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Generation of Steam from Solid Wastes

Metcalf and Eddy, Inc.

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The economic feasibility of a refuse-fired waterwall incinerator that would supply steam to an industrial firm is investigated for a community looking for an acceptable solid waste disposal method. Several different combinations of grate type, equipment ownership, and equipment location are cost-compared in detail. Plant equipment components and manpower requirements are described. Other solid waste disposal alternatives are discussed. The City of Lynn concludes that a waterwall incinerator facility is the region's most feasible future solid waste disposal method.

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GENERATION OF STEAM FROM SOLID WASTES

This publication (SW-49d) reports on work performed under Federal solid waste management demonstration grant No. G06-EC-00195 to the City of Lynn, Massachusetts, and is reproduced as received from the grantee.

Part I was written by METCALF & EDDY, INC.
Part II was written by the CITY OF LYNN, MASSACHUSETTS

U.S. ENVIRONMENTAL PROTECTION AGENCY

1972

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FOREWORD

The concept of a solid waste waterwall incinerator generating steam for the General Electric River Works plant, which was studied in this report, is now being implemented in Saugus, Massachusetts, by the Thermal Energy Systems Company, a joint venture of Combustion Engineering, Inc., and the DeMatteo Construction Company. Construction was scheduled to begin during the summer of 1972 on the 1200 TPD waterwall incinerator. Due to problems encountered in organizing the North Shore Solid Waste District among the cities in the Saugus area, an operating agreement, as contemplated by the City of Lynn in this report, was never reached between the District and the General Electric Company.

--ARSEN J. DARNAY
Director
Resource Recovery Division

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CHAPTER I

INTRODUCTION

On October 9, 1967, the major dumping area of Greater Lynn, the DeMatteo landfill, was closed as a result of action taken by a group of citizens who were dissatisfied with the operation of the facility. Though a "stay of execution" has been granted by the Commonwealth of Massachusetts, allowing selected communities to continue using the facility, the problem of refuse disposal in this area has become critical. It is clear that continued use of the DeMatteo area will not be tolerated much longer.

The City of Lynn, excluded from using the DeMatteo facility, formulated an agreement with the New England Power Company whereby it would establish a sanitary landfill on an area of land owned by that firm.

This is the only current source of land for refuse disposal in the City of Lynn and it is rapidly being depleted. A plan to construct an adequate solid wastes facility is absolutely necessary.

The General Electric Company's River Works Plant, located in Lynn, has a need for additional steam. This need for steam at the industrial facility, and the severe problem of disposal of solid wastes in the community, have brought the General Electric Company and the City of Lynn together in this joint venture.

There are facilities in operation, such as the United States Navy's incinerator-boiler at Norfolk, Virginia, which utilize the heat from the combustion of refuse for steam generation. It was therefore proposed that the two parties combine in a joint venture for their mutual benefit. The refuse will have a value as a fuel to the General Electric Company, and the disposal service will have a value to the community.

Application was made to the Bureau of Solid Wastes Management of the United States Public Health Service for a study and investigation grant to help finance a study of the concept of utilizing refuse from the City of Lynn as a low-grade fuel to generate steam for use by the General Electric Company, thereby achieving a mutual economic savings. Metcalf & Eddy, Inc., Boston, Massachusetts, and the Foster Wheeler Corporation, New York, New York, were engaged by the City of Lynn and the General Electric Company, respectively, as consultants.

Authorization to begin work under Grant No. 1-DO1-U1-00195-01A1 was received on June 24, 1969.

The study will investigate several alternative solutions with varying degrees of involvement, in regard both to initial capital outlay and to the operation of the facility by the two parties. A site plan showing the relationship of the proposed truck-unloading facility and the existing General Electric Company boiler complex is shown on Figure 1.

The recommendations herein apply to a situation existing in the City of Lynn, Massachusetts, and is based on several conditions that apply only to the study area. It is felt, however, that the basic concept is applicable to any location in the United States where there is a market for steam. For the recommendations to be applicable to other localities, it would be necessary to obtain specific data for the situation and reanalyze.

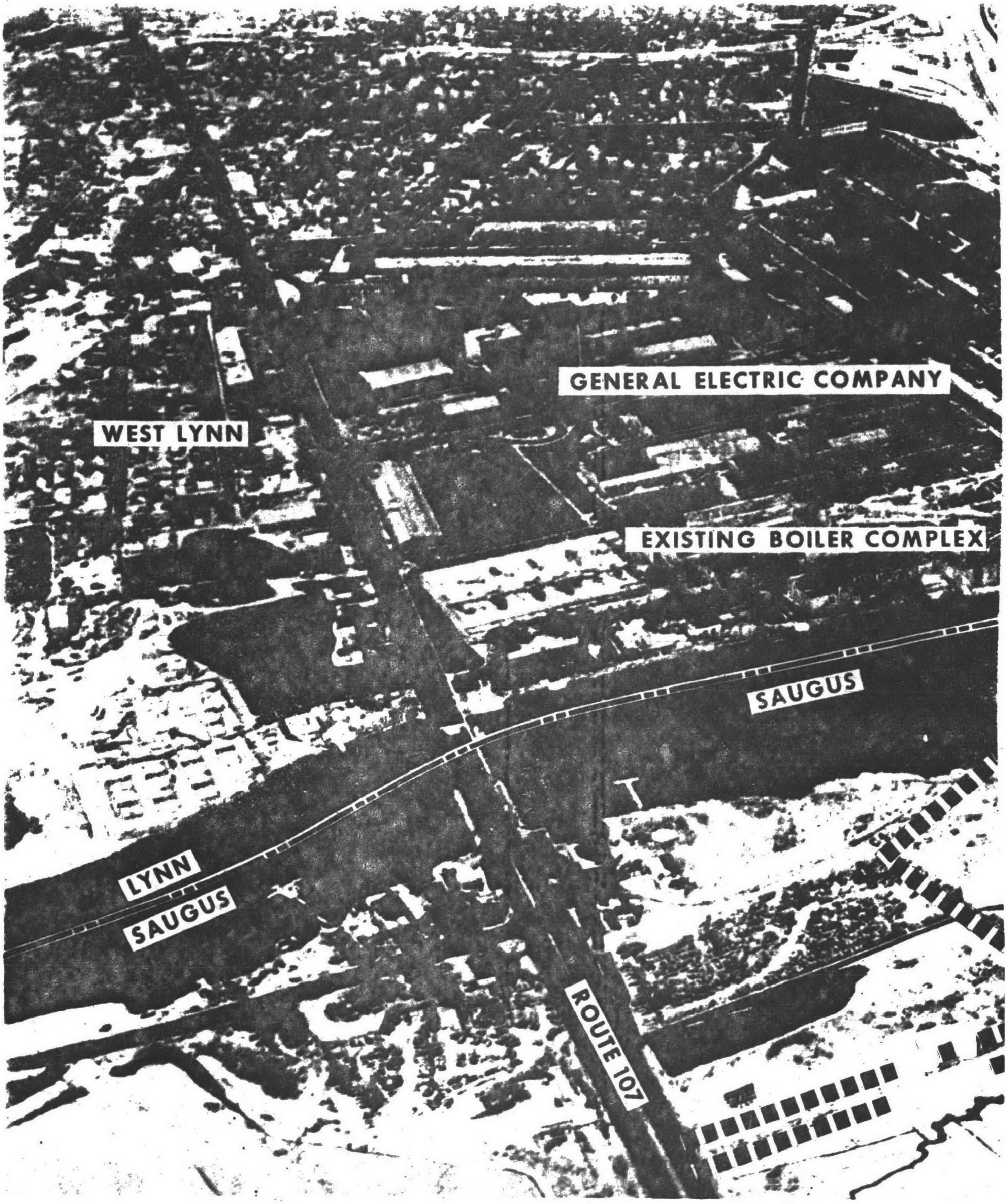

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FIG. 1 LOCATION PLAN

1-3

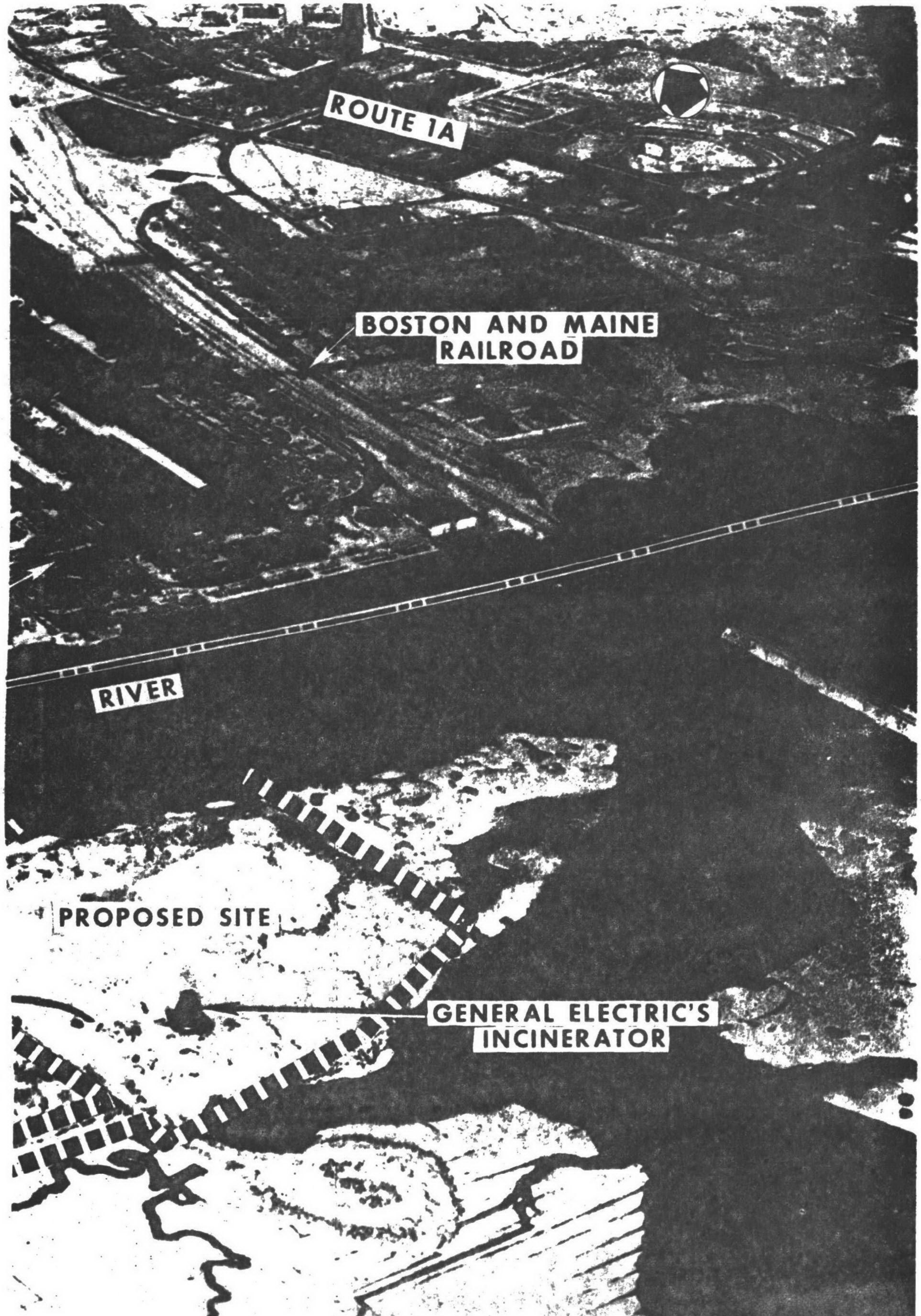

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FIG. I LOCATION PLAN (CONT'D)

CHAPTER 2

PURPOSE AND OBJECTIVES

The basic purpose of the project was to study and investigate the feasibility of a governmental unit (the City of Lynn) and a large industrial firm (River Works Plant, General Electric Company) operating as a joint venture a solid waste disposal facility that would use municipal solid waste as a low-grade fuel for steam generation.

The River Works of the General Electric Company, located in Lynn, Massachusetts, owns and operates a multiboiler steam-generating plant which carries the steam load of this large industrial complex. The firm is presently planning to add a large new boiler to this plant. The General Electric Company has proposed to use municipal solid waste as a supplementary fuel for the new boiler. Though the concept of using solid waste as a low-grade fuel to generate steam is being applied successfully in the United States, the concept needs to be studied for financial feasibility under specific conditions prior to implementation.

The report compares the economic feasibility of three alternatives for the ownership and operation of the proposed steam-generating system:

A. Waste-preparation plant to be owned and operated by the City of Lynn; the boiler and superheater to be owned and operated by the General Electric Company. (There would be 800-foot long conveyors connecting the two facilities.)

B. Waste-preparation plant and boiler to be owned and operated by the City of Lynn; the superheater to be owned and operated by the General Electric Company. (There would be an 800-foot long steam main between the boiler and the superheater.)

C. Same ownership and operation as Alternative A, but the two plants would be located adjacent to each other; therefore the 800-foot long conveyors would not be necessary.

The specific objectives of the study were as follows:

a. To determine the optimum refuse-burning method in the steam-generating boiler.

b. To determine refuse-preparation requirements associated with the optimum burning method.

c. To determine the best method of conveying refuse from the preparation plant to the boiler.

d. To develop preliminary engineering details sufficiently to determine site, equipment and building requirements for the several alternatives.

e. To determine capital and operating costs of alternative possible preparation and burning methods, and to select and develop details on the optimum overall system.

f. To demonstrate that the cost of refuse disposal and the cost of steam generation can both be reduced by utilizing refuse as a fuel.

g. To demonstrate that a substantial reduction in the amount of public capital funds and public operating costs can be achieved if the facility is partially owned and operated by private enterprise.

h. To develop an overall plan in such a way as to demonstrate the feasibility of an industry or utility engaging in a joint enterprise with municipalities for refuse disposal purposes, at other locations in the United States.

CHAPTER 3

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. There is a need for a new means of refuse disposal for the City of Lynn, and in fact, most of the communities in the area just north of Boston.

2. The local government-private enterprise joint-venture concept of refuse disposal and steam generation is feasible, and it offers mutual economic benefits to the City of Lynn and the General Electric Company.

3. Alternative A-II, shown on Figure 2, and Alternative B-II are more attractive from an economic standpoint than the other feasible alternatives. Alternative B-II offers greater flexibility in that, being located in Saugus, there is room for future expansion. In Alternative A-II the boiler is located in General Electric's plant, where expansion is limited due to nonavailability of space.

4. The present heating value of refuse in the Greater Lynn area is estimated to be 4,970 Btu (British thermal unit) per pound as fired. It is expected to go to 6,000 Btu per pound as fired by the year 1990.

5. When operating with refuse having an as-fired heating value of 4,970 Btu per pound the boiler will have the capacity to burn 384 tpd (tons per day) with a reciprocating grate stoker, and 612 tpd with a spreader stoker.

6. The present residential refuse-generation rate in the City of Lynn is estimated to be 160 tpd. This is expected to increase to 238 tpd by the year 1990.

7. There is sufficient refuse in the Greater Lynn area to satisfy the requirements of the boiler with either a reciprocating grate or spreader-type stoker.

8. Alternative C, in which both the process plant and boiler are located in the General Electric Yard near the existing boiler complex, is not implementable due to the lack of available space, although it would be suitable for some areas in other parts of the country.

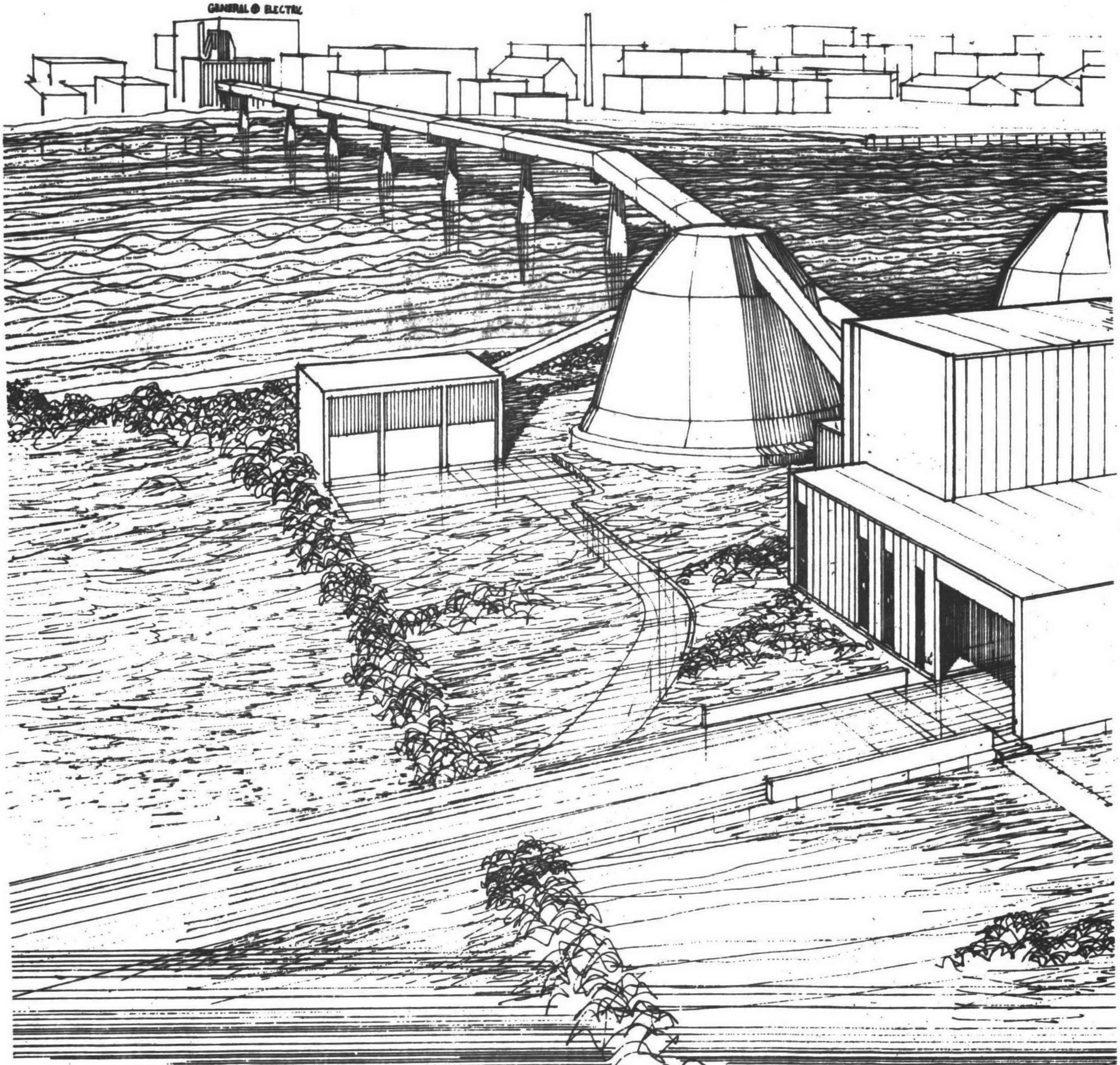

FIG. 2 REFUSE PROCESSING PLANT AND STEAM GENERATION FACILITY

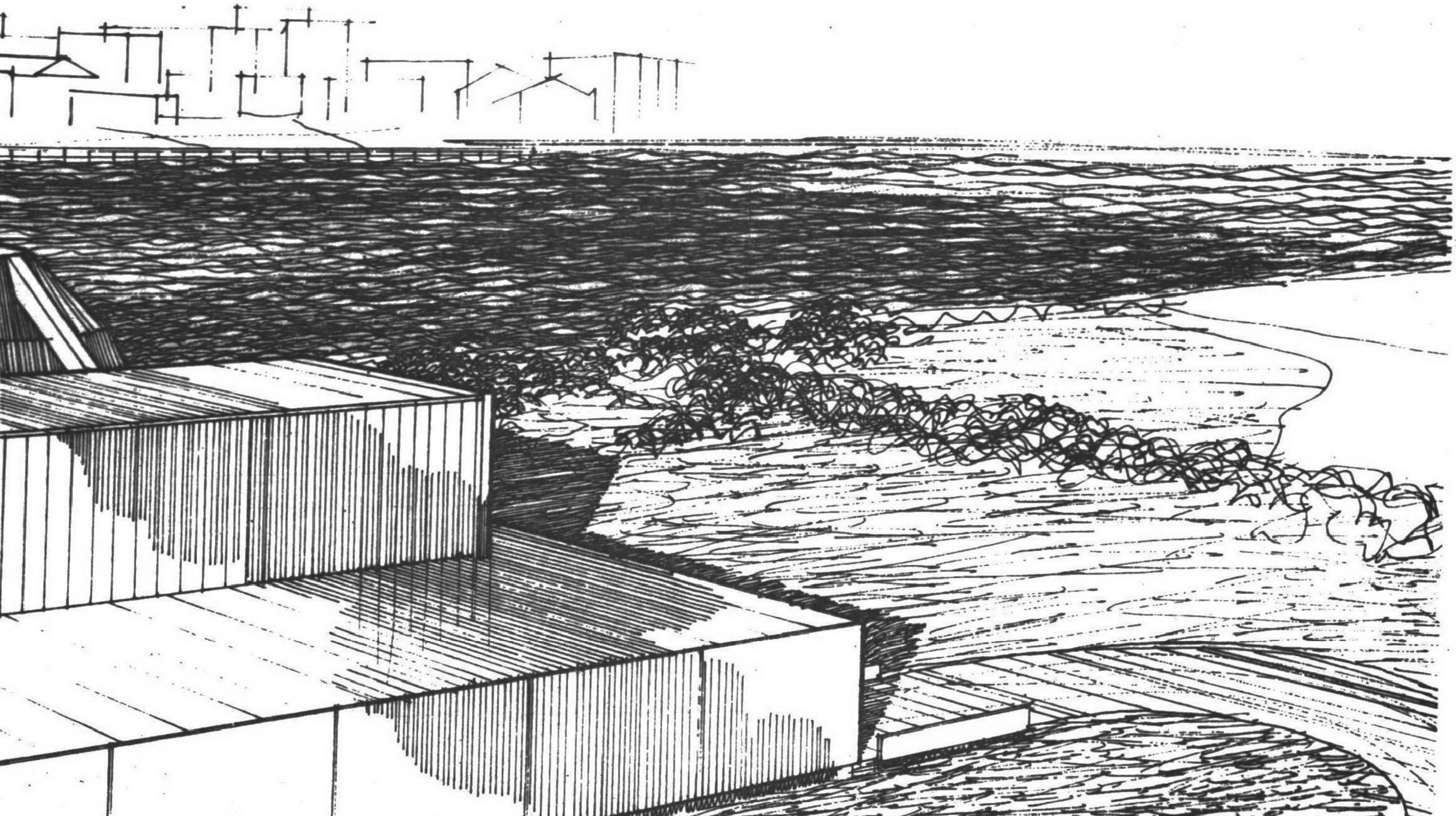

FIG. 2 REFUSE PROCESSING PLANT AND
STEAM GENERATION FACILITY (CONT'D)

9. All refuse must be shredded to less than 4 inches when the spreader stoker is used, whereas only bulky wastes must be shredded when the reciprocating grate stoker is used.

10. Refuse must be fed to the boiler continuously, 24 hours per day, 350 days per year.

11. The boiler will be capable of producing up to 400,000 pounds of saturated steam at approximately 750 psig when burning a combination of No. 6 oil and refuse, and also when burning No. 6 oil alone.

12. The river crossing must have a horizontal clearance of at least 50 feet and an unrestricted vertical clearance of at least 40 feet above mean water level.

13. A crossing under the Saugus River would be more costly than an overhead crossing.

14. Storing refuse in a storage bin and removing it with overhead bridge cranes would be less costly than storing refuse on a slab at grade and using front-end loaders to feed the conveyors.

15. The boiler must be shut down annually for a two-week maintenance period. During this time, an alternate method of refuse disposal will be necessary.

16. The value of the steam produced by the proposed boiler and superheater, based on General Electric's current production costs is $0.877 per 1,000 pounds.

17. Conventional incineration and rail-haul to a remote landfill are the only feasible alternate methods of disposal currently available to the City of Lynn.

18. The annual cost for refuse disposal and steam generation would be in the vicinity of $2,500,000.

19. Based on a value of $0.877 per 1,000 pounds for steam and an average General Electric demand of 200,000 pounds per hour, the steam would have an annual value of $1,480,000.

20. For comparison with other methods of refuse disposal, the net cost of refuse disposal has been estimated to be $4.87 and $4.48 per ton in Alternatives A-II and B-II respectively.

21. This joint venture concept appears quite suitable to any region of the country where sizeable quantities of refuse are generated and where there is a need for steam.

Recommendations

1. The City of Lynn and the General Electric Company should form a joint venture to construct and operate a solid wastes disposal-steam generation facility which would use municipal solid wastes as a low-grade fuel for steam generation.

2. A spreader stoker should be used rather than a reciprocating grate stoker because it has a greater capacity and because it offers a lower cost per ton of refuse burned.

3. Questionnaires should be sent to neighboring communities, industries, and private collectors to ascertain the amount of refuse that would be available at the facility. If this quantity is significantly greater than 612 tons per day, the economies of an enlarged facility should be compared with those of Alternative B-II before a final selection is made.

4. The existing fuel storage and distribution system and the existing boiler feedwater treatment facilities at the General Electric Company should be used regardless of the alternative selected. Also, power should be obtained from the General Electric Company.

5. The superheater should be separated from the incinerator, regardless of the alternative selected, to prevent impingement of refuse gases on the high-temperature tubes of the superheater.

6. An overhead river crossing should be used rather than an underwater crossing. There should be a vertical clearance of at least 50 feet above mean water level and a horizontal clearance between abutments of at least 50 feet also. Prior to final design, the appropriate authorities should be contacted regarding the river crossing.

7. A set of rules and regulations should be established by the City of Lynn to control the types of refuse coming into the process plant.

8. The collection schedules of all of the communities and private haulers using the facility should be coordinated by the City of Lynn to balance the daily incoming refuse load.

9. Noncombustible bulky refuse should not be accepted at the process plant.

10. The City of Lynn should investigate existing and proposed financial aid programs of the Massachusetts Department of Public Works and the United States Department of Health, Education, and Welfare to ascertain if there are any governmental moneys available to finance all or a portion of the design and construction of the facilities. In particular, the proposed Resource Recovery Act (H.R. 11833), if passed, would authorize the expenditure of moneys by the Department of Health, Education, and Welfare for solid wastes treatment.

CHAPTER 4

BASIC DESIGN CRITERIA

General

The basic criteria used for the design and selection of the major components of the refuse-processing and burning systems are presented under the respective components in Chapters 7 and 8. Other basic design criteria used in this report are presented below.

Heating Value of Refuse

The heating value of a substance is the number of Btu produced by combustion for each pound of the original substance. Heating values have been determined in laboratories for most combustible substances. A summary of these values can be found in most mechanical engineering handbooks.* The heating value of a mixture consisting of several separate substances can be determined by using a weighted percentage based on the weight of each separate substance. Because the composition of refuse varies greatly, and because many different substances with differing heating values are found in refuse, the heating value has been found to vary greatly. For example, commercial refuse, because of the relatively high proportion of garbage, would have a lower heating value than industrial refuse, which has little garbage in it. The heating values used in this report are shown in Table 1.

Table 1. Present Heating Values of Refuse

Source	Heating value, Btu per pound as fired
Residential refuse	5,000
Commercial refuse	4,000
Industrial refuse	6,000

*Salisbury, J. K., ed. Kent's mechanical engineers' handbook; power volume. Section 2. Combustion and fuels. 12th ed. New York, John Wiley & Sons, Inc., 1950. p.2(01)-2(98).

The composite heating value of refuse that would be expected at the process plant was determined by multiplying the weight of residential, commercial, and industrial refuse by the respective heating values shown above, and then dividing by the combined weight of all the refuse. The resulting heating value was found to be 4,970 Btu per pound as fired.

The trend in the past has been a steady rise in heating value due to the decreased proportion of garbage and increased proportions of combustible packaging materials in the total refuse. Based on this trend, a heating value of 6,000 Btu per pound as fired was assumed for the year 1990.

General Electric's Steam Requirements

The General Electric Company has requested that steam be provided at boiler outlet conditions of 650 psig (pounds per square inch gage), and at a temperature of 850 deg F.

The demand is not constant over a 24-hour period, but varies from a minimum of 200,000 pounds per hour to a maximum of 400,000 pounds per hour. Hourly rates, together with the percentage of time they are required, as established by General Electric, are shown in Table 2.

Table 2. General Electric's Steam Requirements

Demand Pounds per hour	Percent of time
400,000	5
350,000	10
300,000	50
200,000	35
Total	100

The steam requirements in Table 2 include an allowance for the steam required to preheat the feedwater and to operate the deaerator. Accordingly, even if the boiler is to be operated by the City of Lynn, the total steam production required from the boiler would remain as shown in the table.

Boiler Requirements

The boiler must be capable of handling over 300 tons of refuse per 24-hour day. Ability of the equipment to handle larger quantities of refuse is a desirable feature. The physical size of the boiler is, however, limited by the space available in the General Electric Company yard.

The boiler will be capable of generating the full load (400,000 pounds per hour) when firing a combination of oil and refuse and also when firing oil alone. It will also be capable of firing over the full range indicated in Table 2.

General Electric has established requirements that the boiler be entirely above ground level and that the firing aisle be 20 feet above the present ground-floor elevations.

Backup Facilities

The design of the processing plant will be such that the operating capacity is obtainable with any one piece of equipment out of service. This backup may be provided with standby equipment, by operating other equipment for additional hours during the day, or a combination.

Available Utilities

The existing fuel storage and distribution system, and portions of the existing boiler feedwater treatment facilities, at the General Electric Company would be used for the new boiler.

The General Electric Company generates its own power which will be used to operate both the equipment associated with the boiler and the refuse-processing equipment.

Water for drinking and fire protection can be obtained from a Metropolitan District Commission water main located in Route 107, which is about 1,000 feet from the proposed plant, or from the General Electric Company distribution system.

Sanitary sewage originating on the southwest side of the Saugus River can be collected and pumped across Route 107 to an existing sanitary sewerage system.

Refuse Densities

The density of refuse varies depending upon the degree of compaction and the particular constituents of the batch being investigated. For instance, municipal refuse at the curb side has an average density between 5 and 10 pcf (pounds per cubic foot). When placed in a packer truck, the density reaches about 20 pcf. Refuse compacted in huge compaction machines can reach a density of over 60 pcf.

The densities used in this report are presented in Table 3.

Table 3. Refuse Densities

Degree of preparation	Pounds per cubic foot
Normal refuse	
Packer truck	18.0
Storage bin	12.5
Shredded refuse	
Conveyor	6.0
Storage silo	15.0
Residue	
Dry	40.0
Wet	50.0

CHAPTER 5

REFUSE GENERATION

General

The total quantity of refuse generated in a community is related to the size and socioeconomic status of its population, and to the extent of its commercial and industrial activity.

The quantity of residential refuse estimated to be generated in Lynn, and the quantity of refuse generated by the General Electric Company, during the economic life of the preparation plant and boiler equipment is not sufficient to satisfy the capacity of the boilers recommended by the Foster Wheeler Company. Therefore, additional refuse quantities could be processed through the facilities and thereby reduce costs to the City of Lynn and the General Electric Company.

The controversial DeMatteo landfill, subject of repeated court actions to close it down, is located less than one mile south on Route 107.

No attempt was made to get a firm commitment from any community or private collector to use the proposed Lynn facility, since at this time Lynn cannot guarantee that the proposed plan will be implemented. Once the construction of the Lynn disposal facility has been committed, negotiations should begin with interested communities and private collectors. Due to the controversy surrounding the DeMatteo landfill, we feel that there will be sufficient refuse available to enable complete utilization of the proposed refuse-burning facilities.

Population

The United States Census and the Massachusetts Decennial Census population figures for Lynn from 1930 to 1965, as well as population projections through the year 1990, have been plotted on Figure 3.

The population of Lynn has been decreasing since 1945, and an increase is not anticipated in the foreseeable future. Thus, we have projected the population through the year 1990 using an average of 90,000 persons.

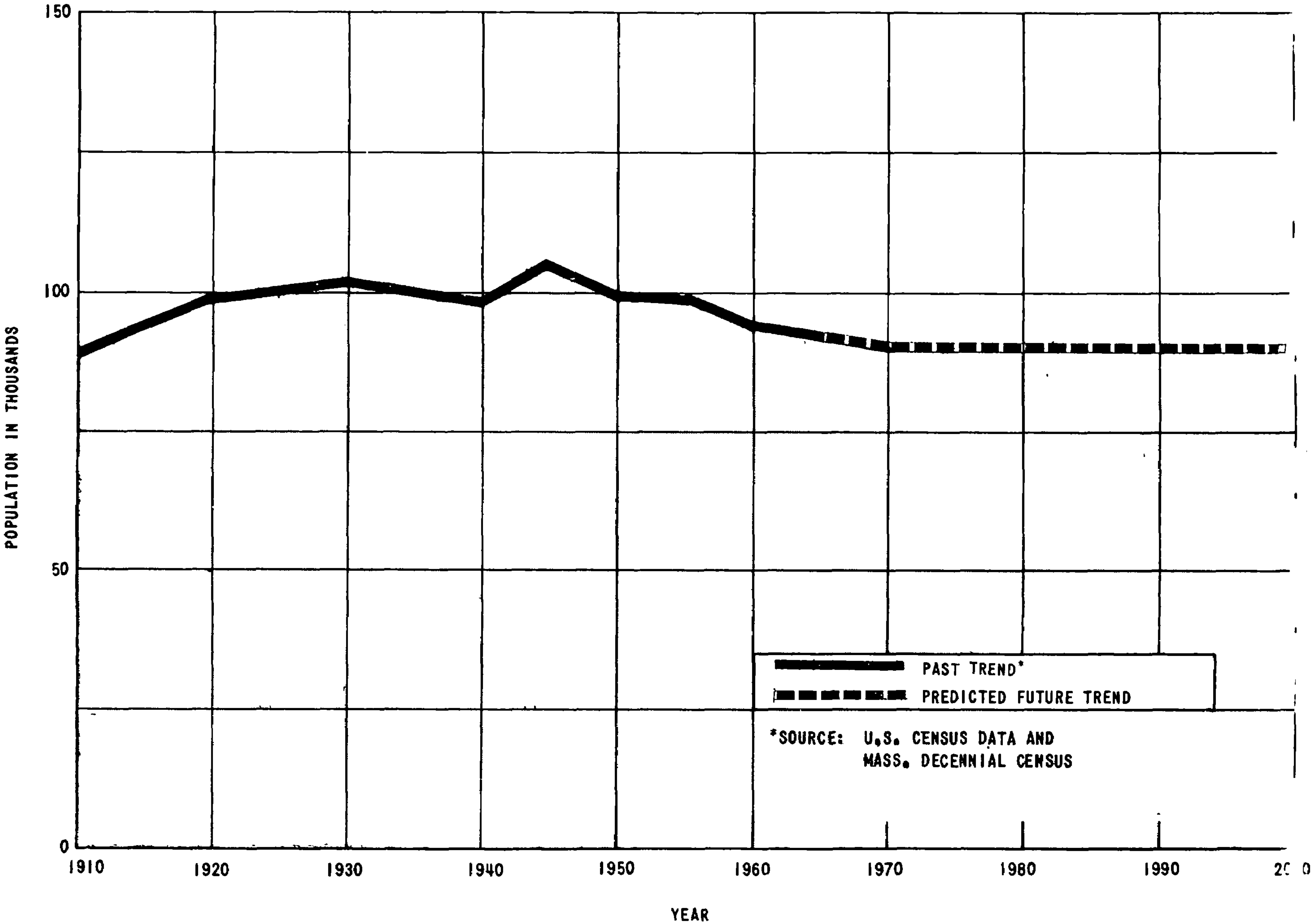

FIG. 3 POPULATION (CITY OF LYNN)

Available Data

In 1967 the Director of Public Works reported that there were 127 tons of residential rubbish per day generated in Lynn. This figure does not include an allowance for garbage. The present quantity of garbage is estimated to be 20 tpd. Projecting the rubbish figure on the basis of a two percent yearly increase, and adding to it the garbage quantity, results in an estimated generation rate of 160 tpd of residential refuse at the present time. Based on a population of 90,000, this is equivalent to a residential refuse generation of 3.45 pounds per capita per day.

General Electric, in addition to having a need for the steam generated by this project, also has a sizable refuse disposal need. They estimate that an average of 16.5 tpd of refuse is generated at the River Works complex.

Based on the fact that General Electric employs over one-third of all industrial workers in the City of Lynn,* and that because of the nature of its operations it generates more refuse on a per-capita basis than most of the other classifications of industrial activities, we estimated that General Electric contributes one-half of the total industrial refuse generation in Lynn. Therefore, the total industrial contribution is estimated to be 33 tpd.

Commercial refuse is, in general, not collected by the city, but by private collectors. Several of these collectors were contacted in an attempt to ascertain the commercial refuse generation rate in Lynn. From these collectors, making certain allowances for uncooperative and unreporting collectors, a commercial rate of 45 tpd was established.

The estimated residential, commercial and industrial refuse generation rates are summarized in Table 4.

Refuse Projection in Lynn

Although the population of the City of Lynn is expected to remain in the vicinity of 90,000 over the next 20 years, the per-capita refuse generation rate will increase, and therefore the total refuse to be handled will increase.

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*City and town monograph--City of Lynn, Massachusetts. Boston, Department of Commerce and Development, 1967. [17 p.]

Table 4. Estimated Refuse Production in Lynn

Refuse classification	Tons per day(1)	
	1970	1990
Residential	160.0	238.0
General Electric (industrial)	16.5	24.5
Subtotal	176.5	262.5
Commercial	45.0	67.0
Other industrial	16.5	24.5
Total	238.0	354.0

1. Based on a 7-day week.

Predictions for the next 20 years vary from one-half percent to five percent increase per year. We have assumed an average value of two percent per year. The 1990 estimated residential, commercial, and industrial refuse generation rates based on an average annual increase of two percent are shown in Table 4.

Additional Communities

The residential refuse production in the City of Lynn, together with General Electric's industrial contribution, is estimated to be 176.5 tpd in 1970 and 262.5 tpd in 1990. Two alternative refuse-burning systems were proposed by Foster Wheeler. The first alternative incorporates a reciprocating grate stoker; the second, a spreader stoker. The boiler using a reciprocating grate stoker has a capacity of 384 tpd; the one using a spreader stoker has a capacity of 612 tpd. The refuse-burning systems are explained in detail in Chapter 8 and compared in Chapter 10.

The inclusion of additional refuse in both boiler concepts is possible. The total of residential, commercial, and industrial refuse generated in the

City of Lynn is estimated to be 238 tpd and 354 tpd in 1970 and 1990, respectively. The estimated refuse generation rate for several neighboring communities is presented in Table 5.

Table 5. Estimated 1970 Refuse Production in Nahant, Saugus and Swampscott

Community	Tons per day
Nahant	11
Saugus	65
Swampscott	30

Those communities listed in Table 5 could be included initially regardless of the refuse-burning system selected. If the 384 tpd reciprocating grate stoker is selected, however, one or more of these communities will have to be phased out of the operation as the refuse load increases. If the 612 tpd reciprocating grate stoker is selected other communities in addition to those listed in Table 5 could be included in the system. As explained previously in this chapter, we feel that there will be sufficient refuse available in the area to enable the complete utilization of either refuse-burning system.

CHAPTER 6

DESCRIPTION OF BASIC ALTERNATIVES

General

As shown on Figure 1, a natural boundary, the Saugus River, separates the proposed site for the refuse delivery area (referred to as the process plant) from General Electric's boiler complex. Because of this boundary and as a result of correspondence with the Bureau of Solid Waste Management of the U.S. Public Health Service, three major alternatives were investigated:

A. In Alternative A, the process plant is located on the south side of the Saugus River in the marshland presently used by General Electric as a dump. Either the refuse is all shredded at this process plant or the bulky wastes only are shredded and then conveyed across the Saugus River, a distance of approximately 800 feet, to the General Electric boiler complex on the north side of the Saugus River. Here the refuse is burned in the steam-generating boiler.

B. In Alternative B, both the process plant and the boiler are located on the south side of the Saugus River. Saturated steam is conveyed to the General Electric Company, where it is superheated in a separately fired superheater owned and operated by the General Electric Company

C. In Alternative C, both the process plant and the boiler are located in the General Electric yard on the north side of the Saugus River. There is not sufficient area available for this alternative and, because of security problems, General Electric does not desire to have refuse vehicles entering its plant. However, an economic feasibility study of combined boiler and preparation facilities located at the existing boiler facility in General Electric's plant was undertaken for comparison purposes.

Each of the above alternatives is studied using one of the following:

1. Reciprocating grate stoker with a capacity of 16 tph (tons per hour), 384 tpd.

II. Spreader stoker with a capacity of 25.5 tph, 612 tpd. The maximum size of refuse that can be fed onto the spreader stoker is 4 inches in the longest dimension.

In addition, under Alternative A, using a reciprocating grate stoker, which does not require that normal refuse be shredded, the use of a shredder and storage silo is investigated. Shredded refuse does not require as wide a conveyor as does nonshredded refuse. As it is possible to meter the refuse discharging from a silo, the plant staff requirements could be reduced. This study will determine if the additional investment necessary for shredders, silos, and associated equipment will result in an overall economic benefit.

The several alternatives described above are hereinafter referred to by a capital letter, a Roman numeral, and where necessary, a small letter is used to distinguish between different minor concepts of the same basic alternative. For example, consider Alternative B-II. The letter B means both the process plant and the boiler are located on the south side of the Saugus River and that steam is conveyed to the General Electric Company. The Roman numeral II refers to the type of stoker used, in this case, a spreader stoker with a capacity of 612 tons of refuse per day. A summary of the seven alternatives studied in this report is shown in Table 6.

The seven alternatives, A-Ia, A-Ib, A-II, B-I, B-II, C-I and C-II, are explained in detail in the following sections of this chapter. A schematic flow diagram of each system is included in the respective sections. In addition, a site plan, a preliminary building design, and an equipment arrangement is included for alternatives A-Ia, A-II, B-I and B-II.

The background behind the size and capacity of the units selected in the following sections of this chapter is explained in Chapters 7 and 8. The personnel necessary to operate each alternative are discussed in Chapter 11.

Alternative A-Ia

Under Alternative A-Ia, the process plant is owned and operated by the City of Lynn. It is located on the south side of the Saugus River. Refuse is conveyed across the Saugus River to a boiler located in the General Electric plant. The boiler is owned and operated by the General Electric Company, and employs a reciprocating grate stoker capable of handling 384 tons of refuse per day. A schematic flow diagram is shown on Figure 4. A site plan, a preliminary building design, and an equipment layout are shown on Figures 5 and 6.

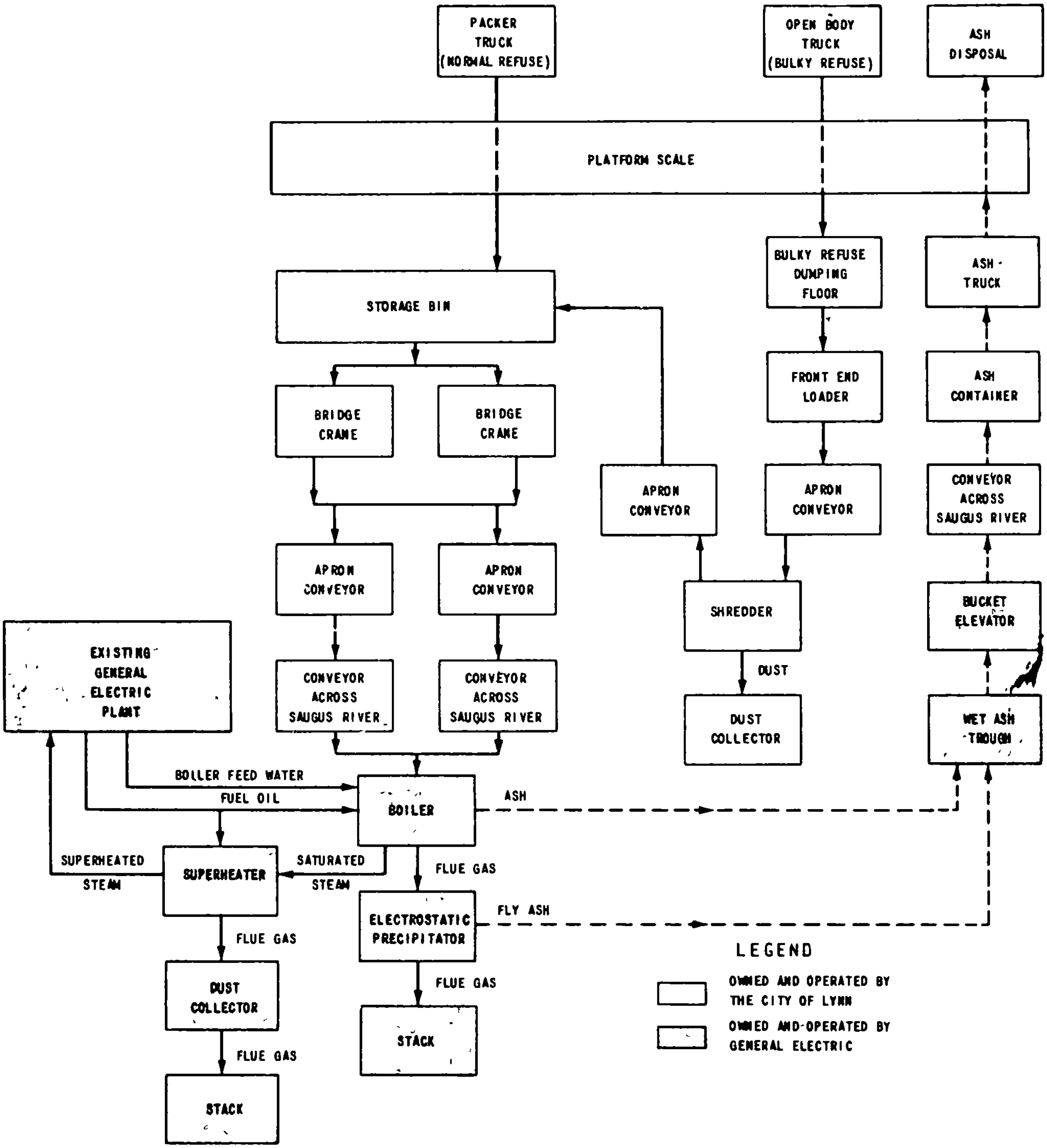
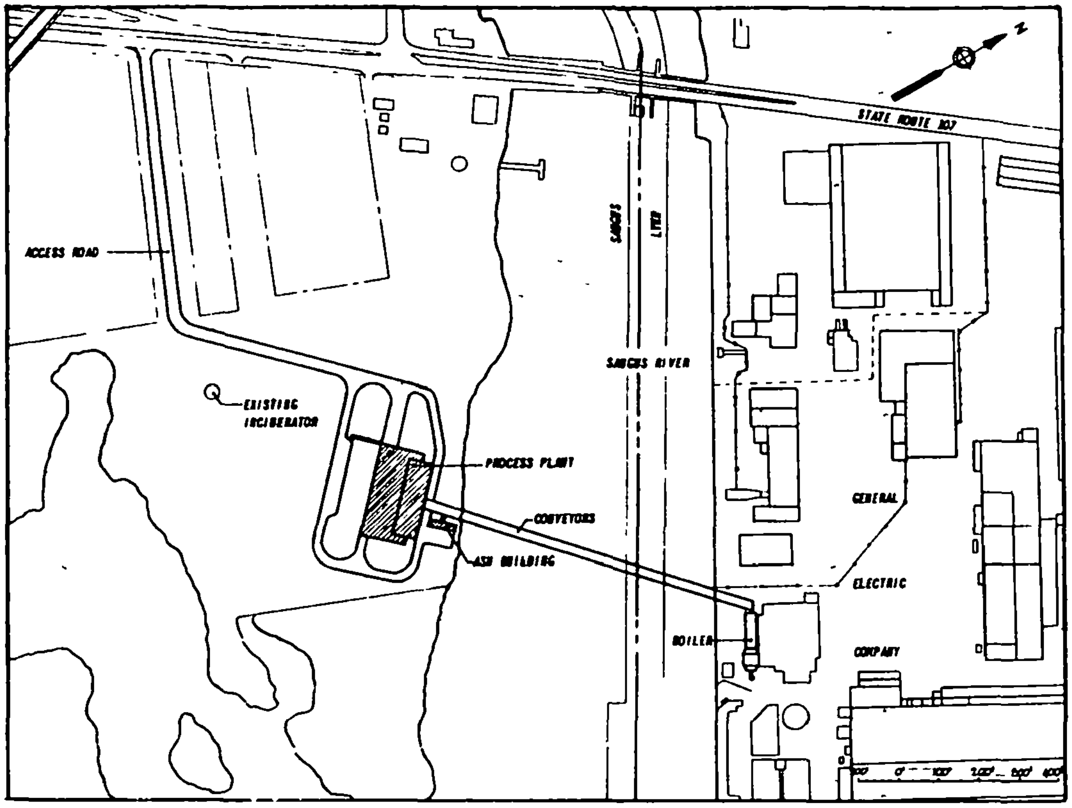
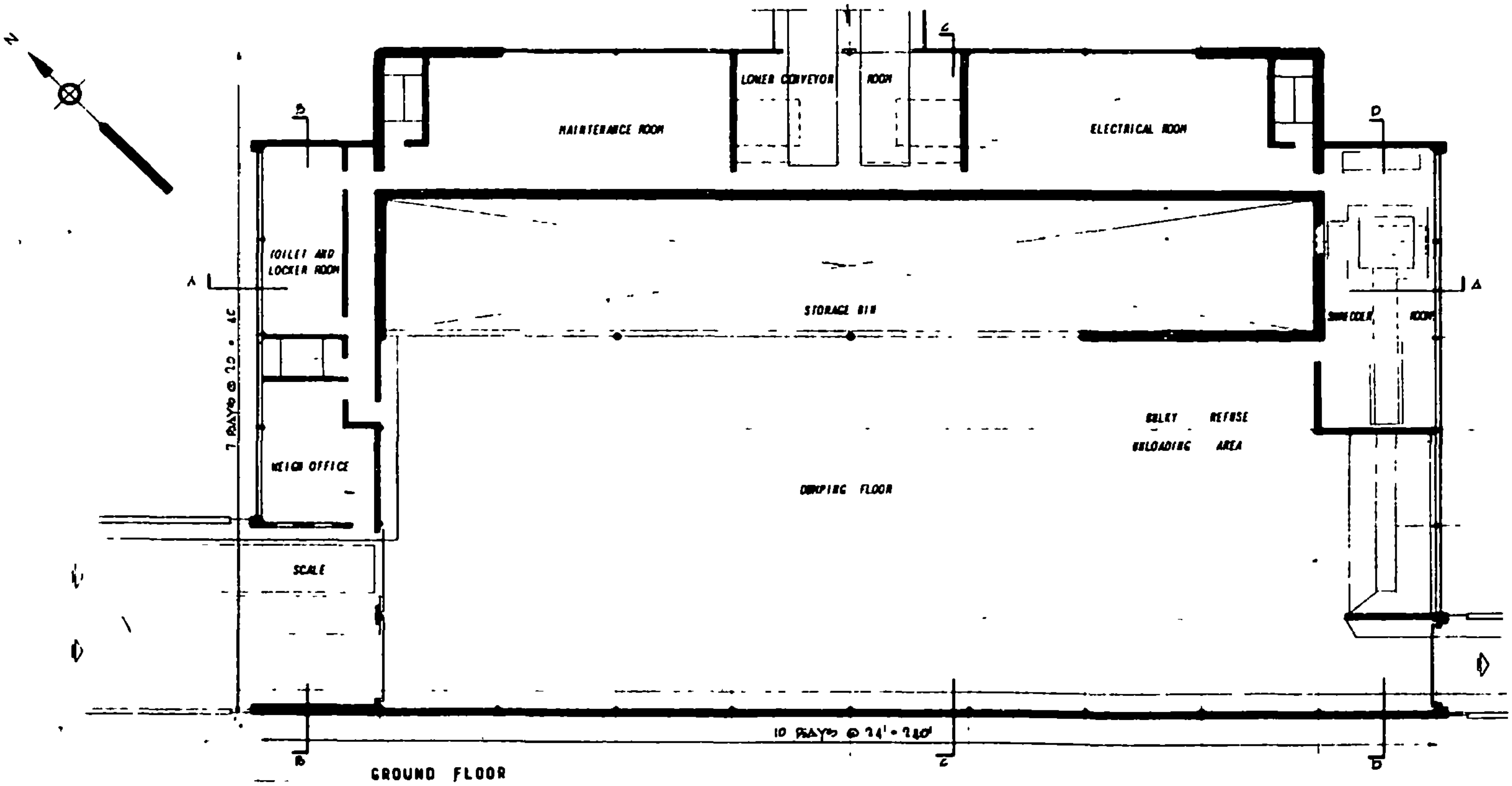


FIG. 4 SCHEMATIC FLOW DIAGRAM - ALTERNATIVE A-1a

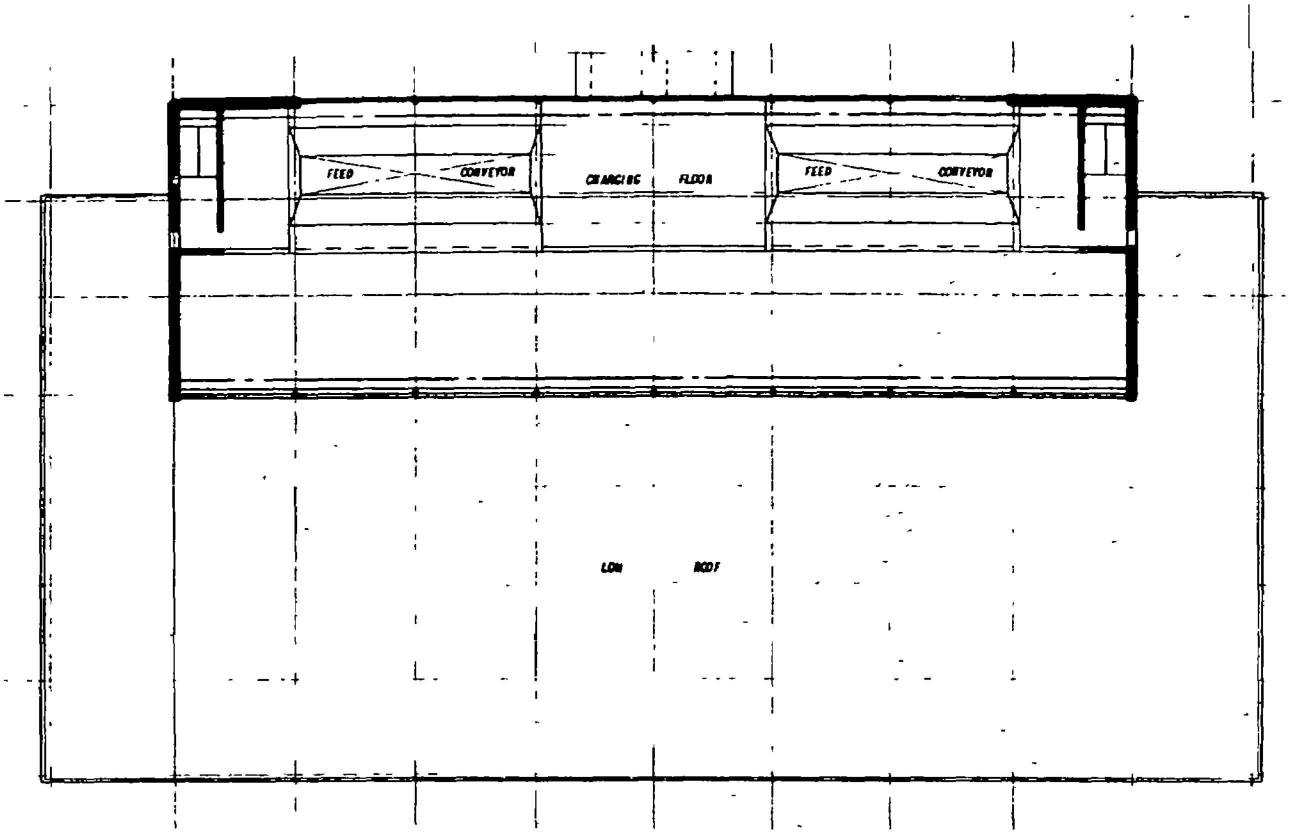


SITE PLAN

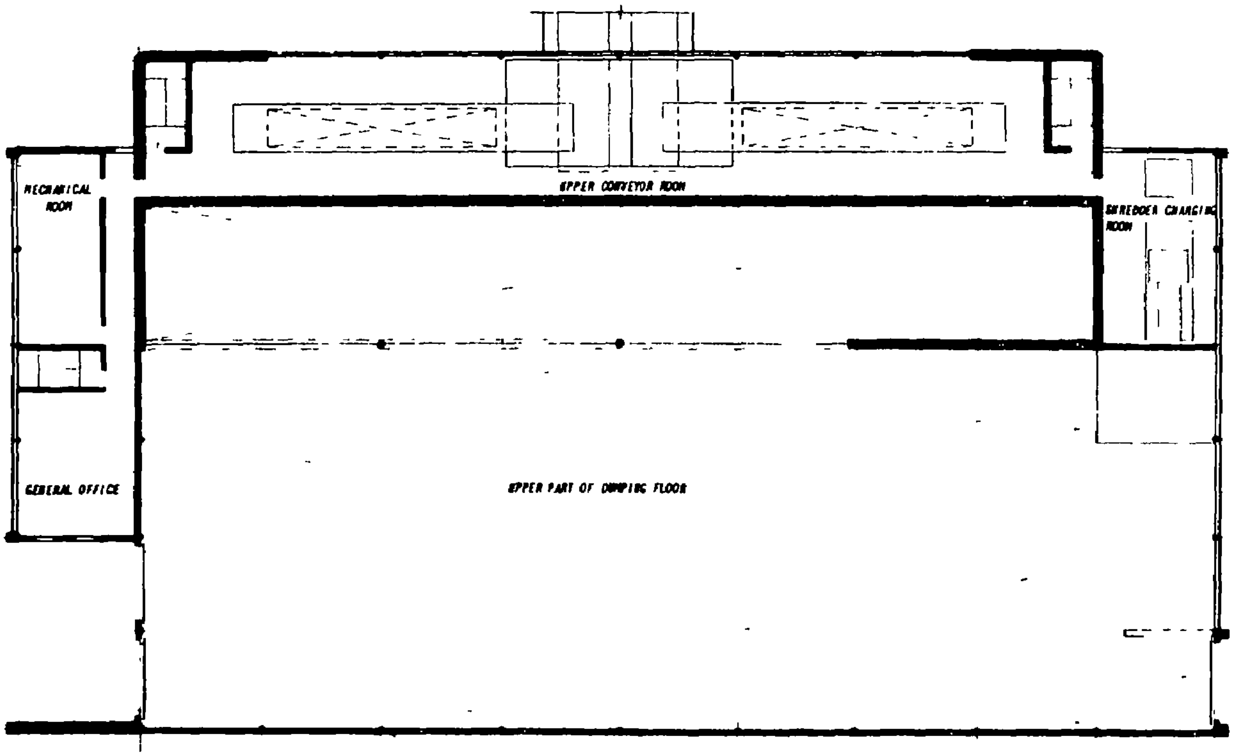


GROUND FLOOR

FIG. 5 ALTERNATIVE A-1a
SITE PLAN AND PLANS



UPPER FLOOR



MEZZANINE

FIG. 5 ALTERNATIVE A-1a - SITE PLAN AND PLANS (CONT'D)

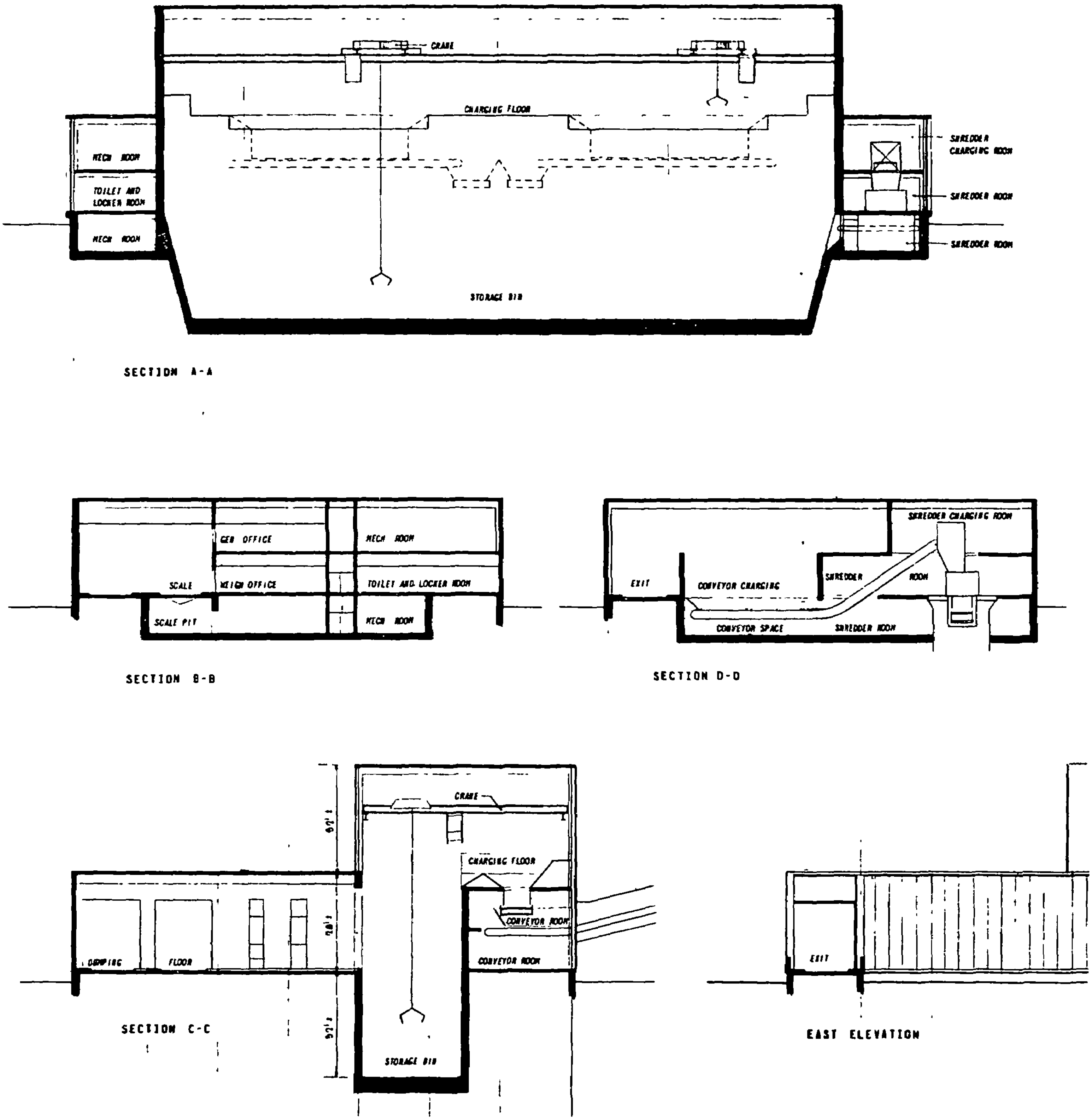
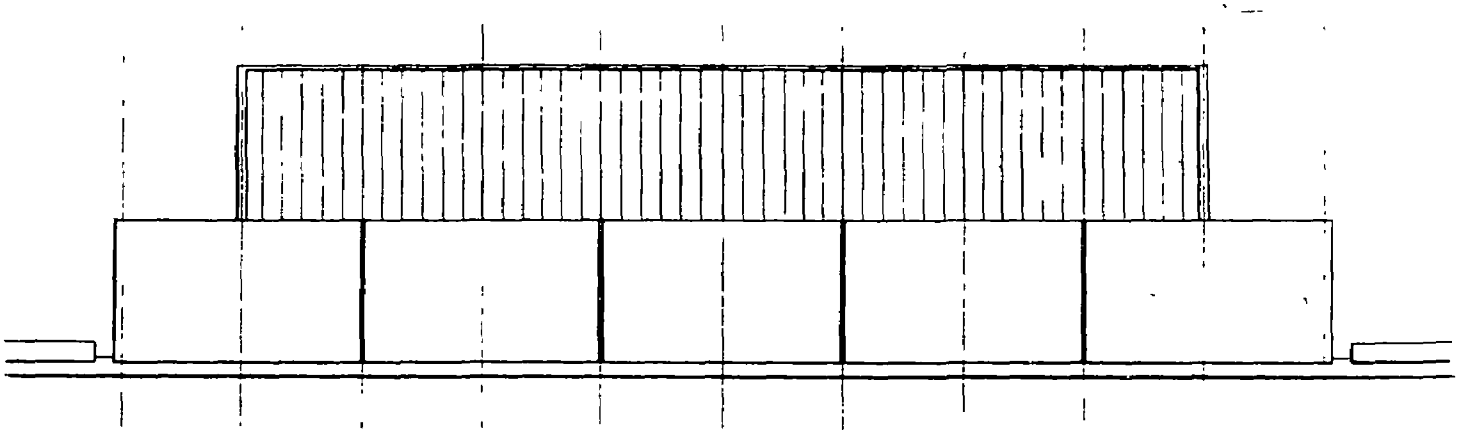
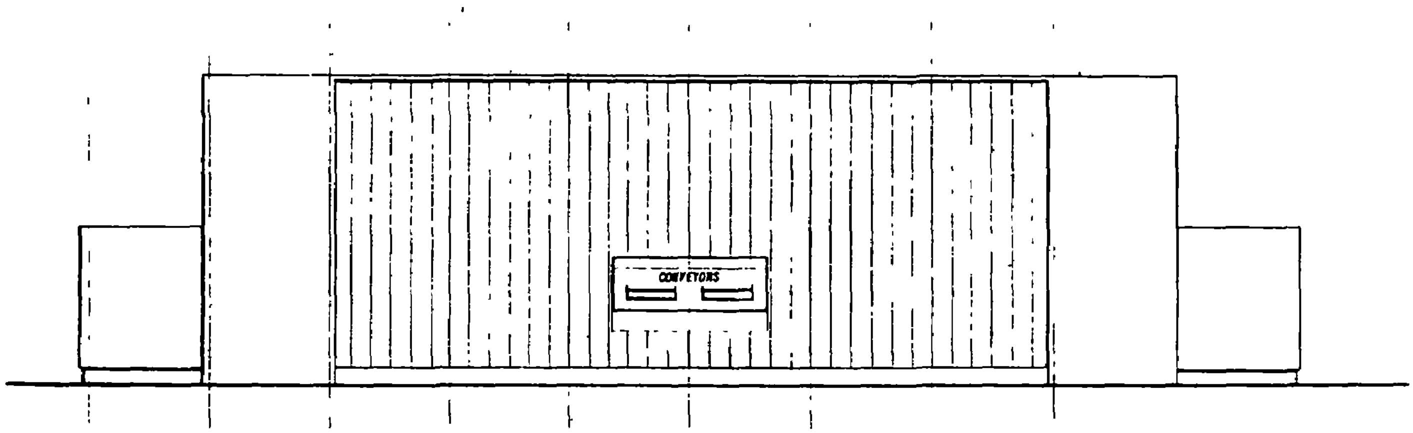


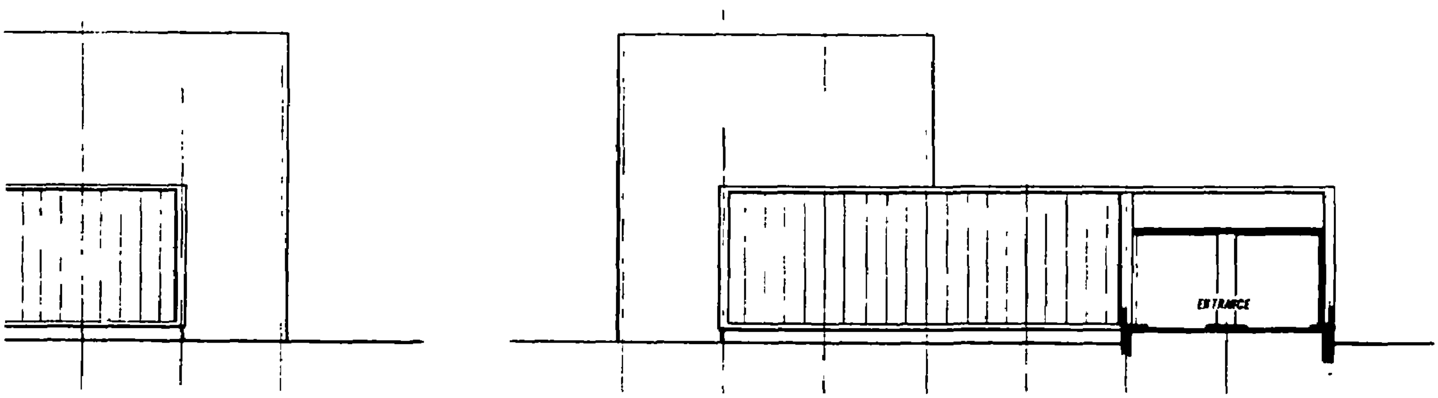
FIG. 6 ALTERNATIVE A-1a
SECTIONS AND ELEVATIONS



SOUTH ELEVATION



NORTH ELEVATION



WEST ELEVATION

FIG. 6 ALTERNATIVE A-1a - SECTIONS AND ELEVATIONS (CONT'D)

Table 6. Summary of Alternatives

	Process location			
Alternative	Preparation plant	Boiler	Type of stoker	Degree of preparation
A-Ia	Saugus	General Electric	Reciprocating grate	Bulky waste shredding only
A-Ib	Saugus	General Electric	Reciprocating grate	Complete shredding
A-II	Saugus	General Electric	Spreader	Complete shredding
B-I	Saugus	Saugus	Reciprocating grate	Bulky waste shredding only
B-II	Saugus	Saugus	Spreader	Complete shredding
C-I	General Electric	General Electric	Reciprocating grate	Bulky waste shredding only
C-II	General Electric	General Electric	Spreader	Complete shredding

Trucks carrying normal refuse will be weighed on the platform scale prior to entering the process plant The trucks will then proceed across the dumping floor and empty into the storage bin.

Trucks hauling bulky refuse will also be weighed. These trucks will dump directly on the dumping floor in the area designated for bulky wastes shown on Figure 5. The bulky wastes will be loaded by means of a front-end loader onto an apron conveyor where they are fed into a shredder. The shredded refuse will be conveyed directly from the shredder into the storage bin.

The process plant would be open for delivery of refuse 8 hours per day, Monday through Friday. The intent is to provide a 40-hour normal shift work week for as many of the employees as possible. Plant staff requirements are discussed in a separate chapter of this report.

The refuse storage bin has a capacity for 2.8 days' volume, based on the stoker rate of 384 tpd.

The refuse will be removed from the storage bin by one of two 3-cubic yard bridge cranes and placed on one of two apron conveyors. Each bridge crane will be capable of handling the design rate of the boiler (16 tph). Only one crane will be in operation; the other acts as a standby. The crane will continually load refuse onto the apron conveyors 24 hours a day, 7 days a week.

The apron conveyor discharges onto a 10-foot wide belt conveyor which carries the refuse 800 feet across the Saugus River, to the boiler. There are two 10-foot wide belts, one acting as a standby. The boiler produces saturated steam. The steam is superheated in a separately fired superheater and put into the General Electric distribution system.

Boiler feedwater, fuel oil and power for the boiler and separately fired superheater will be obtained from existing facilities at the General Electric Company. In addition, the General Electric Company will provide the power necessary to run the process plant.

The residue from the boiler will be collected and quenched at the General Electric plant and then conveyed back across the Saugus River to ash containers. A complete description of the residue handling system is given in Chapter 7.

Alternative A-II

Under Alternative A-II, the process plant is owned and operated by the City of Lynn. It is located on the south side of the Saugus River. The refuse will be shredded and conveyed across the Saugus River to a boiler located in the General Electric plant. The boiler is owned and operated by the General Electric Company, and employs a spreader-stoker capable of handling 612 tons of refuse per day. A schematic flow diagram is shown on Figure 7. A site plan, a preliminary building design, and an equipment layout are shown on Figures 8 and 9.

Trucks carrying all types of refuse will be weighed on the platform scale prior to entering the process plant. The trucks will then progress across the dumping floor and empty into the storage bin.

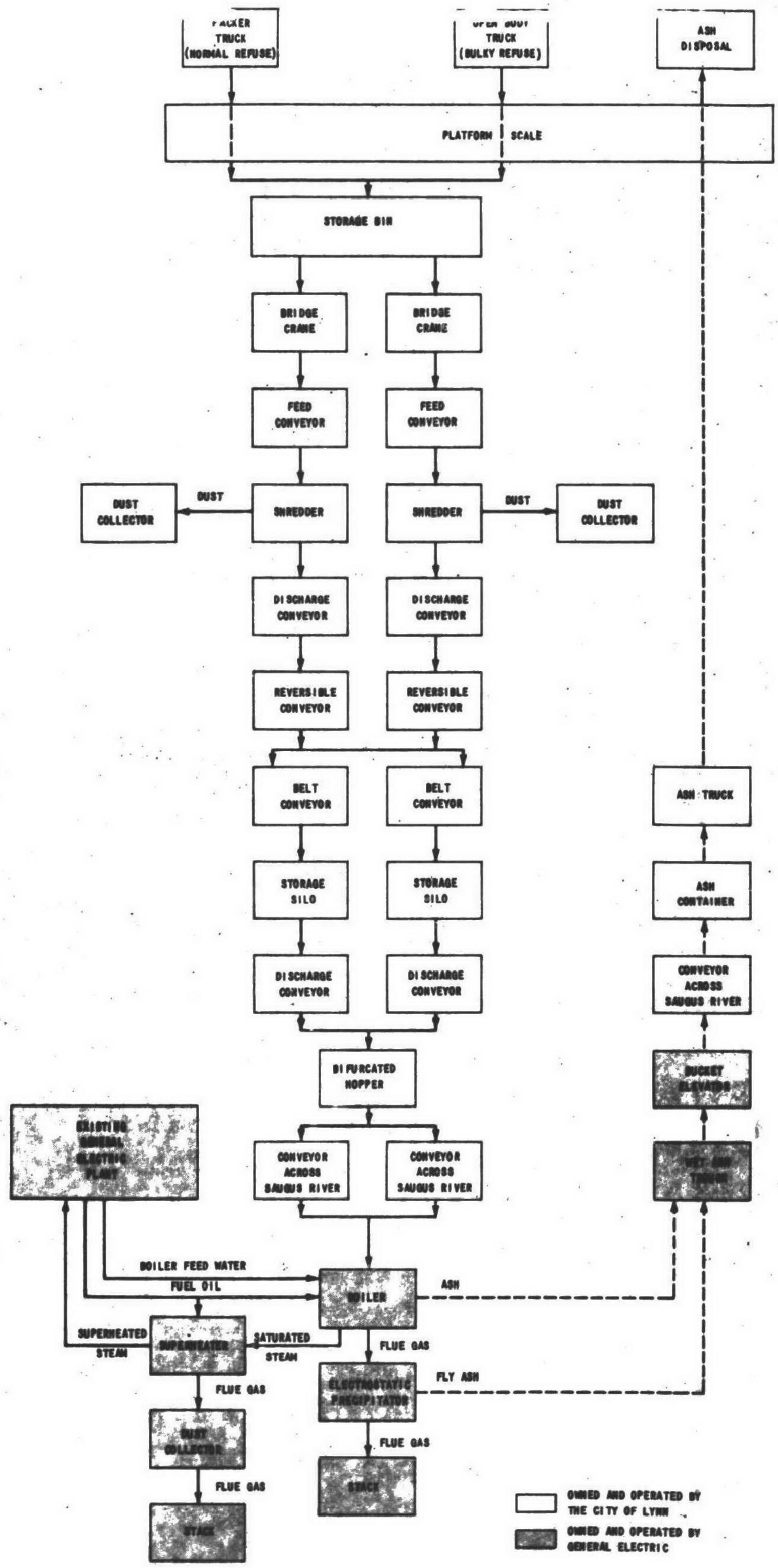
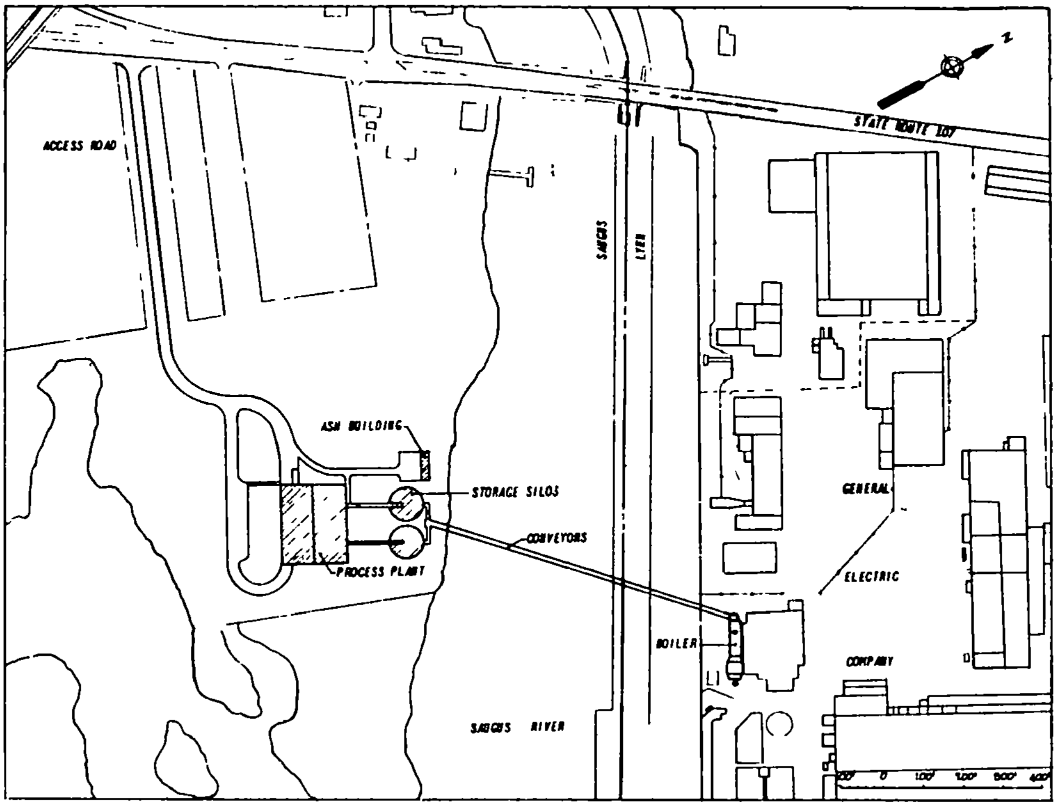
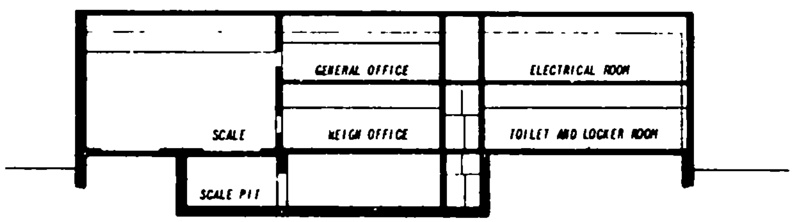


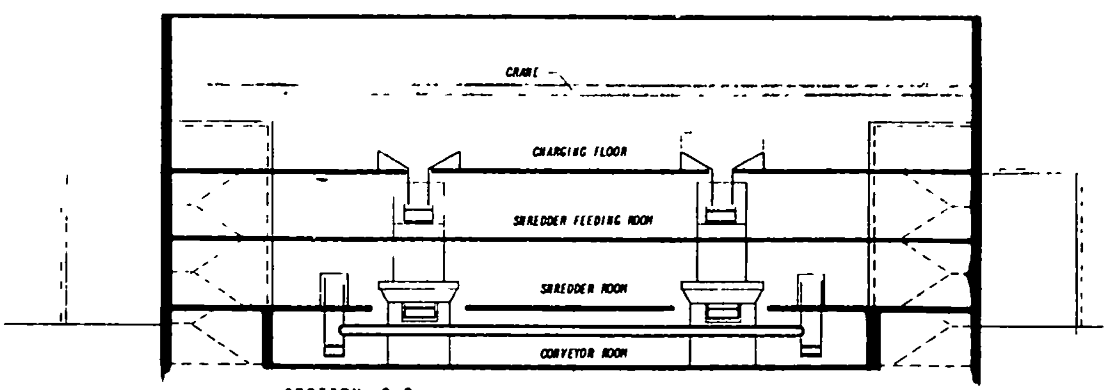
FIG. 7 SCHEMATIC FLOW DIAGRAM - ALTERNATIVES A-Ib AND A-II



SITE PLAN



SECTION A-A



SECTION B-B

FIG. 8 ALTERNATIVE A-II - SITE PLAN, PLANS AND SECTIONS

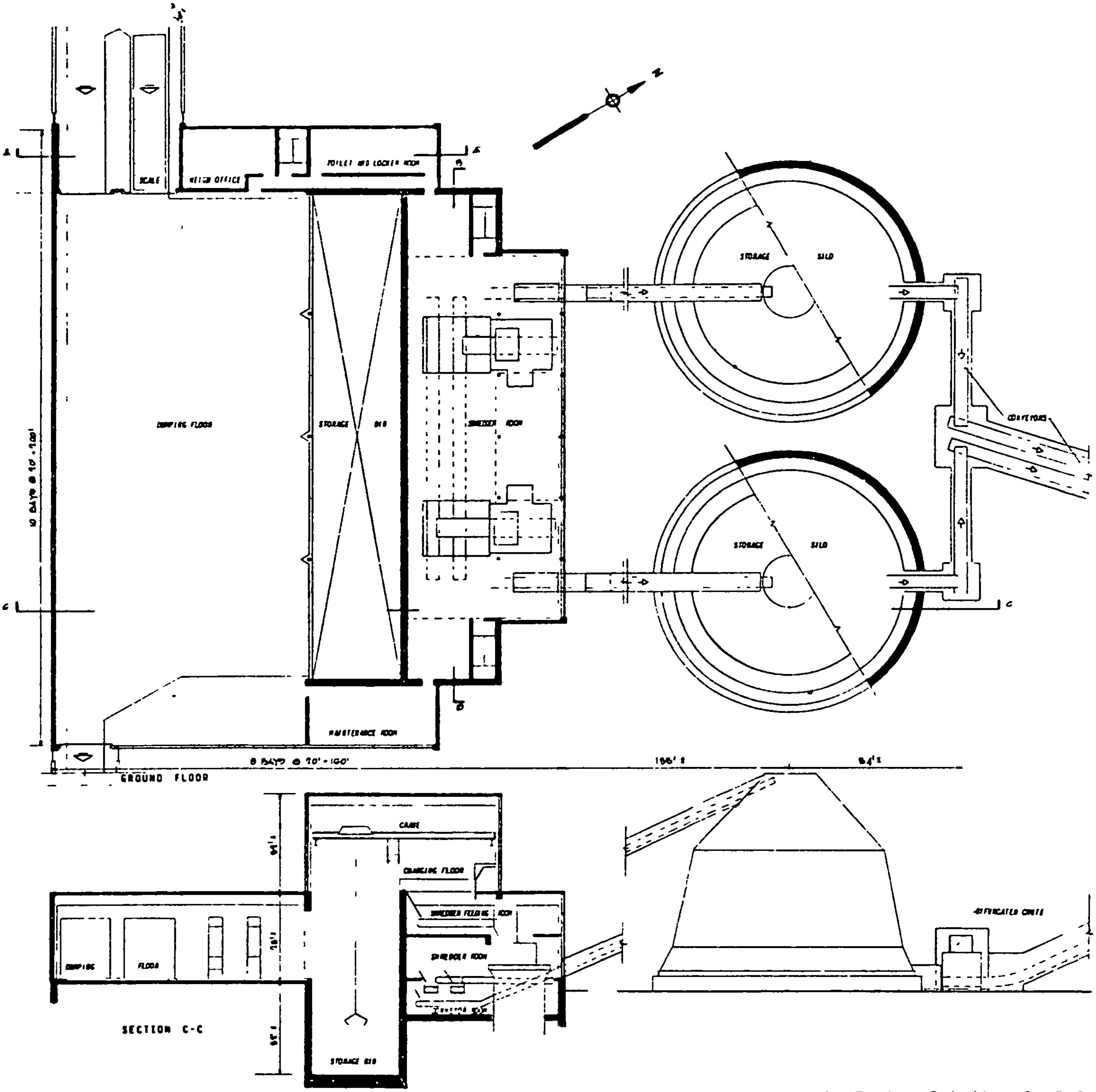


FIG. 8 ALTERNATIVE A-II - SITE PLAN, PLANS AND SECTIONS (CONT'D)

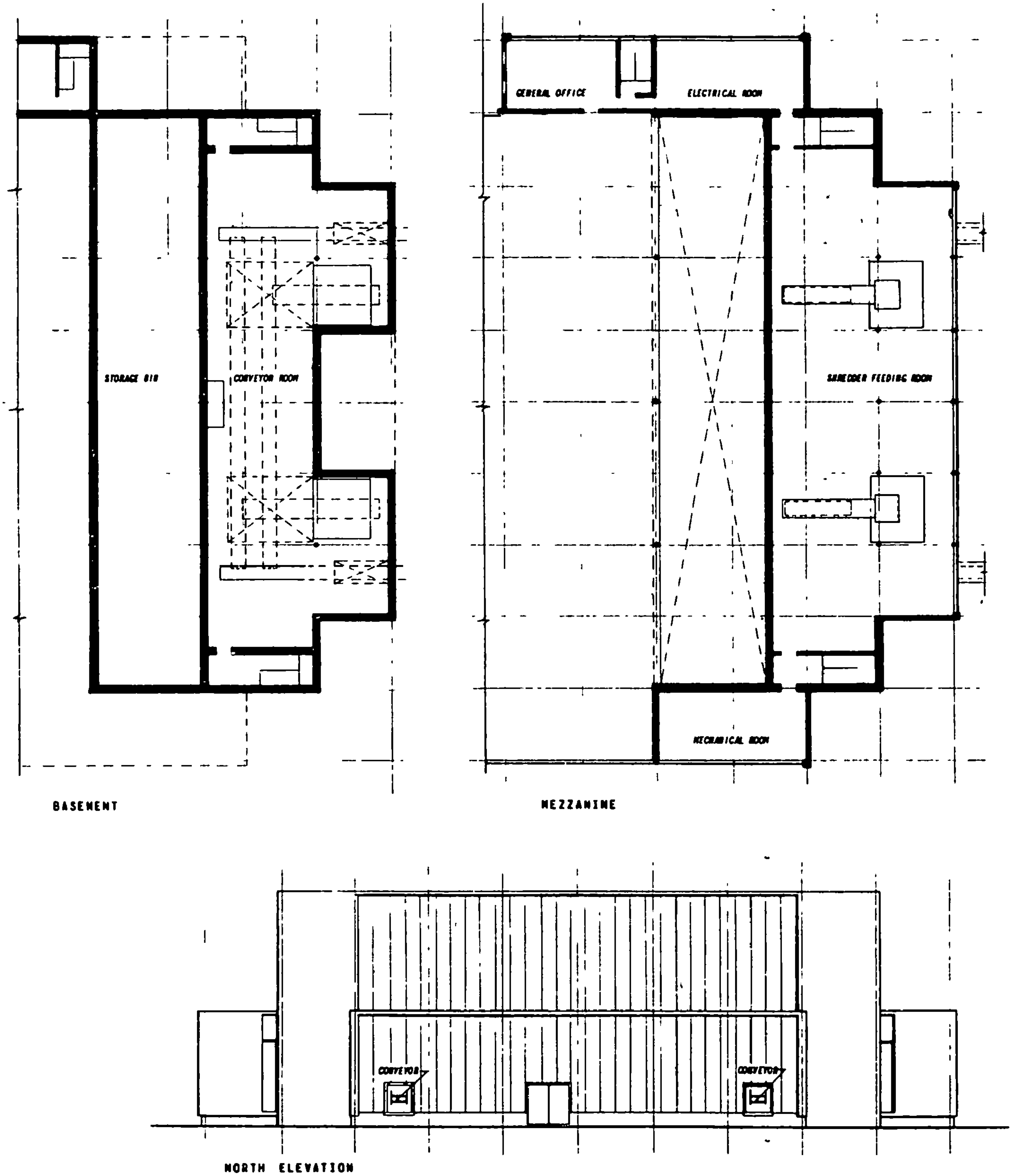
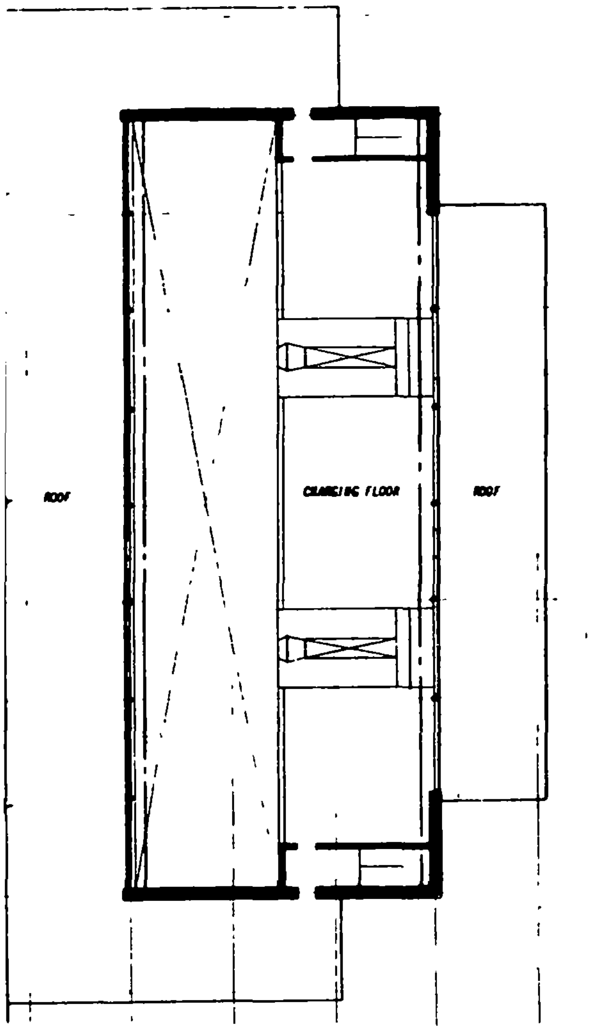
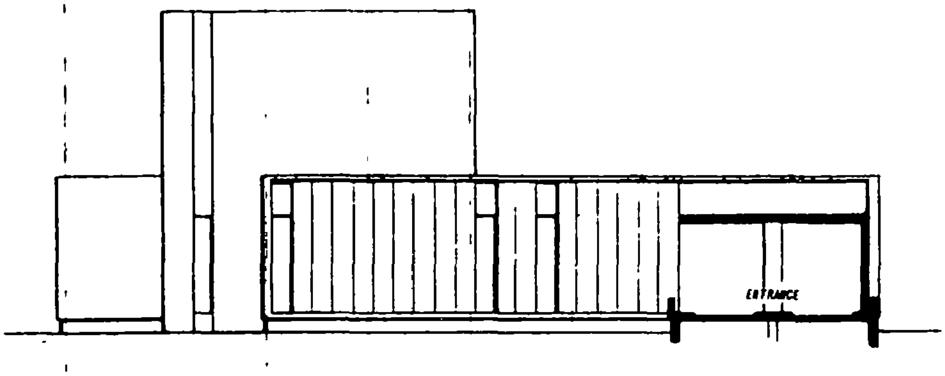


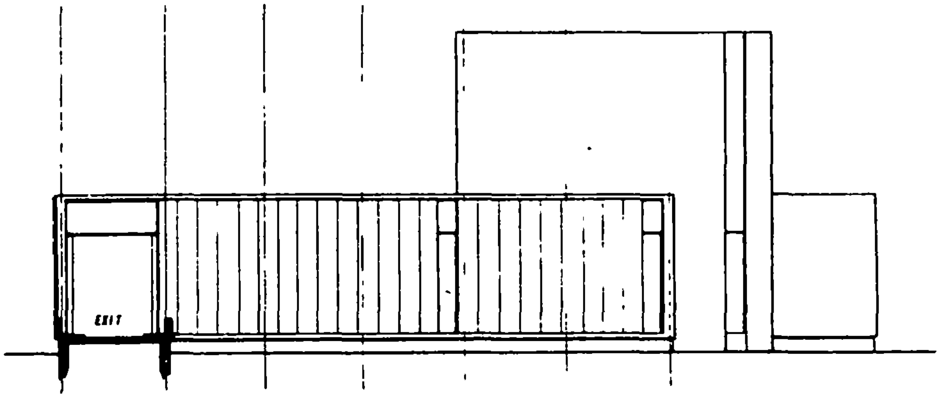
FIG. 9 ALTERNATIVE A-II -
PLANS AND ELEVATIONS



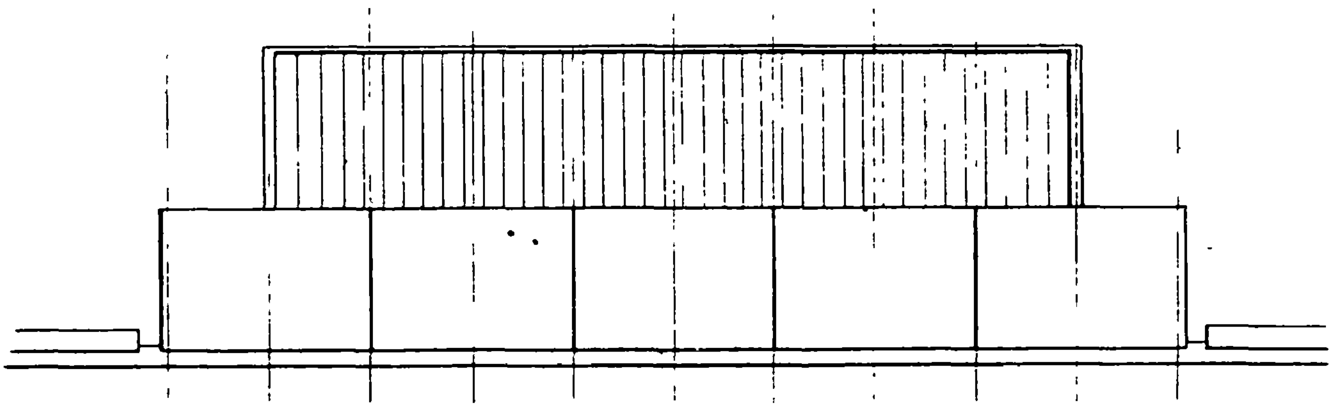
UPPER FLOOR



WEST ELEVATION



EAST ELEVATION



SOUTH ELEVATION

FIG. 9 ALTERNATIVE A-II -
PLANS AND ELEVATIONS (CONT'D)

Again, as in Alternative A-Ia, the process plant would be open to the delivery of refuse 8 hours per day, Monday through Friday. The refuse storage bin will have a capacity of 1.4 days' storage, based on the stoker rate of 612 tpd.

The refuse will be removed from the storage bin by one of two 5-cubic yard bridge cranes and placed on one of two apron conveyors. Each apron conveyor feeds a shredder. Both cranes, the apron conveyors, and the shredders will be operated for 16 hours a day, 5 days a week. The shredder will have a capacity of up to 35 tph, and a product size output of 4 inches in maximum dimension After shredding, the refuse will be discharged onto a transfer conveyor, suitably designed to withstand the shock of the material being processed through the shredder. From this conveyor, the refuse will be conveyed by a series of reversible-belt conveyors into either of two silos. Each silo has a capacity of 910 tons of refuse. The silos shown will not only be used for storage, but also as a metering device. Each silo will be capable of discharging at a rate equal to 610 tpd (25.5 tph).

The silos discharge onto conveyors, which feed a bifurcated hopper. The bifurcated hopper can feed either of two 36-inch belt conveyors for transfer across the Saugus River (approximately 800 feet) to the boiler. There will be two 36-inch wide belts, one acting as a standby. The boiler will produce saturated steam. The steam will be superheated in a separately fired superheater and put into the General Electric distribution system.

As in Alternative A-Ia, all utilities will be supplied by the General Electric Company.

The residue from the boiler will be collected and quenched at the General Electric plant, and then conveyed back across the Saugus River to ash containers. The complete description of the residue handling is given in Chapter 7.

Alternative A-Ib

Alternative A-Ib is similar to Alternative A-II with the following exceptions:

a. A reciprocating grate stoker with a capacity of 384 tpd will be used rather than a spreader stoker.

b. The buildings and equipment will be sized based on a burning rate of 384 tpd rather than 612 tpd.

c. The cranes, apron conveyors, and shredders will operate 8 hours per day, 5 days per week rather than 16 hours per day.

d. Each silo will have a capacity of 650 tons rather than 910 tons and will discharge 16 tons per hour rather than 25.5 tons per hour.

e. The belt conveyor across the Saugus River will be 30 inches wide rather than 36 inches.

A schematic flow diagram is shown on Figure 7. The site plan, preliminary building design, and equipment layout shown on Figures 8 and 9 for Alternative A-II are applicable, with the exceptions noted above, to Alternative A-Ib.

The size of the process plant, the size of the river crossing structure, the width of the major conveyors, and the labor requirements would be less than in an alternative of the same size which does not employ shredding (i.e., as Alternative A-Ia). A comparison of Alternatives A-Ia and A-Ib will show whether shredding can be economically justified, if the stoker requirements do not dictate it.

Alternative B-I

Under Alternative B-I, the process plant and the boiler are owned and operated by the City of Lynn. They are located on the south side of the Saugus River. Saturated steam will be conveyed to the General Electric Company, where it will be superheated in a separately fired superheater, owned and operated by the General Electric Company. The boiler employs a reciprocating grate stoker, capable of handling 384 tons of refuse per day. A schematic flow diagram is shown on Figure 10. A site plan, a preliminary building design, and an equipment layout are shown on Figures 11 and 12.

Trucks carrying normal refuse will be weighed on the platform scale prior to entering the process plant. Trucks will then proceed across the dumping floor and empty into the storage bin.

Bulky wastes will be handled in the same manner they were in Alternative A-Ia. The plant would also be open for delivery of refuse the same number of hours as in Alternative A-Ia. The refuse storage bin will have

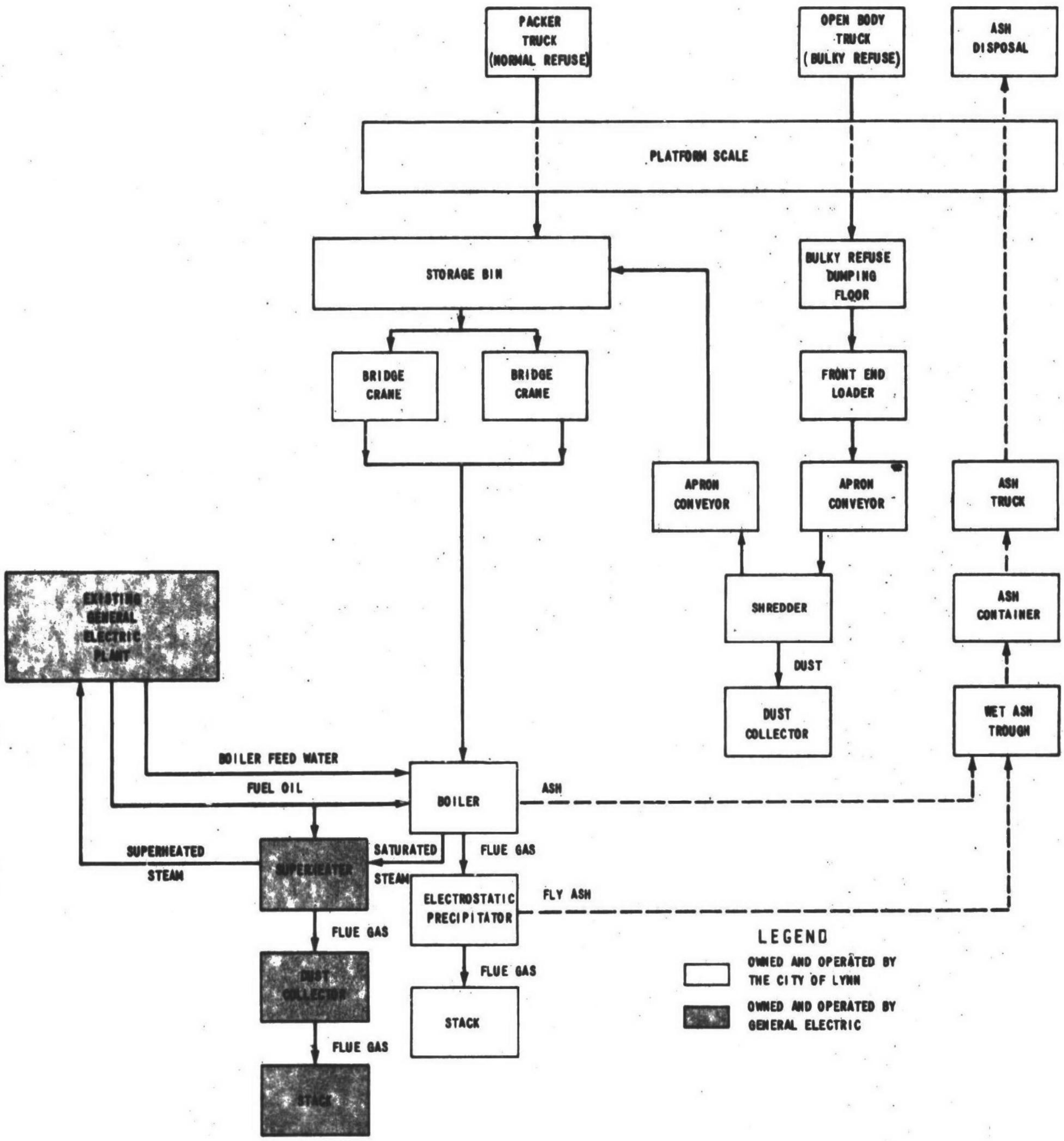


FIG. 10 SCHEMATIC FLOW DIAGRAM - ALTERNATIVE B-1

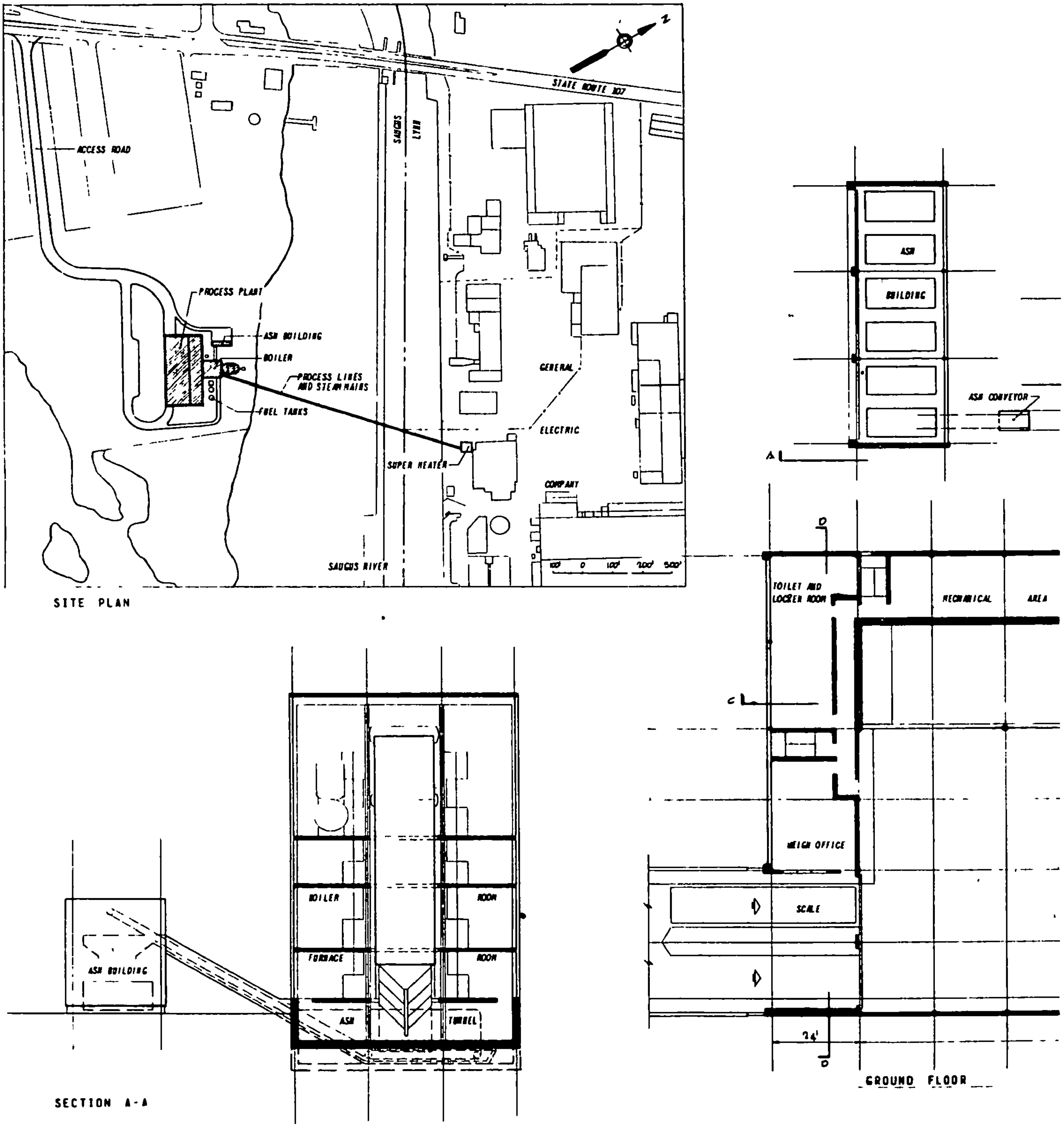


FIG. 11 ALTERNATIVE B-1 - SITE PLAN, PLAN AND SECTIONS

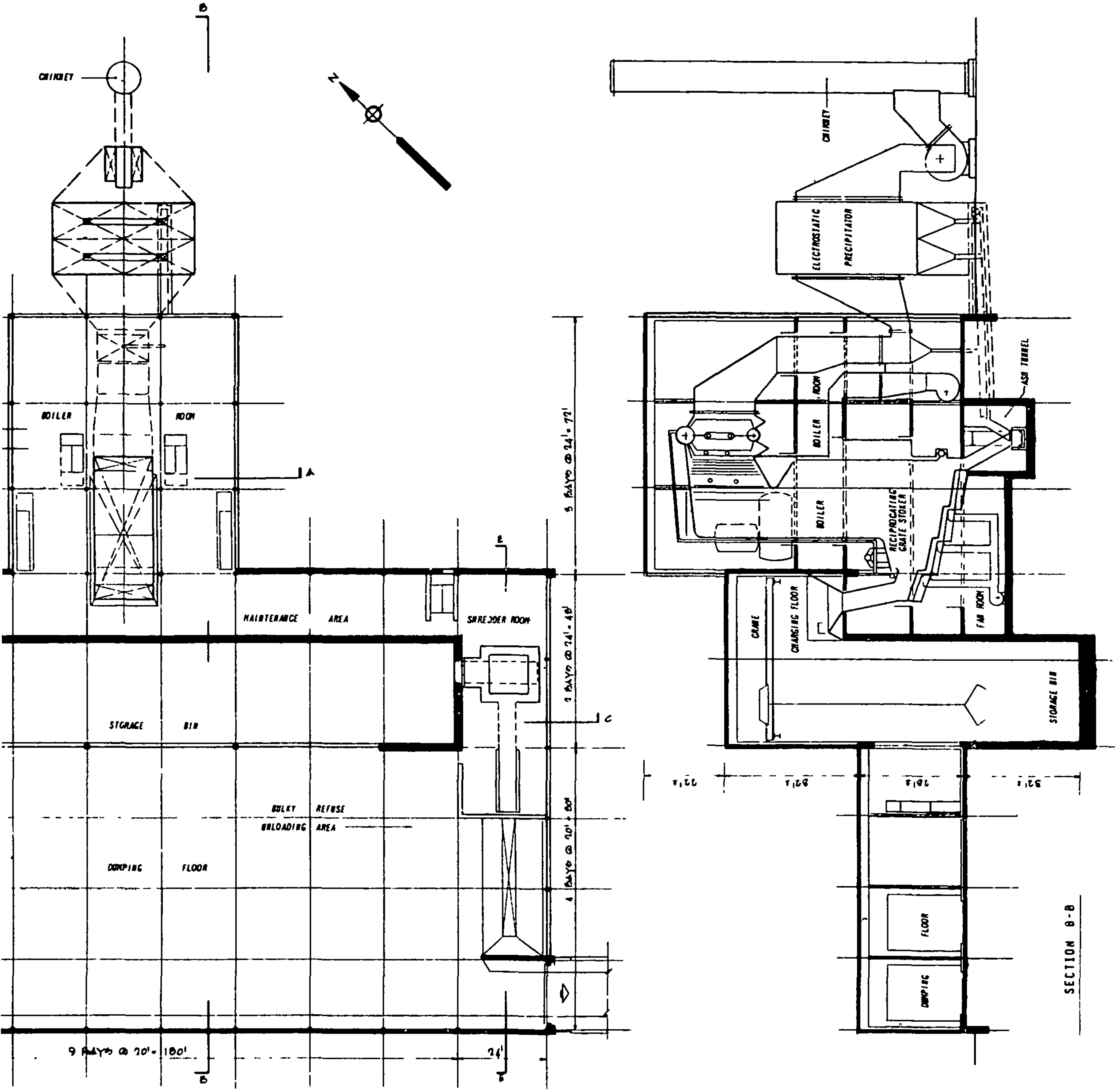


FIG. 11 ALTERNATIVE B-1 - SITE PLAN, PLAN AND SECTIONS (CONT'D)

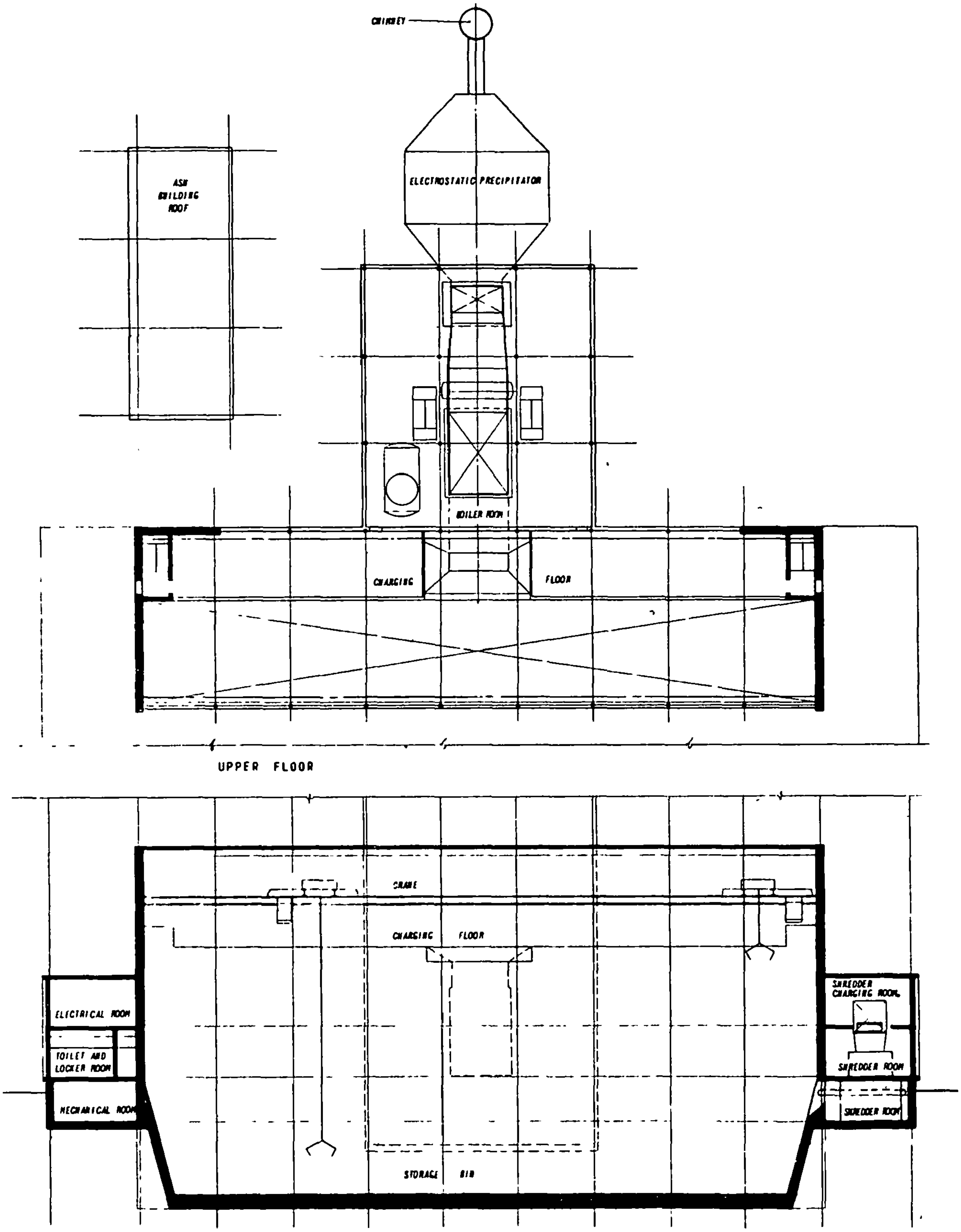
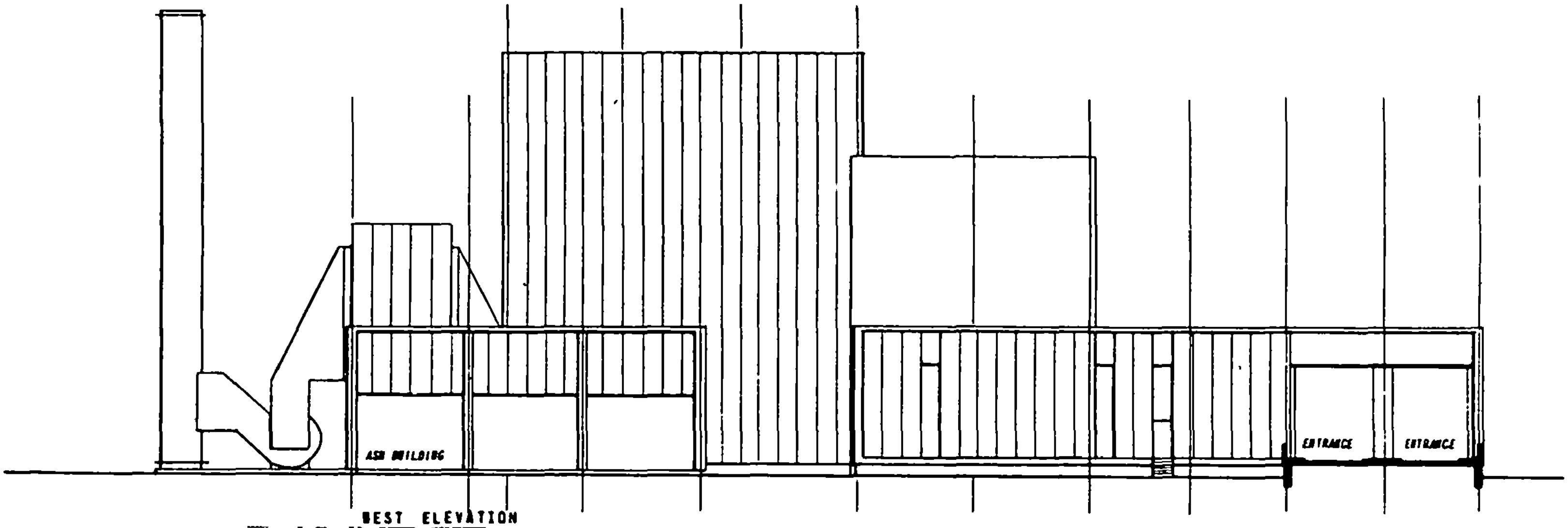
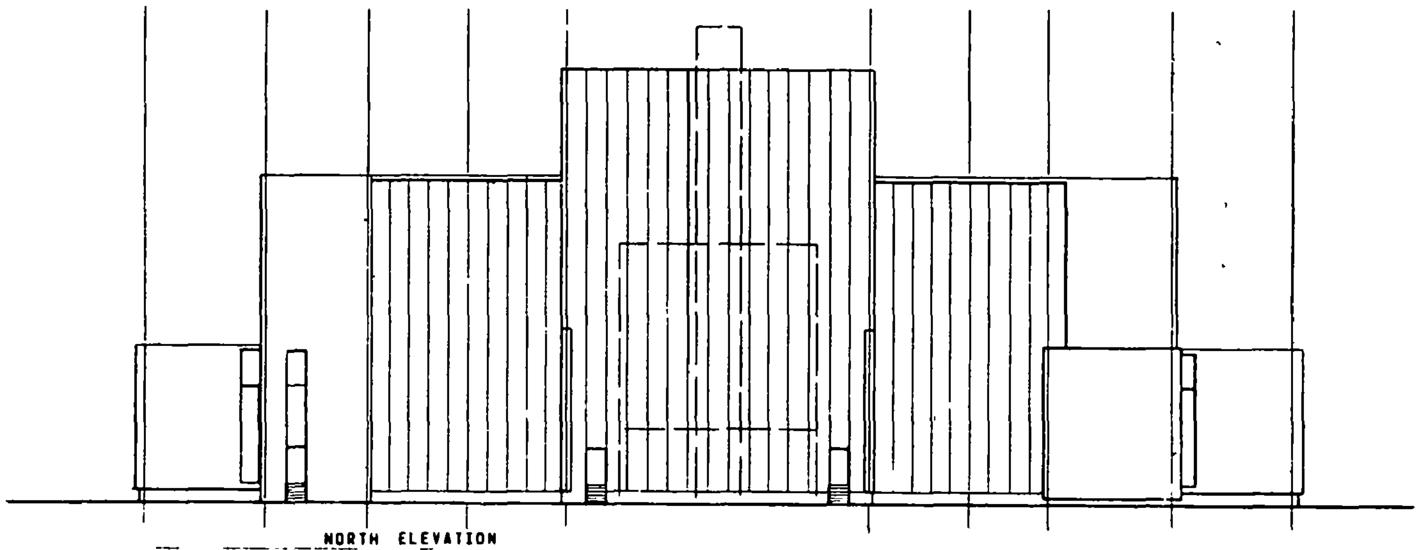


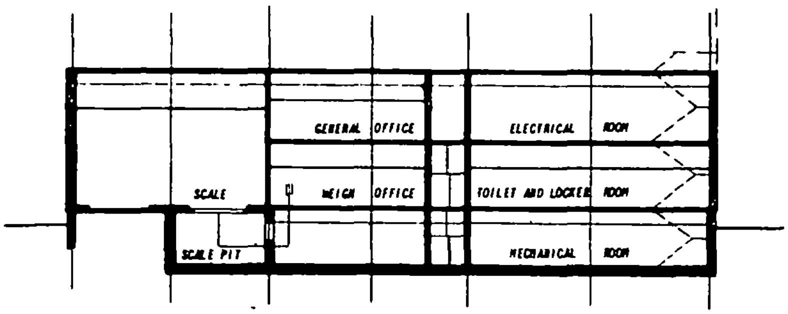
FIG. 12 ALTERNATIVE B-I - PLANS, SECTIONS AND ELEVATIONS



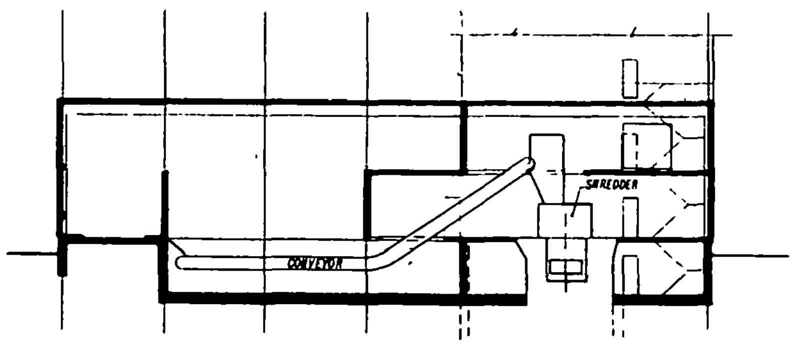
WEST ELEVATION



NORTH ELEVATION



SECTION D-D



SECTION E-E

FIG. 12 ALTERNATIVE B-1 - PLANS, SECTIONS AND ELEVATIONS (CONT'D) a capacity for 2.8 days' storage, based on the stoker capacity of 384 tpd. The refuse will be removed from the storage bin by one of two 3-cubic yard bridge cranes and placed directly in the hopper of the boiler as shown on Figure 11. Each bridge crane will be capable of handling the design rate of 16 tph. Only one crane will be in operation, the other acting as a standby. The crane will continually load refuse into the boiler-hopper 24 hours a day, 7 days a week. The boiler will produce saturated steam; this steam will be conveyed 800 feet across the Saugus River to the separately fired superheater located in the General Electric plant. The saturated steam will be superheated and put into the General Electric distribution system.

Boiler feedwater, fuel oil, and power for the boiler and the process plant will be brought across the Saugus River, from the General Electric Company, to the process plant and boiler located on the Saugus side of the river.

The residue from the boiler and the precipitator will be collected and quenched in a trough underneath the boiler and conveyed up and into the ash building where it will be dumped into containers. A complete description of the residue handling is given in Chapter 7.

Alternative B-II

Under Alternative B-II, the process plant and the boiler with spreader-type stoker are owned and operated by the City of Lynn. They are located on the south side of the Saugus River. Saturated steam will be conveyed to the General Electric Company, where it will be superheated in a separately fired superheater, owned and operated by the General Electric Company. A schematic flow diagram is shown on Figure 13. A site plan, a preliminary building design, and an equipment layout are shown on Figures 14 and 15.

Trucks carrying all types of refuse will be weighed on the platform scale prior to entering the process plant The trucks will then proceed across the dumping floor and empty into the storage bin. The plant will be open for the delivery of refuse during the same hours as Alternative A-Ia. The refuse storage bin will have a capacity for 1.4 days' storage, based on a stoker rate of 610 tpd.

The refuse will be removed from the storage bin, placed on conveyors, shredded, conveyed into silos, and metered from the silos in the same manner as in Alternative A-II. The silos will discharge onto a series of

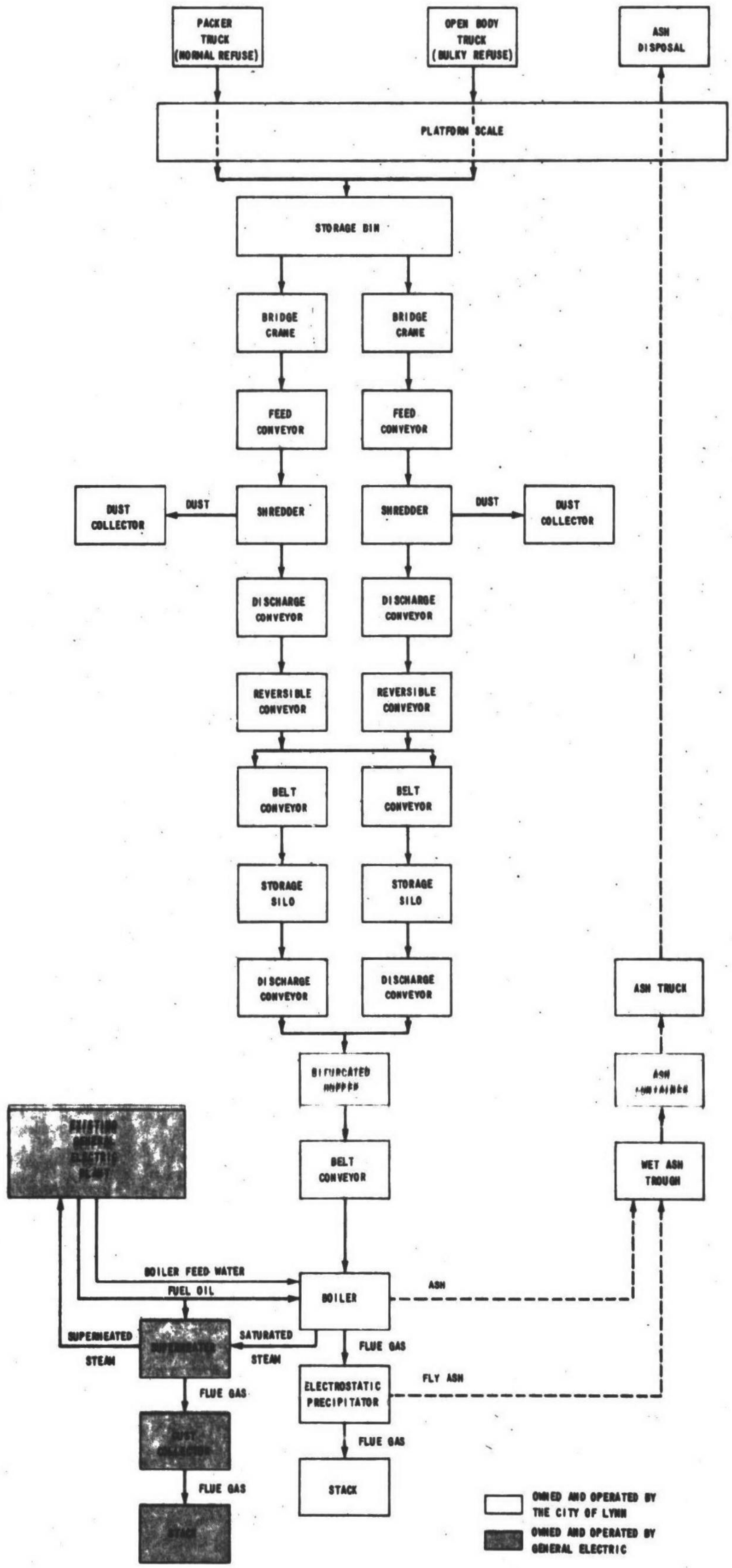


FIG. 13 SCHEMATIC FLOW DIAGRAM - ALTERNATIVE B-II

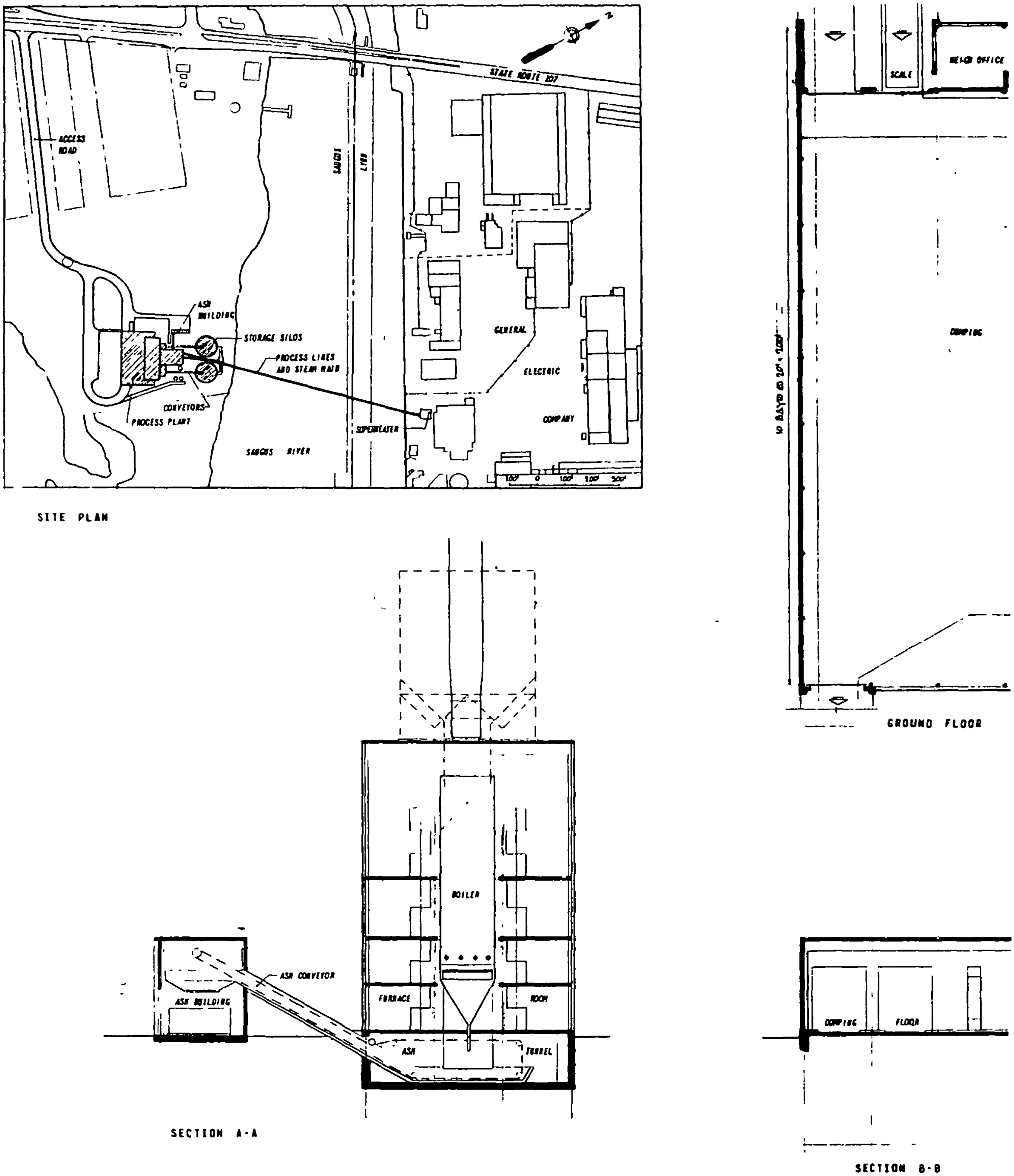


FIG. 14 ALTERNATIVE B-II - SITE PLAN
PLANS AND SECTIONS

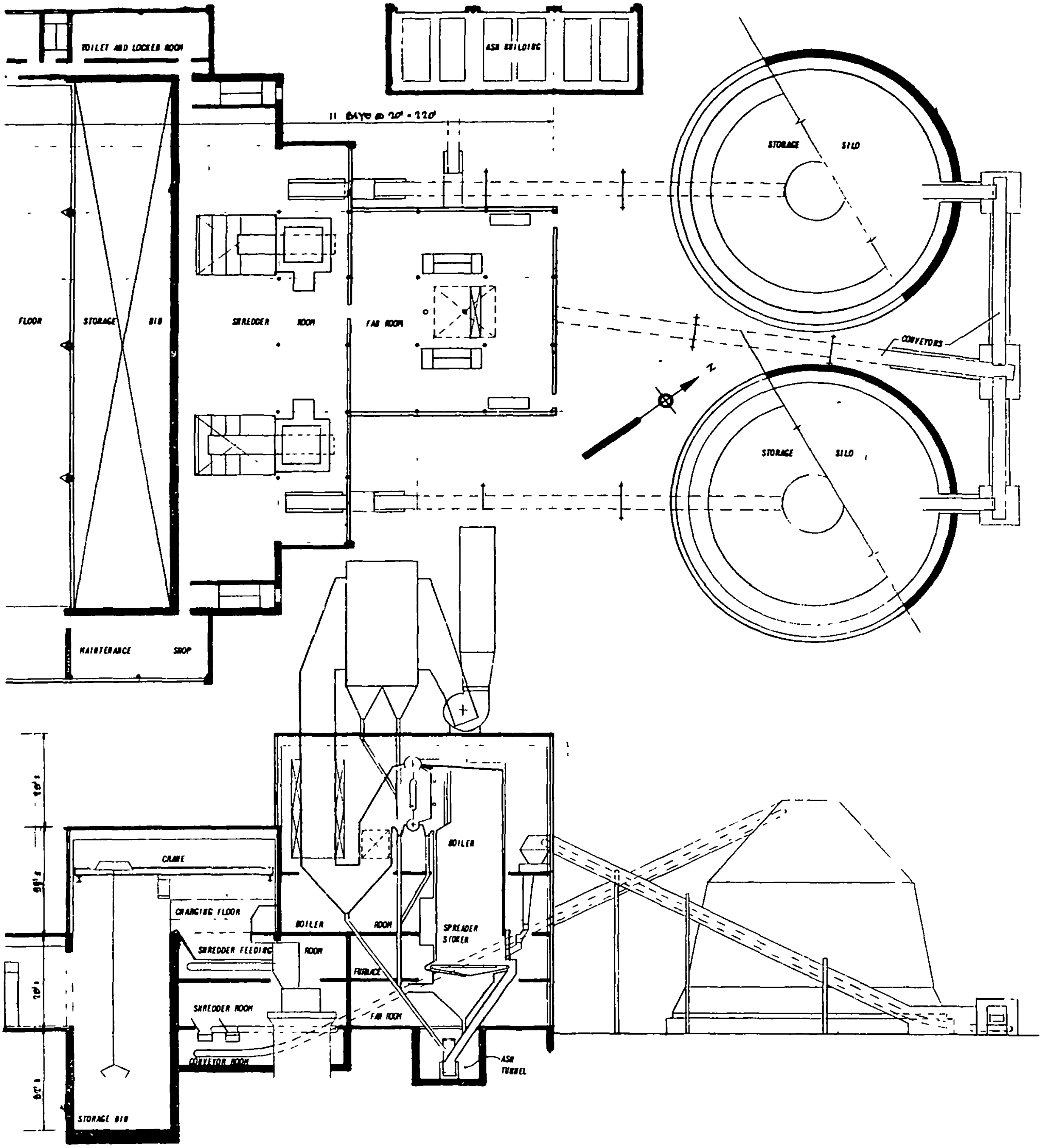
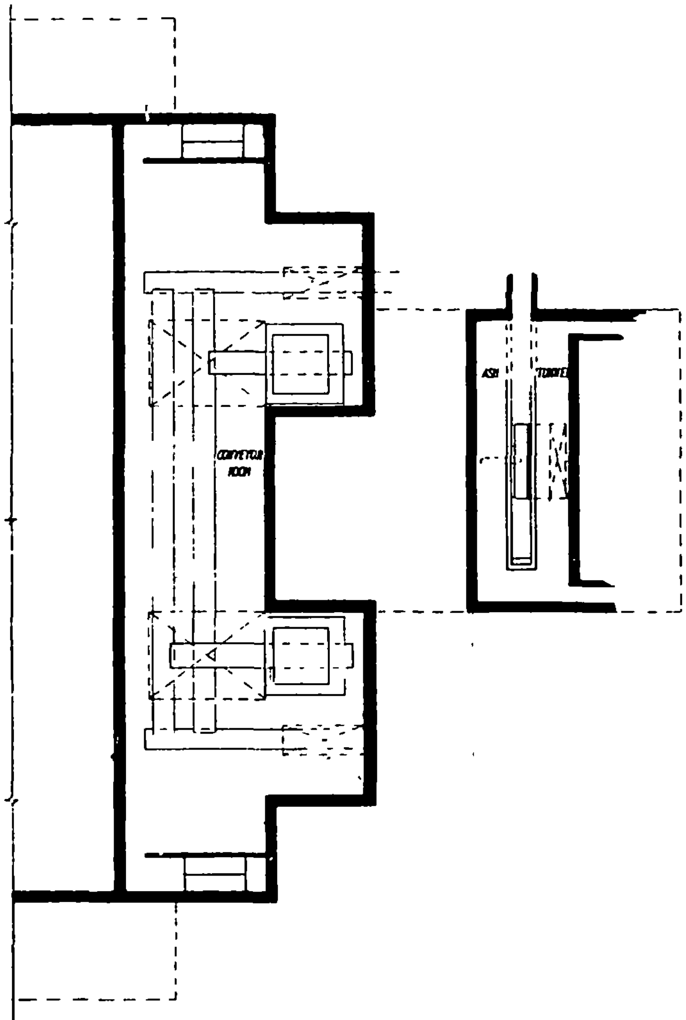
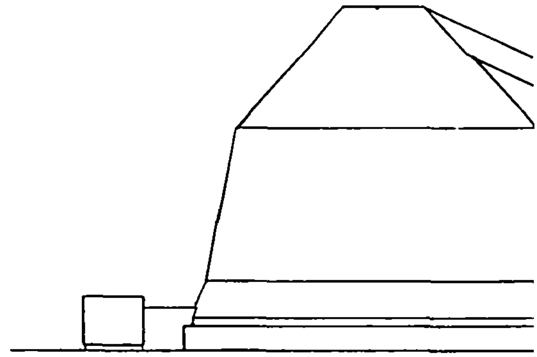


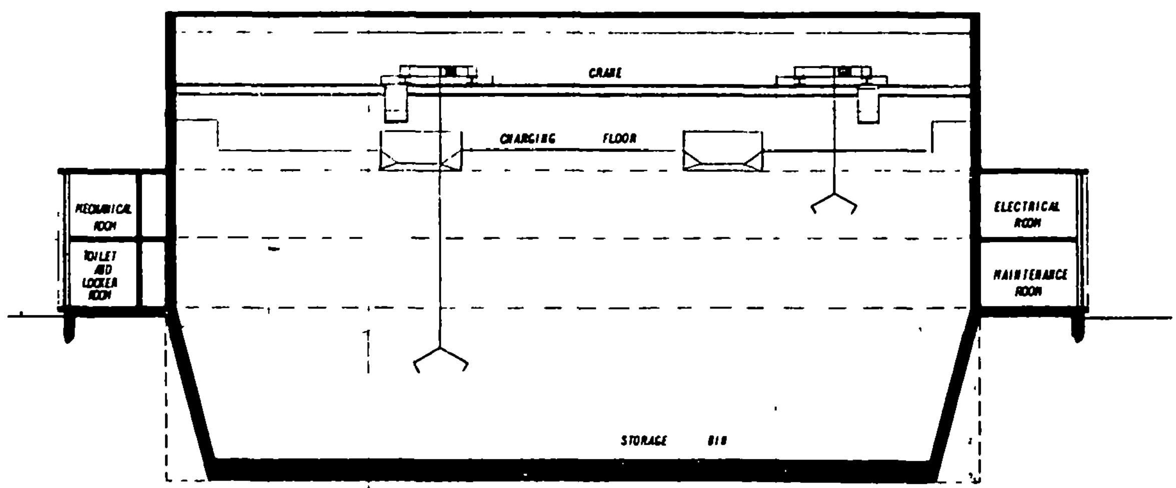
FIG. 14 ALTERNATIVE B-II - SITE PLAN PLANS AND SECTIONS (CONT'D)



BASEMENT

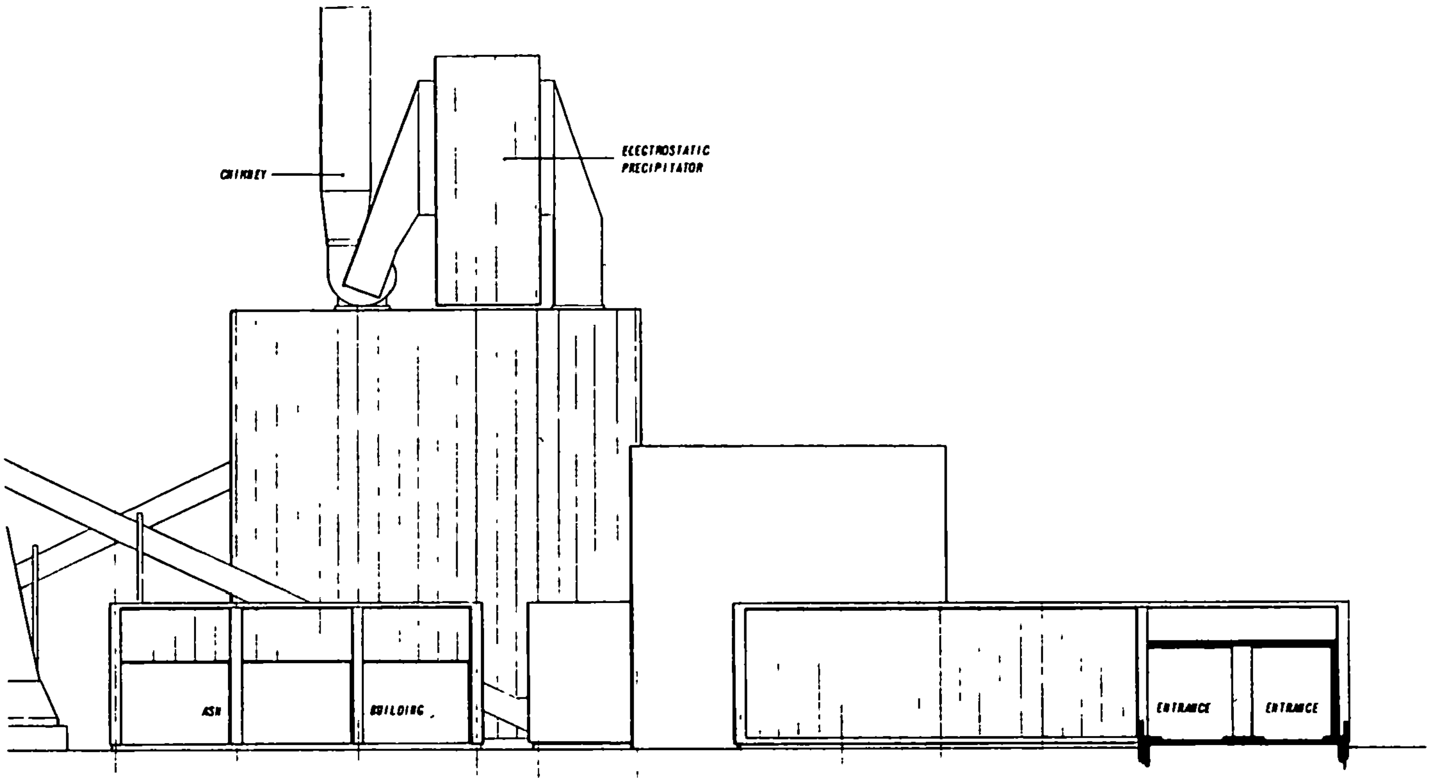


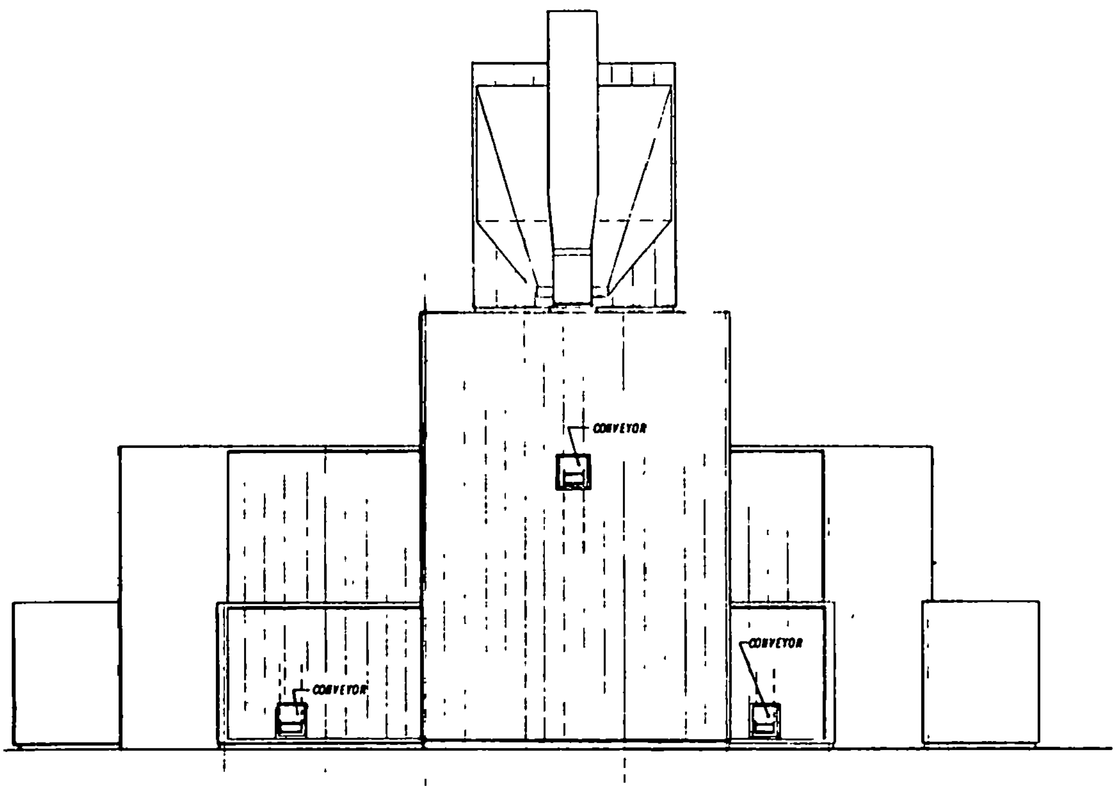
WEST ELEVATION



SECTION C-C

FIG. 15 ALTERNATIVE B-II - PLANS, SECTIONS AND ELEVATIONS





NORTH ELEVATION

FIG. 15 ALTERNATIVE B-II - PLANS, SECTIONS AND ELEVATIONS (CONT'D) conveyors which will convey the material up to the boiler. The boiler will produce saturated steam. This saturated steam will be conveyed approximately 800 feet across the Saugus River to the superheater located in the General Electric yard. Here the steam will be superheated and put into the General Electric distribution system. As in Alternative B-I, all of the utilities (boiler feedwater, fuel oil, and power) will be obtained from the existing facilities at the General Electric Company.

The residue from the boiler and the precipitator will be collected and quenched in a water-filled trough beneath the boiler and conveyed to containers located in the ash building. A complete description of the residue handling is given in Chapter 7.

Alternative C-I

Under Alternative C-I, the process plant and the boiler are located on the north side of the Saugus River adjacent to the existing boiler complex in the General Electric Company yard. The City of Lynn will own and operate the process plant. The General Electric Company will own and operate the boiler and superheater. As previously mentioned, there is not sufficient area available for this alternative, and because of security problems, General Electric does not desire to have refuse vehicles entering their plant. However, an economic feasibility study of this alternative is presented in this report. The boiler has a reciprocating grate stoker capable of handling 384 tons of refuse per day. A schematic flow diagram is shown on Figure 16. The preliminary building design and equipment layout shown on Figures 11 and 12 for Alternative B-I are applicable to Alternative C-I also.

The major difference between this alternative and Alternative B-I, in which the process plant and boiler are also located at the same site, is that the steam main, the fuel oil line, the power line, and the process water line across the Saugus River are not necessary since both the process plant and the boiler will be located at the existing General Electric boiler complex. The operation of the process plant and the boiler would be identical to Alternative B-I. The boiler would produce saturated steam which would be conveyed to a separately fired superheater where the steam would be superheated and put into the General Electric distribution system.

Boiler feedwater, fuel oil, and power for the boiler, the separately fired superheater and the process plant will be obtained from the existing facilities at the General Electric Company. The residue would be collected beneath the boiler as in Alternative B-I, and placed in containers for removal.

Once again, this alternative is presented only for cost comparison purposes. The amount of space necessary to implement this alternative is just not available in the General Electric plant within the vicinity of the existing boiler complex. Another location apart from the boiler complex would present the same problems as the location across the Saugus River, that is, a long steam main, a long feedwater main, a long connection for power supply, or, if the refuse processing plant were located within the General Electric Company apart from the boiler complex, and the boiler were located adjacent to the boiler complex, conveyors and a power supply line would be necessary. These restrictions would make this alternative similar to either Alternative B-I or A-Ia.

This alternative is being studied with the assumption that there is space adjacent to the boiler, and all cost estimates will be based on that assumption.

Alternative C-II

Under Alternative C-II, both the process plant and the boiler are located adjacent to the existing boiler complex in the General Electric yard on the north side of the Saugus River. The process plant is owned and operated by the City of Lynn. The boiler and superheater are owned and operated by the General Electric Company. Here again, there is not sufficient room available to actually implement this alternative, but it is presented herein as a comparison with both alternatives A-II and B-II to show the effect of the natural boundary, the Saugus River, on the overall system. A schematic flow diagram is shown on Figure 17. The preliminary building design and equipment layout shown on Figures 14 and 15 for Alternative B-II are applicable to Alternative C-II also. The operation of the process portion of this system and the boiler would be similar to the operation under Alternative B-II. The boiler would produce saturated steam which would be conveyed to a separately fired superheater, where it would be superheated and placed in the General Electric distribution system.

The residue from the boiler and the electrostatic precipitator would be collected in a water-filled trough beneath the boiler and conveyed up to ash containers for storage and later disposal at a sanitary landfill site.

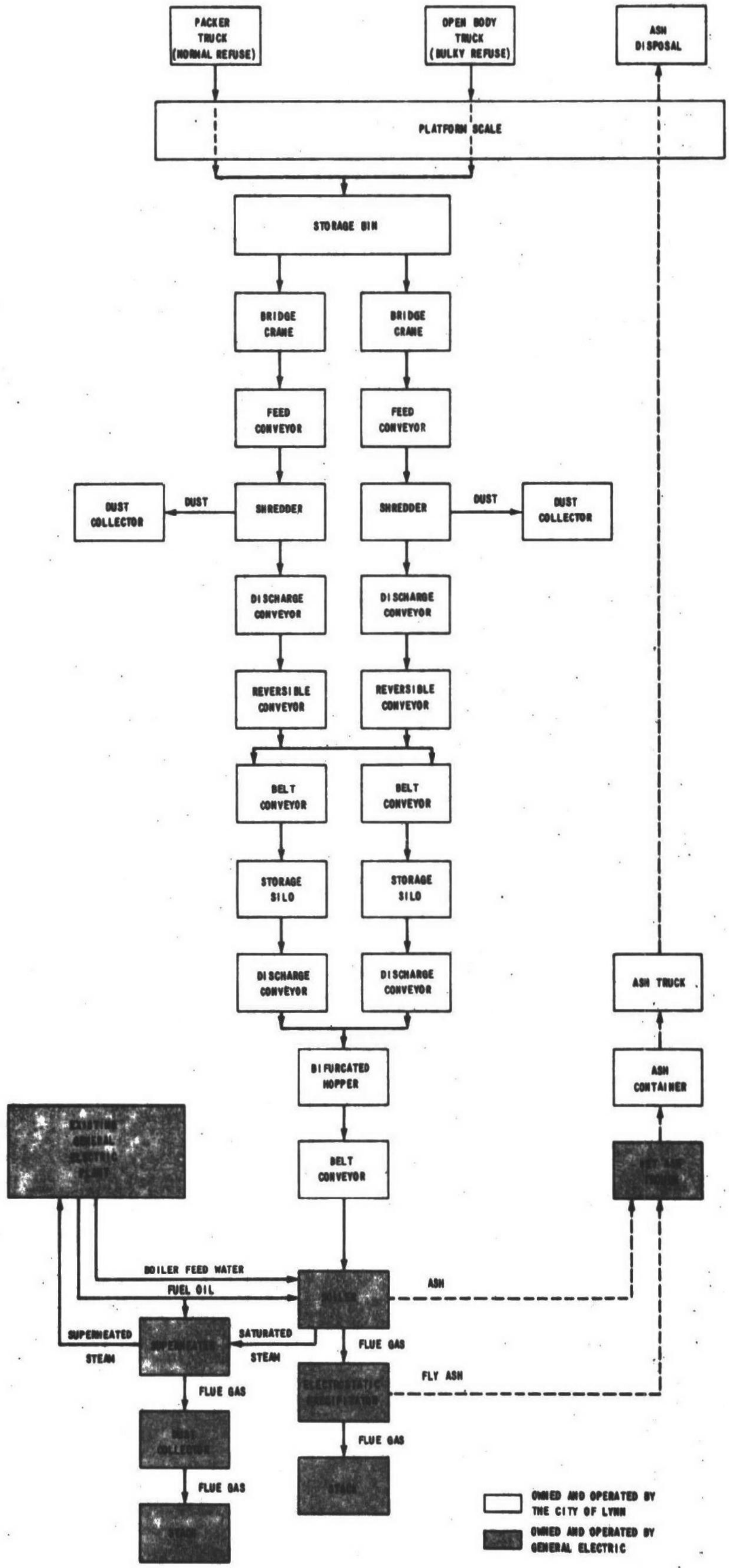


FIG. 17 SCHEMATIC FLOW DIAGRAM - ALTERNATIVE C-II

CHAPTER 7

UNITS OF REFUSE PROCESSING SYSTEM

Weighing Facilities

Maintaining records of the amount of refuse entering an incinerator and the amount of ash leaving the incinerator serve as an excellent source of information for checking incinerator operation. At incineration plants that serve more than one community, charges can be apportioned on the basis of the weight of the incoming refuse.

Scales are available which will automatically record the weight of the refuse vehicle on a card inserted into a recorder attached to the scale. Since communities other than Lynn may be using the incinerator, the scale should be long enough to accommodate the largest refuse collection vehicles presently on the market. This appears to be an 80-cubic yard transfer vehicle which has an overall length of over 50 feet. The scale should also be of sufficient capacity to handle the heaviest vehicles allowed on the highways. Based on these criteria, the scale should be 60 feet long, with a capacity of 40 tons.

Once a vehicle's tare weight has been established, this can be used each time the vehicle returns to the incinerator with only an occasional check. Therefore, only the gross weight need be recorded each time the truck enters. Subtracting the tare weight from the gross weight gives the weight of refuse on the vehicle.

The weighmaster is located so that he can easily see both the truck being weighed and the dumping floor. He can then direct the drivers to the appropriate section of the dumping floor.

Dumping Floor

Due to the climate and for aesthetic reasons, most of the larger incinerators constructed in New England have an enclosed floor where the refuse vehicles maneuver prior to dumping their refuse.

The dumping floor should extend the full length of the refuse storage area and should be of sufficient width to accommodate the largest refuse vehicle that could be expected to use the facility The length is also governed by the number of vehicles expected to be dumping at one time.

We have estimated that there should be dumping space for a minimum of 10 and 15 vehicles, respectively, under the 384 tpd and 612 tpd refuse-burning systems. A width of 80 feet would provide sufficient maneuvering space for the largest transfer vehicles in use today.

In the alternatives where only the bulky refuse is shredded, a space approximately 50 feet wide by 75 feet long, as shown on Figure 5, has been reserved on the dumping floor for the storage of bulky objects The handling of bulky wastes is covered in a later section of this chapter.

Storage Bin

General Electric's steam requirements are such that the boiler must be operated 24 hours per day, 7 days per week Refuse would be delivered to the plant Monday through Friday, during the day only. Therefore, some means of refuse storage will be required. Refuse may be stored in silos only if it is shredded.

In the alternatives that do not incorporate total shredding, all of the required storage will be provided in the storage bin. A storage bin capacity equal to the quantity of refuse required from the time the last vehicle leaves on Friday evening until the first truck arrives on Monday morning, plus a backlog of several hours as a safety factor, would be necessary.

Since many of the legal holidays in Massachusetts will fall on a Monday in the future, we compared the cost of providing an additional day's storage in the bin versus the cost of burning just oil on those Mondays. An important consideration in this analysis was that, because it is a holiday, General Electric would require only a minimum amount of steam from the system We concluded that it would be more economical to burn oil on the Monday holidays than to add an additional day's capacity to the storage bin.

The volume of the storage bin is then calculated using a density of 333 pounds per cubic yard for refuse in the bin. The width of the bin has been set at 28 feet. The depth of the bin is influenced by the condition of the underlying soils. There is approximately 35 feet of silty material underlain by several layers of clay. The clay appears as if it would support the bin without piles, whereas piles would be required if the bin were placed in the silt layer. Therefore, the bin was made deep enough so that the base would rest in the clay layer. With the depth and width established, the length was calculated from the total required volume.

Under the alternatives where all material is shredded, it is assumed that the entire volume of refuse is delivered to the storage bin in approximately equal portions Monday through Friday, and that all of the refuse is shredded and delivered to the storage silo during the same day that it is delivered. A storage-bin capacity equal to the quantity to be delivered in one day was selected. This capacity will provide time for maintenance without interfering with the boiler operation, should some part of the processing system break down. The bin capacity will be seven-fifths of the daily burning rate or 1.4 days' storage.

Cranes

Based on the size of the storage bins, and the quantities of refuse to be handled, bridge cranes were deemed to be the best means to transfer the refuse from the storage bin to the charging hopper. A comparison of cranes with front end loaders is made in Chapter 10.

The crane sizes were selected based on the distances the crane would have to travel, speeds recommended by the manufacturers, an effective working time of between 40 and 50 minutes per hour, and the quantity of refuse required by the downstream capacity of the system.

A minimum of two cranes have been provided in each alternative. In some alternatives, one of the cranes is completely standby; in others, standby is provided by working one crane additional hours.

Shredders

In the alternatives employing a spreader stoker. the refuse will be shredded to a maximum of 4 inches in the longest dimension. In the alternatives employing a reciprocating grate stoker, only the bulky refuse would need to be shredded.

Several makes of shredders were investigated including both the horizontal and vertical shaft models. The size of the shredder is somewhat governed by the rate at which it can be fed. The preliminary building designs have sufficient space for either the vertical shaft or the horizontal shaft shredders.

Based on one crane feeding one shredder, the maximum practical quantity that a crane could handle would be between 30 and 40 tph. Therefore, shredders with a capacity in this range were selected. The number of machines and hours of operation were then determined.

Because shredders are a high maintenance item, backup was provided. Two shredders have been provided where total shredding is employed, since a major overhaul would otherwise shut down the system. Minor repairs and routine maintenance could be performed during the hours that the shredder is not operating.

Where only bulky refuse is shredded, the size of the shredder is based on the feed opening required to accept bulky material such as mattresses, packing crates, furniture, etc. The bulky refuse shredders would discharge onto a conveyor emptying directly into the storage bin.

Dust Collector

As the shredder operates, the speed of the rotor causes air to flow through the machine. When material is being shredded, this exhausted air is loaded with dust. Therefore, the air is passed through a scrubbing-type dust collector before it is discharged to the atmosphere. The particulate material collected in the dust collector is discharged onto the conveyor system downstream of the shredder or into the storage bin.

Conveyors

Rubber-belt conveyors were selected in all cases except where cranes, front-end loaders or shredders would discharge onto them. Under such circumstances, belt conveyors would experience an excessive degree of wear, therefore, metal-pan conveyors were selected instead Where refuse is to be discharged from another belt, the rubber-belt type was selected for the receiving conveyor. The initial cost of metal-pan conveyors is about twice as much as rubber-belt conveyors, however, the savings in belt replacement and downtime more than offsets the initial cost differential.

Reliability is provided by using reversible belts and in other instances parallel belts. The angle of incline of all conveyors transporting refuse is kept to a maximum of 27 degrees.

The width of the conveyors is selected considering a variety of factors. The width of the in-feed conveyors to the shredders, and the discharge conveyors from the shredders, was based on the physical dimensions of the shredder. The width of the conveyors fed by the cranes, but not discharging to shredders, was based on the physical dimensions of the crane bucket. Conveyors carrying shredded material were sized by the volume of material, the density of the material, and the speed of the conveyor. The width of the conveyors carrying unshredded refuse across the Saugus River was set at 10 feet. The width is necessary, not for the volume of material, but because large items which inadvertently bypass the shredder may become lodged and cause a backup if a narrower width were selected.

The conveyor handling ash from the boiler will be a drag-type conveyor. This type of conveyor has metal flights suspended from a traveling chain operating in a water-filled trough. The residue will be discharged from the boiler into the water-filled trough. As it settles to the bottom of the trough, the metal flights drag the ash along the bottom of the trough and up an incline where most of the water is drained from the ash. The water-filled trough also serves as a seal on the boiler to prevent hot gases from escaping. The residue-handling system is covered in more detail in a subsequent section of this chapter.

Pneumatic conveyors were considered for conveying shredded refuse but they were found to be much more expensive overall than mechanical conveyors, and therefore are not recommended.

Storage Silos

Storage silos can be discharged automatically; therefore, they provide a much more economical means of storage than a bin which requires a bridge crane and operator to empty. Silos, however, can only be used to store shredded refuse: therefore, they are only used in the alternatives where all of the refuse is shredded.

With storage silos, it would be possible to shred the total weekly volume of refuse during one or two 8-hour shifts per day under the 384- and 612-tpd alternatives, respectively. This would place the majority of the labor required for the process operation on a 40-hour week and would reduce the total number of personnel.

The silos would have a positive discharge, which is necessary because of the unpredictable nature of the material. A typical silo is shown on Figure 8. The bottom diameter of the silo is such that bridging will not occur.

The refuse is not expected to freeze in the silo. Some freezing may occur near the outer edge of the silo, but this should act as an insulation to prevent further freezing. It would be possible to insulate and heat the silos at a later date if freezing is found to be a problem.

The capacities of the silos were based on the amount of refuse needed in the boiler from the end of the last shift on Friday evening until the beginning of the first shift on Monday morning, plus several hours' backlog. Two silos would be used in all instances. Each silo would have a capacity of one-half the total requirement. Each would be capable of discharging at a rate equal to the capacity of the boiler so that, in the event one silo is down for repairs, the overall operation is not affected

Based on the above criteria, two silos, each with a capacity of 650 tons, would be needed for the 384-tpd alternatives, and two silos, each with a capacity of 910 tons, would be needed for the 612-tpd alternatives.

The rate of discharge from a silo can be varied over a wide range, and the silos can therefore be used to "meter" the quantity of refuse fed into the boiler.

Bulky Refuse Handling

Bulky refuse is composed of large items such as bureaus, upholstered chairs, sofas, mattresses, tree trunks, washing machines, refrigerators, etc., discarded from the home, and pallets, packing crates, machinery parts, and other large items discarded from industrial and commercial establishments. Bulky refuse can be subdivided into two categories. combustible and noncombustible. In this report, combustible refuse is material that will burn at temperatures equal to or less than the normal furnace operating range of 1,600 deg F to 2,000 deg F. Noncombustible bulky refuse will not be accepted at the plant.

In the alternatives where refuse is fired on a spreader stoker, all of the refuse will be shredded In these alternatives, combustible bulky refuse will be deposited into the storage bin and follow the same flow pattern as the remainder of the refuse.

In the alternatives where refuse is fired on a reciprocating grate stoker, the refuse will be fired as it is received, except that Foster Wheeler requires that bulky items be reduced in size prior to firing. Therefore, a shredder is provided in these alternatives for bulky refuse.

The arrangement of the bulky refuse shredder is shown on Figures 5 and 6. Bulky items are placed directly on the dumping floor in the area shown. From here a front-end loader places the bulky items on an apron conveyor feeding the shredder. A short apron conveyor underneath the shredder discharges the shredded material directly into the storage bin.

Since the combustible bulky refuse is composed mainly of wood, which has a relatively high heat value compared to average refuse, the bridge crane will be used to mix the shredded bulky refuse with the remainder of the refuse prior to charging, to avoid uneven Btu loading on the boiler.

Residue Handling

The residue from an incinerator can be divided into three general categories:

Bottom ash – Bottom ash is the noncombustible and unburned material remaining on the grates. The bottom ash will be discharged from the end of the grate directly into a water-filled trough as shown on Figures 11 and 14.

Fly ash – Fly ash is the small particulate matter collected in the electrostatic precipitator. Where the electrostatic precipitator is installed at ground level, the fly ash will be discharged onto a slider-belt conveyor and conveyed to the water trough as shown on Figure 11. This material is very fine in nature, ranging in diameter from 120 to less than 5 microns; therefore, a steam spray will be installed to wet the material down to prevent it from blowing about. Where the electrostatic precipitator is installed on the roof of the building, the fly ash will be conveyed by gravity in pipes down to the water trough.

Miscellaneous residue – The siftings collected under the grates, and particulate matter collected in miscellaneous hoppers throughout the process, constitute the miscellaneous residue. This residue will also be conveyed to the water trough as shown on Figures 11 and 14.

A drag conveyor in the bottom of the water-filled trough will move the residue from the trough up an incline where most of the water will be drained from the residue. In the alternatives where the process plant and boiler are located adjacent to one another, the residue would go directly from the drag conveyor into 30-cubic yard ash hoppers. In the alternative where the boiler is located in the General Electric yard and the process plant in Saugus, residue will be conveyed by means of a bucket elevator up to a belt conveyor which subsequently would transport it back across the Saugus River and into 30-cubic yard containers. Details of the residue-handling system under each of the alternatives are outlined in Chapter 6.

The quantity of ash, on a dry basis, is estimated to be 20 percent, by weight, of the original quantity of refuse. The density of dry ash is approximately 40 pounds per cubic foot and the density of wet ash is approximately 50 pounds per cubic foot, and the average moisture content is 20 percent. Therefore, the average quantity of ash from the 384-tpd reciprocating grate fired alternatives would be approximately 100 tpd, and the quantity of ash from the 612-tpd spreader-stoker fired alternatives would be approximately 150 tpd. These are equivalent to an annual landfill volume of about 30 acre-feet and 50 acre-feet, respectively

Incinerator residue has been used successfully as a landfill material to reclaim unused tracts of land. Areas where groundwater would pass through the residue should be avoided however, since soluble salts and alkalies would be leached from the ash and carried along with the groundwater. The residue anticipated from the boilers considered in this report should have a relatively small percentage of volatile matter and therefore should be relatively stable.

The effective use of residue to reclaim land areas, thereby increasing the city's tax base, can help to offset the cost of residue disposal.

Under the reciprocating grate fired alternatives, the fly ash would be approximately 25 percent of the total residue, by weight. Under the spreader-stoker fired alternatives, because of the small particle size and the nature of the firing, the fly ash would be approximately 50 percent of the total residue, by weight. However, since all of the residue would be transported to the same water-filled trough, the method of refuse handling as outlined above would be applicable to either type of firing.

The weight of all residue leaving the plant should be recorded. This can easily be accomplished by weighing the residue trucks on the same platform scale used to weigh the incoming refuse collection vehicles. This weight when compared to the weight of refuse entering the plant can be used to check on the efficiency of the operation.

CHAPTER 8

UNITS OF REFUSE-BURNING SYSTEM

Steam-Generating Unit

The refuse-burning, steam-generating unit will be a natural circulation, water-walled boiler with a stoker specifically designed for refuse burning. When operating with refuse having an as-fired heating value of 4,970 Btu per pound, the boiler will have the capacity to burn 384 tpd with a reciprocating stoker, and 612 tpd with a spreader stoker. The refuse-burning capacity of the boiler with 6,000 Btu per pound of refuse will remain at 384 tpd for the boiler with the reciprocating grate stoker. The boiler capacity with 6,000 Btu per pound of refuse and a spreader stoker will decrease to 510 tpd, since this grate is designed on the basis of 750,000 Btu per square foot regardless of the refuse characteristics.

The boiler burning refuse and No. 6 oil simultaneously will produce 400,000 pounds of saturated steam at approximately 750 psig, which will, in turn, be delivered to a separately oil-fired superheater. The superheater is designed to deliver 650 psig steam at 850 deg F into the General Electric Company distribution system. Normally, the superheater is an integral part of the boiler. Because of the corrosive nature of refuse gases containing constituents such as chlorine, the superheater will be separated from the incinerator and thus will prevent impingement of these gases on the high-temperature tubes of the superheater. Although the separately fired superheater is located on General Electric Company property in all alternatives, it would be possible to locate the superheater adjacent to the boiler on the Saugus side of the river if advantageous to do so. Location of the superheater on General Electric Company property is desirable, however, from a heat loss standpoint, since the thermal gradient or heat loss driving force is about 1.5 times as great for the superheated steam as it is for the saturated steam due to the higher temperature of the superheated steam.

At the full load design rating, the boiler will be designed for a range of 40 to 100 percent excess air for the refuse component of the fuel, and approximately 15 percent excess air for the No. 6 oil component.

When using the spreader stoker and burning 612 tons of refuse per day and sufficient oil to produce 400,000 pounds of steam per hour, the calculated overall boiler efficiency will be 78.5 percent. When using the reciprocating grate stoker and burning 384 tons of refuse per day and sufficient oil to achieve the same steaming rate, the boiler overall efficiency will be 81.4 percent. On oil alone, for the same steaming rate, the boiler overall efficiency will increase to 86.4 percent.

Reciprocating Grate Stoker

The reciprocating grate stoker is designed in lateral rows, each overlapping its upstream neighbor in a shingle-like manner. Alternate rows are linked to a hydraulic power cylinder which slowly reciprocates them back and forth across the face of the alternate stationary rows. A section of the reciprocating grate stoker is shown on Figure 11.

The proposed unit for this application will consist of four independently driven and controlled stoker sections. The first section will be a charging section and the three remaining sections will be designed for combustion of the refuse.

A vertical drop-off is provided between grate sections to break up and reorient the refuse to provide maximum surface exposure to the flame.

Pressure drop through the grate venturi air openings is relatively high to ensure a more uniform air distribution and to minimize the effects from the varying characteristics of the refuse bed. Not only does this provide more uniform combustion, but it also ensures more uniform cooling of the grates.

Feed is uniform and continuous, and noncombustibles and ash are discharged continuously from the grates. Siftings removal is automatic. The removal devices are tied to the stoker operating mechanism and thus reciprocate in unison with the stoker. The siftings are conveyed to the discharge end of the unit and discharged along with the bottom ash to the ash conveyor.

Spreader Stoker

The spreader stoker system consists of a traveling grate, four air-swept spouts and a swinging distributor assembly. The spreader stoker is shown on Figure 14.

The grates are divided into rows longitudinally, one row for each air-swept spout or feeder. Each row is carried on two chains which ride over hardened-tooth sprockets. A hydraulic system drives the grate toward the front of the boiler, discharging the ash immediately below the feed spout. The grate design is specifically for suspension firing, and individual grate bars open on the return run of the grate facilitating air admission to the fuel bed, and the discharge of siftings to the chamber below the grate. The air-swept spouts spread the shredded material evenly over the grate. The lighter material burns in suspension and the heavier material falls to the relatively fast-moving grate. The air to the spout is controlled by a motorized rotary air damper, which alternately increases and decreases both quantity and pressure of the air several cycles per minute. This assures even fuel distribution from front to rear of the furnace.

Control System

The steam, condensate, and combustion control systems will be pneumatic, or combination pneumatic and electric operated, and will function generally as described below.

When the water-walled incinerator is in the General Electric yard and the process plant is in Saugus, and only bulky refuse is shredded, the refuse feed control will be performed by automatically varying the feed conveyor speed in conjunction with the stoker. With the water-walled incinerator in Saugus, feed control will be achieved by stoker speed variation only. In both cases, a bridge crane will be utilized to move the material from the storage pit to the conveyor or incinerator charging hopper.

With total shredding, feed control will be achieved by varying the silo discharge and associated conveyor speeds in conjunction with the stoker speed, regardless of the water-walled incinerator location.

It should be noted that the refuse feed control should be minimal since the anticipated steam requirements as shown on Table 2 exceed that which can be produced by the refuse alone.

In addition to the refuse feed control, the fuel oil system will have modulating flow rate controls. This system will meter the fuel as the required steam flow changes over the anticipated range. This, together with automatic control of the separately fired superheater, will ensure that steam characteristics are well maintained.

Regardless of the water-walled incinerator location, the feedwater supply to the incinerator will be controlled by a three-element controller, i.e., steam flow, feedwater flow, and drum level.

The feedwater supply to the boiler will in all cases originate from the General Electric Company property. Their softening, polishing, and storage facilities must be expanded to accept the added load, however.

For the alternative in which the water-walled incinerator is located in Saugus, a condensate tank will be required adjacent to the incinerator. Softened water will be pumped from General Electric to this tank and from this tank to the deaerator. The condensate storage tank will have at least 20 minutes' storage capacity in addition to the 10-minute storage in the deaerator to ensure safe shutdown of the incinerator upon inadvertent loss of water.

A steam-turbine drive will be provided on one of the condensate pumps at the storage tank and on one of the boiler feed pumps to maintain feedwater to the boiler in the event electric power is lost.

The fuel oil (No. 6) will be obtained from General Electric in all alternatives. For the alternatives in which the water-walled incinerator is located adjacent to the superheater on General Electric property, the system will require only a means of heating and transporting the oil from General Electric's storage tanks to the boiler and superheater.

When the boiler is in Saugus, however, a separate storage tank adjacent to the boiler will be necessary as intermediate storage for No. 6 oil. The level in this tank will be controlled by a float switch connected to an electrically operated control valve. The valve will be located at the inlet to the tank.

The No. 6 oil tank will be large enough to hold approximately 20,000 gallons of oil to provide an alternate source of oil should the supply originating from General Electric be interrupted.

The fuel oil system for the boiler will be controlled by steam pressure and for the superheater by temperature. Both these systems would be designed to meet local and state safety codes.

Water-Softening System

The water-softening system will have sufficient capacity to process all raw water to the boiler assuming 100 percent makeup, and also a polishing system to remove primarily iron and copper from the recycled condensate.

This condensate will be pumped in plastic-lined steel pipe either directly to the deaerator or via the fiber glass condensate tank, as described under instrumentation, to the deaerator, depending upon the location of the water-walled incinerator.

A predetermined level will be maintained in the condensate storage tank by a float-operated control valve. Sufficient heat will be supplied to the tank to prevent freezing when the system is not in operation.

The pipe crossing the river will be on roller supports to allow for expansion and will have expansion joints at both ends.

A minimum-flow bypass valve will be provided downstream of the condensate pumps to allow the condensate to flow back to the tank under low-flow conditions and prevent damage to the pump due to overheating.

Boiler Feed and Steam Systems

Downstream of the deaerator, the feedwater will flow to two boiler feed pumps, one motor driven and the other steam turbine driven. Both pumps will be sized to take the full boiler capacity.

A recirculating valve will be provided on the discharge of each pump. At excessively low flow rates the feedwater will be bypassed to the deaerator storage tank.

The boiler feed pump drive turbine is designed for 200 psig steam. Its exhaust will be piped to the deaerator which operates at 5 psig. In order to obtain the necessary feedwater temperature for the boiler studied, a feedwater heater is provided between the boiler feed pump and the economizer. When the boiler is located in the General Electric yard, the required steam for the feedwater heater will come from the General Electric 200-psig steam system. On the other hand, when the boiler is in Saugus, steam from the main header will be reduced to approximately 175 psig and piped to the feedwater heater. The condensate from the feedwater heater will then go directly to the deaerator. After having been heated to 365 deg F in the feedwater heater, the feedwater will be pumped to the economizer and then to the boiler itself.

The boiler pressure must be sufficient to overcome all losses between the boiler drum and the superheater outlet. With the boiler in Saugus, the drum pressure will have to run 20 to 30 psi (pounds per square inch) greater than with the boiler in the General Electric yard, since the steam flow losses will include an additional 1,200 feet of pipe and two gate valves. Regardless of boiler location, the saturated steam pressure must be high enough to overcome the stop valve pressure drop, the superheater pressure drop, and all valves in this circuit.

The steam pipe crossing the river in the alternatives where the boiler is located in Saugus will rest on roller supports to provide a means of expansion. The pipe will be suspended about 50 feet above the Saugus River and the boiler and superheater connections will be about 50 feet above this elevation. With this configuration four hinged expansion joints will be used at each end of the pipe to provide sufficient flexibility to absorb the full pipe expansion.

Two chemical feed systems and a blowdown tank have been included in the plant to provide a means of maintaining a total suspended solids concentration of less than 1,500 ppm (parts per million) as required by the American Boilermakers Association.

Fuel Oil Systems

The fuel oil systems consist of the oil system for the water-walled incinerator, and the oil system for the separately fired superheater.

In all alternatives, we have assumed the separately fired superheater to be located on General Electric property. This will require pipeline heating and a pump and heater set sized for approximately 15 gpm (gallons per minute). General Electric has sufficient oil storage capacity available to supply both this system and the system required for the water-walled incinerator.

For the alternatives in which the boiler is located in Saugus, duplex pumps will be used to transfer the oil from General Electric's tanks to a 20,000-gallon tank located in Saugus. A bypass valve is provided downstream of these pumps to recirculate the oil back to General Electric's tanks when the day tank is full.

Pipeline heating is provided for the entire length of pipe, including the portion crossing the river, to maintain an oil temperature of about 125 deg F. Beyond the day tank, a suction heater, and a pump and heater set are provided to supply up to 50 gpm of oil to the boiler. This is sufficient oil to generate 400,000 pounds of steam per hour when burning oil alone.

A No. 2 oil storage tank is provided in the alternatives which have buildings in Saugus. The oil is used for the process building heating system when it alone is in Saugus. When both the process building and boiler are located in Saugus, the No. 2 oil tank would provide oil for the incinerator oil burner pilots, and the building would be heated with low-pressure steam from the low-pressure reducing station.

Combustion-Air and Induced-Draft Systems

The combustion-air system is designed with three combustion-air fans: an underfire air fan, an overfire air fan, and an oil burner fan. In addition, an induced-draft fan will transport the flue gas from the incinerator to the atmosphere.

The overfire air fan will serve a dual function when associated with the spreader stoker, i.e., it will supply air to the air-swept nozzles, and also combustion air above the grates. In the reciprocating grate stoker arrangement, it will supply overfire air only.

The oil burner air fan will be directly connected to the oil burner and will modulate according to the burner's demands.

At this stage, we have assumed the underfire air fan to be automatically modulated to maintain a predetermined excess air. Since this is often a point of contention among manufacturers themselves, and between manufacturers and engineers, this point should be finalized in the design stage of the plant.

The induced-draft fan will automatically maintain a slightly negative pressure in the water-walled incinerator to minimize heat loss through openings and doors.

Air Pollution Control Systems and Stacks

An electrostatic precipitator will be provided on the water-walled incinerator to reduce particulate emission below the level required by local, state, and federal air pollution control codes.

The electrostatic precipitator is a particularly desirable device since high efficiencies are possible. There is only a small pressure drop through the unit, and the particulate matter is collected dry.

On the separately fired superheater, a mechanical cyclone will be used. Since particulate emission from oil burning is relatively small, it has been found in the past that cyclone separators were sufficient to meet air pollution control codes. Due to the rapid changes in air pollution control codes, it is advisable that this decision be reviewed carefully at the design stage of this project to determine if a cyclone collector is adequate. If the cyclone separator is not acceptable, an electrostatic precipitator specifically designed for oil-fired boilers can be used. An electrostatic precipitator is much more expensive than a cyclone separator, however.

A double-walled stack of corrosion-resistant steel will be provided rather than an unlined stack. Because of the insulating effect brought about by the double-wall construction, the temperature of the gas will not drop to the dew point even at low load conditions. As a result, corrosion is appreciably reduced, and the life of the stack is extended considerably.

CHAPTER 9

RIVER CROSSING

General

As shown on Figure 18, the Saugus River separates the General Electric Company from the area where the refuse will be deposited in two of the three basic alternatives. The river is approximately 800 feet wide at this point.

Figure 19 is a section of Coast and Geodetic Survey Chart No. 240, showing the location of the existing bridges and the proposed river crossing, as well as soundings in the Saugus River and surrounding waters. All three bridges in the vicinity of the proposed river crossing are bascule-type bridges which, when open, do not impose any height restriction on the water craft.

There are several governmental agencies from which approval must be obtained for river crossings. A permit must be obtained from the U. S. Army Corps of Engineers before a structure can be constructed in a river. The U. S. Coast Guard has jurisdiction over the height of fixed structures over rivers. A letter requesting that a Public Notice be issued must accompany the request to the Coast Guard. A license must be obtained from the Massachusetts Department of Public Works for a crossing over or under a river located in Massachusetts.

Following discussions with these agencies, it was decided that a vertical clearance of 50 feet would be used over the main channel of the river. As shown on Figure 19, the Boston and Maine Railroad bascule bridge just downstream of the proposed river crossing is 50 feet wide between abutments. We have, therefore, based our preliminary design on a minimum horizontal clearance of 50 feet.

An investigation was made into the use of a tunnel under the river bed. A preliminary design was made using an 78-inch diameter subaqueous precast concrete pipe. The 78-inch pipe would be sufficient to carry a 16-inch steam main, a 8-inch boiler feedwater main, a 6-inch fuel oil line, a power cable, and also provide sufficient space for a person to walk the entire length of the lines. A typical cross section of the proposed tunnel is shown on Figure 20. We estimate that the tunnel will cost between 20 and 25

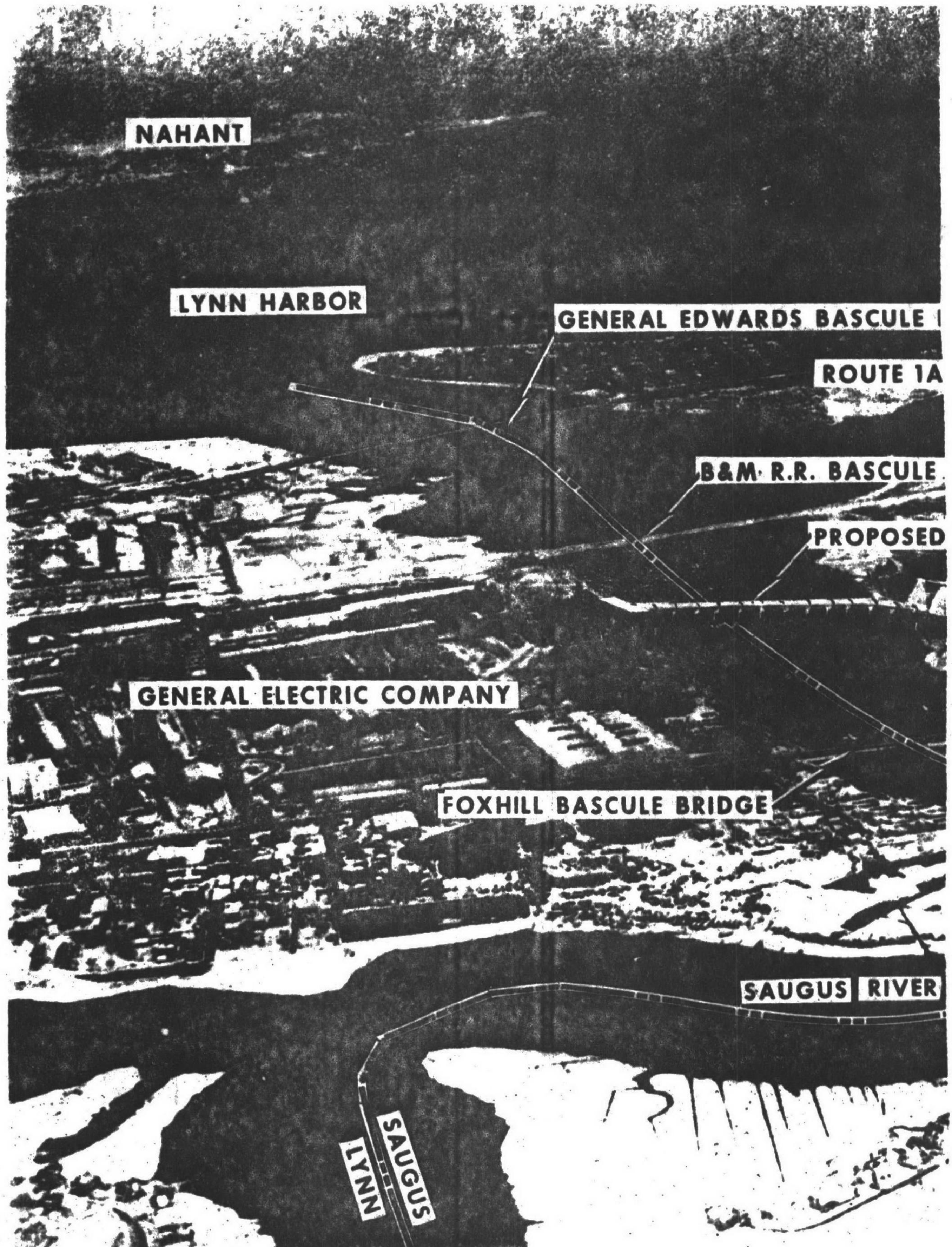


FIG. 18 AERIAL VIEW - VICINITY OF PROPOSED SAUGUS RIVER CROSSING

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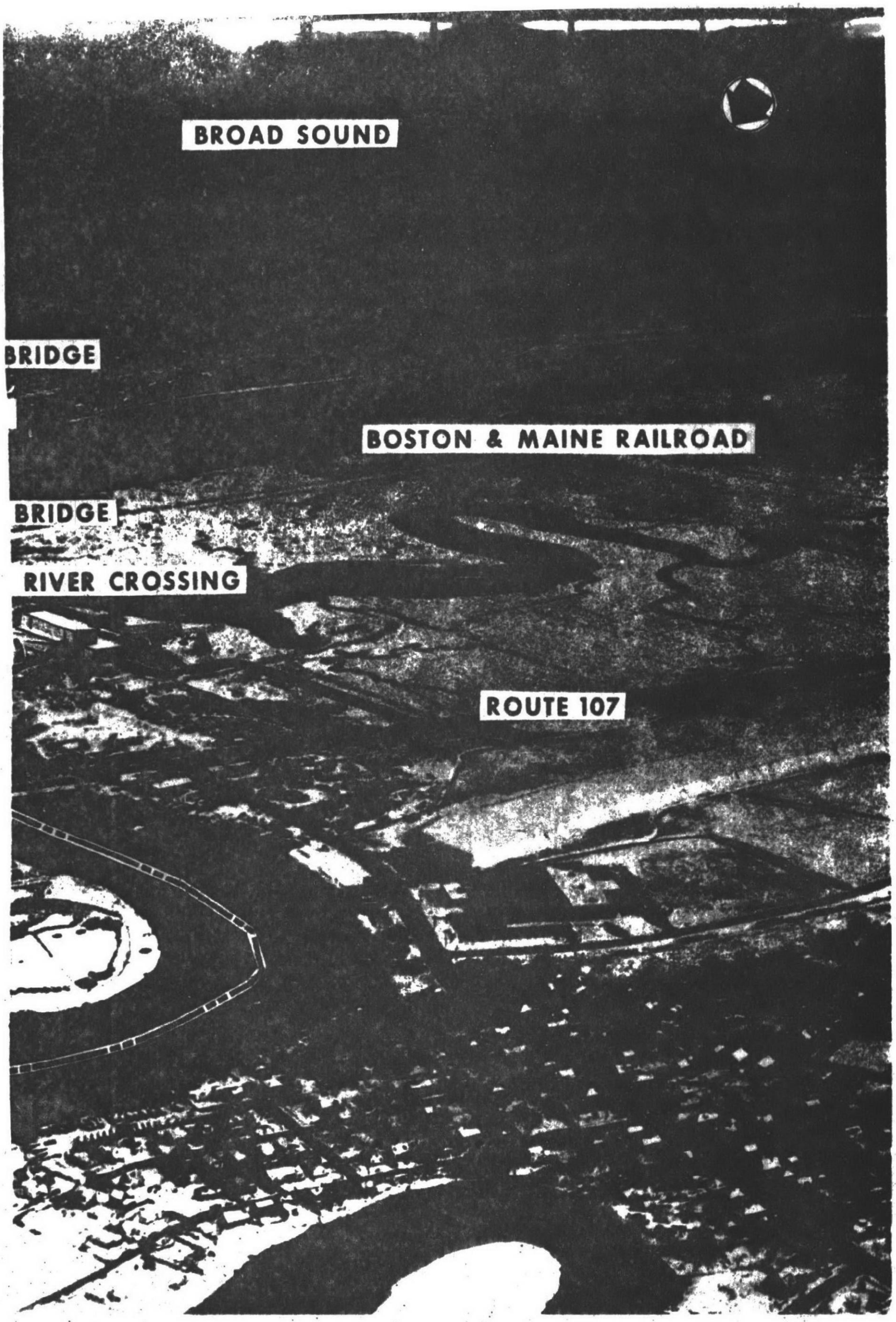

FIG. 18 AERIAL VIEW - VICINITY OF PORPOSED SAUGUS RIVER CROSSING (CONT'D)

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FIG. 19 LOCATION OF PROPOSED SAUGUS RIVER CROSSING

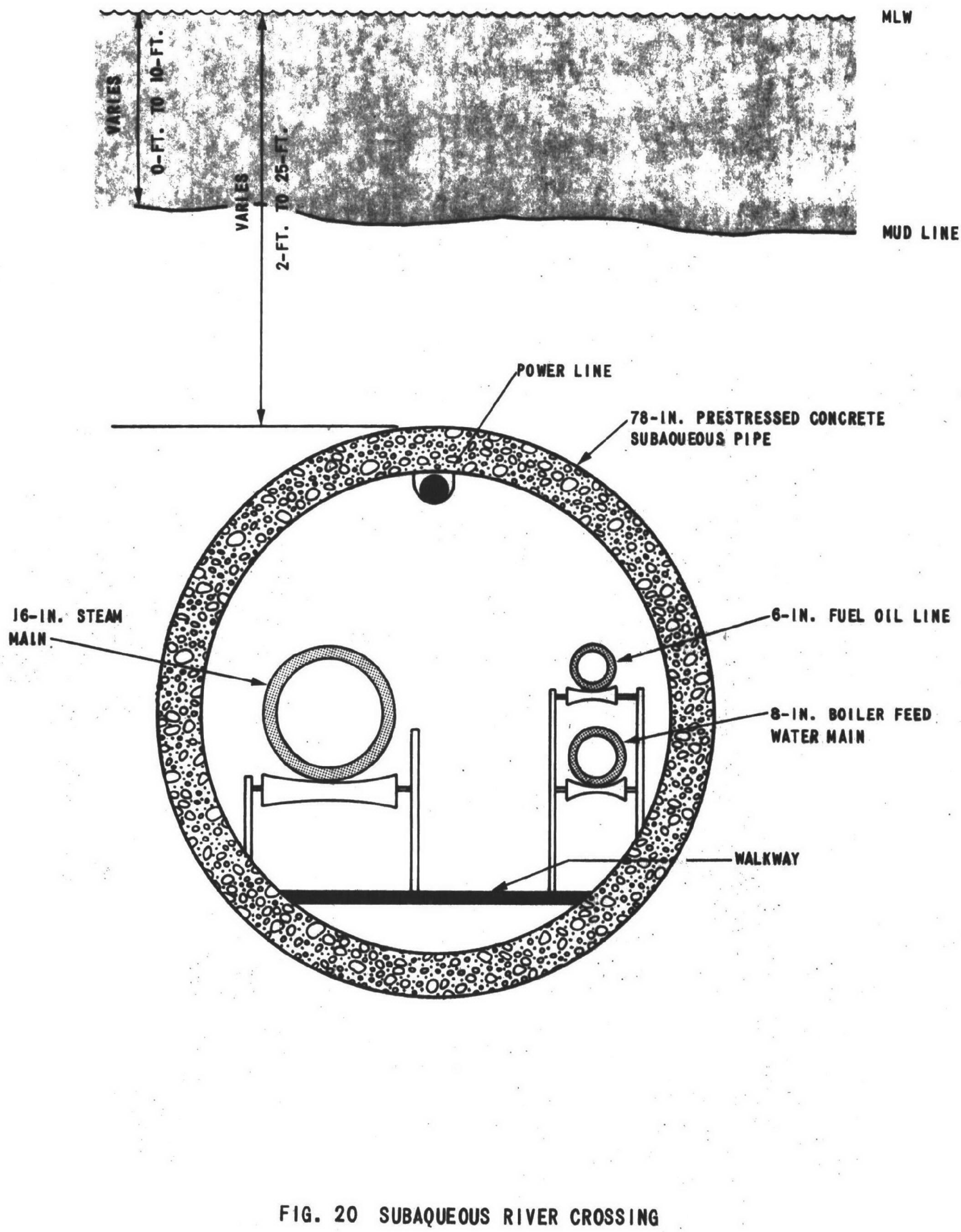

FIG. 20 SUBAQUEOUS RIVER CROSSING

percent more than the overhead structure. In addition, with the tunnel arrangement, entrance structures and ventilation equipment would be required.

The tunnel shown on Figure 20 will be suitable only when steam is being transported across the river. When refuse is transported across the river, a much larger cast-in-place tunnel would be required to accommodate the conveyors. Since the cost of the overhead river crossing structure to support the conveyors was only slightly higher than the overhead river crossing structure required to carry the steam, boiler feedwater and oil pipelines alone, the overhead structure would be more economical than the subaqueous river crossing structure to support the refuse and ash conveyors.

A typical pier supporting the river crossing structure is shown on Figure 21. A cross section of the shredded refuse conveyors, the residue conveyor, and the conveyor housing is shown on Figure 22. There is sufficient room to allow personnel to walk the entire length of the conveyors for inspection and maintenance.

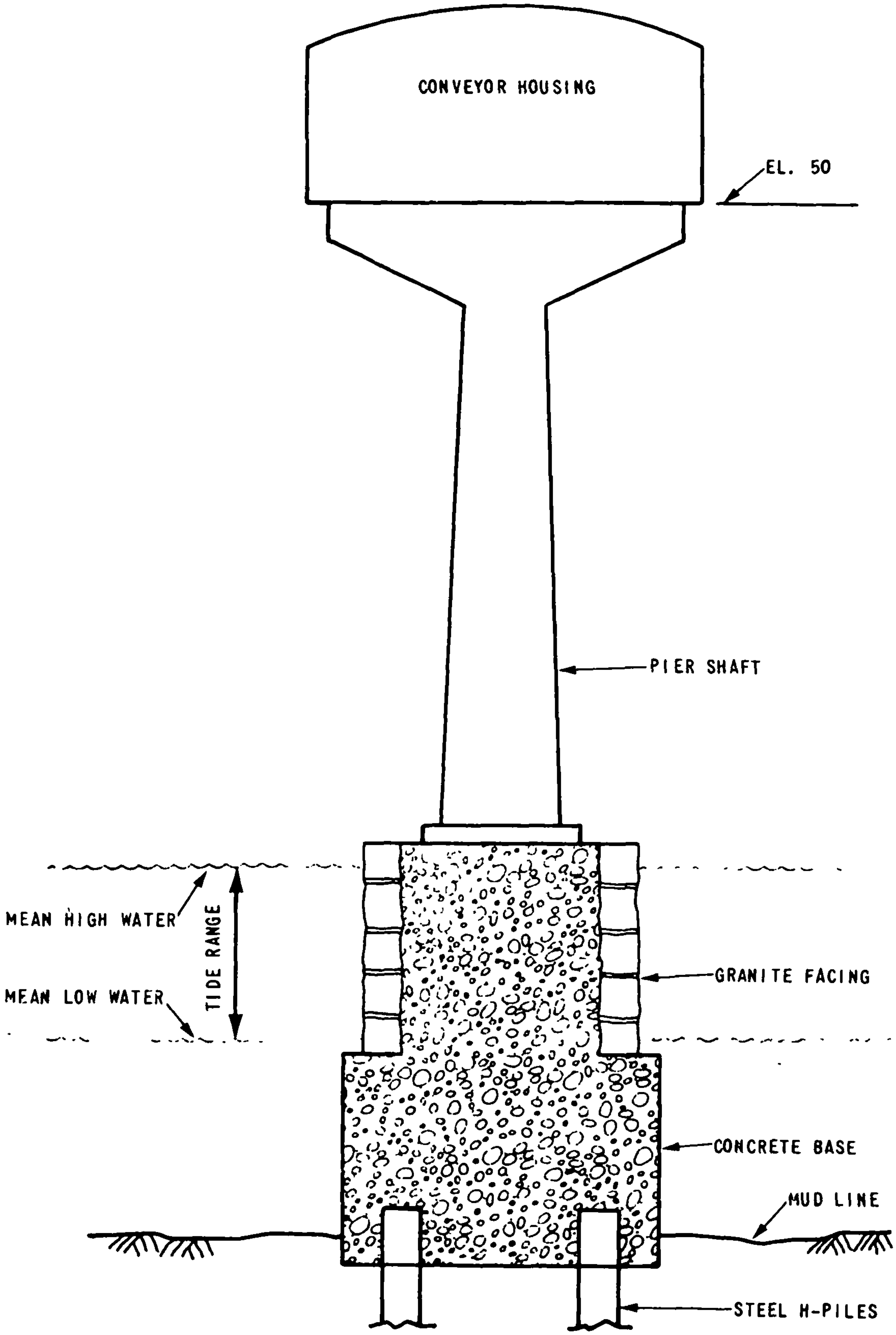

FIG. 21 TYPICAL PIER SUPPORT FOR RIVER CROSSING STRUCTURE

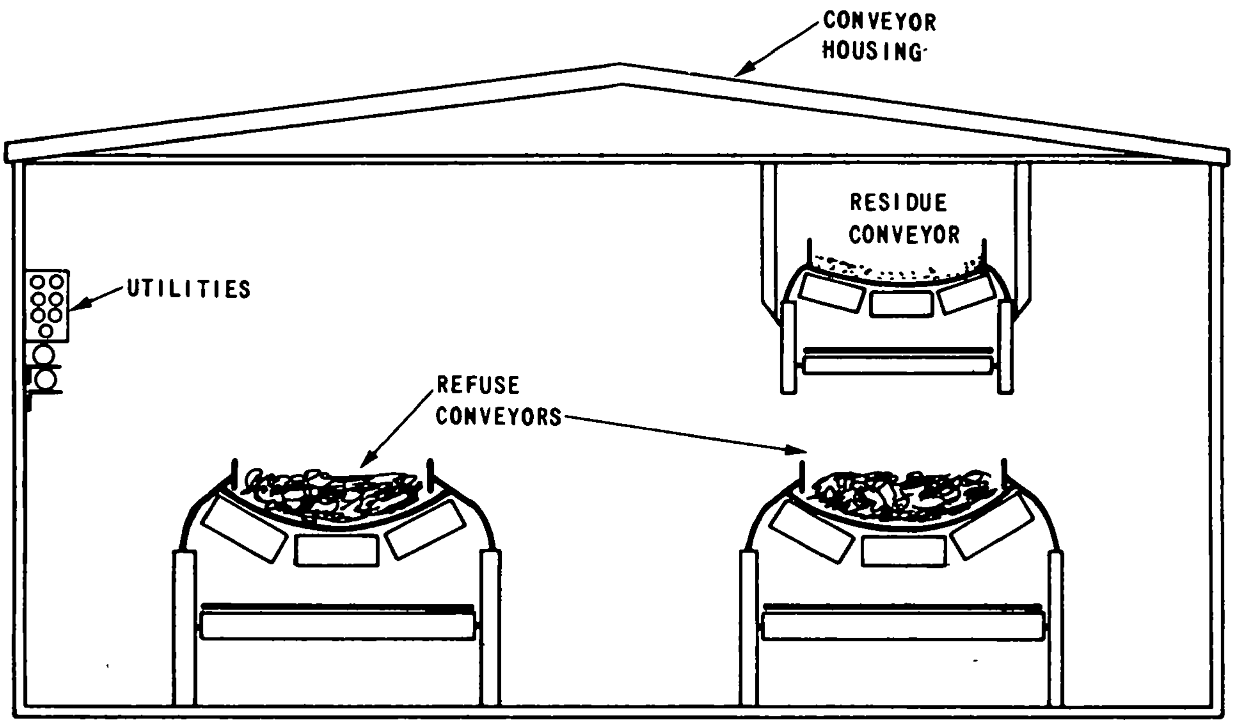

FIG. 22 TYPICAL SECTION - CONVEYOR HOUSING ACROSS SAUGUS RIVER

CHAPTER 10

SEPARATE STUDIES

General

The discussion and evaluation of some features of the solid waste disposal and steam generating systems are given in this chapter. This information supplements that given in Chapters 6, 7, 8, and 9.

Reciprocating Grate Stoker versus Spreader Stoker

The reciprocating grate, as indicated in the opening paragraphs of Chapter 8, is sized on the basis of loading in pounds of refuse per hour per square foot of grate area. To avoid damage to the grate, a loading of 60 to 65 pounds per square foot per hour should be used when burning refuse. Foster Wheeler used a loading of 62 pounds of refuse per square foot per hour based on the horizontal projected area of the reciprocating grate stoker. Therefore, the reciprocating grate stoker considered is rated to burn 384 tons of refuse per day at the design loading.

In the unit incorporating the spreader stoker, much of the heat is released while the shredded material is in suspension. Therefore, more of the heat is absorbed by the boiler walls, and the grate is exposed to less heat than when a reciprocating grate stoker is used. As a result, the spreader stoker is capable of burning more refuse per day than a reciprocating grate stoker of the same physical size.

The spreader stoker is designed on a heat release of 750,000 Btu/hr-ft^2 of grate area. Utilizing a standard size having 38 percent less horizontally projected grate area, the proposed spreader stoker can burn considerably more refuse than the reciprocating grate stoker. With present refuse having a heating value of 4,970 Btu/lb, the spreader stoker can burn 612 tons per day as compared to only 384 tons per day with the reciprocating stoker.

The spreader stoker is therefore evaluated for use in the proposed incineration plant, even though the refuse must be shredded prior to firing, since with relatively the same water-walled boiler, over 50 percent additional refuse can be burned with the spreader stoker. In addition, this means that less oil will be needed as supplementary fuel.

Dumping Floor versus Storage Bin

The general ground elevation in the vicinity of the proposed process plant is less than 10 feet above mean tide level. Therefore, any subsurface construction would require expensive dewatering facilities. For this reason, we considered storing the refuse on a flat slab rather than in a below-ground storage bin. A typical storage bin is depicted on Figure 8.

With the refuse on a flat slab, front-end loaders could be used to place the refuse onto the feed conveyors. Since front-end loaders are much less expensive than bridge cranes, this alternative was explored in depth.

Building cost estimates were made from preliminary building designs; equipment costs were acquired from manufacturers; and personnel requirements were estimated based on equipment ratings and the required feed rate. The background of the cost estimates is explained in Chapter 11.

Although expensive excavation could be eliminated by using the slab construction, the size of the storage area would be much larger, since it would not be practical to stockpile refuse higher than 10 feet with front-end loaders. Consequently, the building cost for the flat slab alternative would be only about $100,000 less than the building costs for the storage bin alternative. The bridge cranes are estimated to cost about $250,000 more than the front-end loaders. However, because the density of refuse on the floor will be less than in the pit, and because front-end loaders with a capacity of 8 cubic yards can handle only about one-half the amount of refuse a crane can handle in the same work period, the number of personnel required for the flat slab alternative is greater than the number required for the bin and crane alternative. The additional labor cost would amount to about $50,000 per year. We estimate that the operation costs, other than labor, for the front-end loaders would be about $20,000 greater than the comparable operation costs for the cranes.

Based on an economic life of 30 years for the buildings, 20 years for the cranes, 5 years for the front-end loaders, and interest at 6 percent, $20,000 could be saved annually by using the bin and crane method rather than the flat slab and front-end loaders. From the viewpoints of public health and sanitation, confining the refuse to a below-grade pit would be much more desirable. For these reasons the bin and cranes will be used in all alternatives.

Shredding versus Handling Raw Refuse

The shredded refuse system has several advantages over the nonshredded refuse system. When conveying the material, particularly over long distances, narrower belts, which are much less expensive both initially and from an operation and a maintenance standpoint, can be used with shredded refuse. The belts used in the nonshredded systems are 10 feet wide while those for the shredded refuse system are only 3 feet wide. Conveyor selections are explained in Chapter 7.

Shredded refuse can be stored in silos, and with a positive means of discharge, it can be metered to the incinerator. As a result, the feed to the incinerator is more uniform.

Because of the smaller particle sizes, the burning process will be more complete, thereby improving the efficiency of the incineration process.

A major factor in favor of shredding and utilizing a spreader stoker is the added incinerator capacity as explained under the Reciprocating Grate versus Spreader Stoker Section of this chapter.

The primary disadvantage with total shredding is the added cost of owning and operating the shredders and the refuse storage silos. This cost is partially offset by the fact that the crane is operated for a shorter period of time per day, thereby reducing crane operation and labor costs.

When burning raw refuse, there are no shredding costs and storage silo costs. Since, however, a spreader stoker cannot be used to burn unshredded refuse, the 612 tpd burning capacity cannot be achieved, and the plant would not be able to burn more than 384 tons of refuse per day with the proposed boiler and a reciprocating grate stoker. In addition, as mentioned above, very wide belts must be used to convey the raw refuse.

Disposal During Two-Week Annual Outage

It is common practice in the power industry to completely shut down boilers for a two-week repair and maintenance period each year. During this period, the inside of the boiler is cleaned; soot and slag that have accumulated on the boiler tubes are removed; the stokers are repaired; worn sections of the refractory liners throughout the system and the cast-iron wear plate liners above the grates are repaired or replaced; and the fans, electrostatic precipitator, air heater and other pieces of equipment are serviced.

Sufficient provisions have been made in the refuse process plant to allow for equipment maintenance without interference with the operation; therefore, a two-week shutdown period is not necessary at the process plant. However, since the boiler will be out of service for this two-week period, major equipment maintenance in the process plant should be scheduled at that time.

During this two-week annual outage, the refuse will have to be disposed of at an alternate location. With the 384 tpd system, there would be a total of 5,400 tons of refuse, and with the 612 tpd system, a total of 8.600 tons of refuse would require disposal.

We suggest that arrangements be made with the New England Power Company to use the present sanitary landfill site for the disposal of refuse during this annual two-week period. In addition, wherever possible, contractual agreements with private collectors and other communities should be limited to the 50-week operating period. This would lift some of the burden from the City of Lynn.

Trucking the refuse to neighboring incinerators was investigated. However, because there is such a large quantity, this method of disposal does not appear to be feasible at this time. The situation may exist in the future, however, whereby a community near Lynn might have excess capacity. Therefore, this possibility should not be overlooked when the actual two-week outage occurs.

It is anticipated that by the time this facility has been on line for a year, the DeMatteo landfill in Saugus will have been closed. If, however, it is still open, permission could be requested from the State Department of Public Works to dispose of the refuse there during the two-week annual outage.

Value of Steam

Based upon data provided by the General Electric Company regarding their present operation, we estimate that steam at 650 psig and 850 deg F is worth $0.877 per 1,000 pounds, when produced using oil as fuel.

CHAPTER 11

PLANT STAFF REQUIREMENTS

General

A complete description of the method of operation under each of the seven basic alternatives was outlined in Chapter 6. The personnel necessary to operate the Lynn-owned and the General Electric-owned facilities are discussed in this chapter. The General Electric Company provided the estimate of the personnel necessary to operate their portion of each alternative. Table 7 summarizes plant staff requirements.

City Staff

In all alternatives, the process plant would be open for the delivery of refuse 8 hours per day, Monday through Friday. This would enable the major portion of the employees to work a straight-shift 40-hour week.

There would be a plant manager under each alternative who would be in charge of the city-owned facility. In Alternatives B-I and B-II, where the city operates the boiler also, the manager would be a graduate mechanical engineer with a minimum of 20 years' experience in power plant operation.

There are five shift supervisors on the City of Lynn's payroll in each alternative. This includes an allowance for vacation, sick leave, and other absences, and provides for one shift supervisor at the facility at all times.

One weighmaster would be employed by the City of Lynn on a 40-hour per week basis. He would record the weight and other pertinent data from the incoming vehicles.

In Alternatives A-Ia, B-I, and C-I, a single crane would continually remove refuse from the pit. Therefore, to meet this requirement and to allow for sick leave, vacation, and other absences, there would be five crane operators on the payroll. In Alternative A-Ib both cranes feed the shredders 8 hours a day, Monday through Friday. Should one of the crane operators be absent, the other operator would work additional hours to meet the load requirements; therefore, there will be two crane operators on the payroll. In Alternatives A-II, B-II, and C-II, the two cranes feed the shredders for 16 hours a day, Monday through Friday. This would require four men; but to

TABLE 7 PLANT STAFF REQUIREMENTS AND SALARY COSTS

JOB CLASSIFICATION	ANNUAL SALARY	ALTERNATIVE A-Ia NUMBER PER WEEK	A-Ia TOTAL SALARY	A-Ib NUMBER PER WEEK	A-Ib TOTAL SALARY	A-II NUMBER PER WEEK	A-II TOTAL SALARY	B-I NUMBER PER WEEK	B-I TOTAL SALARY	B-II NUMBER PER WEEK	B-II TOTAL SALARY	C-I NUMBER PER WEEK	C-I TOTAL SALARY	C-II NUMBER PER WEEK	C-II TOTAL SALARY
CITY OF LYNN															
PLANT MANAGER (PROCESS PLANT)	$12,000	1	$ 12 000	1	$ 12 000	1	$ 12 000	-	-	-	-	1	$ 12 000	1	$ 12 000
PLANT MANAGER (COMBINED FACILITY)	18 000	-	-	-	-	-	-	1	$18 000	1	$ 18 000	-	-	-	-
SHIFT SUPERVISOR	9 500	5	47 500	5	47 500	5	47 500	5	47 500	5	47 500	5	47,500	5	47,500
WEIGHMASTER	6 000	1	6 000	1	6 000	1	6,000	1	6 000	1	6 000	1	6 000	1	6 000
CRANE OPERATOR	8 100	5	40 500	2	16 200	5	40 500	5	40 500	5	40 500	5	40 500	5	40 500
SHREDDER OPERATOR	8 100	1	8 100	1	8 100	2	16,200	1	8,100	2	16 200	1	8,100	2	16 200
MAINTENANCE PERSONNEL	8,900	2	17 800	3	26 700	3	26,700	4	35 600	4	35 600	2	17,800	3	26 700
LABORER	6 000	7	42 000	7	42 000	8	48,000	8	48 000	9	54 000	7	42 000	8	48 000
ASH HANDLERS	6 000	2	12 000	2	12,000	3	18 000	2	12 000	3	18 000	2	12 000	3	18 000
FRONT END LOADER OPERATOR	8 100	1	8 100	-	-	-	-	1	8 100	-	-	1	8 100	-	-
FIRST CLASS BOILER OPERATOR	10 000	-	-	-	-	-	-	5	50 000	5	50 000	-	-	-	-
ASSISTANT BOILER OPERATOR	8 000	-	-	-	-	-	-	5	40 000	5	40 000	-	-	-	-
TOTAL		25	$194 000	22	$170 500	28	$214,900	38	$313 800	40	$325 800	25	$194 000	28	$214 900
TOTAL SALARY			$194 000		$170 000		$215 000		$314 000		$326 000		$194 000		$215 000
FRINGE BENEFITS (25 PERCENT)			48 000		43 000		54 000		78 000		82 000		48 000		54 000
TOTAL			$242 000		$213 000		$269 000		$392 000		$408 000		$242,000		$269 000
GENERAL ELECTRIC COMPANY[1]															
FIRST CLASS BOILER OPERATOR	$10 000	4	$ 40 000	4	$ 40 000	4	$ 40 000	4	$40 000	4	$40 000	4	$ 40 000	4	$ 40 000
STOKER OPERATOR	8 900	4	35 600	4	35 600	4	35 600	-	-	-	-	4	35 600	4	35 600
EQUIPMENT OPERATOR	8 100	4	32 400	4	32 400	4	32 400	-	-	-	-	4	32 400	4	32 400
SERVICE PERSONNEL	6 000	2	12 000	2	12 000	1	6 000	-	-	-	-	2	12 000	1	6 000
MAINTENANCE PERSONNEL	8 900	2	17 800	2	17 800	1	8 900	-	-	-	-	2	17 800	1	8,900
TOTAL		16	$137 800	16	$137 800	14	$122,900	4	$40 000	4	$40 000	16	$137 800	14	$122 900
TOTAL SALARY			$138 000		$138 000		$123 000		$40,000		$40 000		$138 000		$123 000
FRINGE BENEFITS (25 PERCENT)			34 000		34 000		31 000		10 000		10 000		34,000		31 000
TOTAL			$172 000		$172 000		$154 000		$50 000		$50 000		$172 000		$154 000

(1) ESTIMATES SUPPLIED BY THE GENERAL ELECTRIC COMPANY

allow for sick leave, vacations, and other absences, there will be five crane operators on the payroll.

One shredder operator would be required in Alternatives A-Ia, B-I, and C-I to operate the bulky refuse shredder. A shredder operator would be required in Alternative A-Ib, Monday through Friday, during the first shift. In Alternatives A-II, B-II, and C-II, a shredder operator would be required Monday through Friday during both the first and second shifts. Standby operators would be provided by the available operators working longer hours if necessary.

A maintenance crew would be employed in the Lynn-owned facility Monday through Friday during the first shift. Since backup and standby equipment has been provided in most cases for maintenance and repairs, the crew should be able to accomplish their work during the first shift. The City of Lynn will employ two men in Alternatives A-Ia and C-I; three men in Alternatives A-Ib, A-II, and C-II; and four men in Alternatives B-I and B-II, which includes both preparation plant and boiler. The crew would consist of at least one mechanic and one electrician.

There would be four laborers employed during the first shift in Alternatives A-Ia, A-Ib, and C-I for routine work such as sweeping the dumping floor, inspecting the conveyors, maintaining the grounds, shifting ash containers, assisting the maintenance crew, and directing traffic. There would also be one laborer at the plant at all other times, making a total of seven laborers on the payroll.

In Alternatives A-II and C-II, where shredding is carried on for 16 hours per day, Monday through Friday, one additional laborer would be employed during the second shift, when the cranes and shredders are operating. In Alternative B-I, an additional laborer would be employed to clean the boiler area. In Alternative B-II, two additional laborers would be employed, one during the second shift when the shredders are running, and one to clean the boiler area.

Two ash handlers would be employed by the city to take the ash from the ash storage building to the disposal area and to operate the ash conveyors in Alternatives A-Ia, A-Ib, B-I, and C-I. In Alternatives A-II, B-II, and C-II, where 612 tons of refuse are incinerated each day, as opposed to only 384 tpd in the above alternatives, three ash handlers would be employed.

One front-end loader operator is required to feed the oversized refuse to the bulky refuse shredder in Alternatives A-Ia, B-I, and C-I.

The City of Lynn would need five licensed first-class boiler operators and five assistant boiler operators on their payroll for Alternatives B-I and B-II in which the boiler is operated by the city. The boiler would operate continuously, and an allowance for sick leave, vacations, and other absence is provided.

General Electric Staff

General Electric would not require any additional management personnel.

The General Electric Company would have four licensed first-class boiler operators, four stoker operators, and four equipment operators on their payroll for Alternatives A-Ia, A-Ib, A-II, C-I, and C-II in which they would operate the boiler.

General Electric would employ two service personnel and two maintenance personnel in Alternatives A-Ia, A-Ib, and C-I which utilize a reciprocating grate stoker, and only one service and one maintenance person in Alternatives A-II and B-II which utilize a spreader stoker.

Salary Costs

A summary of the City of Lynn's and General Electric's plant staff requirements is shown together with salary costs in Table 7. Salary costs are based on wages paid for similar work in the Greater Lynn area.

CHAPTER 12

UNIFORM COLLECTION ORDINANCES

General

It was noted in Chapter 5 that the residential refuse production in the City of Lynn, combined with General Electric's refuse production, would be less than the capacity of the boiler with either the reciprocating grate or spreader-stoker alternative. The difference would be made up with refuse from neighboring communities, private haulers, or commercial and industrial firms. It is, therefore, important that Lynn adopt an ordinance to ensure uniform collection practices, and that other communities involved should have regulations to ensure this end.

Collection Practices

A collection ordinance is necessary to prevent unwanted and hazardous materials from entering the plant, and to ensure that there will be proper control over the vehicles entering the process plant, and their contents.

Dangerous materials such as explosives, gasoline, paints, solvents, cleaning fluids, drugs, and poisons should not be disposed of at the process plant.

Unburnable bulky refuse such as stoves, bed springs, water tanks, refrigerators, dryers, washing machines, automobile parts, and lawn mowers should not be disposed of at the process plant. Large quantities of ashes, gravel, sand, stones, plaster, and demolition wastes should not be allowed into the plant, either. These materials have no heating value and would place an additional burden on the equipment. The shredders that will be used in the process plant are capable of handling these items, but it is this type of material that causes excessive shredder wear. Such wear may result in considerable downtime if maintenance is not routinely performed.

Large burnable bulky refuse such as bureaus, chairs, packing crates, pallets, pieces of wood less than 6 feet long, desks, mattresses, and sofas could be disposed of at the process plant. Where only bulky refuse is being shredded, these objects should be brought in separately and placed on the dumping floor as shown on Figure 5.

Garbage should be accepted only if properly wrapped and mixed with at least an equal weight of rubbish. The intent here is to prevent a truck carrying only garbage from dumping at the process plant. Garbage, because of its high moisture content, has a lower heating value than an average batch of refuse. To avoid an uneven heating load on the stokers, the garbage must be mixed with the remainder of the refuse. In short, communities intending to dispose of their refuse at the plant should adopt regulations requiring refuse to be mixed as placed in storage containers at points of origin. Segregation of garbage, cans, bottles, and ashes from other refuse should not be permitted.

A community without municipal refuse collection should not be allowed in the plan since the dumping floor is not designed to handle a large volume of private automobiles. It would also be very dangerous if private citizens were allowed on the dumping floor or near the storage bin.

Collection Schedule

A coordinated collection schedule should be developed to balance the daily load entering the plant. Once outside users have been selected, such a collection schedule should be established so that the amount of refuse delivered to the process plant will be relatively uniform Monday through Friday.

CHAPTER 13

OTHER METHODS OF REFUSE DISPOSAL

General

Refuse disposal is not a new problem - numerous methods have been used since the beginning of time. As villages grew into towns, and towns into large cities, the problem of refuse disposal became more apparent. Governments were faced with the questions of where and how to dispose of the growing quantities of refuse, and residents had no interest in the refuse once it was out of their sight. Accordingly, the appropriate authority usually disposed of the refuse by dumping it on the ground and burning it. As population centers grew, various other methods of refuse disposal were tried.

Today, several acceptable methods of refuse disposal are available. The final determination of the best method depends largely on public acceptance of the method selected, and the total cost. In this chapter are presented several of these methods, and discussions as to their feasibility as a solution for the solid wastes disposal problem in the City of Lynn.

Sanitary Landfill

Sanitary landfill is a method of disposing of refuse on land without creating nuisances, or hazards to public health or safety. This method of refuse disposal involves the placing and compaction of refuse, both combustible and noncombustible, in layers; and the daily covering of this refuse with a 6-inch compacted layer of suitable cover material. As areas of the landfill site are filled to a desired final elevation, a 2-foot layer of suitable cover material is placed and compacted. The layers of cover material provide protection against possible underground fires, eliminate flies and mosquitoes, and seal off organic wastes which would provide food for rodents or other vermin. This cover also helps to control odors resulting from the decomposition of the refuse.

Most types of refuse can be disposed of at a sanitary landfill; however, hazardous or special wastes must be excluded. It is also desirable to separate the oversize (bulky) wastes for disposal into selected areas within the landfill.

Sanitary landfill, although the most widely used and usually the most economical method of refuse disposal, has some disadvantages. The land area required to operate a sanitary landfill is many times that required for an incinerator. A sufficient quantity of suitable cover material must be available on the site, or it will have to be trucked at additional expense. Unless a sanitary landfill is properly operated and maintained, it can take on the undesirable features of an open dump and become a nuisance affecting public health and safety.

We have estimated that 110 acre-feet per year would be required to dispose of the residential refuse generated in the City of Lynn alone. An additional 50 acre-feet would be required to dispose of the commercial and industrial refuse. With the increase in per-capita refuse production discussed in Chapter 5, a total of 6,000 acre-feet of landfill volume would be required over the next 30 years. The city has informed us that there are no areas of this magnitude, suitable for a sanitary landfill operation, within the city limits.

Several communities throughout the country have attempted hauling their refuse to a sanitary landfill in another community. This has not generally met with favorable acceptance by the residents of the receiving community, and in some instances court injunctions have been issued to prevent refuse originating outside a community from being deposited within the boundaries of the community. For these reasons, we cannot recommend sanitary landfilling as the solution to the solid wastes disposal problem in Lynn.

Conventional Incineration

The conventional incineration process is quite similar to incineration in a boiler. The capital and operating costs would be relatively the same. Therefore, the main difference would be in the sale of steam under the boiler concept. In addition, utilities necessary to operate the boiler could be obtained from the General Electric Company at a significant savings over the price the city alone would pay.

Since there is a market for the steam, we do not recommend conventional incineration for the City of Lynn.

High-Temperature Incineration

High-temperature incineration has been under development for several years. The Melt-Zit Destructor, designed by American Design and Development Corporation, is the only equipment developed far enough to warrant consideration.* They have a pilot plant in Whitman, Massachusetts, and are proposing to construct a full-scale plant in New Jersey.

The basic concept of the high-temperature equipment is to incinerate using a supplemental fuel at a high temperature, approximately 3,000 deg F, and to produce a very dense and stable residue. Volume reduction is claimed to be about 98 percent compared to approximately 90 percent attainable by normal incineration.

We cannot recommend consideration of this method until further test program results are available, operating experience has been gained, and the cost of this disposal method established.

Compaction and Rail Haul

Under this disposal process, refuse is compacted to a greatly reduced volume to facilitate hauling by rail or other means to a distant point of disposal, and for better utilization of landfill space. A compaction-transfer station must be provided and a disposal site available at reasonable distance for this method to be practical.

There is presently under construction in East Cambridge, Massachusetts, a compaction-transfer station. It will be privately owned and operated, and capable of handling up to 2,000 tons per day. The Boston *Globe* on October 7, 1969, reported that the disposal cost at the plant will be in the vicinity of $7.50 per ton. All that a user would be required to do is to bring his refuse to the station. The remainder of the process would be taken care of by the private company. We estimate that it would cost between $2.00 and $4.00 per ton to haul the refuse from Lynn to the compaction-transfer station. The haul cost is dependent upon the number of persons making the trip to the station. In summary, it would cost the City of Lynn between $9.50 and $11.50 per ton to dispose of its refuse in this manner.

*Kaiser, E. R. Evaluation of the Melt-Zit high-temperature incinerator; operation test report, August 1968. Cincinnati, U.S. Department of Health, Education, and Welfare, 1969. [116 p.]

It was indicated to us by the City of Lynn Planning Department that there is a possibility that a facility such as this one in East Cambridge could be constructed in the Lynn area by the same company. If this facility were constructed and if sufficient quantities of refuse were made available, the cost of disposal might possibly be the same as that charged in East Cambridge.

Composting

A few composting plants have been placed in operation in the United States in the past few years. Most of these are not in operation now.

Basically, the composting process involves biological degradation of organic material by aerobic digestion for a period of time, resulting in a stable and innocuous product

There are two major disadvantages to this method of solid waste disposal for the City of Lynn. The first is that the process is capable of handling only the organic portion of the refuse. The waste must be segregated and the nonorganic material disposed of separately. The second objection is that the compost has a very low value for use as a fertilizer. It can be considered only as a soil conditioner similar to humus. To make the process economically feasible, it is necessary to establish a market for the compost. It is doubtful that even with an extensive sales effort, such a market could be developed. If the processed humus-like material could not be sold, it would have to be disposed of in a sanitary landfill. As previously noted, there are no areas available in the city suitable for a landfill operation. For these reasons, we do not recommend composting as a solution to the solid wastes disposal problem in Lynn.

Ocean Disposal

Compacting refuse into bales having a density greater than that of sea water and sinking them out in the ocean has been mentioned as a method of solid wastes disposal.

In an informal meeting with a representative of the Corps of Engineers, the possibility of sea disposal was discussed. The Corps' position seems to be that this method of disposal would be acceptable only if it can be proved that no nuisance would be created, and the ecology of the disposal area will not be adversely affected.

Approval of various State and Federal agencies such as the Massachusetts Department of Health, the Federal Water Pollution Control Administration, the Department of Health, Education, and Welfare, etc., would also be necessary, both in conducting demonstrations and in issuance of permits.

In view of the difficulties involved in obtaining these approvals and the fact that any permits issued would be subject to cancellation on comparatively short notice, at this time we do not recommend sea disposal of baled refuse.

CHAPTER CHAPTER 14

COST ESTIMATE

General

Building cost estimates were developed using a value of 1,000 for the ENR (Engineering News-Record) Construction Cost Index. This index, created in 1921, is based on a hypothetical block of construction material and labor valued at $100 at 1913 prices.

Equipment cost estimates were obtained from manufacturers during the course of the study. The average ENR Construction Cost Index during the study period was 1,300.

Both building and equipment costs have been adjusted to an ENR of 1,375, expected to be reached in mid-1970. The construction cost at any time in the future can be estimated by the following method:

1. Divide the total building costs and the total equipment costs by 1,375.

2. Multiply these values by the ENR Construction Cost Index at the time the costs are desired.

3. Add 10 percent for general conditions.

4. Add 25 percent for engineering and contingencies.

Annual capital costs were calculated using an interest rate of 6 percent on capital investments made by the City of Lynn, and 10 percent on capital investments made by the General Electric Company. Since the average useful life of the equipment is estimated to be 20 years, the capital cost of the equipment was amortized over a period of 20 years. The average useful life of the buildings and structures is estimated to be at least 30 years, and the total costs of the buildings and structures were amortized over a period of 30 years.

The cost estimates are included as Appendix A of this report, and the Economic Evaluation is presented in Chapter 15.

Buildings and Structures

Costs for the process plants in Alternatives A-Ia and A-II were estimated from the preliminary building layouts shown on Figures 5 and 6 and Figures 8 and 9, respectively. Costs for the process plant in Alternative A-Ib was estimated by proportioning the cost of the Alternative II process plant on the basis of building volume.

Costs for the buildings in Alternatives B-I and B-II were estimated from the preliminary building layouts shown on Figures 11 and 12 and Figures 14 and 15, respectively.

Cost estimates for the buildings in Alternative C-I were based on the preliminary building layouts shown on Figures 11 and 12 for Alternative B-I.

Cost estimates for the buildings in Alternative C-I were based on the preliminary building layout shown on Figures 14 and 15 for Alternative B-II.

The estimate includes the cost of site development, substructure, superstructure, electrical, plumbing, heating, and ventilation. It also includes the cost of equipment foundations, support structures, outside utilities, and the river crossing structure. The items included in the electrical and the river crossing structure estimates are explained in detail in a subsequent section of this chapter.

Boiler Plant

Boiler costs are based on tentative proposal 0-2-83106 made by the Foster Wheeler Corporation to the General Electric Company, Lynn, Massachusetts, dated October 20, 1969, and supplemented by a letter dated December 29, 1969, from Foster Wheeler to General Electric.

The boiler plant cost includes the cost of a steam generator, which will produce 400,000 pounds of saturated steam per hour at approximately 650 psig when burning a combination of municipal refuse and No. 6 fuel oil, and when firing No. 6 fuel oil alone.

All of the accessories necessary for the steam generator, with the exception of the instrumentation which is carried separately, are included in this price. The cost includes the welded wall furnace; the economizer, a regenerative-type air heater, including the drive mechanism and cleaning device; and the electrostatic precipitator, energized by two 70-kv (kilovolts), 750-ma (milliampere) silicon rectifier sets. The price also includes all of the flues, ducts, wind boxes and hoppers associated with the boiler, the precipitator, and the stack; a stack and the soot blowers and their controls. The cost also includes all of the insulation and refractory work on the inner and outer surfaces of the incinerator, including the furnace, drums, flues, and ducts. It also includes all of the structural steel necessary to support the boiler, precipitator, and associated equipment, and the grating, platforms, walkways, stairtreads, and handrails necessary for the operation and inspection of the boiler. In addition, the cost includes the forced-draft oil burner air supply fan and drive, the underfire air and overfire air supply fans and drives, and the induced-draft fan and drive. It also includes the cost of the stoker and all of its associated equipment.

A water-cooled refuse charging chute, the furnace residue discharge chute, and the undergrate siftings removal hoppers and conduits are included in the price of the boiler plant. The cost of the ash-handling equipment is included separately. The price also includes the oil burners and associated equipment.

The cost for the erection of the proposed equipment listed under the boiler plant is also included in the total.

Superheater

This cost includes the price of the separately fired superheater, mechanical dust collector, induced-draft fan, steam air heater, piping and valves for the fuel system, and an oil pump and heater set. The cost of installation of these items is also included in the total.

Feedwater System

This cost includes only the price of equipment necessary to supplement the capacity of General Electric's existing system to meet the needs of the new boiler.

The feedwater system for the alternatives in which the boiler is located on the General Electric property includes the following items. two deaerator booster pumps, two softeners, two condensate polishers, a deaerator, two boiler feed pumps, a feedwater control valve and accessories, a feedwater heater, two chemical feed systems, and three sample coolers.

The feedwater system for the alternatives in which the boiler is located across the Saugus River from the General Electric plant includes the following: the deaerator, two boiler feed pumps, two condensate polishers, two softeners, two condensate tank feed pumps, a condensate storage tank, a condensate tank level control valve, two deaerator booster pumps, a feedwater control valve and accessories, a feedwater heater, two chemical feed systems, and three sample coolers.

The cost of installation is included in the price.

Auxiliary Oil System

For Alternatives A-Ia, A-Ib, and A-II, the price includes a No. 6 oil pump and heater set, and a No. 2 oil tank and pumps. For Alternatives C-I and C-II, the price includes only the pump and heater set; and for Alternatives B-I and B-II, it includes two pump and heater sets, a pipeline heat system, a No. 6 oil day tank, a pump suction heater, a No. 2 oil tank, and two No. 2 oil booster pumps. All costs include installation.

Ash-Handling System

The price for the ash-handling system includes purchase and installation of the following items: bottom ash conveyor, two ash slurry pumps, grit chamber, ash removal system for the electrostatic precipitator; also, a bucket elevator for Alternatives A-Ia, A-Ib, and A-II.

Other Equipment

Costs of the other pieces of equipment are based on quotations from manufacturers, or from data obtained in recent design projects in which Metcalf & Eddy has been engaged.

Estimates include cost of equipment delivered to the job site and its installation

Process Piping

The price for process piping includes the 650-psig superheated system piping and valves; the 200-psig and 3-psig saturated steam piping and valves; and the raw water, softened water, feedwater, steam line drips, brine, chemical feed, fuel oil, gas or No. 2 oil, and the compressed-air piping and valves. The price includes the cost of installation.

Instrumentation

The price for instrumentation includes the cost of all instrumentation associated with the boiler plant. It includes control equipment for the combustion regulation system, steam temperature control, feedwater control, draft control, boiler safety system, and the boiler control panel.

Electrical

The cost includes purchase and installation of transformers, high- and low-voltage cable, motor starters, control equipment, circuit breakers, panels, fixtures, the lighting system, and all of the associated conduits and cables.

River Crossing Structure

The river crossing structure costs are based on a preliminary design of the structure. It includes the cost of the piles and piers shown on Figure 21, the cost of the housing shown on Figure 22, and the cost of the structural framing between piers.

Pipes Crossing River

A 16-inch steam main, an 8-inch boiler feedwater supply main, and a 6-inch fuel oil supply main across the Saugus River in Alternatives B-I and B-II are proposed. The cost includes all of the material and labor necessary to install these mains, including the valves and fittings.

Operation

Operation costs include the costs of boiler feedwater, fuel oil, and power, all of which will be supplied by the General Electric Company in all alternatives. The prices were supplied by the General Electric Company for this study.

The cost also includes an allowance for process and drinking water, heating, and materials for equipment and building maintenance.

Labor

Labor costs are based on job classifications and salaries paid for similar work in the Greater Boston area adjusted to mid-1970.

Summary

The results of the cost estimates are included in Appendix A and an Economic Evaluation is presented in Chapter 15. The possible effect of the state sales tax should be explored in greater depth when financial arrangements are finalized. There are no allowances for it in this report.

CHAPTER 15

ECONOMIC EVALUATION – COST APPORTIONMENT

General

The total annual costs that would be incurred by both the General Electric Company and the City of Lynn under each alternative are presented in Tables A-1 through A-6 in Appendix A of this report. They are summarized in Table A-7 and shown graphically on Figure 23. The total annual cost includes all of the costs incurred by both the City of Lynn and the General Electric Company from the time a refuse vehicle enters the access road until the 650 psig, 850 deg F steam leaves the superheater including the cost of the supplemental fuel oil and the capital investments. It is based on a total annual volume of refuse of 135,000 and 215,000 tons per year in the alternatives utilizing a reciprocating grate stoker and a spreader stoker respectively and an annual quantity of 1,685 million pounds of steam (average: 200,000 pounds per hour, 350 days per year) going into the General Electric Company distribution system.

The annual cost varies from a low of $2,374,000 in Alternative C-II to a high of $2,761,000 in Alternative A-Ia, a range of only $387,000.

The same amount of steam is produced with each alternative, but because the refuse is burned on a reciprocating grate stoker in Alternatives A-Ia, A-Ib, B-I and C-I, only 135,000 tons of refuse can be incinerated per year, whereas in Alternatives A-II, B-II, and C-II, which utilize a spreader stoker, 215,000 tons of refuse per year can be incinerated.

General Electric's steam requirements are discussed in Chapter 4 and the value of the superheated steam that would be produced by the proposed boiler is presented in Chapter 10. Based on the figures presented in Table 2, the average load that will be produced by the boiler will be 275,000 pounds of steam per hour. We estimate that approximately 75,000 pounds of steam per hour will be returned to the system for deaeration, feedwater heating and other uses, leaving an average net quantity of 200,000 pounds of steam per hour available for the General Electric Company. Using the value of $0.877 per 1,000 pounds of 650 psig, 850 deg F steam, this steam would be worth $1,480,000 per year.

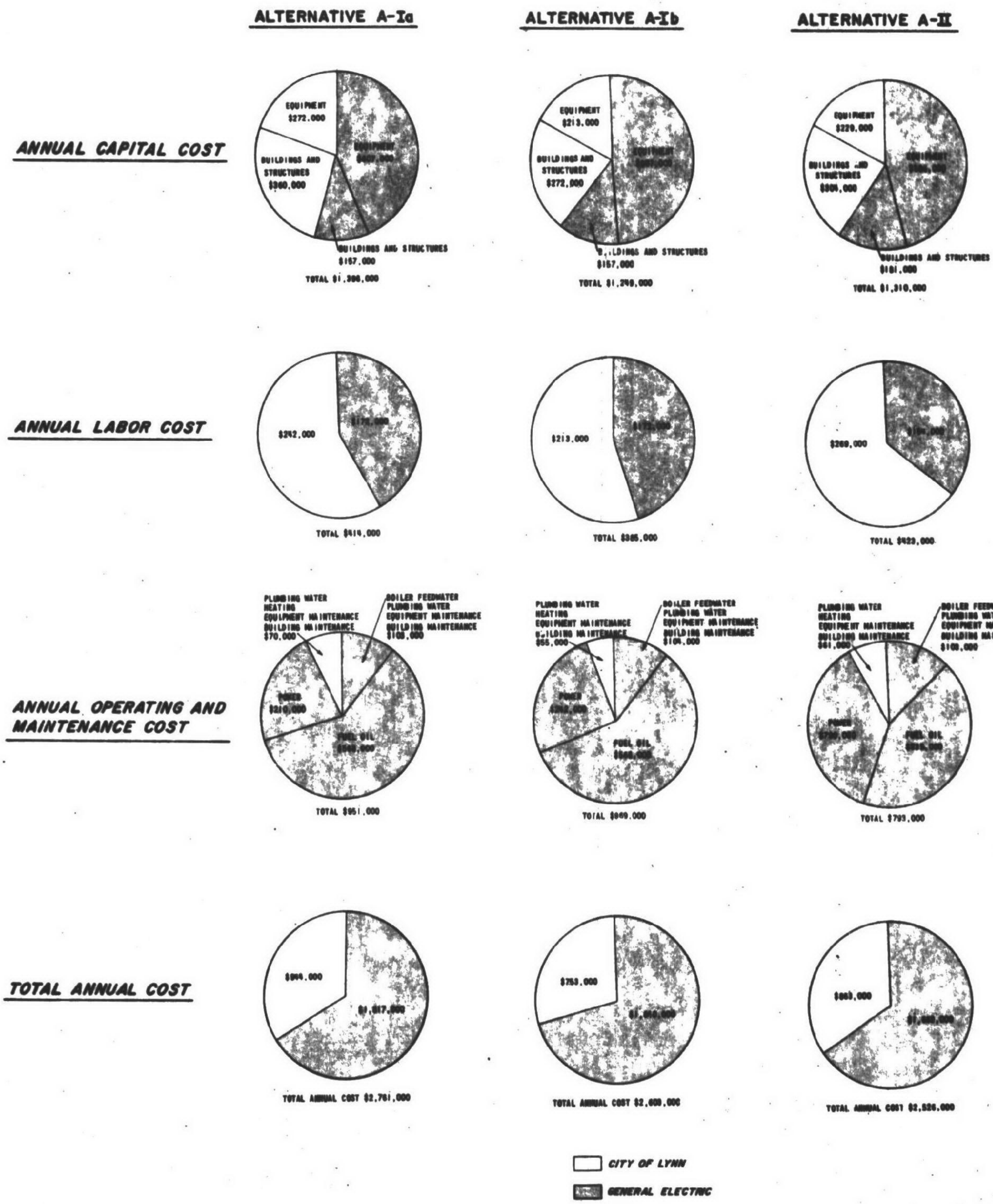

FIG. 23 COST APPORTIONMENT - SUMMARY

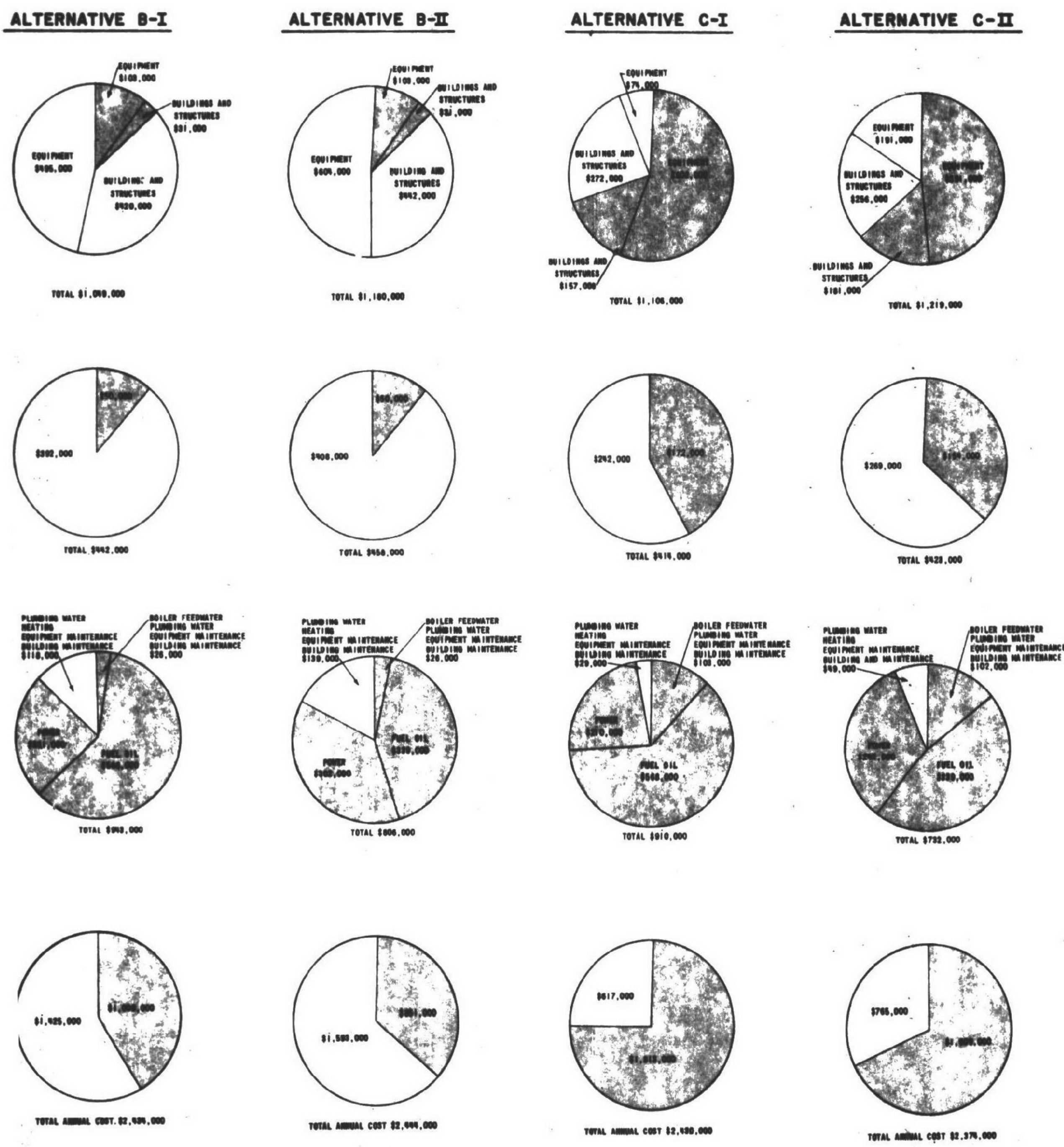

FIG. 23 COST APPORTIONMENT - SUMMARY (CONT'D)

The total annual cost and the value of the steam produced under each alternative are shown on Table 8. The difference between these two totals which represents the net cost of refuse disposal is also presented. Because the quantity of refuse handled is not constant in each of the alternatives, all of the above figures are also shown on the basis of the cost per ton of refuse burnt.

The total cost minus the value of the steam is $9.49, $8.32, $7.07, and $7.04 per ton of refuse burned in Alternatives A-Ia, A-Ib, B-I and C-I respectively, and $4.87, $4.48, and $4.16 per ton of refuse burned in Alternatives A-II, B-II, and C-II respectively. These figures represent the net cost of refuse disposal. They are less in the three latter alternatives than in the four former alternatives, chiefly because approximately 50 percent more refuse is burned in the three latter alternatives.

It was explained earlier in this report that the C alternatives were not implementable, but were presented only for comparison purposes.

Both Alternative A-II and Alternative B-II are attractive from the standpoints of implementation and costs. The $4.87 and $4.48 is much lower than the cost of conventional incineration, which we estimate is in the range of $7 00 to $10.00 per ton and the $7.50 per ton quoted in Chapter 13 for rail haul. These figures show, therefore, that the concept has definite merit.

The above cost analysis is presented in order to demonstrate the overall economic benefit of this concept. There are several additional factors that enter into the economic evaluation. Since this is a joint venture, a portion of the economic benefit should be allocated to the General Electric Company. Private haulers and other communities should be charged a competitive fee for the use of the facilities. Based on data presented in Chapter 5, over two-thirds of the refuse would come from sources other than the City of Lynn or the General Electric Company. For comparison purposes, we divided the 215,000 tons of refuse per year into three categories according to sourc: City of Lynn, 63,000 tons per year; General Electric, 7,000 tons per year; and other users, 145,000 tons per year.

It is not the intent in the feasibility report to decide on the financial arrangements between the two parties in this joint venture. Much of this would be subject to negotiations between the two parties. We have, however, prepared several case studies for Alternatives A-II and B-II based on

TABLE 8 COMPARISON OF ALTERNATIVES

ITEM	A-Ia	A-Ib	A-II	B-I	B-II	C-I	C-II
	ALTERNATIVE						
1. TOTAL ANNUAL COSTS	$2,761,000	$2,603,000	$2,526,000	$2,434,000	$2,444,000	$2,430,000	$2,374,000
COSTS PER TON OF REFUSE BURNED	$ 20.45[1]	$ 19.28[1]	$ 11.75[2]	$ 18.03[1]	$ 11.36[2]	$ 18.00[1]	$ 11.04[2]
2. VALUE OF STEAM (@ $0.877/1000#) PER YEAR	$1,480,000	$1,480,000	$1,480,000	$1,480,000	$1,480,000	$1,480,000	$1,480,000
VALUE PER TON OF REFUSE BURNED	$ 10.96[1]	$ 10.96[1]	$ 6.88[2]	$ 10.96[1]	$ 6.88[2]	$ 10.96[1]	$ 6.88[2]
3. TOTAL COST MINUS VALUE OF STEAM	$1,281,000	$1,123,000	$1,046,000	$ 954,000	$ 964,000	$ 950,000	$ 894,000
COST PER TON OF REFUSE BURNED	$ 9.49[1]	$ 8.32[1]	$ 4.87[2]	$ 7.07[1]	$ 4.48[2]	$ 7.04[1]	$ 4.16[2]

1 BASED ON 135,000 TONS OF REFUSE PER YEAR.

2 BASED ON 215,000 TONS OF REFUSE PER YEAR.

theoretical, but possible, economic arrangements. The revenue taken in in the case studies is summarized in Figure 24.

In Case I, the total annual value of steam is based on $0.877 per 1,000 pounds. This value is subtracted from the total annual costs incurred by both parties and the resultant figure divided by the 215,000 tons of refuse burned annually. The result is a cost of $4.87 and $4.48 per ton of refuse burned in Alternatives A-II and B-II respectively. These are the figures presented in Table 8 and discussed earlier in this chapter.

In Case II, the value of steam was arbitrarily set 10 percent lower than the actual value based on General Electric's present capabilities. In addition, the charge to other users for refuse disposal was set at $6.00 per ton. These values were subtracted from the total annual costs incurred by both parties and the resultant figure divided by the 70,000 tons of refuse estimated to be generated by the City of Lynn and the General Electric Company annually. The result is a cost to the City of Lynn and the General Electric Company of $4.66 and $3.49 per ton of refuse burned in Alternatives A-II and B-II respectively.

In Case III, the value of steam was again arbitrarily set 10 percent lower than the actual value based on General Electric's present capabilities. The charge to other users for refuse disposal was set at $7.00 per ton. Following the same procedure outlined in Case II, the result is a cost to the City of Lynn and the General Electric Company of $2.59 and $1.41 per ton of refuse burned in Alternatives A-II and B-II, respectively.

An analysis of Alternative A-II, Case III, shows that all of the annual costs ($2,526,000), shown on Table A-7, incurred by both the General Electric Company and the City of Lynn, can be paid for by charging other users $7.00 per ton to dispose of their refuse, by debiting the accounts of the General Electric Company and the City of Lynn $2.49 per ton for the refuse they deliver to the plant, and by debiting General Electric's account at 10 percent less than the actual value of steam based on General Electric's present capabilities.

Each of the case studies can be analyzed in a similar manner. Again, these case studies are presented only to show various possible ways of balancing the annual expenses and do not necessarily represent our recommended method of financing.

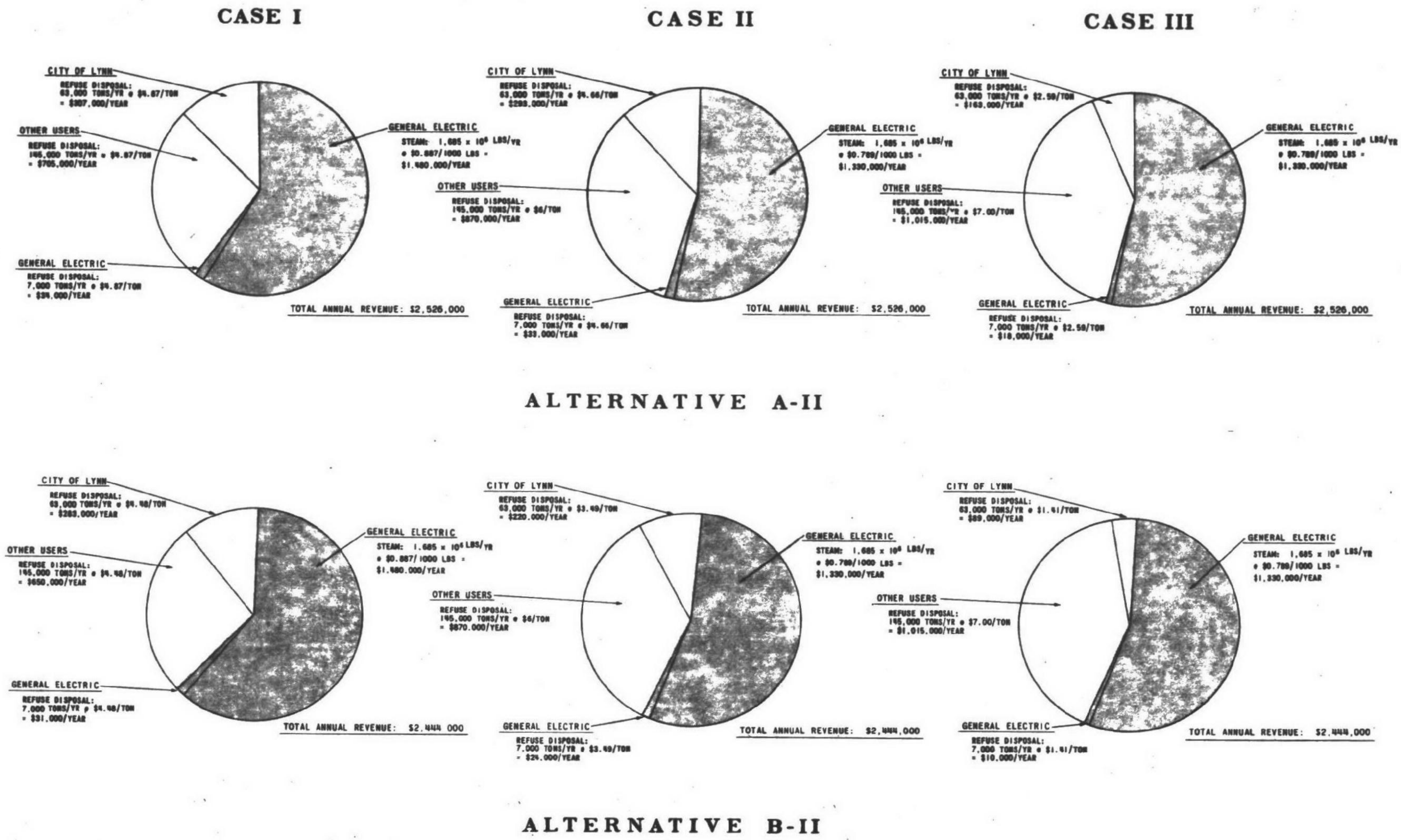

FIG. 24 SUMMARY - ESTIMATED ANNUAL REVENUE

CHAPTER 16

EXPANSION AND ADAPTABILITY TO OTHER AREAS

Expanded Facilities at the Lynn-Saugus Location

There is need for a refuse disposal solution in many of the other communities in northeast Massachusetts, particularly those communities and private haulers who presently use the DeMatteo landfill in Saugus. Because of the special need for an economical refuse disposal facility to service the area just north of Boston, and because of the rising cost of steam production using fossil fuels, it would be appropriate to investigate the installation of a larger facility at this site.

Preliminary investigations would be necessary to determine the quantity of refuse that would be available at the facility and to determine the maximum amount of steam General Electric could utilize. Preliminary investigations should also be made to ascertain if there are any existing or planned industries in the immediate area that could also use some of the steam.

The basic concept has been shown to be sound. The refuse disposal needs of the City of Lynn can be solved economically; but, from a larger viewpoint, there is a very good possibility that the refuse-disposal needs of a major portion of the area north of Boston might also be solved by expanding this concept.

Adaptability to Other Areas

The Joint Venture Concept. The joint venture concept of refuse disposal and steam generation appears quite suitable to any region of the country. There are two major requirements, however, that must first be met. The first is a sizeable quantity of refuse. The economic advantage that comes with increased quantities of refuse is evident in Table 8. The second requirement is a user for the steam.

The steady depletion of the fossil-fuel reserves, the steady rise in production and transportation costs of fuels and the more stringent air pollution code requirements have and will continue to increase the cost of steam production using fossil fuels.

The scarcity of suitable sites for sanitary landfill operations, the recent bans on open burning, and the steady increase in population have caused the severity and the cost of the refuse-disposal problem to increase at alarming rates.

As the costs of refuse disposal and steam generation increase, the concept presented herein becomes even more attractive.

Additional Considerations at Other Locations. The Lynn-General Electric joint venture is unusual in the following ways:

1. Sufficient fuel oil storage capacity is already available at the General Electric Company; therefore, the costs of fuel oil storage tanks are not included in the estimate.

2. Sufficient land is available and is owned by the General Electric Company; therefore, the cost of land is not included in the estimate.

3. The General Electric Company generates its own power, which will be used to run the refuse processing and burning equipment. As a result, power is available at a slightly lower cost than from the local utility.

4. Portions of the feedwater system are presently available at the General Electric Company; therefore, the cost of that equipment is not included in the estimate.

In other locations where the above are not available, the cost of providing them should be included in the overall economic analysis.

CHAPTER 17

ACKNOWLEDGMENTS

We wish to acknowledge our appreciation to Mr. William E. George, Planning Director of the City of Lynn; Mr. Thomas J. Muckian, member of the City of Lynn Planning Board; Mr. John F. Milo, Manager of the River Works Utilities Services at the General Electric Company in Lynn; and Mr. Alden H. Howard, Manager of Utilities Operation at the General Electric Company in Lynn, for their cooperation and assistance in furnishing data, information, and suggestions for this report.

We also wish to acknowledge the cooperation of Mr. Stephen Levy, Solid Waste Management Representative of the Bureau of Solid Waste Management.

Respectfully submitted,

METCALF & EDDY, INC.

Andrew C. Paton
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Registered Professional Engineer
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APPENDIX A

TABLE A-1 ESTIMATED CAPITAL INVESTMENT - BUILDINGS AND STRUCTURES (CITY OF LYNN)

ITEM	COST						
	ALTERNATIVE A-Ia	ALTERNATIVE A-Ib	ALTERNATIVE A-II	ALTERNATIVE B-I	ALTERNATIVE B-II	ALTERNATIVE C-I	ALTERNATIVE C-II
SITE WORK	$ 210 000	$ (4)	$ 218 000	$ 235 000	$ 248 000	$ 210,000	$ 218 000
EXCAVATION BACKFILL, DEWATERING, ETC	180 000	(4)	140 000	228 000	165 000	180 000	140 000
WOOD PILES	36 000	(4)	53,000	68 000	120 000	36,000	53,000
CONCRETE	620,000	(4)	536 000	742 000	764 000	620 000	536,000
STRUCTURAL STEEL	88 000	(4)	80 000	190 000	290 000	88,000	80,000
EXTERIOR WALLS (MASONRY AND METAL PANEL)	65 000	(4)	80,000	192 000	180 000	65,000	80,000
ROOFING, FLASHING AND SHEET METAL	25,000	(4)	23,000	26,000	29 000	25,000	23 000
MISCELLANEOUS ITEMS(1)	245 000	(4)	216 000	324 000	302,000	245 000	216 000
HEATING AND VENTILATING(2)	120 000	(4)	108,000	170,000	168,000	120 000	108,000
PLUMBING(2)	48 000	(4)	43 000	68 000	74 000	48 000	43 000
FIRE PROTECTION(2)	27 000	(4)	30 000	31 000	33 000	27 000	30,000
ELECTRICAL(2)	207,000	225 000	228,000	346,000	405,000	204,000	234,000
WATER AND SEWER MAINS	35 000	35 000	35,000	35 000	35 000	-	- -
RIVER CROSSING STRUCTURE	600 000	308 000	308,000	288 000	288 000	-	-
ASH HANDLING BUILDING(3)	109 000	109 000	109,000	109,000	109,000	109,000	109 000
TOTAL COST (ENR = 1000)	$2 615 000	$1 977 000	$2,207 000	$3 052 000	$3 210 000	$1 977 000	$1 870 000
TOTAL COST (ENR = 1375)	3,600 000	2 720 000	3,040,000	4 200 000	4 420,000	2,720 000	2,570,000
GENERAL CONDITIONS 10%	360,000	272 000	304 000	420 000	442,000	272,000	257 000
SUBTOTAL	3,960 000	2 992 000	3,344,000	4 620,000	4,862 000	2,992,000	2,827 000
ENGINEERING AND CONTINGENCIES 25%	990 000	747,000	835,000	1 155 000	1 215,000	747 000	707,000
TOTAL	$4 950 000	$3 739 000	$4 179,000	$5 775,000	$6,077 000	$3 739,000	$3 534 000
ANNUAL CAPITAL COST (30 YRS @ 6%)	$ 360,000	$ 272,000	$ 304 000	$ 420,000	$ 442,000	$ 272,000	$ 256,000

1 INCLUDES ACOUSTICAL TREATMENT, TILE FLOOR FINISHES CARPENTRY DOORS WINDOWS, GLASS AND GLAZING, MISCELLANEOUS METALS, ETC

2 INCLUDES ALLOWANCE FOR GENERAL CONTRACTOR'S MARKUP

3 INCLUDES HEATING VENTILATING, PLUMBING AND ELECTRICAL

4 TOTAL COST BASED ON 85 PERCENT OF TOTAL COST OF THE RESPECTIVE ITEMS IN ALTERNATIVE A-II

TABLE A-2 ESTIMATED CAPITAL INVESTMENT - EQUIPMENT
(CITY OF LYNN)

ITEM	ALTERNATIVE A-Ia		ALTERNATIVE A-Ib		ALTERNATIVE A-II		ALTERNATIVE B-I		ALTERNATIVE B-II		ALTERNATIVE C-I		ALTERNATIVE C-II	
	QUANTITY	TOTAL COST	QUANTITY	TOTAL COST	QUANTITY	TOTAL COST	QUANTITY	TOTAL COST	QUANTITY	TOTAL COST	QUANTITY	TOTAL COST	QUANTITY	TOTAL COST
SCALE AND RECORDER	1	$ 14 500	1	$ 14 500	1	$ 14 500	1	$ 14 500	1	$ 14 500	1	$ 14 500	1	$ 14 500
BRIDGE CRANE	2	260 000	2	320 000	2	320 000	2	260 000	2	320 000	2	260 000	2	320 000
SHREDDER	1	130 000	2	260 000	2	260 000	1	130 000	2	260 000	1	130 000	2	260 000
SPARE PARTS FOR SHREDDER	LS	20 000	LS	20 000	LS	20 000	LS	20 000	LS	20 000	LS	20 000	LS	20,000
DUST COLLECTION SYSTEM	1	22 000	2	44 000	2	44 000	1	22 000	2	44 000	1	22,000	2	44 000
LEVELING DEVICE	-	-	2	22 000	2	22 000	-	-	2	22 000	-	-	2	22 000
MISCELLANEOUS REFUSE CONVEYORS	4	110 200	10	194 000	10	194,000	2	51 000	11	251 000	2	51 000	11	251 000
STORAGE SILO	-	-	2	378 000	2	474 000	-	-	2	474 000	-	-	2	474 000
BIFURCATED CHUTE	-	-	1	15 000	1	15 000	-	-	LS	15 000	-	-	LS	15,000
800 FT REFUSE CONVEYOR	2	1 360,000	2	222 000	2	252 000	-	-	-	-	-	-	-	-
800 FT ASH CONVEYOR	1	116 000	1	86 000	1	86 000	-	-	-	-	-	-	-	-
RESIDUE TRANSFER CONVEYOR	1	13 500	1	13 500	1	13 500	-	-	-	-	-	-	-	-
RESIDUE HOPPER	LS	6 000	LS	6 000	LS	6 000	LS	6 000	LS	6 000	LS	6 000	LS	6 000
RESIDUE CONTAINER	6	18 000	6	18 000	6	18 000	6	18 000	6	18,000	6	18 000	6	18 000
RESIDUE HAULING VEHICLE	1	36 500	1	36 500	1	36 500	1	36 500	1	36 500	1	36 500	1	36 500
SUMP PUMP	2	6 000	2	6 000	2	6 000	2	6 000	2	6 000	2	6 000	2	6,000
FRONT END LOADER	1	6 000	-	-	-	-	1	6 000	-	-	1	6 000	-	-
HEATING PLANT	LS	10 000	LS	10 000	LS	10 000	-	-	-	-	-	-	-	-
BOILER PLANT	-	-	-	-	-	-	LS	2 250 000	LS	2 190 000	-	-	-	-
FEEDWATER SYSTEM	-	-	-	-	-	-	LS	155 400	LS	155 400	-	-	-	-
AUXILIARY OIL SYSTEM	-	-	-	-	-	-	LS	33 000	LS	33 000	-	-	-	-
BOILER - ASH HANDLING SYSTEM	-	-	-	-	-	-	LS	170 700	LS	166 000	-	-	-	-
PROCESS PIPING	-	-	-	-	-	-	LS	190 000	LS	190 000	-	-	-	-
PIPES CROSSING RIVER	-	-	-	-	-	-	3	341 000	3	341 000	-	-	-	-
INSTRUMENTATION	-	-	-	-	-	-	LS	185 000	LS	185 000	-	-	-	-
CENTRAL VACUUM SYSTEM	LS	15 000	LS	15 000	LS	15 000	LS	18,000	LS	18 000	LS	15 000	LS	15 000
TOTAL INSTALLED COST (ENR = 1300)		$2 143 700		$1,680 500		$1 806 500		$3 913 100		$4 765 400		$585 000		$1 502 000
TOTAL INSTALLED COST (ENR = 1375)		2 270 000		1,775 000		1 910 000		4,130 000		5 040 000		619 000		1 590 000
GENERAL CONDITIONS 10%		227 000		177 500		191 000		413 000		504 000		61 900		159,000
SUBTOTAL		2 497 000		1 952 500		2 101 000		4 543 000		5 544 000		680 900		1 749 000
ENGINEERING AND CONTINGENCIES 25%		624 000		488,000		525,000		1,134,000		1 385 000		170 000		437 000
TOTAL		$3 121 000		$2 440 500		$2 626 000		$5 677 000		$6 929 000		$850 900		$2,186,000
ANNUAL CAPITAL COST (20 YRS @ 6%)		$ 272 000		$ 213,000		$ 229 000		$ 495 000		$ 604 000		$ 74 000		$ 191,000

TABLE A-3 ESTIMATED CAPITAL INVESTMENT - BUILDINGS AND STRUCTURES (GENERAL ELECTRIC)

ITEM	COST						
	ALTERNATIVE A-Ia	ALTERNATIVE A-Ib	ALTERNATIVE A-II	ALTERNATIVE B-I	ALTERNATIVE B-II	ALTERNATIVE C-I	ALTERNATIVE C-II
BOILER BUILDING							
EXCAVATION, BACKFILL, DEWATERING, ETC	$ 37 000	$ 37,000	$ 45 000	$ -	$ -	$ 37 000	$ 45 000
WOOD PILES	20 000	20 000	31,000	-	-	20 000	31,000
CONCRETE	141 000	141,000	162,000	-	-	141,000	162 000
STRUCTURAL STEEL	48 000	48 000	67,000	-	-	48,000	67 000
EXTERIOR WALLS (MASONRY AND METAL PANEL)	121 000	121,000	118 000	-	-	121,000	118,000
ROOFING, FLASHING AND SHEET METAL	5 500	5 500	5,000	-	-	5,500	5,000
MISCELLANEOUS ITEMS[1]	68 500	68,500	104 000	-	-	68,500	104 000
HEATING AND VENTILATING[2]	42 000	42,000	51,000	-	-	42 000	51,000
PLUMBING[2]	17,000	17 000	21 000	-	-	17 000	21,000
FIRE PROTECTION[2]	7 000	7,000	7 000	-	-	7 000	7,000
ELECTRICAL[2]	125,000	125,000	139,000	-	-	125,000	139,000
SUBTOTAL	$ 632 000	$ 632 000	$ 750,000	$ 0	$ 0	$ 632,000	$ 750,000
SUPERHEATER BUILDING							
EXCAVATION, BACKFILL, DEWATERING, ETC	4 900	4 900	4 900	4 900	4,900	4 900	4,900
WOOD PILES	9 100	9 100	9 100	9 100	9 100	9 100	9,100
CONCRETE	8,800	8,800	8,800	8,800	8 800	8,800	8,800
STRUCTURAL STEEL	21 000	21 000	21,000	21 000	21,000	21,000	21 000
EXTERIOR WALLS (MASONRY AND METAL PANEL)	42 000	42 000	42,000	42 000	42,000	42,000	42 000
ROOFING, FLASHING AND SHEET METAL	1 600	1 600	1,600	1 600	1 600	1 600	1 600
MISCELLANEOUS ITEMS[1]	36 000	35 000	36 000	36,000	36,000	36 000	36 000
HEATING AND VENTILATING[2]	13 000	13,000	13,000	13,000	13 000	13 000	13 000
PLUMBING[2]	4 700	4 700	4,700	4 700	4,700	4 700	4,700
FIRE PROTECTION[2]	1 500	1 500	1 500	1 500	1 500	1,500	1,500
ELECTRICAL[2]	12 000	12 000	12 000	12 000	12,000	12,000	12,000
SUBTOTAL	$ 154 600	$ 154,600	$ 154 600	$154 600	$154 600	$ 154,600	$ 154 600
TOTAL BUILDING COST (ENR = 1000)	$ 786 600	$ 786 600	$ 904,600	$154 600	$154 600	$ 786,600	$ 904 600
TOTAL BUILDING COST (ENR = 1375)	1 080 000	1 080 000	1 240 000	212 000	212,000	1,080,000	1,240 000
GENERAL CONDITIONS 10%	108 000	108 000	124,000	21,200	21,200	108 000	124 000
SUBTOTAL	1 188 000	1 188 000	1 364,000	233 200	233 200	1 188 000	1 364,000
ENGINEERING AND CONTINGENCIES 25%	297 000	297 000	341 000	58 300	58,300	297 000	341,000
TOTAL	$1 485 000	$1 485 000	$1 705 000	$291 500	$291 500	$1 485,000	$1 705 000
ANNUAL CAPITAL COST (30 YRS + 10%)	$ 157 000	$ 157 000	$ 181 000	$ 31 000	$ 31 000	$ 157 000	$ 181 000

1 INCLUDES ACOUSTICAL TREATMENT TILE FLOOR FINISHES CARPENTRY DOORS WINDOWS GLASS AND GLAZING, MISCELLANEOUS METALS ETC

2 INCLUDES ALLOWANCE FOR GENERAL CONTRACTOR'S MARKUP

TABLE A-4 ESTIMATED CAPITAL INVESTMENT - EQUIPMENT
(GENERAL ELECTRIC)

ITEM	COST						
	ALTERNATIVE A-Ia	ALTERNATIVE A-Ib	ALTERNATIVE A-II	ALTERNATIVE B-I	ALTERNATIVE B-II	ALTERNATIVE C-I	ALTERNATIVE C-II
BOILER PLANT	$2 250 000	$2 250 000	$2 190 000	-	-	$2 250 000	$2 190,000
SUPERHEATER	455 000	455 000	455 000	$455 000	$455 000	455 000	455,000
FEEDWATER SYSTEM	254 700	254 700	254 700	115 300	115 300	254 700	254,700
AUXILIARY OIL SYSTEM	23 500	23 500	23 500	500	500	20 000	20,000
ASH HANDLING SYSTEM	170 700	165 700	160 000	-	-	136 700	131,000
PROCESS PIPING	210 000	210 000	210 000	20 000	20 000	210 000	210 000
INSTRUMENTATION	200 000	200 000	200 000	15 000	15,000	200 000	200,000
TOTAL INSTALLED COST (ENR = 1300)	$3 563 900	$3 558 900	$3 493 200	$605 800	$605,800	$3 526,400	$3 460 700
TOTAL INSTALLED COST (ENR = 1375)	3 760 000	3 760 000	3 690 000	640 000	640 000	3 730 000	3 660 000
GENERAL CONDITIONS 10%	376 000	376 000	369,000	64 000	64,000	373 000	366,000
SUBTOTAL	4 136 000	4 136 000	4,059 000	704 000	704 000	4,103,000	4,026,000
ENGINEERING AND CONTINGENCIES 25%	1 030 000	1,030,000	1 010,000	176 000	176,000	1 030,000	1 010,000
TOTAL	$5 166 000	$5,166 000	$5 069 000	$ 880 000	$880,000	$5 133 000	$5 036 000
ANNUAL CAPITAL COST (20 YRS @ 10%)	$ 607 000	$ 607 000	$ 596 000	$ 103 000	$103,000	$ 603 000	$ 591,000

TABLE A-5 ESTIMATED OPERATING COSTS (CITY OF LYNN)

ITEM	COST						
	ALTERNATIVE A-Ia	ALTERNATIVE A-Ib	ALTERNATIVE A-II	ALTERNATIVE B-I	ALTERNATIVE B-II	ALTERNATIVE C-I	ALTERNATIVE C-II
PLUMBING WATER	$ 3 000	$ 3 000	$ 4 000	$ 14 000	$ 16,000	$ 3 000	$ 4 000
HEATING	4 000	3 000	4 000	0	0	0	0
EQUIPMENT MAINTENANCE	45 000	35 000	38 000	83 000	101 000	12,000	32 000
BUILDING MAINTENANCE	18 000	14 000	15,000	21 000	22 000	14 000	13 000
TOTAL	$70 000	$55 000	$61 000	$118 000	$139,000	$29 000	$49 000

TABLE A-6 ESTIMATED OPERATING COSTS (GENERAL ELECTRIC)

ITEM	COST						
	ALTERNATIVE A-Ia	ALTERNATIVE A-Ib	ALTERNATIVE A-II	ALTERNATIVE B-I	ALTERNATIVE B-II	ALTERNATIVE C-I	ALTERNATIVE C-II
BOILER FEED WATER	$ 12,000	$ 12,000	$ 12 000	$ 12 000	$ 12,000	$ 12,000	$ 12 000
FUEL OIL	568 000	568 000	339,000	568 000	339 000	568,000	339,000
POWER	210 000	242 000	290 000	231 000	302 000	210 000	242 000
EQUIPMENT MAINTENANCE	75 000	76,000	74,000	13,000	13 000	75 000	73 000
BUILDING MAINTENANCE	5 000	5 000	6,000	1,000	1,000	5,000	6,000
PLUMBING WATER	11 000	11 000	11 000	0	0	11 000	11 000
TOTAL	$881 000	$914 000	$732 000	$825 000	$667 000	$881 000	$683 000

TABLE A-7 SUMMARY - ESTIMATED ANNUAL COSTS

ITEM	A-Ia	A-Ib	A-II	B-I	B-II	C-I	C-II
	ALTERNATIVE						
CITY OF LYNN							
EQUIPMENT	$ 272.000	$ 213.000	$ 229.000	$ 495.000	$ 604.000	$ 74,000	$ 191.000
BUILDING AND STRUCTURES	360 000	272.000	304.000	420.000	442.000	272.000	256.000
LABOR	242.000	213.000	269.000	392.000	408.000	242.000	269.000
OPERATING AND MAINTENANCE	70 000	55.000	61.000	118.000	139.000	29.000	49.000
SUBTOTAL	$ 944.000	$ 753.000	$ 863.000	$1.425.000	$1.593.000	$ 617.000	$ 765.000
GENERAL ELECTRIC							
EQUIPMENT	$ 607.000	$ 607.000	$ 596.000	$ 103.000	$ 103.000	$ 603.000	$ 591.000
BUILDING AND STRUCTURES	157.000	157.000	181.000	31.000	31.000	157.000	181.000
LABOR	172.000	172.000	154.000	50.000	50.000	172.000	154.000
OPERATING AND MAINTENANCE	881 000	914.000	732 000	825.000	667.000	881 000	683.000
SUBTOTAL	$1.817.000	$1.850.000	$1,663.000	$1,009.000	$ 851.000	$1,813.000	$1,609.000
TOTAL	$2.761.000	$2 603.000	$2,526,000	$2,434.000	$2.444.000	$2.430.000	$2.374 000

PART II

CITY OF LYNN
PLANNING DEPARTMENT
CITY HALL ROOM 412
LYNN, MASSACHUSETTS
01901

Action Plan for Solid Waste Disposal Facility

For discussion purposes, alternative B-11 (See Part I, Metcalf and Eddy's Generation of Steam From Solid Wastes) is designated as the long-range solid waste disposal recommendations for the Lynn[1] and North Shore Area.[2] This alternative has been selected because of existing circumstances in the area:

1. a large industrial complex (Riverworks-General Electric Company) requiring additional steam
2. an adequate supply of municipal solid waste
3. shortage of land for exclusive sanitary land-fill

Alternative B-11 appears to provide the best mutual economic savings to the various participants involved in the venture.

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[1] Lynn area consists of the communities of Lynn, Saugus, Nahant, and Swampscott, as used in Part I of this report.

[2] North Shore Area consists of the above four communities (Lynn, Saugus, Nahant, and Swampscott) plus Revere, Lynnfield, Marblehead, and Peabody.

1. Formal Notification (January, 1971).

The City of Lynn will formally notify the General Electric Company (Riverworks) that it desires to cooperate in a joint venture that adheres to the recommendations of the B-11 alternative. This is the alternative in which the process plant and boiler with spreader-stoker are located in Saugus. Official notice of participation to the General Electric Company is deemed necessary at this time because 24 to 30 months must be allocated for design and construction of the proposed facility. As the General Electric Company has a schedule of boiler replacement, a firm commitment at this time will enable future steam demands to be met through this municipal solid waste process. Therefore, City notification through the Mayor is appropriate and necessary. Favorable action is anticipated within the month.

2. Notification of Surrounding Communities (January, 1971).

Simultaneously to the above action, the Mayor and Project Director will meet with representatives of the surrounding cities and towns to discuss the study recommendations and solicit their participation in the joint venture project. Favorable action is anticipated.

3. <u>North Shore Solid Waste Organization (January, 1971).</u>

The Mayor of Lynn will propose to the representatives of the communities that a North Shore Solid Waste District be established. This will involve only disposal services and will exclude collection. The exact form of the organization in which the communities will join for the special purpose of solid waste disposal will be prepared and recommended by the selectmen and legal counsels of the respective communities in concert with the City of Lynn. After consensus has been achieved on the form of the organization, the proposed agreement or pact will be drafted for approval by the legislatures of the participating municipalities. Existing public works boards in each respective community will handle the solid waste subject at the town or city meeting in conjunction with the Chief Executives. No major political nor legal obstacles are anticipated.

The bulk of the above negotiations in the solid waste pact are expected to center around the financing and administration of the disposal facility.

Projected capital and operating costs of the B-11 alternative will be cited and thoroughly discussed at a joint meeting of the participants. An agreement will be reached on cost apportionment between the communities and the General Electric Company. Although operating costs of the latter for the superheater, feed-water, fuel oil, and power have already been determined by Metcalf and Eddy Engineers, the participants must also agree to the capital value of each existing system to the venture.

An application for a Federal grant under the provisions of the National Recovery Act on behalf of the communities involved will be made for capital assistance within the next ninety days by the Project Director.

Administration of the Solid Waste Disposal facility will be the responsibility of a nine-member board composed of one member from each of the participating communities and two members from the City of Lynn. Board members from the participating towns will be Selectmen or their designees. Board members from Lynn will be the Mayor or his designee and the D.P.W. Commissioner. Voting and costs will be performed on a weighed basis. The Board will be authorized to execute third party contracts for the operation of the joint facility. Contracts negotiated by the Board cannot exceed two years in length and will have quarterly evaluation by an outside engineering firm hired at public expense.

4. <u>Design of B-11 Alternative (March, 1971).</u>

Although a 612 ton prototype facility (alternative B-11) will be proposed for construction, instructions will be issued prior to design for making ancillary provisions to expand the facility to 1800 to 2000 tons. In this manner, additional increments can be added to the original facility at minimal cost whenever other communities are admitted into the solid waste pact.

5. <u>Formal Designation of Site (February, 1971).</u>

The involved North Shore communities, through the Project Director, will initiate actions with the Town of Saugus and the Massachusetts Department of Public Health for formal designation of a site for a solid waste disposal facility. Although preliminary intentions have been made known and are well publicized, official concurrence must be secured. No difficulties are anticipated in this area. The Massachusetts Department of Public Works will be concurrently notified on the activities of the North Shore communities. A request to use the DeMatteo Dump as a sanitary landfill site for the residue will be made.

6. <u>City Department of Public Works (April, 1971)</u>.

A. The City of Lynn, through its D.P.W. Commissioner, will notify the New England Power Company and the Massachusetts Department of Public Health that sanitary landfill operations will be continued for an additional two years at the present location until the new solid waste disposal facility has been constructed. A request will be made for reopening the present landfill site, as an alternative site to the DeMatteo site, for two weeks per year due to boiler shut-down for maintenance.

B. Excluding landfill and open burning, the proposed solid waste disposal method is the best feasible system available to Lynn with a cost per ton of $4.48. This is the cost which should be anticipated in the City's operating budgets in the future.

C. New regulations governing the collection of refuse should be established by the City D.P.W. Arrangements for curb pick-up of bulky items like stoves, refrigerators, and washers should be made. Only ad hoc rules now exist. New regulations instructing residents on the revised procedures should be issued and publicized.

D. Revisions of the existing collection routes should be reviewed in view of the new disposal site in Saugus. This is considered to be minor, but important for efficient collection and minimizing additional cost.

7. Additional Uses of Fly-ash and Residue.

Without additional processing, it has been determined that fly-ash can be used as a filler in roofing material, cement, concrete, bituminous concrete, and as a filtering medium.

Residue can be used as a landfill, particularly to improve vacant and depleted gravel pits in the North Shore area. It is proposed that residue be utilized, also, as a sub-grade material for road construction. A demonstration road construction project using residue will be launched as soon as the by-product is available. Research will continue for additional uses.

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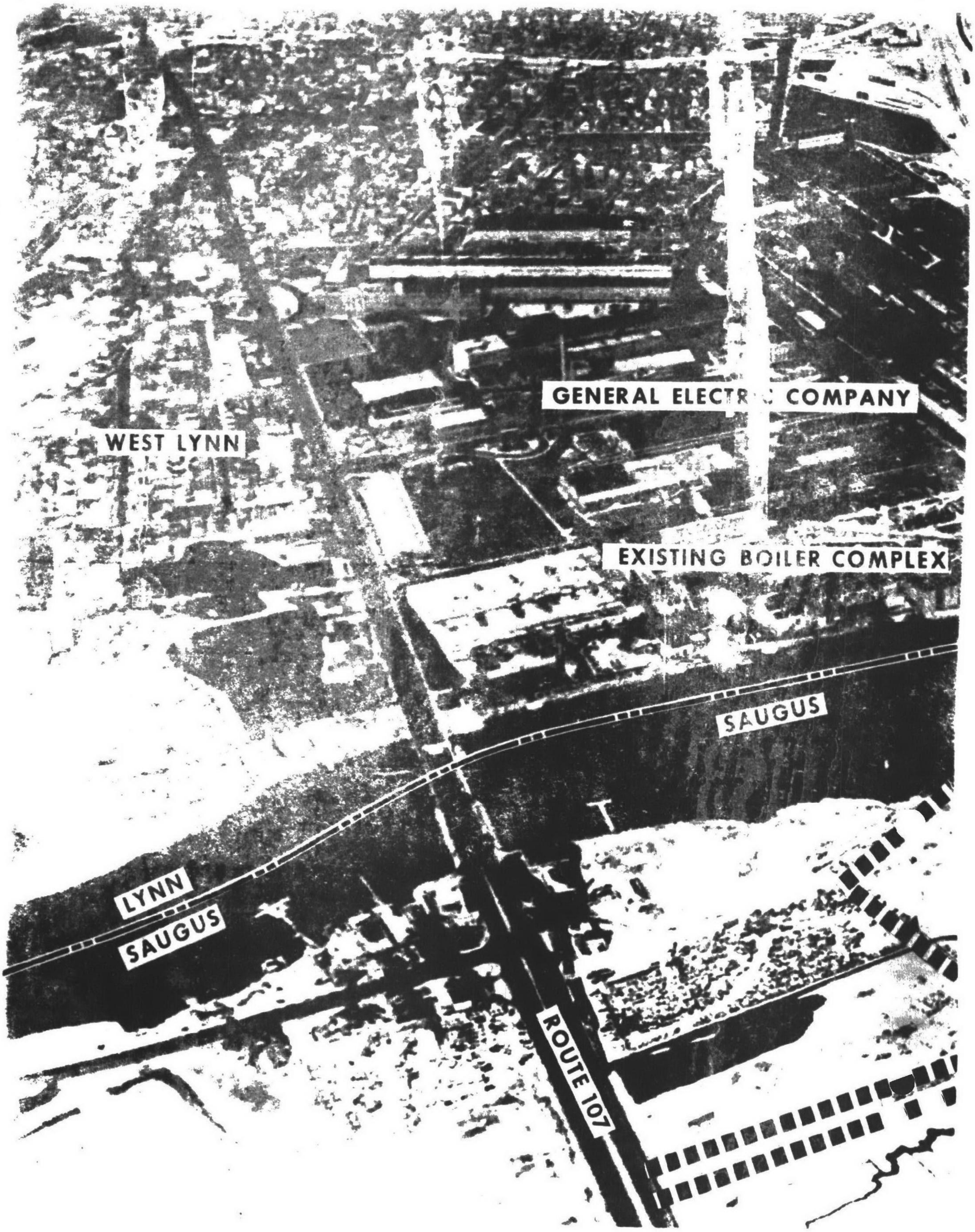

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FIG. 1 LOCATION PLAN

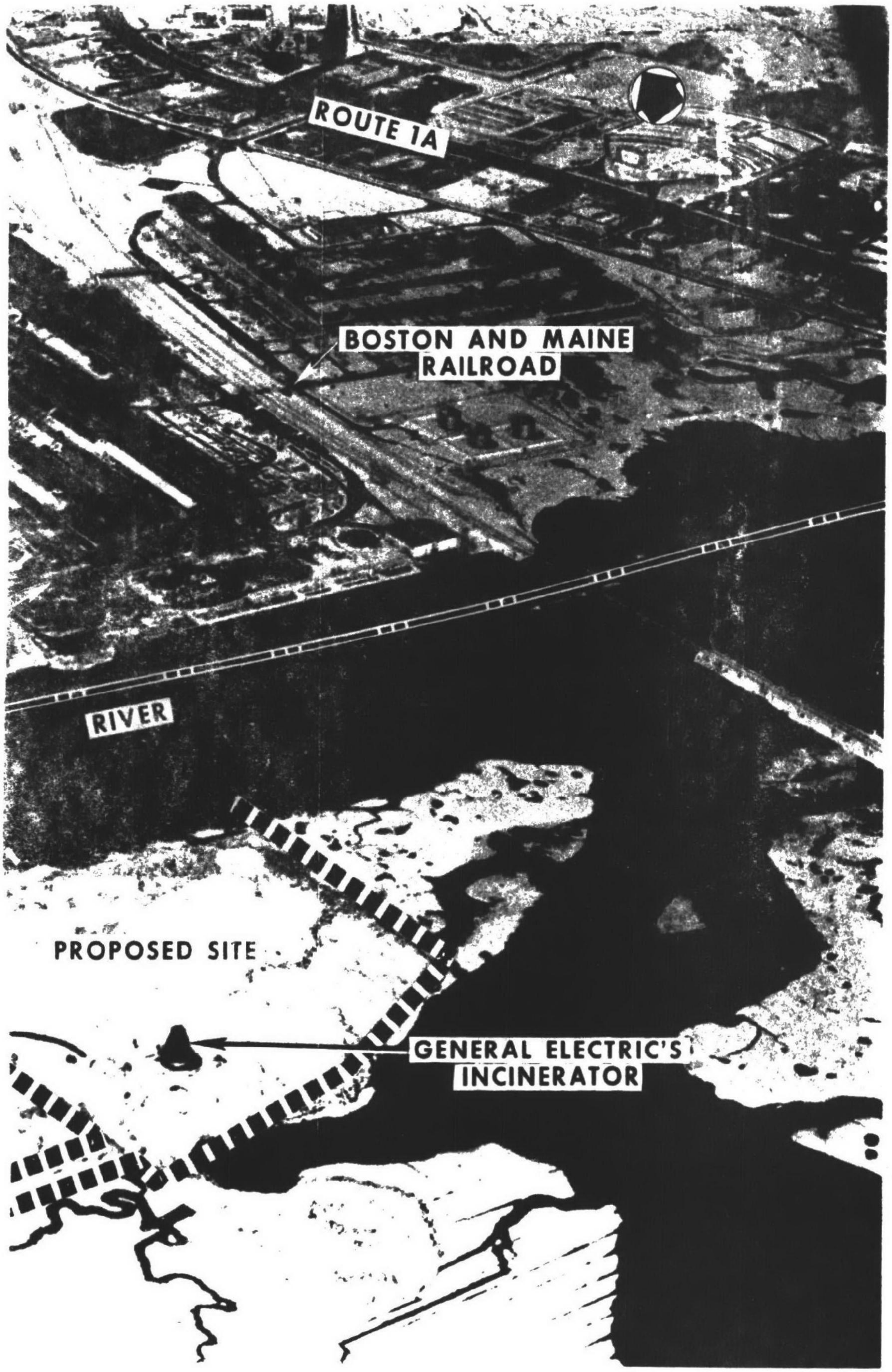

FIG. I LOCATION PLAN
(CONT'D)

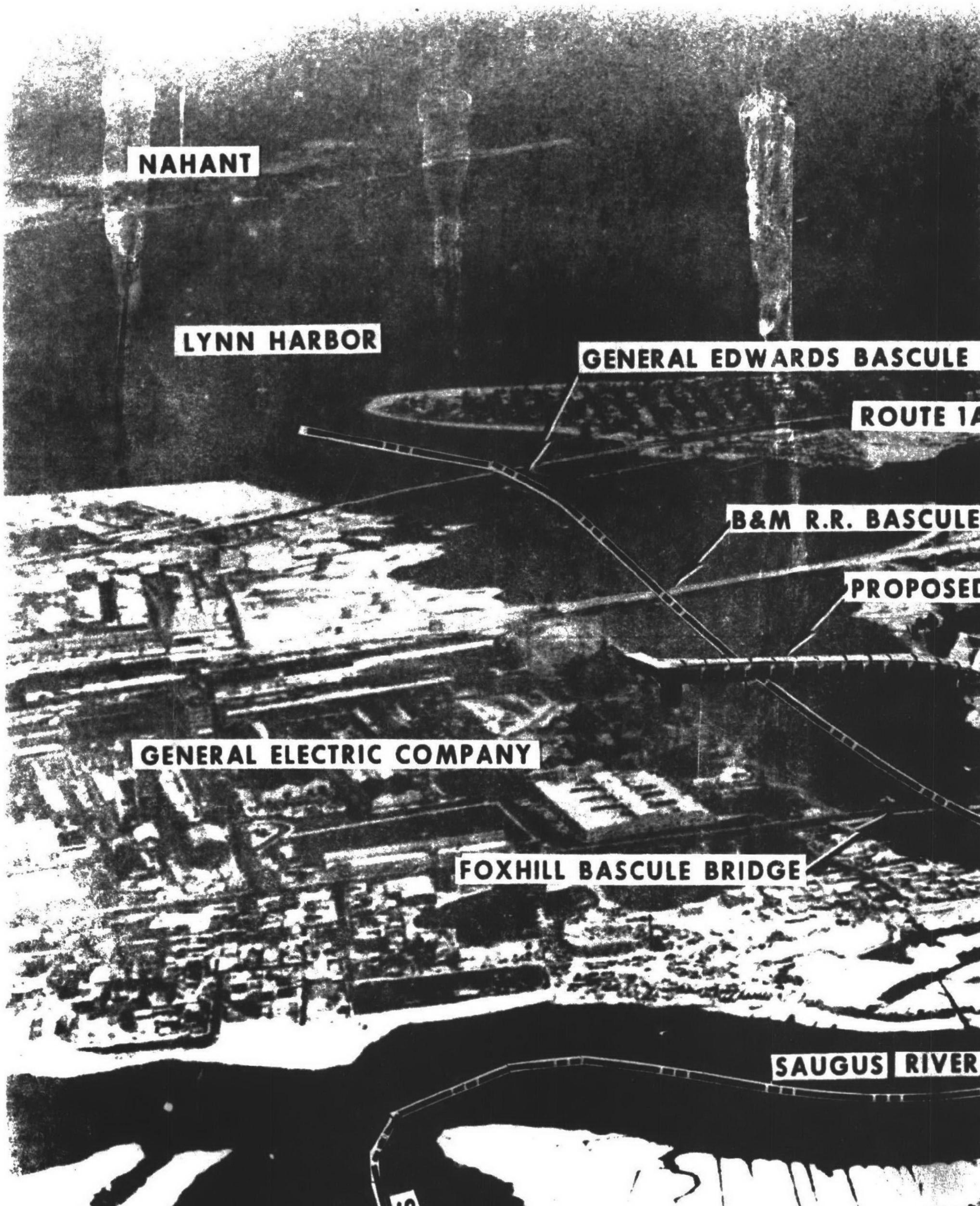

FIG. 18 AERIAL VIEW - VICINITY OF PROPOSED SAUGUS RIVER CROSSING

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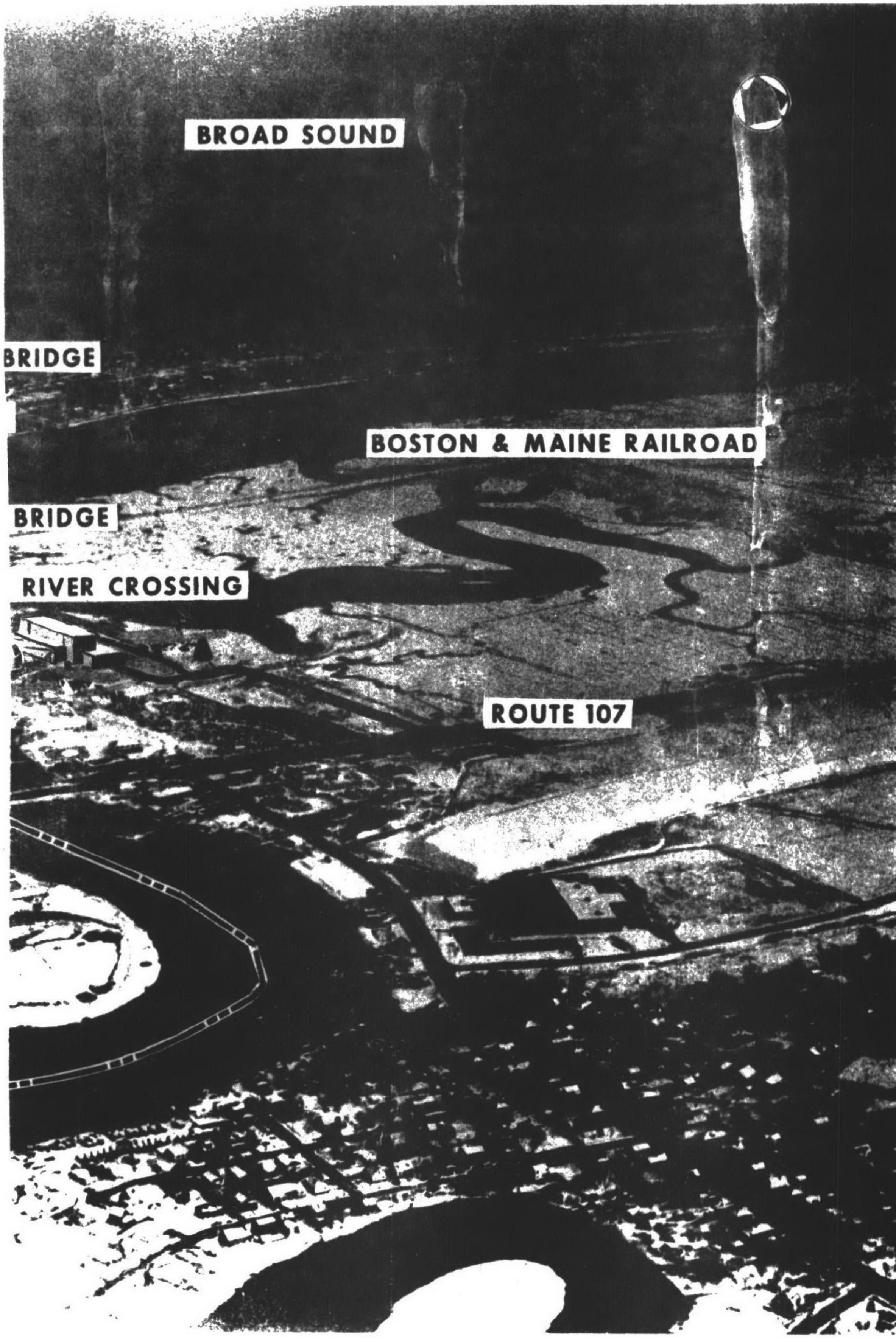

FIG. 18 AERIAL VIEW - VICINITY OF PORPOSED SAUGUS RIVER CROSSING (CONT'D)