification
($/MMBTU - Net)

Customer Classification	Units Per MMBTU Net	Current Fuel Costs	Future Fuel Costs									
			Low (3% Per Year Escalation)					High (10% Per Year Escalation)				
			1980	1985	1990	1995	2000	1980	1985	1990	1995	2000
Large Industrial												
Natural Gas	15.38 therms	4.91	5.06	5.86	6.80	7.89	9.14	5.40	8.69	14.00	22.55	36.32
No. 2 Fuel Oil	11.04 Gallons	4.78	4.93	5.71	6.62	7.68	8.90	5.26	8.47	13.64	21.95	35.35
No. 4 & 5 Fuel Oil	10.92 Gallons	4.69	4.83	5.60	6.44	7.53	8.72	5.16	8.30	13.37	21.54	34.68
No. 6 Fuel Oil	10.84 Gallons	4.09	4.21	4.88	5.65	6.55	7.60	4.50	7.25	11.67	18.80	30.27
Small Industrial												
Natural Gas	15.38 therms	5.33	5.48	6.36	7.36	8.54	9.89	5.86	9.45	15.20	24.49	39.42
No. 2 Fuel Oil	11.04 gallons	5.26	5.41	6.27	7.28	8.43	9.77	5.79	9.31	15.01	24.17	38.92
No. 4 & 5 Fuel Oil	10.92 gallons	4.87	5.02	5.81	6.74	7.81	9.06	5.37	8.64	13.92	22.40	36.07
No. 6 Fuel Oil	10.84 gallons	4.88	5.03	5.84	6.77	7.84	9.09	5.37	8.64	13.92	22.42	36.10
Large Commercial												
Natural Gas	15.38 therms	5.06	5.22	6.05	7.02	8.12	9.42	5.57	8.97	14.45	23.26	37.45
No. 2 Fuel Oil	11.04 gallons	4.31	4.44	5.15	5.97	6.92	8.02	4.74	7.63	12.29	19.79	31.87
No. 4 & 5 Fuel Oil	10.92 gallons	5.04	5.19	6.02	6.97	8.08	9.37	5.54	8.93	14.36	23.13	37.25
No. 6 Fuel Oil	-	-	-	-	-	-	-	-	-	-	-	-
Small Commercial												
Natural Gas	15.38 therms	5.57	5.74	6.65	7.71	8.94	10.37	6.13	9.86	15.88	25.58	41.19
No. 2 Fuel Oil	11.04 gallons	5.19	5.35	6.20	7.18	8.33	9.65	5.71	9.20	14.81	23.85	38.40
No. 4 & 5 Fuel Oil	10.92 gallons	4.81	4.95	5.74	6.65	7.71	8.94	5.29	8.51	13.71	22.08	35.56
No. 6 Fuel Oil	10.84 gallons	4.21	4.34	5.03	5.84	6.76	7.83	4.63	7.46	12.01	19.34	31.15

PUBLIC SERVICE ELECTRIC & GAS
DEPARTMENT OF ENERGY DISTRICT HEATING STUDY

COMPARATIVE NET ENERGY COSTS AT HIGH (10%) AND LOW (3%) DIFFERENTIAL ESCALATION RATES

LARGE INDUSTRIAL SECTOR



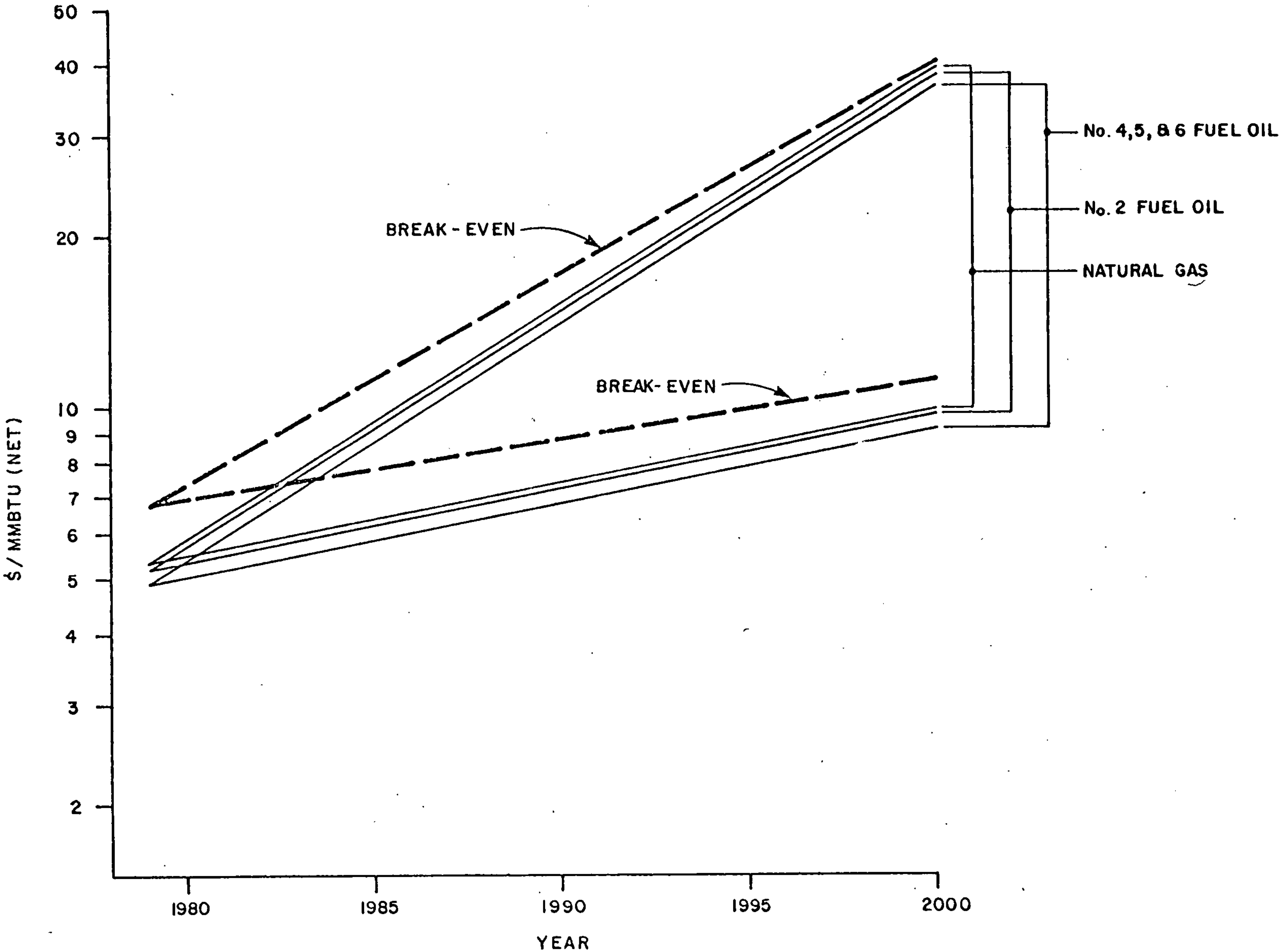
3-59

Exhibit 2.3.3 - IV

PUBLIC SERVICE ELECTRIC & GAS
DEPARTMENT OF ENERGY DISTRICT HEATING STUDY

COMPARATIVE NET ENERGY COSTS AT HIGH (10%) AND LOW (3%) DIFFERENTIAL ESCALATION RATES

SMALL INDUSTRIAL SECTOR



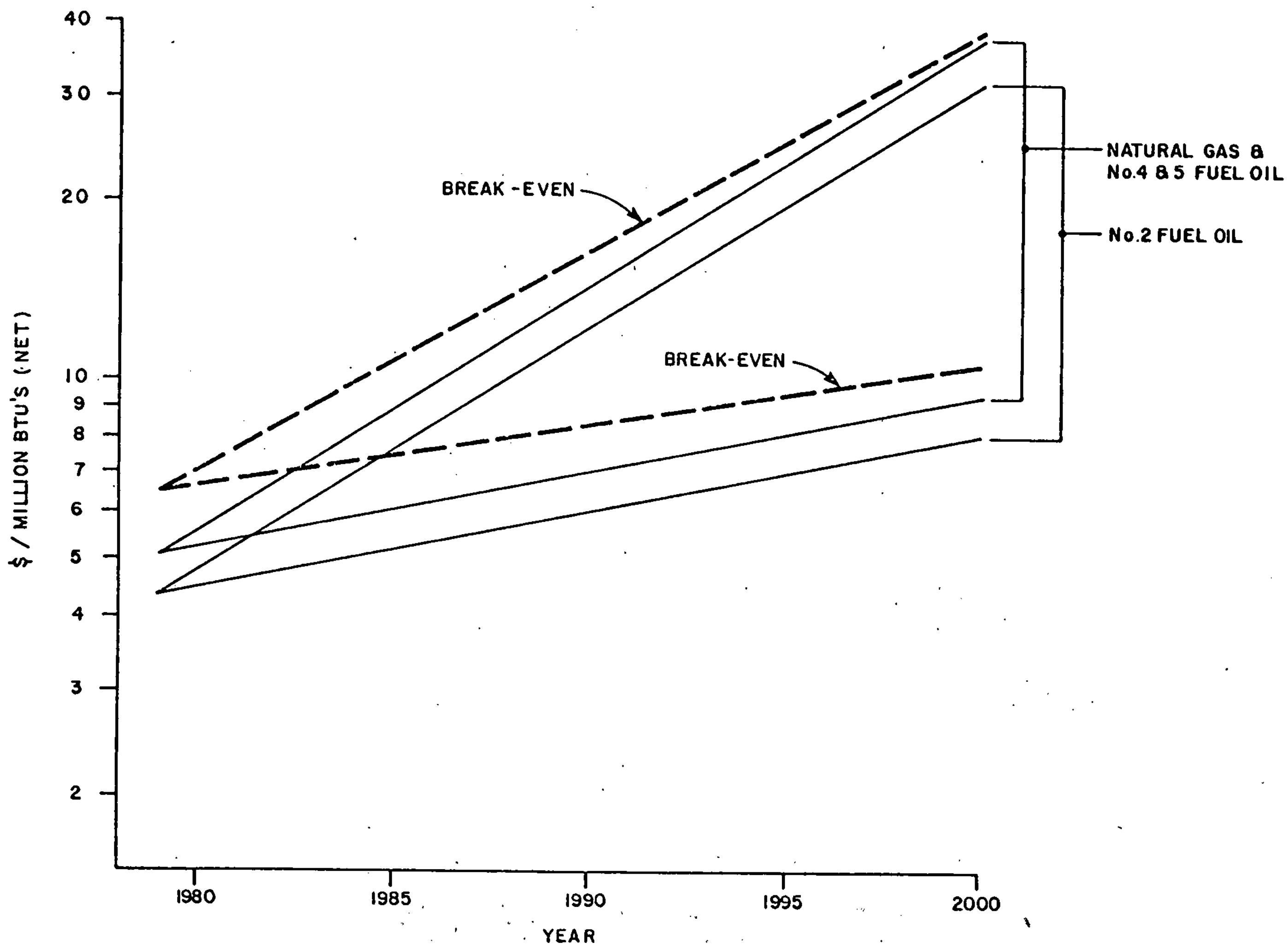
3-60

Exhibit 2.3.3 - V

PUBLIC SERVICE ELECTRIC & GAS
DEPARTMENT OF ENERGY DISTRICT HEATING STUDY

COMPARATIVE NET ENERGY COSTS AT HIGH (10%) AND LOW (3%) DIFFERENTIAL ESCALATION RATES

LARGE COMMERCIAL SECTOR



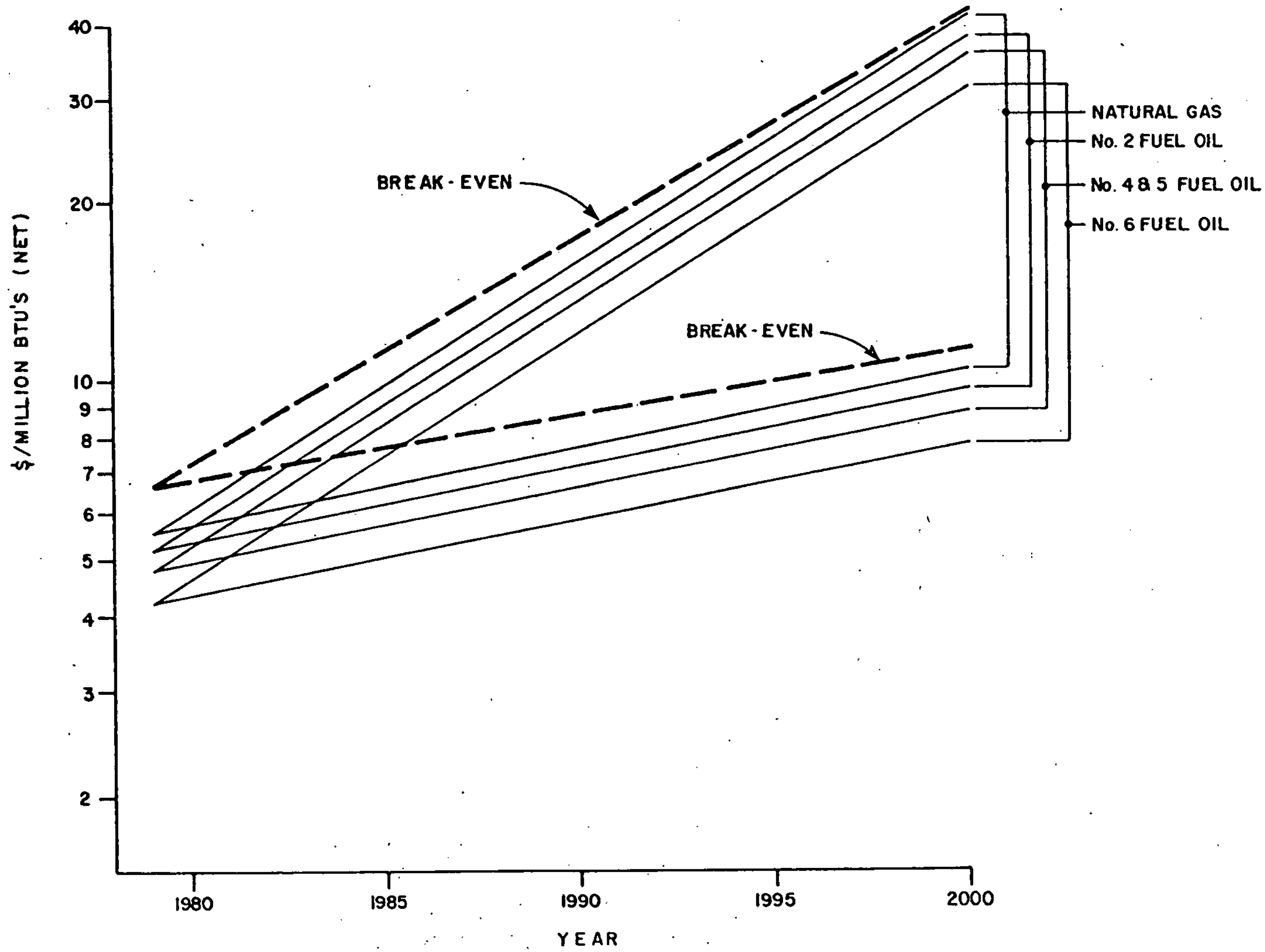
3-61

Exhibit 2.3.3 - VI

PUBLIC SERVICE ELECTRIC & GAS
DEPARTMENT OF ENERGY DISTRICT HEATING STUDY

COMPARATIVE NET ENERGY COSTS AT HIGH (10%) AND LOW (3%) DIFFERENTIAL ESCALATION RATES

SMALL COMMERCIAL SECTOR



3-62

Exhibit 2.3.3 - VII

Public Service Electric & Gas
Department of Energy District Heating Study
Calculation of Premium Value of District Heating Service to New Establishments Capital

Customer Class	Average Use Therms	Peak Capacity(1) Therms	Peak Capacity(1) MBtu	Estimated Investment Cost(2)	Payback Period Minimum + 1	Annual Savings	Savings Per Therm	Savings per MMBtu Net
Large Industrial	226,750	143.8	14,380	93,470	4.24	$22,045	9.7¢	$1.49
Small Industrial	74,650	47.3	4,734	30,770	4.44	6,930	9.2¢	1.42
Large Commercial	262,100	166.2	16,622	108,040	4.59	23,538	9.0¢	1.38
Small Commercial	53,920	34.2	3,420	22,230	5.62	3,956	7.3¢	1.12
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

(1) based on 27% annual load factor and installed capacity of 1.5 times the peak $\left[\text{therm/year} \times \frac{1.5}{8760 \times .27}\right]$

(2) based on $6.50/MBTU

2.3.4 Generic Nature of the Market Area Studied and Relationships that May Relate to Other Urban Industrial Areas

In the research and analysis conducted for the purpose of this site specific study several factors have been identified which may be of assistance in evaluating the potential for district heating in other urban industrial areas. These factors deal with the end use and location of the potential loads.

The major end use seen for energy from the district heating system studied in the northern New Jersey area is for space heating. While there are some potential domestic water heating and process heating applications they are not seen to be significant enough to change the seasonality of the anticipated district heating load.

Areas which are experiencing growth, i.e., new construction, have greater potential for district heating system than locations with existing structures containing operating heating systems which would have to be replaced. As the district heating service envisioned in this study would provide heat exchangers in the customer building as part of the thermal rate and new buildings would not have to invert in heating plants a greater savings could be shown for a new building than an existing structure. The higher the density of loads in a given geographic area the greater the potential for district heating as distribution facilities are a major cost factor and high density area would allow more economic distribution systems.

2.4.7 Scarce Fuel Savings Potential

For the purpose of this analysis natural gas and fuel oil have been defined as scarce fuels. As there is no coal currently being used in the service areas being considered in this analysis 100% of the sales from the district heating system would replace the consumption of these scarce fuels. At the same time there would be an increase in the fuel oil consumed by PSE&G and the entire PJM power pool as a result of the loss of generating capacity required for district heating and for the production of the thermal energy to be distributed. These incremental volumes of fuel oil have been calculated by PSE&G for its own plant and for the entire PJM system. The scarce fuel savings for Schemes I, II, and III are shown in Exhibits 2.4.7-I, II and III respectively. These quantities were calculated for the years shown assuming that the district heating system will replace scarce fuels in the same proportion as they are currently used in the service area of interest. Based on the field survey 40% of the net thermal energy used is natural gas and 60% various grades of fuel oil. The total district heating sales was then divided on this basis between natrual gas and fuel oil. The natural gas portion in billions of Btu's was divided by 65% seasonal efficiency and 100,000 Btu's per therm to determine the equivalent input being replaced. The fuel oil portion was divided by a weighted 63% seasonal efficiency and a weighted 6,078,000 Btu's per barrel to determine the equivalant input being replaced. The fuel oil savings were further adjusted for the increased consumption of PSE&G and the PJM system.

Exhibit 2.4.7-I

Public Service Electric & Gas
Department of Energy District Heating Study
Scarce Fuel Savings
Scheme I

	1985	1990	1995
District Heating Sales (10^{12} Btu)	3.399	3.399	3.399
Scarce Fuel Savings			
Equivalent Fuel Oil (bbl's)	887,700	887,700	887,700
Increased Oil Consumption (bbl's)			
PSEG	23,000	255,000	255,000
PJM	325,000	325,000 (1)	325,000 (1)
Total	348,000	580,000	580,000
Net Scarce Fuel Savings			
Equivalent Fuel Oil (bbl's)	539,700	307,700	307,700

(1) PJM uses 55,000 tons less coal.

Exhibit 2.4.7-II

Public Service Electric & Gas
Department of Energy District Heating Study
Scarce Fuel Savings
Scheme II

	For all years that the unit is on
District Heating Sales (10^{12} Btu)	1.461
Scarce Fuel Savings	
Equivalent Fuel Oil (bbl's)	381,500
Increased Oil Consumption (bbl's)	
PSE&G	655,000
PJM	(320,000)
Total	335,000(1)
Net Scarce Fuel Savings	
Equivalent Fuel Oil (bbl's)	46,500

(1) PJM uses 20,000 less coal.

Public Service Electric & Gas
Department of Energy District Heating Study
Scarce Fuel Savings
Scheme III

	1985	1990	1995
District Heating Sales (10^{12} Btu's)	3.399	5.828	7.289
Scarce Fuel Savings Equivalent Fuel Oil (bbl's)	871,000	1,522,000	1,903,500
Increased Oil Consumption (bbl's)			
PSE&G	23,000	725,000	1,380,000
PJM	325,000	688,000	368,000
Total	348,000	1,413,000(1)	1,748,000(2)
Net Scarce Fuel Savings Equivalent Fuel Oil (bbl's)	523,000	109,000	155,500

(1) PJM uses 209,000 tons less coal.

(2) PJM uses 229,000 tons less coal.

Public Service is a member of the PJM (Pennsylvania-New Jersey-Maryland) power pool. To satisfy the hour-by-hour electrical demands of the member company's customers, PJM coordinates the economic operation of all generating units throughout the pool as though the pool were a single large generating company. In this way, the lowest possible cost power is made available to all customers of PJM's member companies.

Due primarily to the more stringent air quality standards applied to PSE&G's service territory, Public Service tends to have higher operating costs than the other PJM companies. Therefore PSE&G purchases a large amount of power from PJM. As a result, changes to the cost and operational characteristics of Public Service generators due to modifications to provide district heating energy have a significant impact on PJM as a whole.

During high load periods, most of the electrical capability lost as a result of district heating would be replaced by purchases from PJM. This replacement energy comes from older, relatively less efficient, oil fired steam units and gas turbine peaking units. This is true throughout the year, since the base load nuclear and coal fired units are removed from service during the offpeak fall, winter, and spring months for maintenance and overhaul.

During low load periods, nuclear and coal fired base load units supply the bulk of PJM's electrical demand. As more nuclear capacity is added to the system during the 1980's, the most expensive coal and oil fired base load capacity will be shifted to cycling operation. Units such as Bergen 1 and 2, Hudson 1, and even Hudson 2 will be affected. The need to operate these units to supply district heating when they would otherwise be taken off-line will affect the operation of other PJM generators. The output of less expensive coal fired generators will have to be curtailed to make room for the operation of the more expensive district heating generators.

PSE&G

Public Service Electric and Gas Company 80 Park Place Newark, N.J. 07101 Phone 201 430-7000

☐ CENTRAL FILE No.______________
☑ GROUP FILE No.______________

September 6, 1979

Memorandum to File

DISTRICT HEATING PHASE I REPORT
DOE QUESTION ON SCARCE FUEL SAVINGS

In the USDOE's letter of August 13, 1979 concerning comments on the District Heating Phase I Report, they questioned the change in fuel consumption on the PJM system in Exhibits 2.4.7-I, 2.4.7-II and 2.4.7-III. This memorandum is intended to clarify the projected change in fuel consumption with district heating on the PJM system.

The PJM generating capacity consists of oil fired, coal fired and nuclear units. The entire system is dispatched on an hour-byhour economic basis in order to minimize production costs. In the early-1980's, units such as Bergen 1 and 2 and Hudson 1 and 2 will be dispatched primarily as base load units. As more base load nuclear generation is added to the PJM system, the operating mode of the above-mentioned units will gradually change from base load to intermediate load operation in which the unit output will vary significantly to follow the load.

A generating unit that is retrofitted to supply district heating load will have a restricted electrical operating range. The maximum electrical output will decrease, due to the steam extraction necessary to supply the district heating load. On-peak electric energy production will be decreased and the replacement energy will be supplied by less efficient oil fired steam or combustion turbine units. Minimum load electrical output will be increased, since sufficient steam must be passed through the turbine to supply the district heating load. Off-peak electric energy production will be increased, displacing energy which would otherwise be supplied by coal fired units.

In the Hudson isolated case, Scheme I, the annual thermal energy is 3775 x 10^9 Btu. Approximately 60% of the thermal energy is supplied by the coal fired Hudson No. 2 unit, 26% by the oil fired Hudson No. 1 unit and 14% by oil fired auxiliary boilers. Between 1985 and 1990, the mode of operation of the Hudson No. 1

unit without district heating changes from a base load unit to an intermediate load cycling unit. Hudson No. 2 remains as a base load unit during this time period. Exhibit 2.4.7-I shows that the change in oil consumption on the PSE&G system increases from 23,000 bbls in 1985 to 255,000 bbls in 1990 and that the change in coal consumption on the PJM system decreases by 55,000 between 1985 and 1990 with a district heating system. The primary reason for the change in fuel consumption is that in 1990 Hudson No. 1, which provides 26% of the thermal energy, must be run during certain off-peak hours to provide thermal power whereas without district heating Hudson No. 1 would have either been turned down or turned off. Since this electric energy was produced during off-peak hours, certain PJM coal fired units were turned down which resulted in 55,000 tons of coal less being burned. The change in oil consumption of 325,000 bbls on the PJM system in 1985 and 1990 is primarily due to the decrease in electric generating capacity of Hudson No. 1 and No. 2 during on peak hours. In other words, the electric energy, that would have been produced by Hudson No. 1 and No. 2 during on-peak hours without district heating, is made up by PJM oil fired units in the system simulation with district heating system.

TMP:acb

T. M. Piccirilli

12-30

PSEG Research Corporation

80 Park Place Newark New Jersey 07101 Phone 201/430-7000

August 2, 1979

Mr. John C. Rodousakis
Community Systems Branch
Division of Building and Community Systems
Department of Energy
20 Massachusetts Avenue, NW (2nd Floor)
Washington, DC 20540

Dear Mr. Rodousakis:

DISTRICT HEATING AND COOLING/CONTRACT
EM-78-C-02-4977 SCARCE FUEL SAVINGS

We have reviewed the scarce fuel savings figures that were provided in our Draft Final Report for the above-referenced project.

We want to be sure that there is no misunderstanding regarding these numbers (Section 4 of the report, Exhibits 2.4.7-I, II and III). These figures are preliminary and subject to change by a number of factors not investigated in detail in Phase 1, but which could be examined in Phase 2. Indeed, one could estimate significant oil savings under certain sets of reasonable conditions. Some of these factors are:

1. Sensitivity of savings to gas/oil market mix: The figures given in the Draft Final Report assumed the 40%/60% gas/oil mix of existing installations. There is no reason to assume this same historical ratio for new developments in northern New Jersey. Indeed, the net oil saving is extremely sensitive to the gas/oil mix assumed. A higher percentage of oil would result in more oil being displaced by District Heating, and thus a larger oil saving. A calculation corresponding to 100% oil displaced by District Heating gives the following results for annual net oil savings (bbls):

	1985	1990	1995
Scheme I	539,700	307,700	307,700
Scheme II	46,500	46,500	46,500
Scheme III	523,000	109,000	155,500

2. Translation of gas savings into equivalent oil savings by displacement:

   The assumption of 100% oil displaced by District Heating is actually the most appropriate method of calculation of oil savings regardless of the actual market gas/oil mix. Any gas displaced by District Heating must eventually displace oil. If one assumes a future shortage of gas, the gas displaced by District Heating would be sold elsewhere and displace oil. If there is a gas surplus, the gas could be burned in generating station boilers and gas turbines, and again displace oil.

3. Coal conversion of retrofitted oil-fired generating stations:

   This would decrease the use of oil by the District Heating system, and result in significant increases in oil savings.

4. Examination of actual PJM oil usage at night:

   In calculating fuel savings, the preliminary assumption was made that because of low electrical load and incremental cost dispatching, all PJM generation at night is from coal and nuclear stations. Since providing District Heating at night would result in excess electric generation (partially oil-fired) being "dumped" on the grid, it forces the turning down of coal-fired PJM units. If it should be found that there is significant oil-fired PJM generation at night, this would be turned down first, with an increase in oil savings.

5. Shifting of thermal peak relative to electrical peak using thermal storage and pumped hydro storage:

   When district heating is required at electrical peak hours, the loss in electric capacity due to steam extraction for district heating forces the replacement of this generation by (oil-fired) peaking units. When district heating is required at minimum electric load hours (at night), excess generation forces the replacement of coal-fired by oil-fired generation as explained in (4) above. The shifting of the thermal peak relative to the electrical peak by means of storage could alleviate both these effects and significantly increase oil savings.

6. Fluidized Bed Backup Boilers:

Fluidized bed boilers are now offered commercially up to 50,000 lb/hr steam capacity. The replacement of the oil-fired backup boilers by a set of (coal-fired) fluidized bed boilers could provide an additional increment of oil savings, and avoid problems with the Fuel Use Act regarding the backup boilers.

We hope that this will clarify the significance of the fuel savings figures in the Draft Final Report.

Very truly yours,

MLZ:PS
CRG

C. R. Guerra
Assistant Manager
Advanced Systems - R&D

cc Mr. J. Pr[illegible], ANL

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