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TACOMA REFUSE FIRED COMBUSTOR STUDY

For the City of Tacoma, Washington

MASTER

March 1978

Work Performed Under Contract No. EC-77-C-06-1053

Durham Anderson Freed/HDR
Seattle, Washington

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

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ENGINEERING CERTIFICATE

Tacoma Refuse Fired Combustor Study

Tacoma, Washington

1978

The technical material contained in this report was prepared under the supervision and direction of two professional engineers licensed to practice in the State of Washington.

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CHAPTER ONE

INTRODUCTION

A. GENERAL

The purpose of this study is to examine the feasibility of using refuse derived fuel and other waste fuels to fire a central energy plant to meet the heating and cooling needs of the Central Business District of Tacoma, with the possibility of marketing steam and/or electricity as a by-product.

Rising fuel costs have forced Consumers Central Heating Company (CCHC) to announce a discontinuance of operations. Through an agreement made with a substantial portion of its customers, CCHC will continue heating system operations until August 31, 1979, on a no profit - no loss basis. This agreement allows time to investigate the feasibility of a new central energy plant based on the and/or the individual conversion to an independent heating plant. The results of this study will be instrumental for determining the future of a central district energy system in Tacoma.

B. REPORT ORGANIZATION

The work accomplished in this study has been organized into twelve chapters for report presentation:

CHAPTER ONE - INTRODUCTION. This chapter is a review of the objectives of the study, and includes pertinent background information. Study organization and execution are also discussed.

CHAPTER TWO - CONCLUSIONS, SUMMARY & RECOMMENDATIONS. This chapter reports the findings of this study and recommends specific actions that should be taken based on these findings.

CHAPTER THREE - EXISTING CONDITIONS. This chapter is a description of the present central heating system serving the central business district of Tacoma, other steam generating facilities near the Central Business District, and the City of Tacoma resource recovery facility under construction.

CHAPTER FOUR - MARKET ANALYSIS. This chapter discusses the present and future markets of energy in the Tacoma CBD and the adjacent tide flats industrial area. The forms of energy discussed include steam, high temperature hot water, chilled water, and electricity. A section on projected energy costs completes the chapter.

CHAPTER FIVE - TECHNOLOGY EVALUATION. Chapter Five reports the technical aspects of the combustor systems and energy distribution systems that are applicable to this study.

CHAPTER SIX - ALTERNATIVE SITES. This chapter identifies three possible locations for a central energy plant, with detailed descriptions of each.

CHAPTER SEVEN - AREA WASTE RESOURCES. This chapter discusses the availability of waste fuels in the Tacoma area, focusing on hog fuel and refuse derived fuel.

CHAPTER EIGHT - ENVIRONMENTAL EVALUATION. This chapter reviews the potential environmental impact a new central energy plant would have on air, water, and land. Environmental regulations are discussed and a preliminary list of required permits is recorded.

CHAPTER NINE - CONCEPTUAL DESIGN. This chapter contains a technical description of the ten alternative central energy plants and their associated distribution systems.

CHAPTER TEN - FEASIBILITY ANALYSIS. This chapter reports the economic analysis of the ten alternatives presented in CHAPTER NINE. The analysis is a static, dynamic and sensitivity evaluation of the alternatives.

CHAPTER ELEVEN - FINANCIAL & IMPLEMENTATION PLAN. This chapter is a discussion of financing alternatives, ownership and operation alternatives, and implementation alternatives for a new central energy plant. Risk identification and evaluation for all phases of a project is also performed.

CHAPTER TWELVE - OPERATION AND MANAGEMENT. Chapter twelve describes possible methods of energy facility ownership, with details of necessary agreements applicable for municipal participation.

CHAPTER TWO

SUMMARY AND RECOMMENDATIONS

A. CONCLUSIONS

It is the conclusion of the Tacoma Refuse Fired Combustor Study that an agreement be negotiated with the St. Regis Paper Company, Lumber & Plywood Division to furnish steam to the district heating system. If this cannot be accomplished, the construction of a central energy plant burning waste-type fuels is technically viable, but economic feasibility is dependent upon supplementing the central business district (CBD) heating load with the industrial steam load of the St. Regis Company. If equitable negotiations cannot be completed with St. Regis and the City of Tacoma, the CBD heating load would be served more cost effectively with individual electric boilers.

B. SUMMARY OF FINDINGS

1. Existing Conditions

The Consumer Central Heating Company (CHCC) is a privately owned and operated utility providing steam energy to the central business district of Tacoma. In 1923, CCHC constructed their central steam generating plant and installed a high pressure (125 psig) distribution system. The CCHC central steam plant houses four boilers. The three original boilers, manufactured by Erie City and designed to burn "hog fuel" in dutch oven furnaces, were converted to burn oil and natural gas in 1969. In 1969, a new Combustion-Engineering Inc. (C-E) "Wickes Type A", 120,000 lbs/hr, natural gas/oil fired package boiler was added to the plant and used as the base load boiler of the CCHC system.

The Consumer Central Heating Company is well-managed and has been an effective system for providing steam for the CBD. Burdened with a steam generation system that can not burn cheaper solid fuels (i. e., coal and hog fuel) than its current fuels, (natural gas and fuel oil), steam production costs have created an unprofitable condition for the company. Steam produced by burning gas or oil is not competitive with electric heating in the CBD at the present time.

The CCHC steam distribution system is in good working condition. Line losses are within an acceptable range, but the lack of a condensate return system is an economic liability in the energy-effective production of steam.

Another factor impacting on this project is the construction of a new solid waste resource recovery processing plant by the Solid Waste Utility of the City of Tacoma. The processing plant will convert the combustible portion of Tacoma's solid waste into a shredded, air classified refuse derived fuel

(RDF). The noncombustible fraction will be subjected to magnetic separation for ferrous metal recovery with the remaining nonmagnetic, noncombustible fraction disposed on-site in the city's sanitary landfill. Construction of the resource recovery facility is scheduled for completion during the second quarter of 1978.

2. Energy Markets

Energy markets were identified for the sale of low pressure (150 psig) steam energy and electrical energy. A potential market for high temperature hot water (HTHW) is dependent on the construction of a new HTHW distribution system and individual user modifications in the CBD. The consultant determined that a chilled water market did not exist in the CBD.

The CBD peak and average heating loads are currently 67,000 lbs/hr and 19,600 lbs/hr, respectively. Based on projected development of the CBD, the peak and average heating loads are projected to be 115,900 lbs/hr and 36,800 lbs/hr, respectively in the year 2000. The CBD load variation is typical of municipal heating loads and additional steam markets are deemed necessary to supplement the energy demand of CBD.

Six industrial steam users in the industrial tide flats were approached by the consultant with the concept of purchasing process (150 psig) steam from a central steam plant, thereby supplementing the CBD demand.

Four of the six firms expressed an interest in buying steam if their individual steam specifications, quantity requirements, and price limitations were met.

The St. Regis Paper Company, located close to the CBD, is the most attractive industrial steam market. Discussions have been held with St. Regis Lumber & Plywood Division personnel to establish minimum and maximum steam demands. The average week-day steam load ranges from 60,000 to 90,000 lbs/hr. On the week-ends the average load drops to 50,000 lbs/hr. The St. Regis Pulp and Paper Division Kraft Mill has an average steam load of 833,000 lbs/hr, 40% of which (333,000 lbs/hr) is obtained from fuel oil combustion.

Discussions were also held with representatives of Tacoma City Light concerning the purchase of electrical energy generated by a central energy plant. They responsed affirmatively but stipluated that the electric power purchase price be equal to the projected 1980 Bonneville Power Administration rate structure of between 15 and 18 mills per kilowatt hour. This rate range was used in the feasibility analysis.

Prevailing market values of fuels were determined as part of the market analysis. Table 2-1 lists the late 1977 costs which were used in the feasibility analysis to determine the break-even cost of the central energy plant.

TABLE 2-1

ENERGY COSTS FOR TACOMA
(Nov 1977$)

Fuel Type	Heat Value	Cost ($)	Unit Value($/MMBtus)
Natural Gas	1000 Btus/SCF	0.229/Therm	2.29
Fuel Oil, No. 6	152,000 Btus/gal	0.29/Gal	1.90
Coal	11,000 Btus/lb	32.00/ton	1.45
Wood Waste (Hog Fuel)	5,000 Btus/lb	7.20 to 12.20/ton	0.72 - 1.22
RDF	5,000 Btus/lb	7.20/ton	0.72
Electricity	---	8 Mills/KWH	---

3. Technology

The technology of converting waste fuels, refuse derived fuel, wood wastes (hog fuel) etc, into more useful energy forms were evaluated. Two combustion systems were evaluated; conventional traveling grate spreader-stoker boiler and a fluidized bed boiler. Design parameters of both systems were presented and discussed. Each of the boiler systems is applicable for the type of service contemplated for this project. Each has successfully burned waste type fuels for steam generation. The conventional spreader-stoker boiler has a longer history than the fluidized bed system. But the fluidized bed system was judged to have more flexibility in burning less desirable waste-type fuels than the conventional stoker boiler.

The technology of energy distribution systems, low pressure steam and high-temperature hot water (HTHW), was presented in CHAPTER FIVE. Both systems could be used in this project.

4. Site Evaluation

Three sites were evaluated to house the central energy plant (See Figure 2-1). Parameters used in the site evaluation were presented in Table 6-1. Site findings were reported in Table 6-2. Of the three sites available Site B was the preferred site. Site B had the largest amount of vacant land and is zoned M-3 vs. M-2 for both Sites A&C. Furthermore, Site A lies next to existing city facilities which would prevent any expansion of the central energy plant and Site C lies inside the boundary of the Waterway Redevelopment. For these reasons, the consultant selected Site B for the conceptual design of the central energy alternatives.

Environmental concerns were reviewed in CHAPTER EIGHT. Tables 8-2, 8-3, and 8-4 reported the air quality standards applicable to this project. Table 8-5 listed the permit requirements that would have to be met to build a facility.

5. Alternatives

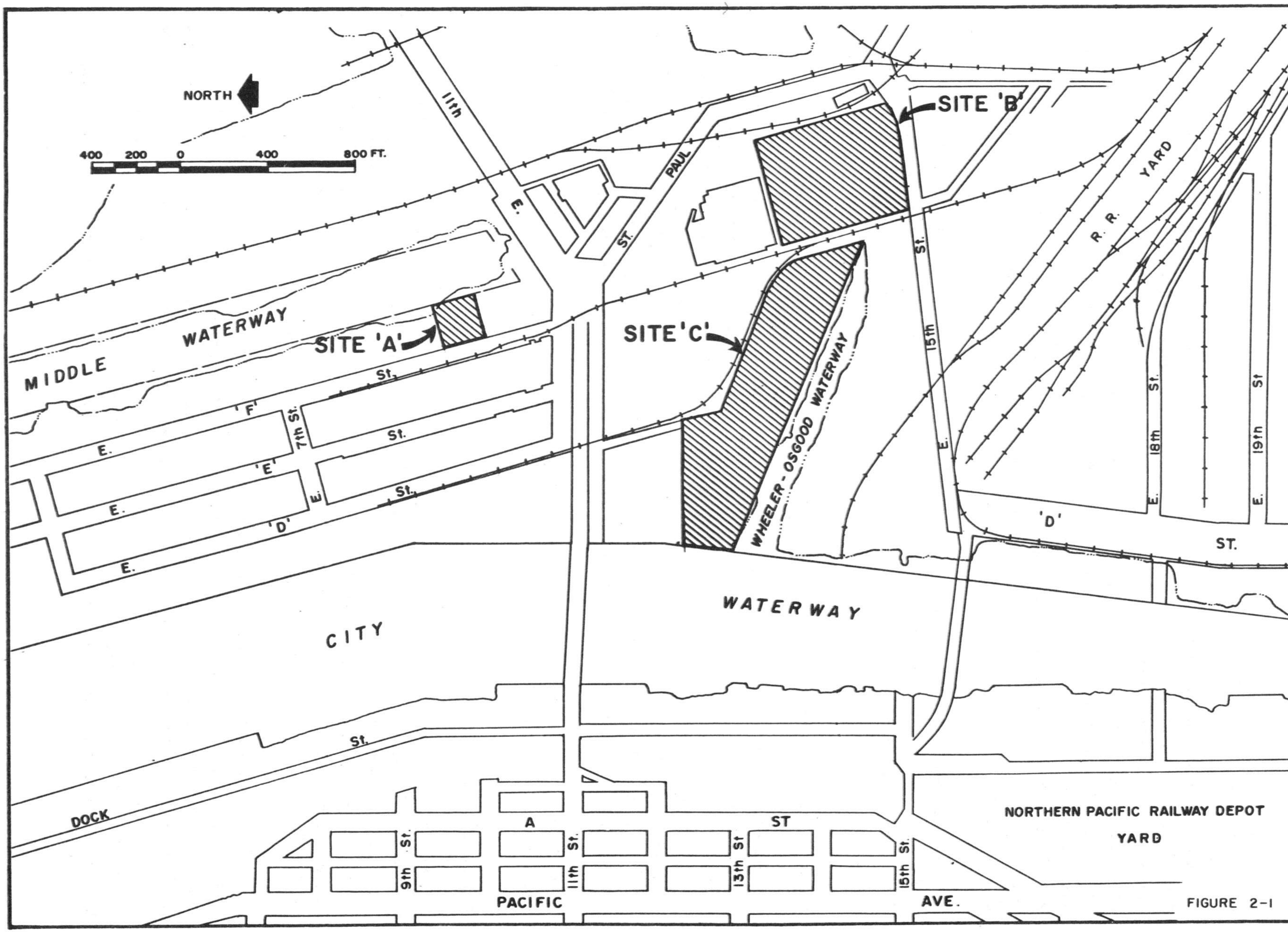
Based on the market analysis, the consultant determined that two generating capacities should be developed. A 125,000 lbs/hr central energy plant to serve the CBD on firm basis and industrial customers on an interruptible basis. As an option to the 125,000 lbs/hr facility, a central energy plant with 200,000 lbs/hr generating capacity was proposed. Each of the facilities would burn refuse derived fuel (RDF), wood wastes, and fuel oil for the production of steam, high temperature hot water and/or electricity.

The ten combustion alternatives, presented and discussed in CHAPTER NINE, are listed in Table 2-2.

6. Feasibility Analysis

CHAPTER TEN reported the feasibility analysis. This analysis was based on determining the respective costs of low pressure steam for each alternative on an equivalent steam basis. Capital cost estimates prepared for each alternative were based on early 1978 dollars with financing costs added to reflect revenue bond financing. The 1980 construction costs listed were based on 1978 capital costs escalated two years at seven percent per year.

The alternatives were initially compared statically based on 1978 capital costs amortized at 8 percent for 20 years and 1978 operating cost for full load conditions (See Table 10-1). The procedure used in comparing the alternatives was to calculate their "break-even" net facility steam cost ($/1000 lbs). The best steam and cogeneration alternatives were then compared at reduced operating levels for each capacity to determine this impact on their respective break-even equivalent steam costs. Based on these comparisons, the fluidized



TACOMA REFUSE FIRED COMBUSTOR STUDY

SITE LOCATIONS

JORDAN / AVENT & ASSOCIATES 1407 E. MADISON STREET SEATTLE, WASHINGTON 98122

FIGURE 2-1

TABLE 2-2
COMBUSTION ALTERNATIVES

Alternative 1:	A new steam plant with a 125,000 pounds per hour (lbs/hr) waste fuel fired boiler generating steam at 150 psig sat. to serve the CBD district heating system and industrial customers. Standby capability will be provided by the CCHC 120,000 pph boiler relocated to the new facility.
Alternative 2:	A new steam plant with a 125,000 lbs/hr waste fuel fired boiler delivering steam at 600 psig/750°F to an extraction type turbine generator. Steam will be extracted at 150 psig to serve the steam loads. The electricity produced will be sold to Tacoma City Light. Standby capability will be provided by the CCHC 120,000 pph boiler.
Alternative 3:	A new steam plant with a 200,000 pph waste fuel fired boiler to serve the district heating system and industrial customers. An existing oil fired packaged boiler owned by the St. Regis Lumber and Plywood Division and the existing CCHC boiler will provide standby capacity.
Alternative 4:	A new steam plant with a 200,000 lbs/hr waste fuel fired boiler delivering 600 psig/750°F steam to an extraction type turbine-generator for electric generator. Steam will be extracted at 150 psig to serve the CBD and industrial steam loads. The electricity generated will be sold to Tacoma City Light. Standby capacity will be furnished by the existing CCHC boiler and existing oil fired package boiler currently owned by St. Regis.
Alternative 5:	A new plant with the same conditions as Alternative 1, except the primary boiler will be a waste fuel fired fluidized bed unit.
Alternative 6:	The same plant as described for Alternative 2, except for the use of a fluidized bed boiler in place of a conventional waste fuel fired unit.
Alternative 7:	The same plant as described in Alternative 3 with the exception of a waste fuel fired fluidized bed boiler replacing the convention boiler.
Alternative 8:	A new plant as outlined in Alternative 4, with a new fluidized bed unit replacing the conventional boiler for primary service.
Alternative 9:	A new high temperature hot water generating plant and distribution system to serve the downtown business district with the same heating capacity as the existing CCHC plant. Hot water is produced by direct fired generators.
Alternative 10:	A plant and distribution system based on high temperature hot water generated in a steam heat exchanger. Steam is supplied by a plant that can produce steam for industrial customers and/or electricity, as in Alternatives 1-8.

bed alternatives had the lowest break-even energy cost for both design capacities (Alternative 5-125,000 lbs/hr and Alternative 7-200,000 lbs/hr).

The co-generation alternatives were not competitive with the steam systems because the electric revenues obtained did not offset the increased capital and annual costs incurred in the generation of electric energy.

The final step in the feasibility analysis was the determination of the "dynamic life cycle" costs. This analysis projected the break-even costs by year (1980 to 2000) for the two fluidized bed steam systems. These costs were compared to the concept of serving the CBD's heating load with individual electric boilers on an equivalent steam basis. (Refer to Figures 10-3 and 10-4). The dynamic cost analysis clearly indicated that an industrial customer is required to supplement the CBD heating load. If adequate steam quantities could be sold on an annual basis to both an industrial customer (e.g., St. Regis Paper Company) the CBD could be competively served by a central steam plant firing waste-type fuels provided the 1980 electric rates were at least 15 mills/KWH and escalated at seven percent per year. With a higher 1980 base year electric rate, the feasibility of the steam systems improves significantly.

Of the two fluidized bed alternatives judged feasible, the 200,000 lbs/hr system would be the most attractive. It would have adequate capacity to serve both the CBD and the St. Regis Paper Company, Lumber and Plywood Division, on a firm basis. The smaller 125,000 lbs/hr system would be capacity-limited and would be unable to accommodate both markets during peak demand periods or accommodate future growth of the CBD. Table 2-2 lists the complete capital and project construction costs of the 200,000 lbs/hr fluidized bed system.

In order to project the visual impact the proposed steam plant would have on the study area, three architectural renderings were developed. Figure 2-2 is an area perceptive view looking east from the CBD. Figure 2-3 is a perspective site and building detail of the complex. Figure 2-4 depicts the typical elevation views of the complex.

Project financing and implementation options were presented in CHAPTER ELEVEN. Figure 11-1 depicted three options available to implement this project. The consultant judged Option 3 (joint participation between the City of Tacoma and the St. Regis Paper Company) to be the most attractive concept. Figure 11-2 illustrated a schedule of pre and post financing project activities required to bring the facility on line in approximately two years after the post feasibility negotiations have been completed.

TABLE 2-2

SUMMARY OF CAPITAL COST FOR
NEW 200,000 LBS/HR FLUIDIZED BED STEAM PLANT

	Item	Cost ($)
1.	Land	300,000
2.	Steam Plant	14,378,000
3.	Steam Distribution System	900,000
4.	Sales Tax	544,000
		16,122,000
5.	Fees	1,612,000
		17,734,000
6.	Financing Cost	
	Capitalized Interest During Construction	2,483,000
	Capitalized 1 year P&I	2,251,000
	Bond Discount	557,000
	Start-up Cost (6 months O&M)	1,416,000
	Interest Earned on Invested Funds	-1,387,000
		5,320,000
7.	Capital Cost (1978$)	23,054,000
8.	Construction Cost (1980$)	26,395,000

7. Alternate No. 11, Steam Supplied By St. Regis Lumber and Plywood Division

Late in the study time period City of Tacoma officials had a meeting with St. Regis Paper Company, Lumber and Plywood Division officials. At this meeting it was revealed that the St. Regis Lumber and Plywood Division would agree to install air pollution control equipment on their two existing hog fuel fired boilers, if the boilers were to be operated at rated capacity again.

The City of Tacoma or a separate new entity would have to finance the installation of a new 14 inch steam line from the St. Regis Lumber & Plywood Division steam plant to the existing steam distribution system, a line length of approximately 3,800 feet. It is estimated this new line will cost about $950,000. Customer billing and steam distribution system maintenance would also be the responsibility of the City or the new entity.

C. RECOMMENDATIONS

1. The City of Tacoma should negotiate a firm agreement with the St. Regis Paper Company, Lumber & Plywood Division for the Lumber & Plywood Division to furnish steam to the district heating system in the central business district, and arrange to have the required connecting steam line installed.

2. In the event the St. Regis Paper Company, Lumber & Plywood Division determines the installation of pollution control equipment on the existing boilers is impractical due to age of the boilers or cost, the City of Tacoma should negotiate with the St. Regis Paper Company to develop jointly the 200,000 lbs/hr fluidized bed steam system on Site B.

3. If negotiations are not successful with St. Regis or they are unwilling to participate in the project, the City of Tacoma should recommend that the CBD building owners convert individually to an electric boiler heating system.

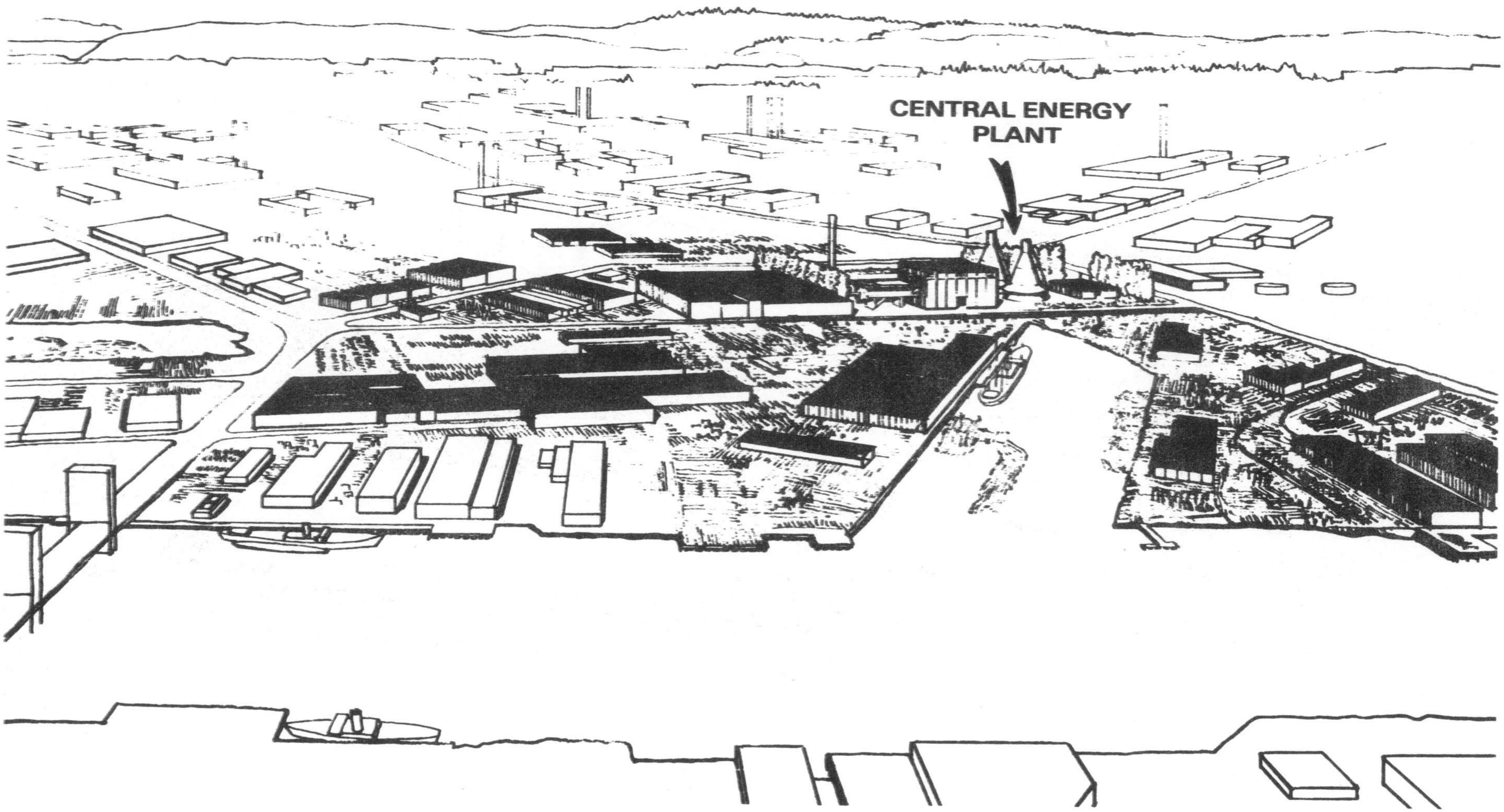


FIGURE 2-2

AREA PERSPECTIVE
LOOKING EAST

TACOMA REFUSE FIRED
COMBUSTOR STUDY

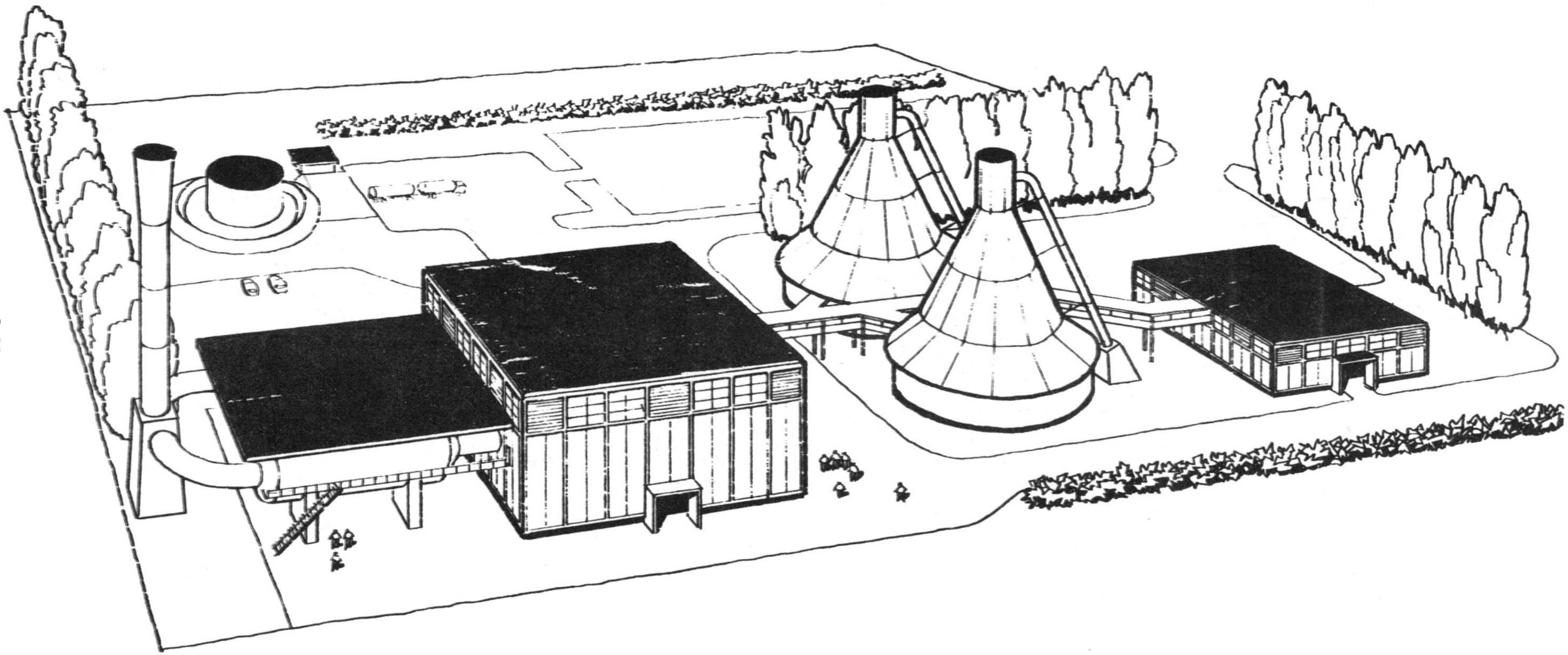


FIGURE 2-3

PERSPECTIVE DETAIL
SITE WITH BUILDINGS

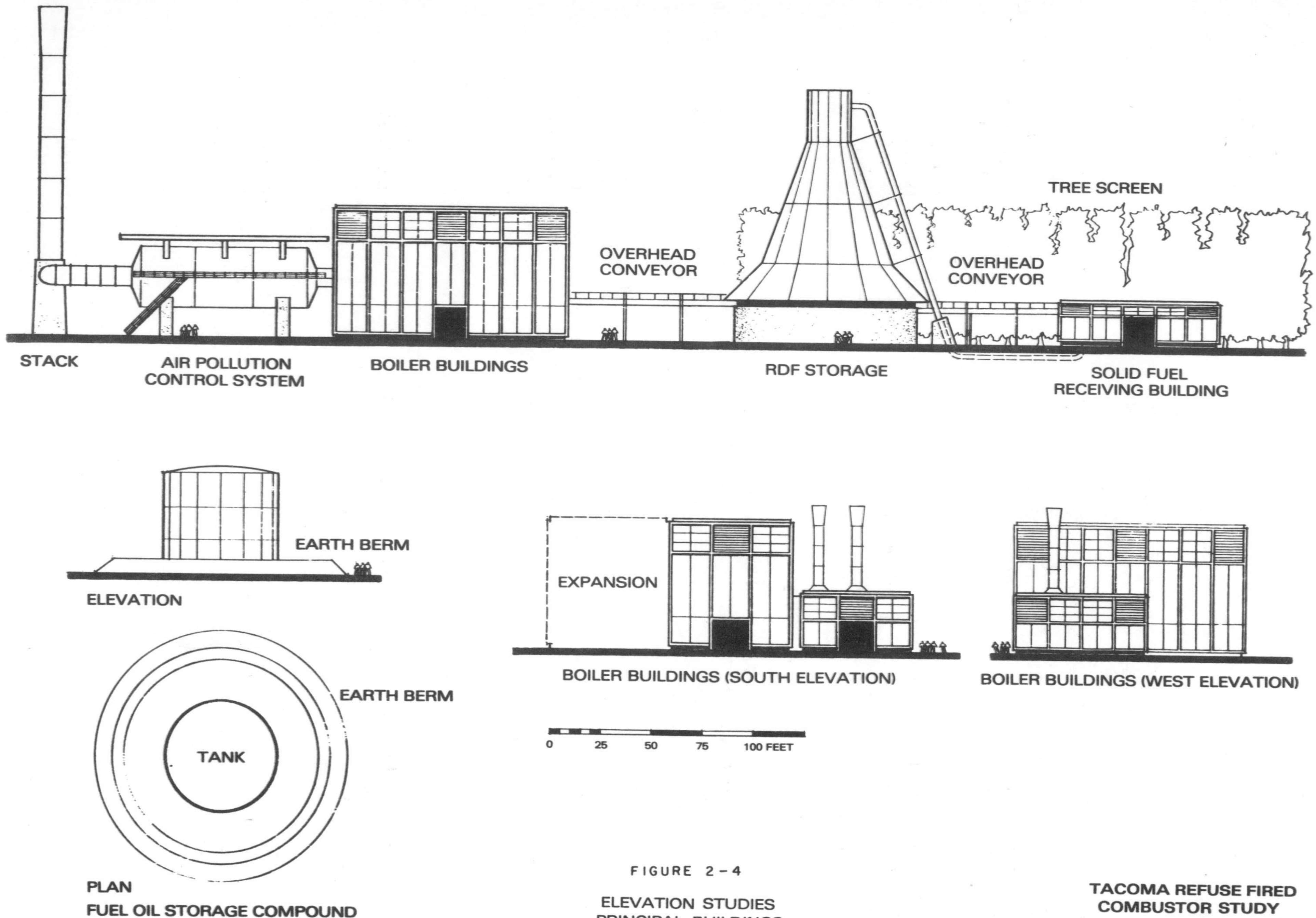


FIGURE 2-4

ELEVATION STUDIES
PRINCIPAL BUILDINGS

TACOMA REFUSE FIRED
COMBUSTOR STUDY

CHAPTER THREE

EXISTING CONDITIONS

A. CONSUMER CENTRAL HEATING COMPANY

Consumer Central Heating Company (CHCC) is a privately owned and operated utility providing steam for heating and cooling of buildings in the Tacoma central business district (CBD). The steam generation and distribution system was constructed in two stages. The low pressure (15 psig) distribution system was installed in 1918. The steam supply was provided by the exhaust from the steam engines that powered the cable car system in the downtown business district. In 1923, CCHC constructed a central steam generating plant and installed a high pressure (125 psig) distribution system to serve additional customers in the CBD.

1. Existing Steam Plant

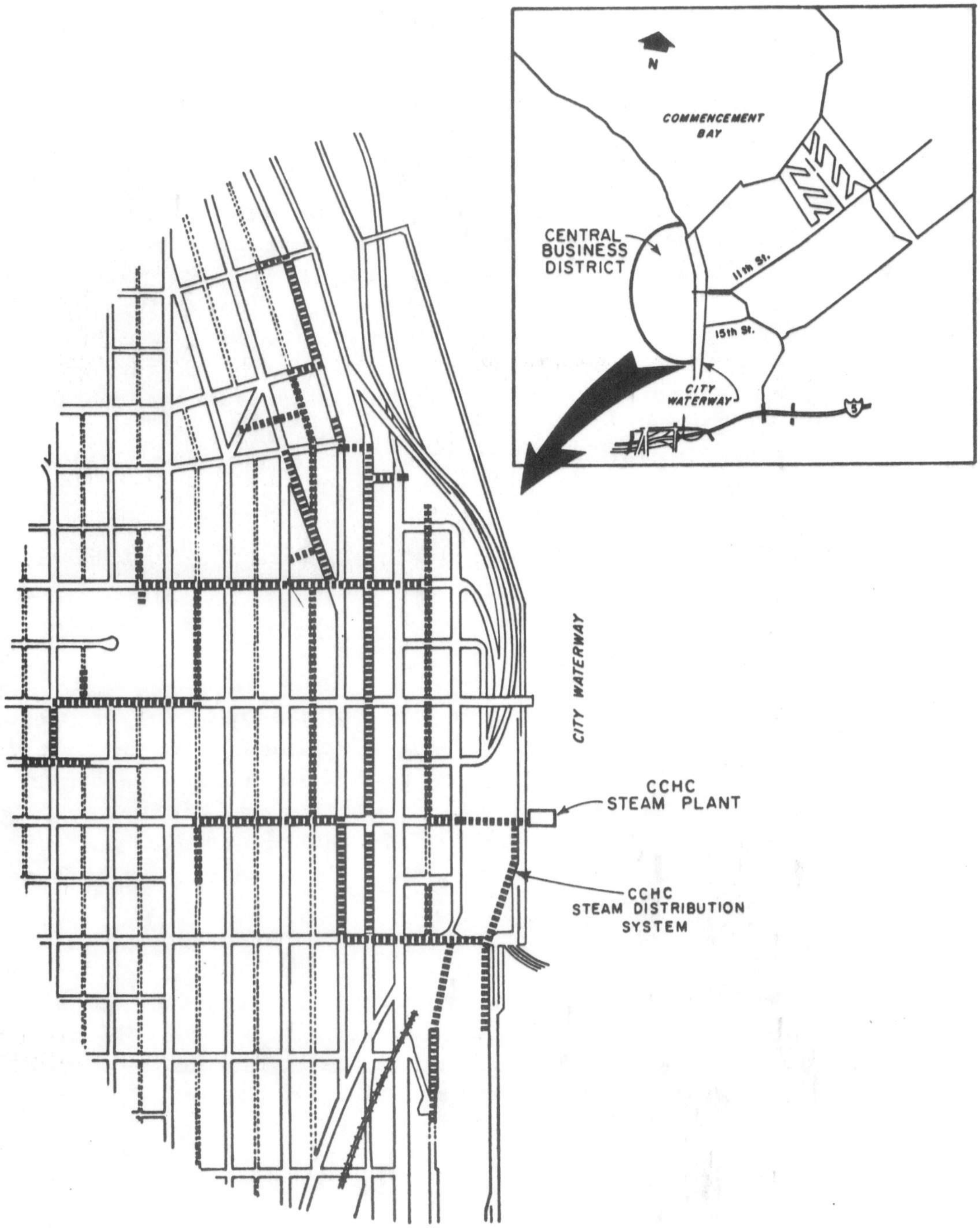
The CCHC steam plant is located at 1147 Dock Street, adjacent to the City Waterway waterfront (See Figure 3-1). The steam plant occupies approximately seven-tenth of an acre along the City Waterway. Figure 3-2 is a pictoral view of the CCHC steam plant.

The central steam plant contains four boilers that generate 125 psig saturated steam. The original boilers, manufactured by Erie City, designed to burn "hog fuel" in dutch oven furnaces were converted to burn oil and natural gas in 1969. In 1969 a new Combustion-Engineering, Inc. (C -E) "Wickes Type A", 120,000 pph natural gas/oil fired package boiler was added to the plant. The C-E unit is the base load unit of the CCHC system.

Table 3-1 summarizes the boiler specifications.

Each of the boilers is in good working condition, but if a new central steam plant were constructed elsewhere to serve the CBD only the C-E package boiler would be considered for relocation to the new site because of the age of the converted Erie City boilers.

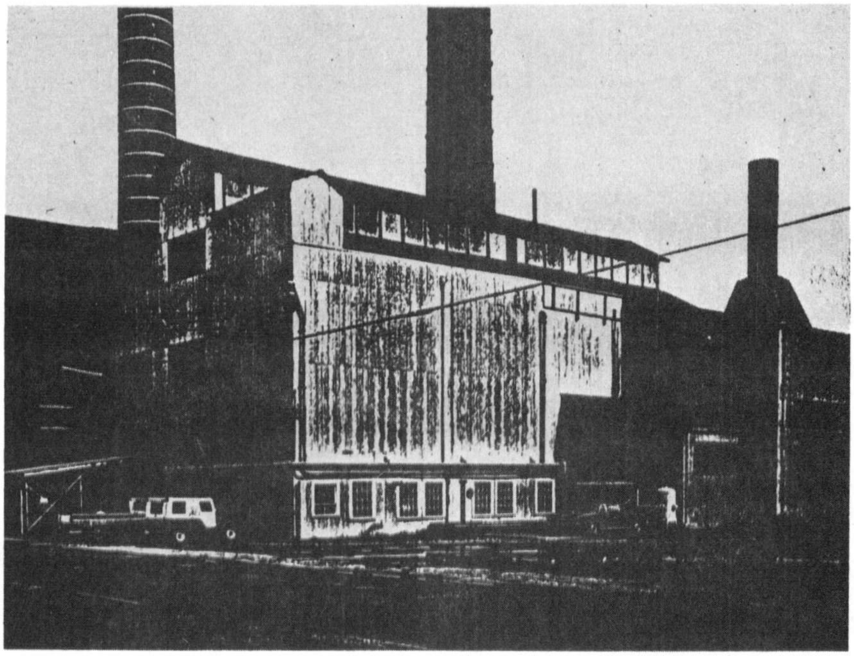
No condensate is returned from the distribution system to the central plant, requiring 100 percent feedwater make up from the City of Tacoma potable water supply. The water is treated by Zealite softners before being used in the boilers.



CONSUMER CENTRAL HEATING SYSTEM

TACOMA REFUSE FIRED COMBUSTOR STUDY

FIGURE 3-1



PICTORAL VIEW OF CCHC STEAM PLANT

FIGURE 3-2

TABLE 3-1
EXISTING BOILERS - CCHC STEAM PLANT
TACOMA, WASHINGTON

Boiler No.	Type	Size (pph)	Steam Pressure (psig)	Steam Temperature (°F)	Fuel	Year of Installation
1	Erie City	40,000	125	350	gas/oil	1923
2	Erie City	40,000	125	350	gas/oil	1923
3	Erie City	40,000	125	350	gas/oil	1923
4	Combustion Engineering Type A Wickes Package Boiler	120,000	125	350	gas/oil	1969

2. Steam Distribution System

The distribution system consists of approximately 50,000 feet of low pressure and high pressure lines. There are no condensate return lines in the existing system.

The low pressure system installed in 1918 was constructed of wrought iron pipe with screwed fittings and cedar wood stave pipe insulation. Approximately 80 percent of the cedar pipe insulation has been replaced with either 85 percent magnesium insulation in a concrete box conduit or gilsonite insulation.

The high pressure lines, installed initially in 1923, were constructed of steel pipe using welded joints and long radius pipe bends. Each joint was reinforced with a welded sleeve to diminsh stresses on the pipe joints. The high pressure lines are insulated with two- 1-1/2 inch layers of 85 percent magnesium insulation, wired on, canvas covered, and wrapped in waterproof building paper. The pipe is installed underground in a concrete box type conduit. Drip traps at the low points are located in manholes.

Based on consultant interviews with CCHC personnel and independent analysis of the available records, the existing steam distribution system is well maintained and in reasonably good working condition considering the age of the system. Table 3-2 lists the steam quantities generated and sold for a three year period. Assuming 15 percent of the steam generated is used internally, average losses by year were: 1974-29.9%, 1976-34.1% and 1977-38.6% respectively. Based on similar type projects completed by the consultant, the CCHC line losses are considered slightly below expected values.

3. Pollution Control

The CCHC steam plant burns primarily natural gas and uses fuel oil as a standby fuel. Because CCHC plant burns "clean fuels" there are no requirements for air pollution control systems. All wastewater produced by the plant is collected and discharged to the metropolitan sewerage system.

4. Steam Sales

Consumer Central Heating Company has maintained excellent records on its overall operation. Because some customers have converted to self-contained heating systems, the consultant reviewed records for a four year period (1973-1977) to determine the typical steam demand of the central business district. Figure 3-3 depicts the steam demand for the first seven months of 1977 and the three year average by month.

TABLE 3-2

AVERAGE LINE LOSSES BY YEAR

YEAR	1975	1976	1977[1]
Generated (lbs)	319,663,620	306,632,574	166,459,169
Feed Water Heating (lbs)	47,949,540	45,994,900	24,968,900
To Distribution System (lbs)	271,714,080	260,637,700	141,491,300
Steam Sold (lbs)	190,434,300	171,822,600	86,888,400
Line Losses (lbs)	81,279,780	88,915,100	54,602,900
Annual Percentage (%)	29.9	34.1	38.6

1. The 1977 analysis is based on only eight months of records.

Based on CCHC records the peak winter demand (January) is approximately 67,000 pph and the minimum Summer demand (August) is approximately 18,000 pph.

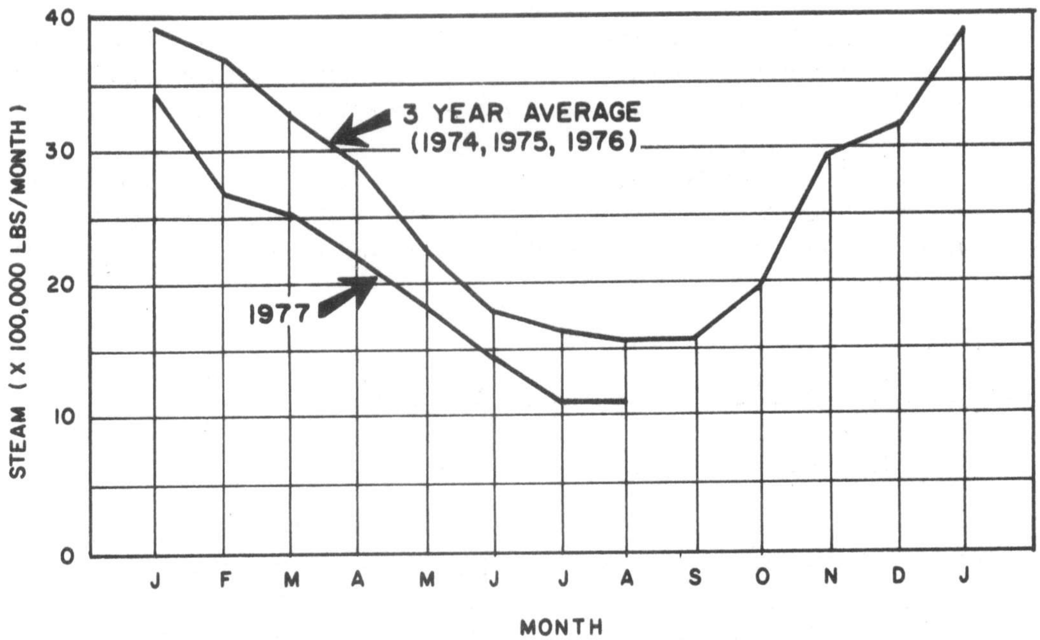
Since March 1, 1977, Consumer Central Heating Company has been operated on a "no loss - no profit" basis to provide a transition until the company formally discontinues operation on August 31, 1979. Cost to the consumers is determined in the following manner:

> "Costs are determined by month for the system. This cost is divided by the total quantity of steam sold. The individual customers are then billed based on their usage and average system steam cost ($/1000 lb)".

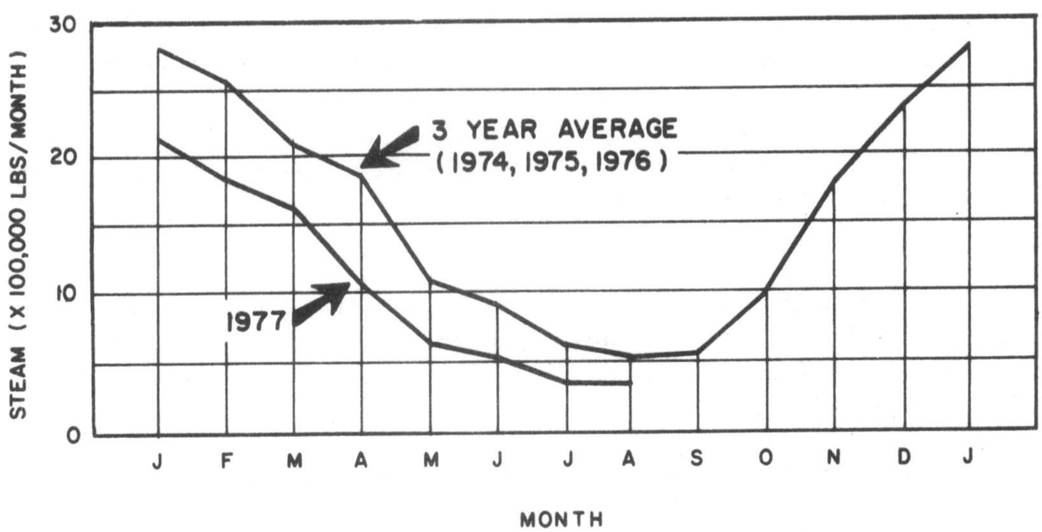
No state taxes are included in the steam rates, but a franchise gross earning tax of four percent is paid annually to the city of Tacoma.

5. Comments

The Consumer Central Heating Company is a well managed and has been an effective system for providing steam for the central business District of Tacoma. Burdened with a steam generation system that can not burn alternative cheaper solid fuels, i.e., coal and hog fuel, than its current fuels, natural gas and fuel oil, the production costs have



STEAM GENERATED



STEAM SOLD

ANNUAL STEAM CONSUMPTION

CONSUMER CENTRAL HEATING DISTRICT

FIGURE 3-3

simply created an unprofitable condition for the company. Steam produced by burning gas or oil is not competitive with electric heating in the City of Tacoma as an alternative heating system at the present time.

The CCHC steam distribution system is in good condition. Line losses are within an acceptable range, but the lack of a condensate return system is an economic liability in the energy effective production of steam.

B. OTHER STEAM GENERATION SYSTEMS

1. St. Regis Pulp & Paper Division

St. Regis Pulp & Paper Division operates a 1050 ton per day kraft mill in the "Tide Flats Industrial Area" of Tacoma. The plant was initially constructed in 1928. The plant is a 100 per cent kraft mill producing various paper container packaging products. St. Regis currently operates an eight-unit steam plant with a gross generating capacity of 950,000 lbs/hr. The mill's average steam consumption is 20 million pounds per day or approximately 833,000 lbs/hr. St. Regis generates both low pressure (185 psig) and high pressure (425 psig) for in plant use. The low pressure steam is generated by four Babcock & Wilcox hog fuel fired boilers installed in 1928 and one oil fired Combustion Engineering (CE) package boiler. The high pressure steam is generated by two CE recovery boilers and two Erie City oil fired package boilers. The two CE units were installed in 1973 and are equipped with odor control systems and designed for 950 psig/900^{o}F steam conditions.

Approximately 60 percent of the steam generated is provided by burning black liquor and hog fuel. The remaining 40 percent of the steam is generated (approximately 8 million pounds per day or 333,000 pph) by burning No. 6 fuel oil.

The Kraft Mill average electrical consumption is 35 megawatts. The Kraft mill currently does not have in-plant electrical generating capability.

2. St. Regis Lumber & Plywood Division

During the course of the study, two meetings were held with the Division Engineer and members of his staff to discuss the possibility of a new central plant to supply steam to both St. Regis Lumber & Plywood

Division and the downtown district heating system. Because interest was expressed in this possibility by the Division Engineer, this arrangement has been used as one of the alternatives evaluated in this study. The information on the St. Regis Lumber & Plywood Division steam plant and steam loads contained in the following paragraphs of this section were given to the Consultant during these meetings.

The Consultant wants to stress that St. Regis' corporate commitment has not been given to a joint steam plant and could not be obtained within the time frame of this study.

The St. Regis Lumber & Plywood Division operates a 50 million board feet (BF) per year sawmill located on the waterfront area of Tacoma. The sawmill's lumber production varies from 150,000 to 200,000 BF per shift. The sawmill's operating schedule is dependent on market demand, but normal operating conditions consist of two shifts per day with the third shift used for clean-up and maintenance. The existing steam plant contains two Babcock & Wilcox (B&W) Sterling boilers with dutch oven furnaces (Units 13 and 14) burning hog fuel, and one B&W 70,000 lbs/hr gas/oil fired package boiler (Unit 15). Unit 13, constructed in 1930 is a Sterling type natural draft boiler and has no auxiliary heat recovery equipment installed. Unit 13's design steam production is 60,000 lbs/hr, but because of air pollution limitations it has been downrated to 30,000 lbs/hr maximum. Unit 14, erected in 1942, is a Sterling type boiler with a multicell dutch oven furnace. Auxiliary equipment includes an air heater, forced draft and induced draft fans. Unit 14's rated capacity varies with the fuels burned. On wood and natural gas Unit 14 is rated at 80,000 lbs/hr. When burning wood only, its rated steam production is 52,000 lbs/hr. Like Unit 13, because of the air pollution limitation, Unit 14 has been downrated to 40,000 lbs/hr.

The sawmill's average weekday station load ranges from 60,000 to 90,000 lbs/hr of 150 psig saturated steam. On weekends the steam load drops to approximately 50,000 lbs/hr.

The St. Regis Lumber & Plywood Division has been evaluating their steam usage and converting steam prime movers to electric power where possible to reduce steam demand. Dry kiln heating is the major remaining steam load.

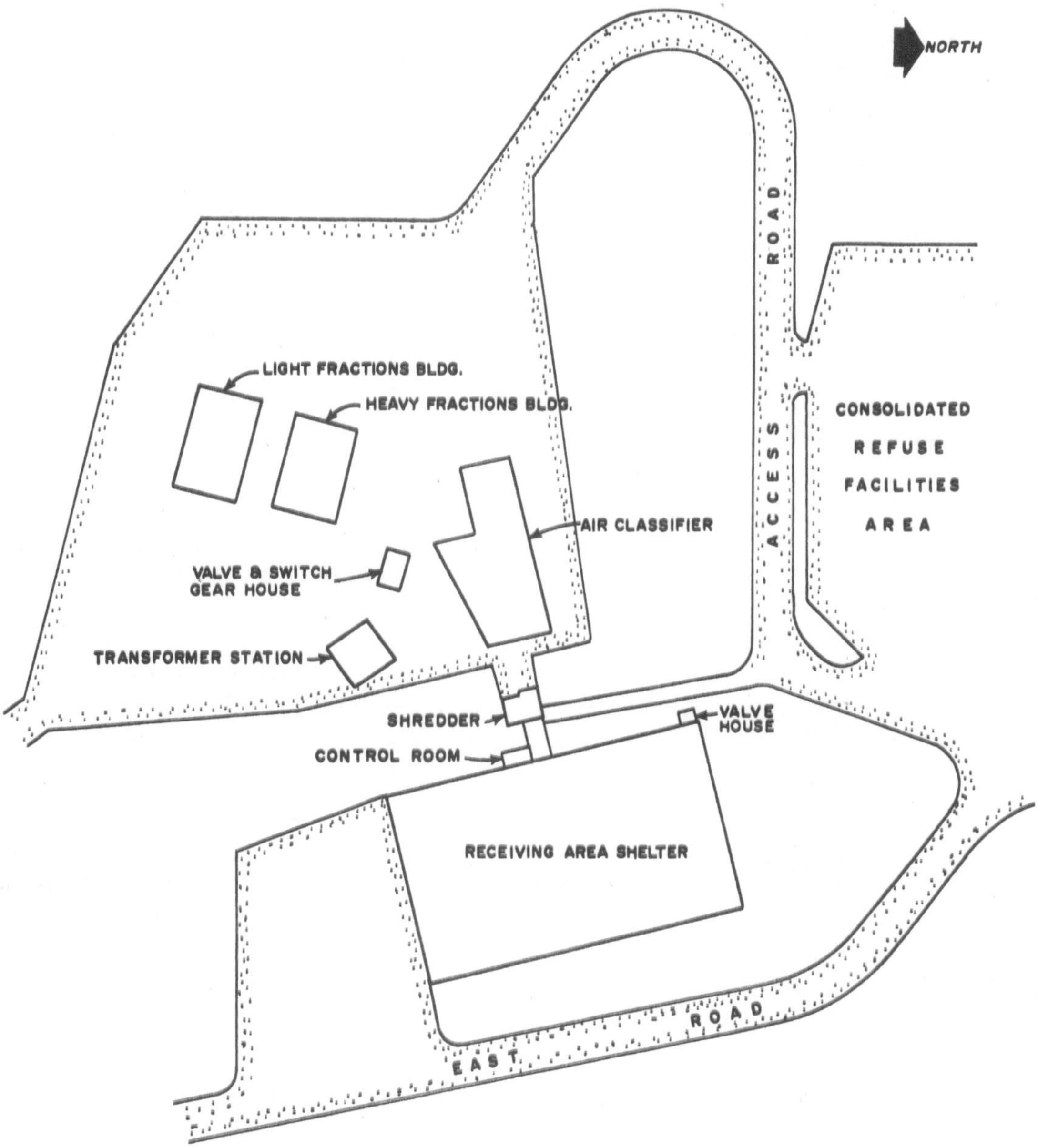
A study is being conducted by the Division Engineer to evaluate future additions or modernizations of the steam plant. The results of this study could not be released at the time of the meetings between the Division Engineer and the Consultant.

C. CITY OF TACOMA'S SOLID WASTE RESOURCE RECOVERY SYSTEM.

The City of Tacoma is currently constructing a 2.4 million dollar solid waste resource recovery system at the city's sanitary landfill. The system will process approximately 500 tons of solid waste daily. Products produced by the processing system will include a shredded, air classified refuse derived fuel, a ferrous metal product and a non-combustible residue. The 2.4 million dollar facility is an extension of the city's shredded waste landfill operation. Figure 3-4 shows the components of the resource recovery system. The system will operate in the following manner:

> Solid waste will be deposited either directly onto an infeed conveyor or on a tipping floor with subsequent movement onto the conveyor. The solid waste will be conveyed mechanically to a Williams 680 reversible horizontal shaft shredder. The solid waste will be shredded to nominal four to six inch particle size and mechanically conveyed to a Boeing air classification system. The air classifier will separate the shredded solid waste into light combustible and heavy non-combustible fractions. The light fraction will be mechanically conveyed to a detached fuel transport loadout building for subsequent haul to energy markets located in the Tacoma area. This fuel transfer system is designed for open top transfer trailers. The heavy fraction produced by the air classifier will pass under an electro-magnet which will remove ferrous metals for sale to metal buyers. The remaining heavy fraction, containing mostly non-combustible residues, will be landfilled.

Construction of the resource recovery facility is scheduled for completion during the second quarter of 1978.



TACOMA RESOURCE RECOVERY FACILITY
TACOMA REFUSE COMBUSTOR STUDY

FIGURE 3-4

CHAPTER FOUR

MARKET ANALYSIS

A. INTRODUCTION

In order to determine the required capacity and best type of central energy plant for the Tacoma Central Business District (CBD), it is necessary to carefully examine and evaluate the current and future energy markets available in the vicinity of the CBD.

This chapter reports local markets for steam, high temperature hot water, chilled water, and electricity. In addition, future energy cost projections are discussed.

B. STEAM

1. General

The CBD's current steam demand has been determined from records of Consumers Central Heating Company (CCHC). The amount of steam sold by month for the years 1974, 1975, and 1976, was shown on Figure 3-3. The steam demand has dropped 23 percent in the past year due to conversions to independent systems by several major users in the CBD. These conversions were caused by the rising steam prices of CCHC and the threat of forced conversion should the CCHC system ultimately close.

2. Market Study Area

The general study area consists of an area bounded by 6th Avenue on the north, South 15th Street on the south, Dock Street on the east, and Yakima Avenue on the west, approximately four tenths of a square mile. (See Figure 3-1.) All of the existing steam distribution lines are inside this area.

Several industrial firms in the tide flats, east of this area, were also considered in this marketing analysis.

3. Steam Load Survey

A questionnaire was used to obtain energy consumption data from the largest energy users in the study area. It was distributed to three types of energy users: the largest current CCHC customers, the largest energy users not with CCHC, and the largest industrial steam users in the tide flats. Figure 4-1 shows the questionnaire as it was distributed. Examples of completed forms are included in Appendix B of this report.

The questionnaire was designed to collect energy related data which could be used to estimate the energy requirements of the study area. A completed questionnaire identifies the building owner, tenant, and building name with addresses. Current heated floor area was requested to cross-check heating loads, and planned building additions could be listed for load projections. Present CCHC customers were asked to record their 1976 annual steam use, maximum monthly use, and minimum monthly use.

The air conditioning section of the questionnaire identifies a building's present cooling load, type of equipment, and measures interest in a centrally supplied chilled water system.

Potential steam customers were asked to record their annual maximum monthly, and minimum monthly use of natural gas and fuel oil. Buildings heated with electricity could be indicated in the remarks space. The information on size and operating pressure of independent steam generation facilities coupled with data on fuel usage and building size, can be used to calculate an equivalent steam load for a building not on the CCHC system. The question on conversion to accomodate a central steam supply registered building manager's attitudes.

The questionnaire was explained at the October meeting of the Downtown Tacoma Association, and several were distributed after the meeting. The remaining questionnaires were hand carried to the survey participants. Ninety percent of the questionnaires distributed were completed and returned.

4. Summary of Survey

The twelve largest CCHC customers returned completed questionnaires. Table 4-1 lists the information provided. None of these users indicated planned building expansion. None expressed any intentions of installing absorption cooling equipment, which would increase annual steam consumption in the CBD.

CITY OF TACOMA, WASHINGTON

STEAM DISTRIBUTION SYSTEM STUDY QUESTIONNAIRE

October, 1977

OWNERSHIP

	Building Owner	Tenant
Name	____________	____________
Mailing Address	____________	____________
	____________	____________

BUILDING

Building Name ____________

Address of Building ____________

Heated Floor Area, Total ____________

Number of Floors ____________

If future building additions are planned, please give estimated heated floor area and approximate dates. ____________

Number of Employees ____________

STEAM USAGE (for Present Steam Customers)

Annual use in 1976, lbs. x 1000 ____________

Maximum Monthly Use in 1976, lbs. x 1000 ____________

Minimum Monthly Use in 1976, lbs. x 1000 ____________

Percentage of steam returned as condensate ____________

-1-

AIR CONDITIONING

Type of existing cooling equipment - absorption or electrical. ____________

Size of cooling equipment in tons of capacity total. ____________

Do you plan to add steam operated cooling equipment in the future? If so, give size of equipment and date. ____________

If an economical centrally operated chilled water supply were available, would you convert existing systems to utilize a centrally supplied chilled water? ____________

FUEL USAGE (for Potential New Customers)

GAS:

Annual Use, 1976, MCF ____________

Maximum Monthly Use, 1976, MCF ____________

Minimum Monthly Use, 1976, MCF ____________

OIL:

Annual use 1976, gallons ____________

Maximum Monthly Use, 1976, gallons ____________

Minimum Monthly Use, 1976, gallons ____________

INTEREST IN CONVERSION

If an economical central steam supply becomes a available to you, would you convert existing heating or cooling systems so that the centrally supplied steam could be used? ____________

EXISTING STEAM GENERATION FACILITIES

Do you presently generate steam? ____________

If so, please state size of boilers and operating pressure. ____________

REMARKS

-2-

FIGURE 4-1

TABLE 4-1

SUMMARY OF SURVEY DATA

PRESENT CCHC CUSTOMERS

Name	Future Additions	Monthly Steam Demand in lbs/hr		Annual Steam Consumption in thousands of pounds
		Max	Min	
Washington Plaza	No	1648	414	8,629
County-City Building [a]	No	2419	428	10,482
State Office Building	No	1465	447	7,264
L. H. Bates Inst.	No	2556	90	8,597
Washington State Armory	No	471	44	1,655
Central School	No	1214	0	3,250
Pacific Northwest Bell-Broadway [c]	No	614	0	2,610
Pacific Northwest Bell-Fawcett [a]	No	479	4	2,931
Doctors Hospital	No	1390	357	4,824
Bicentennial Pavillion	No	836	13	2,169
Schoenfield's Furniture	No	489	1	1,152
Subtotal		13581	1798	53,563
Remaining Customers		17476	4931	118,159
		31057	6729	171,722

a. considering independent system
b. includes heating and cooling
c. future heat recovery equipment will reduce consumption

Table 4-2 shows information obtained from the questionnaires returned by 21 of the largest energy users not on the CCHC system. This group of potential steam users generally uses electricity as its energy source. Their total annual energy consumption for heat converted to equivalent pounds of steam is 77,489,000 lbs, or approximately 9000 lbs/hr on a continuous annual basis. Almost all of the building managers expressed no interest in converting to a centrally supplied steam source, although a few stated that keeping such a system available in the future would provide a desirable alternative for the CBD.

5. Industrial Steam Markets

As is typical with any steam system used primarily for heating, demand is sharply depressed during the summer months. The demand curves in Figure 3-2 illustrate this characteristic. Steam sales to industrial customers can level out the annual heating demand curve.

Six industrial steam users in the tide flats were approached with the concept of purchasing steam from a central generating plant: St. Regis Paper Company, Pennwalt Corporation, Kaiser Aluminum and Chemical Corporation, Reichhold Chemicals, Inc., Puget Sound Plywood, Inc., and Harmon Cabinets Division of Coast Sash/Door Company, Inc. The first four of these firms expressed an interest in buying steam if the pressure, quantity, and price met their requirements.

Located close to the CBD, the St. Regis Paper Company is the most attractive potential industrial steam customer. Discussions have been held with St. Regis personnel to establish minimum and maximum steam demands.

The St. Regis Pulp and Paper Division operates at an average steam load of 833,000 lbs/hr. Boilers fueled with process wastes handle 60 percent of this load. The potential steam market is the remaining 40 percent, now obtained from fuel oil combustion. This potential load is 333,000 lbs/hr.

The St. Regis Lumber and Plywood Division represents an additional potential market, with loads ranging from 60,000 to 90,000 lbs/hr, dropping to 50,000 lbs/hr on weekends.

TABLE 4-2

SUMMARY OF SURVEY DATA

POTENTIAL NEW CUSTOMERS

Name	Future Additions	Heating Source	Annual Energy Consumption for Heating, converted to Thousands of Pounds of Steam
The Winthrop	No	Electric Baseboard	9697
Medical Arts Building	No	Electrode Boiler	7522
Sears	No	Electric Forced Air	2557
Bon Marche	No	Electric Heat Pump	7104
Puget Sound National Bank	No	Electric Baseboard	5550
Peoples & Iverson Building	No	Electric Forced Air	1205
Washington Building	No	Electric Hot Water	5353
Bank of California	No	Electrode Boiler	2800
Security Building	No	Electrode Boiler	2423
United Pacific -Broadway	No	Electrode Boiler	1498
United Pacific - St. Helens	No	Electrode Boiler	2015
Harbor View Manor	No	Electric Baseboard	9028
Harbor View Terrace	No	Electric Hot Water	1105
Tacoma Public Library	No	Oil Fired Boiler	2459
American Federal Building	No	Electrode Boiler	3394
Washington Apts.	No	Gas Fired Boiler	3476
Print N. W.	No	Electric Baseboard & Forced Air	1097
Triona Apts.	No	Electrode Boiler	1280
Tacoma Rubber Stamp	Yes*	Electric Forced Air	674
1400 Market (under construction)	No	Electric Baseboard	5698
Fawcett Park Plaza (to be constructed)	No	Electric Heat Pump	1554
			77489

* Adding 5000 ft^2 in 5 years.

Before St. Regis would make a firm commitment to purchase steam, questions regarding price and fuel sources would have to be resolved.

6. Future Development of Downtown Tacoma

To complete the steam market survey, an inventory of undeveloped land in the study area was taken. Vacant parcels and surface parking lots were located and areas estimated. Figure 4-3 displays the locations of these areas. The total area available for future development is approximately one million square feet.

In making projections of future land use, several assumptions were made. To accomodate a mix of residential, commercial, and office space, an average building height of five floors was assumed, with a land utilization factor of 50 percent. The remaining 50 percent is allowed for walkways, parking, service access, and landscaping. On this basis, there is a potential of 2,500,000 square feet of heated floor space. An exponential growth was assumed: 5 percent of all vacant land developed in 1980, 30 percent in 1990, and 80 percent in 2000.

Table 4-3 lists the potential growth of steam heating load in terms of three quantities: peak demand, average demand, and annual consumption. Included in the 1980 projection are the loads for 37,000 square feet of vacant commercial space in Park Plazas North and South. These spaces are connected to the Consumers Central Steam distribution system. Their peak load is estimated to be 890 lbs/hr, average load 310 lbs/hr, and annual consumption, 2,700,000 lbs.

C. HIGH TEMPERATURE HOT WATER

Because of the problems involved with converting from a steam system to a high temperature hot water (HTHW) heating system, existing energy users were not asked about their interest in converting to this type of system. Significant private capital investment would be required to install HTHW converters in each building. In addition, such converters require more space for installation than comparable steam systems. Buildings still using steam radiators could require new heat radiation equipment. It is possible, albeit inefficient, to produce 15 psig steam with HTHW.

The inability of a HTHW system to handle utilization equipment such as laundry machines without special converters could result in a potential market loss. More importantly, HTHW eliminates the possibility of serving industrial customers and the feasibility of electric co-generation.

TABLE 4-3

SUMMARY OF PROJECTED LOADS FOR TACOMA CBD TO 2000

	Heated Space ($Ft.^2$)	Annual Steam Consumption[a] (lbs)	Average Steam Load[a] (lbs/hr)	Peak Steam Load[b] (lbs/hr)
Existing Customers		171,722,000	19,600	67,000
Add for Development 1978 - 1980	162,000	11,988,000	1,366	3,890
1980 Total		183,710,000	20,966	70,890
Add for Development 1980 - 1990	625,000	46,250,000	5,279	15,000
1990 Total		229,960,000	26,245	85,890
Add for Development 1990 - 2000	1,250,000	92,500,000	10,565	30,000
2000 Total		322,460,000	36,810	115,890

a. Based on an annual consumption of 74 lbs/ft^2. (Strock & Koral, Handbook of Air Conditioning, Heating and Ventilating, 1965

b. Based on peak demand of .024 $lbs/hr/ft^2$ (ibid).

Based on current heating loads of the CCHC system, 1300 gpm of 350°F 135 psig a HTHW could meet the peak heating loads of the system. The future load projections discussed in the previous steam market section can also apply to a HTHW system. The HTHW capacity would have to be approximately 2200 gpm to handle peak loads in the year 2000.

D. CHILLED WATER

A centrally supplied chilled water system[1] to serve the CBD cooling loads is another means of leveling out the summer depression in the energy demand curve. The steam market questionnaire included questions on the size and type of existing cooling equipment. Building managers were also asked about future plans to install additional air conditioning and about interest in converting existing systems to utilize centrally supplied chilled water.

The responses revealed no anticipated changes or additions of cooling equipment. Not surprisingly, only five of the questionnaires received indicated any interest in a central chilled water supply system.

With 1% summer design conditions of 85°F DB - 68°F WB and 5% conditions of 78°F DB - 64°F WB, cooling needs in Tacoma are minimal. Future growth in the CBD will present additional cooling requirements, but handling those requirements with a central chilled water system is not feasible.

E. ELECTRICITY

Discussions were held with representatives of Tacoma City Light concerning its participation as customers for electricity generated by a central energy plant burning waste type fuels. Tacoma City Light indicated that it would consider purchasing electrical energy produced by such a facility. For discussion purposes, Tacoma City Light would tie its purchase price to the Bonneville Power Administration rate structure of 15 to 18 mills per kilowatt hour in 1980 dollars. This rate range will be used in the feasibility analysis presented in Chapter Eight of this report.

F. PROJECTED ENERGY COSTS

An energy product will be produced by the proposed central plant. The energy value is dependent on its cost of production and the relative cost of using other options for heating and cooling in the CBD. For the central

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1 data from ASHRAE Handbook of Fundamentals for Tacoma McChord Air Force Base.

energy plant to be economically feasible, the negotiated energy price must be low enough to be competitive with user's current and projected alternative energy options but at the same time, high enough to create revenues which make the project financially viable.

In reality, the value placed on the energy produced depends in part on the perspective of the evaluator. There are two possible pricing mechanisms; 1) The value of the waste fuel derived energy could be tied to an escalated price index based on alternative energy costs or, 2) The value of the energy produced could reflect the facility's production costs.

Discussed below are alternative methods for heating the CBD by fuel classification.

1. Natural Gas

Natural gas is the cleanest fossil fuel and has been the most desirable fuel for steam generation in Tacoma region. Natural gas has the advantage of requiring no on-site storage. The costs of natural gas are subject to availability and regulation.

Natural gas currently sells at approximately $2.29 per million Btu's. It is well known that the costs of natural gas has escalated dramitically since 1974. Furthermore, the utilization of natural gas by large industrial users (e.g., steam generators) appears to be clearly limited by Federal energy management policy. Therefore, natural gas cannot be considered as a primary fuel for the central energy plant.

2. Oil

Fuel oil is the second most attractive fossil fuel for energy generation from the viewpoint of ease of handling and burning characteristics. Four grades of fuel oil are currently available. Their grades and their approximate heating values are listed below.

No. 2 Oil	138,000 Btu's/gallon
No. 4 Oil	146,500 Btu's/gallon
No. 5 Oil	148,500 Btu's/gallon
No. 6 Oil	152,000 Btu's/gallon

Of the four grades, No. 6 fuel oil has been the lowest cost and has been the most widely used for central energy generation. The average cost of No. 6 oil is currently $0.32 per gallon in the Tacoma area. Like natural gas, fuel oil has increased in price dramatically since 1974 but current regulations do not require a federal oil allocation for use in a new facility.

3. Coal

Coal is not currently used as a basic fuel in the Tacoma area because of the availability and lower costs of other fossil fuels, such as natural gas, fuel oil and wood-waste fuels. As these alternative fuels increase in cost, coal consumption in the Tacoma area may increase.

4. Wood Waste (Hog Fuel).

Burning wood waste in utility boilers for steam generation has been practiced for many years in the Tacoma area. The heating value of the wood waste can be highly variable depending on moisture content and wood species. Its heating value on a dry basis varies from 7,000 to 9,000 Btu's per pound, and its ash content ranges from approximately two to six percent. The price of hog fuel is dependent upon production cost and the cost of transportation to the user location. Currently the price per hog fuel unit varies from $6.50 to $12.20 which is equivalent to $0.72 to $1.22 per million Btu's.

5. Solid Waste

The sale of solid waste as fuel in the Tacoma area does not have a marked history. The City of Tacoma is currently constructing a resource recovery plant at the City landfill that will convert Tacoma's solid waste into a shredded air classified refuse derived fuel (RDF). Approximately 300 tons per day of RDF will be produced on a 5 days per week basis by the resource recovery plant. The RDF is expected to have an average net heating value of 5,000 Btu's/lb with an ash content of approximately 15 percent.

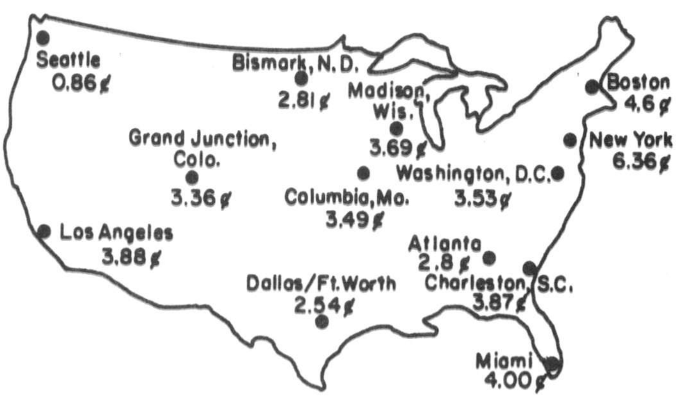
While the sale of RDF does not have a market history, it could be reasonably postulated that the RDF fuel could be tied closely to the price of hog fuel since its firing characteristics are similar. Therefore, the price of RDF will be pegged initially at $0.72 per million Btu's in 1977.

6. Electricity

Tacoma City Light serves the region with low cost electrical energy obtained primarily from hydro-generating facilities. As demands continue to increase, City Light is supplementing it's hydro-generated power with power purchased from nuclear and coal fired generating facilities. The future availability of low cost electrical energy appears to be limited. For instance, aluminum smelters served by the Bonneville system have been notified of substantial rate increases or service curtailments by 1984 because of inadequate hydro-generating capacity.

The current average cost of electrical energy is approximately 8 mills per kilowatt hour. According to City Light personnel, this average cost of electrical energy is expected to increase to approximately 15 to 18 mills per killowatt hour by 1980-81.

Proposals have also been submitted on the Federal level to equalize electric rates across the country. Figure 4-4 depicts typical costs of electrical energy in this country. As illustrated by Figure 4-4, the Northwest has by far the lowest electrical energy rate of any region of the country. The rationale of the Federal proposal is that the Northwest region is benefitting from facilities built by tax dollars disportionately compared to other regions.



COST OF ELECTRICITY PER KILOWATT HOUR
FOR VARIOUS CITIES

TACOMA
REFUSE FIRED COMBUSTOR STUDY

Source: Energy and Development Administrastion
Based on July 1976 winter rates for 500-750 kwh.

FIGURE 4-4

While this proposal has been submitted, the consultant questions seriously the mechanism by which one region is taxed or penalized to subsidize electric rates in other regions of the country.

In summation, low electrical energy rates are a fact of life in the City of Tacoma. Therefore, the building owners in the CBD can convert to all electric heating systems at the present time with little or moderate increases in annual heating costs.

The future availability and price of fossil fuels (i.e., natural gas and fuel oil) cannot be predicted with any degree of reliability based on previous historical trends. The unpredictable influences of political actions, particularly on prices, will have an impact on the prices of fossil fuels in the Tacoma area. The predicted surplus of Alaskan North Slope oil on the west coast further complicates the "crystal balling" of future fuel oil prices. Furthermore, Federal actions to equalize electric rates could impact significantly on the feasibility of this project.

Table 4-4 lists the 1977 energy prices for the Tacoma area.

TABLE 4 - 4

ENERGY COSTS FOR TACOMA

(1977 $)

Fuel Type	Heat. Value	Cost $	Unit Value ($/MM Btu)
Natural Gas	1000 Btu/SCF	0.229/Therm	2.29
Fuel Oil, No. 6	152,000 Btu/Gal.	0.29/Gal.	1.90
Coal	11,000 Btu/Lb	32.00/Ton	1.45
Wood Waste (Hog Fuel)	5,000 Btu/Lb	7.20-12.20 / Ton	0.72 - 1.22
RDF	5,000 Btu/Lb	7.20/Ton	0.72
Electricity	--	8 Mills/KWHr	

Table 4-5 lists the future energy prices for FEA Region 9 based on the Federal Energy Administration(FEA) projections. These projections are based on 1977 (Base Year) dollars and a fuel oil combustion. For the conditions present in Tacoma, the FEA projections may not have universal application. Analysis of FEA projections indicate only nominal increase (5%) in cost for the fourteen year projection period. The FEA findings therefore indicate the cost of residual fuels will follow the general inflation rate.

For this project the consultant assumed that the relative cost of energy in the Tacoma area would be tied to any future increase in energy prices. For example, if fossil fuels,(natural gas and fuel oil) increased in price, the other less desirable fuels (wood wastes and RDF) would increase proportionately thereby maintaining the same relative price relationship.

This assumption may not be wholly applicable to the prices of electric energy in the Tacoma area. If additional fossil fired generation capacity is required, the average cost per kilowatt hour would rise sharply compared to general inflationary trends.

There is no universal answer or accepted standard concerning future energy prices. Projections vary from four percent per year to four percent over the national inflation rate. For example, if the national inflation rate was seven percent, the cost of energy would escalate at 11 percent per year (7 percent plus 4 percent = 11 percent). For this project, the consultant assumed that the relative cost of energy types would remain the same and that their average price would increase seven percent per year. The analysis presented in Chapter Ten will test the sensitivity of this assumption to the overall feasibility of this project.

TABLE 4 - 5
ENERGY PRICES IN 1977 DOLLARS PER MILLION BTU
FEA REGION IX WESTERN
(PRICES ASSUMED CONSTANT FROM 1990 ONWARD)
($/mm Btu)

	Res. Elect.	Comm. Elect.	Ind. Elect.	Res. N. Gas	Comm. N. Gas	Ind. N. Gas	Res. Dist.	Comm. Dist.	Ind. Dist.	Comm. Resid.	Ind. Resid.	Res. LPG	Ind. LPG	Ind. COAL
1975	10.83	9.12	6.96	1.68	1.37	1.09	3.29	3.01	3.01	2.90	2.89	3.07	2.82	1.84
	11.47	9.84	7.73	1.86	1.52	1.42	3.33	3.06	3.06	2.92	2.91	3.14	2.89	1.77
	12.10	10.55	8.49	2.04	1.66	1.74	3.38	3.11	3.11	2.93	2.92	3.21	2.97	1.71
	12.74	11.27	9.26	2.22	1.80	2.07	3.43	3.16	3.16	2.94	2.93	3.29	3.05	1.65
	13.37	11.99	10.02	2.40	1.94	2.40	3.47	3.21	3.21	2.95	2.94	3.36	3.12	1.58
1980	14.01	12.71	10.79	2.57	2.08	2.72	3.52	3.26	3.26	2.96	2.96	3.43	3.20	1.52
	13.86	12.64	10.78	2.77	2.28	2.67	3.56	3.29	3.29	2.96	2.96	3.48	3.25	1.54
	13.71	12.57	10.77	2.97	2.48	2.63	3.59	3.33	3.33	2.97	2.96	3.54	3.31	1.56
	13.56	12.50	10.76	3.16	2.67	2.58	3.63	3.37	3.37	2.97	2.97	3.59	3.36	1.58
	13.41	12.43	10.75	3.36	2.87	2.53	3.67	3.41	3.41	2.98	2.97	3.64	3.41	1.61
1985	13.26	12.37	10.74	3.56	3.07	2.48	3.71	3.44	3.44	2.98	2.98	3.70	3.46	1.63
	13.27	12.46	10.89	3.59	3.10	2.63	3.75	3.49	3.49	3.00	3.00	3.78	3.55	1.65
	13.28	12.56	11.04	3.63	3.14	2.77	3.80	3.54	3.54	3.02	3.01	3.86	3.63	1.67
	13.29	12.65	11.19	3.67	3.17	2.92	3.84	3.58	3.58	3.04	3.03	3.94	3.71	1.69
	13.31	12.75	11.34	3.70	3.21	3.07	3.89	3.63	3.63	3.06	3.05	4.02	3.79	1.72
1990	13.32	12.84	11.49	3.74	3.25	3.21	3.94	3.67	3.67	3.08	3.07	4.10	3.87	1.74
	13.32	12.84	11.49	3.74	3.25	3.21	3.94	3.67	3.67	3.08	3.07	4.10	3.87	1.74

Source: Federal Register, Vol. 42, - Friday, April 15, 1977

CHAPTER FIVE

TECHNOLOGY EVALUATION

A. INTRODUCTION

The Tacoma central business district is currently served by the Consumers Central Heating Company. Because the CCHC steam generation system is tied solely to the combustion of fossil fuels (natural gas and fuel oil) for steam generation, costs have escalated dramatically since 1974. This project was commissioned to evaluate the available technology and determine what combustion system and energy distribution system is applicable to the circumstances present in Tacoma. This chapter discusses the following topics:

- Combustor Systems
- Energy Distribution Systems

B. COMBUSTOR SYSTEMS

1. Conventional Combustion Systems

a. Introduction

Various fuels have been burned in steam generators successfully for a number of years. The basic technology was developed from coal and wood combustion systems. Coal contains between 9,000 Btu's/lb to 14,000 Btu's/lb while waste fuels contain approximately one-half of coal's heating value on a Btu basis. For this project refuse derived fuel and wood wastes (hog fuel) will be the primary fuels with residual fuel oil used as a standby fuel.

Wood wastes and refuse derived fuel have similar combustion characteristics because of their variable moisture content and heating values. Because these waste fuels have a high moisture content, a description of their combustion mechanism is appropriate.

The waste fuels will be combusted in three consecutive stages: (1) the evaporation of the moisture, (2) the distillation and burning of the volatile matter and (3) the combustion of the fixed carbon of the fuel.

The first two stages (evaporation and distillation) burns volatile combustible matter and absorbs heat energy. The evaporation stage requires approximately 1100 Btu's per pound of moisture and proceeds as fast as heat is supplied to convert the water into steam. After the moisture has been evaporated, the volatile matter is driven off and burns. Then the fixed carbon burns as fast as combustion air is brought in contact with the fuel. The combustion system for waste fuels must be designed for their combustion characteristics.

b. Firing Mechanisms

There are two fundamental systems for firing waste fuels. These are semi-suspension (travelling grate) and suspension firing. Both systems are classified as burning by the overfeed principle; i. e., fuel introduced above and in the opposite direction of primary air flow.

In the semi-suspension system, the waste type fuel is normally introduced through ports in the front wall of the furnace by a spreader-stoker or with pneumatic injection nozzles. The fine particles of fuel burn in suspension as they fall through the fire to the bottom of the furnace. The fuel not burned in suspension will fall on the grates where the combustion process is completed.

In the suspension firing system, the waste fuel is introduced in the furnace high enough to allow drying, ignition and complete combustion before the fuel drops to the bottom of the furnace. Adequate turbulence is provided by preheated air injected at various furnace elevations. Primary and secondary air is proportioned in relation to the combustion air requirements of the waste fuel.

Operating experience has shown that particle size and furnace retention time are the most critical factors influencing complete combustion of waste type fuels. If an existing boiler furnace does not provide adequate retention time, a dump grate can be used in the furnace bottom to complete combustion of particles that have not burned in suspension.

The boilers contemplated for this project will be new units designed specifically for the combustion of waste type fuels; i. e., prepared refuse derived fuel and wood wastes (hog fuel) in the 100,000 lbs/hr size range. The well proven spreader stoker with travelling grate firing system will be used. Retention times can be modulated mechanically thereby responding to the variable combustion characteristics of the fuels.

c. Design Parameters.

Figure 5-1 shows an elevation view of a travelling grate spreader stoker boiler system. The effective design of the combustion system is dependent upon eight general parameters. These parameters were developed from coal combustion technology. The parameters are listed below and discussed in the subsequent paragraphs:

1. Maximum Flue Gas Velocity

Burning waste fuels requires that the maximum flue gas velocity be maintained below 30 feet per second, or one-half that of a coal fired unit. Higher velocity will cause increased particulate emissions and incomplete combustion of the waste fuel.

2. Boiler Furnace, Heat Exchanger Surface

Because less heat is released per cubic foot of furnace volume, additional heat absorption surface is provided in a waste fuel fired boiler furnace.

3. Boiler Convection Section

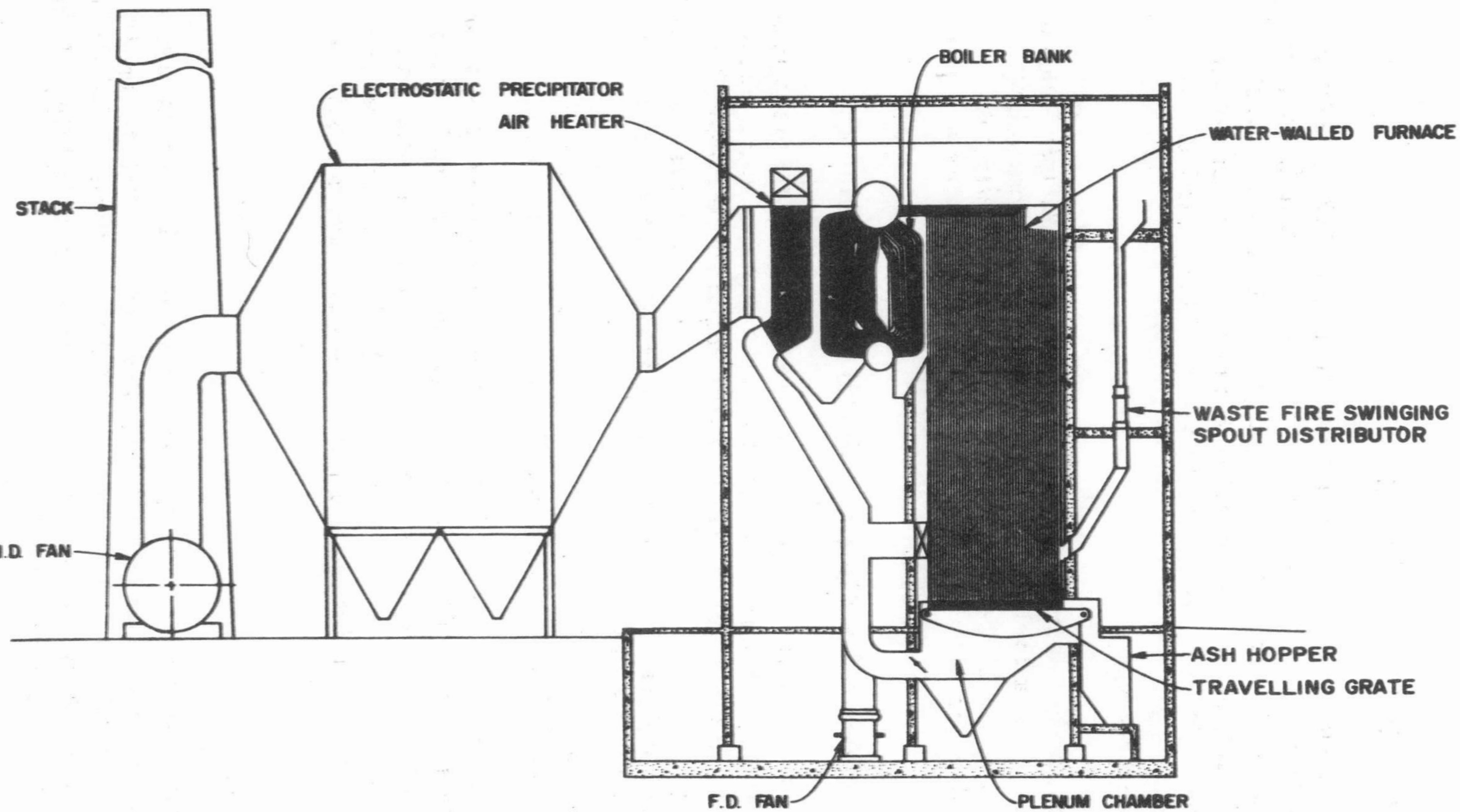
More rows with wider spacing between the tubes are provided to obtain adequate heat transfer surface and prevent possible plugging due to particulate carryover.

4. Grate Area

Combustion systems firing waste type fuels require larger grate areas than conventional systems to obtain comparable steam production. As a rule of thumb, the grate area is increased by approximately 33 percent for waste fuel type units compared to conventional designs.

TITLE:

TYPICAL WASTE FUEL FIRED STEAM GENERATOR



ELEVATION VIEW

TACOMA REFUSE FIRED COMBUSTOR STUDY

FIGURE 5-1

5. Furnace Outlet Temperature

The furnace gas outlet temperature is limited to 1600°F or approximately 25 percent lower than a coal fired unit. The lower temperature is required to limit ash slagging and fouling of the superheater tubes due to the presence of alkalis in the refuse derived fuel. (Na_2O and K O).

6. Soot Blowers

Operating experience based on burning waste fuels has indicated a greater incidence of superheater tube fouling rates than coal fired systems. To accommodate this operating characteristic, additional soot blowers are provided.

7. Maximum Operating Conditions

European operating experience has shown superheater tube corrosion to be a problem when mass burning solid wastes and generating high pressure and temperature steam. Because of this effect the manufacturers of waste-fired boilers are limiting superheated steam to 750°F steam temperature at the superheater outlet.

8. Horsepower and Combustion Air

Because the light waste fuel particles tend to carry over with the gas stream, the quantity of overfire air in the furnace is increased. Larger fan capacity is provided than for conventional coal-fired units as the high moisture content of solid waste fuels increases the gas mass flow through the boiler.

d. Air Pollution

Firing waste type fuels is not a new technology, but the incorporation of sophisticated air emission control systems to meet stringent air emission standards is relatively new. The selection of the air pollution control system is dependent upon the characteristics of the fuels burned in the steam generator.

The technology of controlling emissions from wood fired units is well documented. The technology of controlling air emissions from refuse derived fuel units has developed over the past few years. The systems used to control air emissions, like the combustion system, were developed from coal combustion technology. Table 5-1 lists the general types of air pollution control systems.

TABLE 5-1

Descriptions of Air Pollution Control Systems

Type	Descriptions
Wet Scrubbers	Water is injected through multi-nozzles into the exhaust gas as atomized streams. Fly ash removal efficiency is dependent upon particle/water contact. The system requires a high volume of water which can be clarified and re-used and presents a wet fly ash disposal problem. The collection efficiency of wet scrubbers approaches 90 percent.
Cyclone Collectors.	Particulate laden air is injected tangentially into a cyclone and the velocity greatly reduced which causes the solid particles to to drop out of the gas stream. It is a dry collection system and its collection efficiency approaches 90 percent on particles larger than 10 microns.
Fabric Bag Collectors.	Particulate laden air is passed through a series of fabric bags. The particulates collect in the bag pores. Bag collectors can attain a 99 percent removal efficiency.
Electrostatic Precipitators (ESP)	ESPs operate on the principle of positive/negative attraction of particulates. Particulates are given a negative polarity while the collection surface is positively charged. ESPs are dry collection systems and can maintain a 99 percent collection efficiency including sub-micron particles.

Limited operating experience is available concerning firing refuse derived fuel on travelling grate systems. Preliminary test results obtained from Ames, Iowa are as follows:

- No significant hydrocarbon emissions in the C_1 and C_5 range have been found. Results from the organic acid analysis and mercury tests are not yet available.

- Both uncontrolled particulate emissions before the particulate collector (multiple cyclone) and stack particulate emissions to the atmosphere did not indicate clear, overall trends as a function of refuse derived fuel heat input.

- Nitrous oxides and sulfur emissions both have trends of decreasing emissions with increased percent RDF.

- Chloride emissions increased with increasing waste fuel load.

- Formaldehyde, cyanide and phosphate emissions were quite variable. No clear trends were indicated.

- Many of the heavy organic compounds in the stack emissions were below laboratory detection level and the majority were detected as particulates in the stack gases.

For this project adequate technology is available to control the air emissions. Based on demonstrated cases, electrostatic precipitators have the widest application. Wet scrubbers and cyclone collectors alone can not attain adequate collection efficiency to meet emission criteria. Bag filters with suitable bag material, can also be used.

The particulate removal system proposed would consist of multi-cyclone type collectors with an electrostatic precipitator or bag-type filter unit as the final filter.

2. Fluidized Bed System

a. History

Fluidized bed technology was developed by the petroleum industry. The first commercial use of these units occurred in the early 1940's for catalytic-cracking and catalyst regeneration in oil refining. Since fluidized bed units have been developed for chemical manufacturing, lime calcination, mineral ore roasting, solids drying, and the disposal of difficult-to-handle process wastes and sludges such as sewage treatment plant sludges. Currently, fluidized bed units are being used experimentally to burn high sulphur coals in a limestone bed for sulphur dioxide removal.

b. Unit Description and Operation.

A fluidized bed unit consists of a steel vessel containing from bottom to top a gas inlet plenum, a gas distributor-bed support plate, a fluidized bed zone, and a freeboard or separation zone. For high temperature operation the steel shell is lined with insulating refractory and fire brick. The bed for combustion units consists of high grade silica sand. The shape of the steel shell has commonly been round, but rectangular cells are used when the fluidized bed units are designed for the furnace of a steam generator. Figures 5-2 and 5-3 are typical plan, elevation and cutaway views of a fluidized bed system.

The description of operation that follows is specific to fluidized bed units designed for a combustion process. The silica sand bed depth typically varies from 3 to 8 feet depending on size and capacity. Air, compressed to a pressure adequate to lift the bed, is supplied to the plenum chamber under the distributor plate. The sand bed is lifted and expanded vertically until the sand particles reach a turbulent boiling action resembling a fluid state. Auxiliary fuel (gas or oil) is used to bring the bed to operating temperatures of 1200 to 1800°F depending on material burned and purpose of the unit. For steam generation, a bed temperature of about 1600°F is being used to minimize nitrous oxide emissions.

After operating temperature is reached, the material to be burned is admitted into the unit at a point within the fluidized bed zone or above the bed. Hog fuel, RDF, and coal would be injected into the fluidized zone. Bed temperature is maintained by controlling the rate of fuel feed to the bed. Combustion occurs without flame and is complete due to the intimate mixing of the combustible material and air in the fluidized

TITLE:

FLUID BED STEAM GENERATION SYSTEM

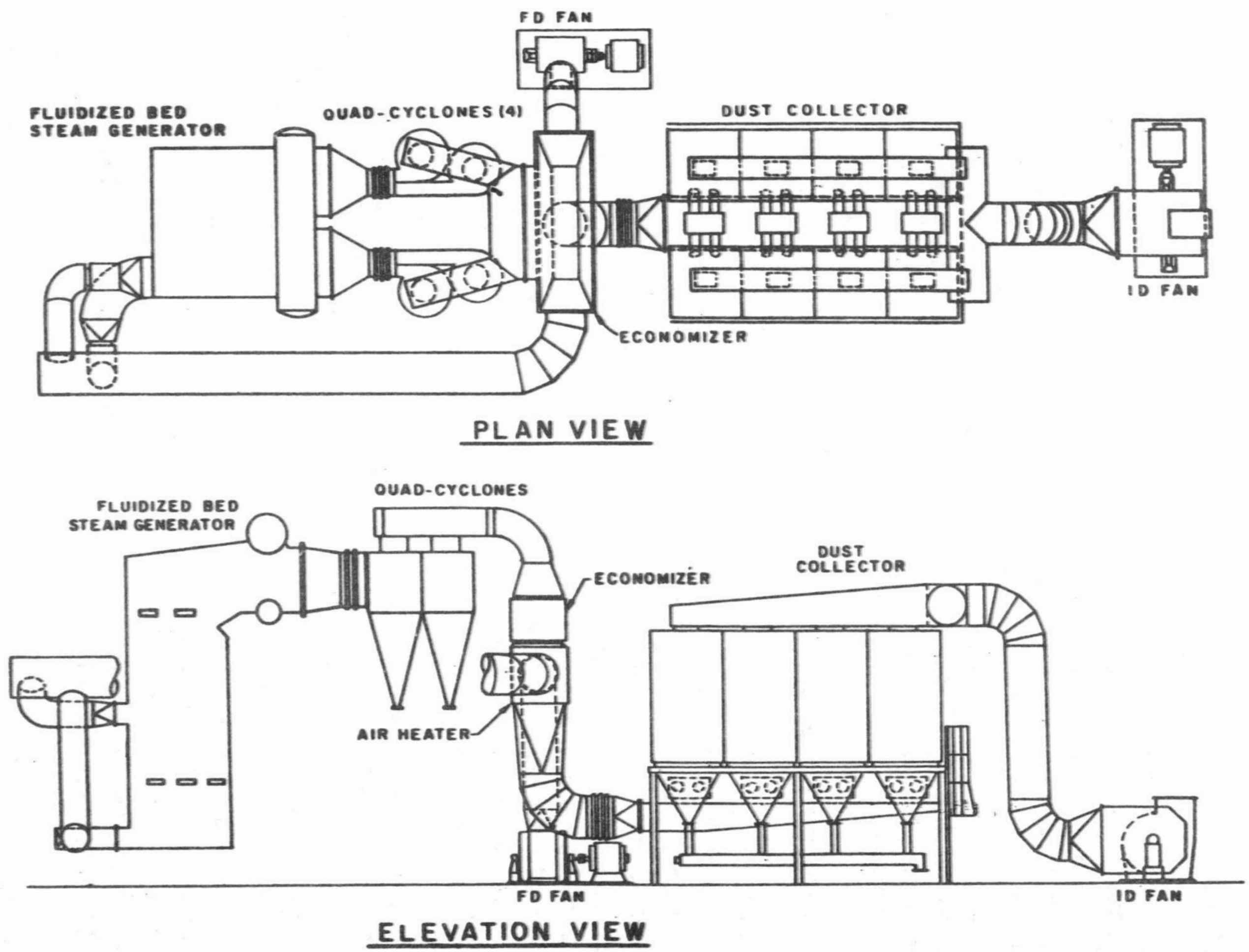


FIGURE 5-2

TACOMA REFUSE FIRED COMBUSTOR STUDY

FLUID BED STEAM GENERATION SYSTEM- CUT AWAY

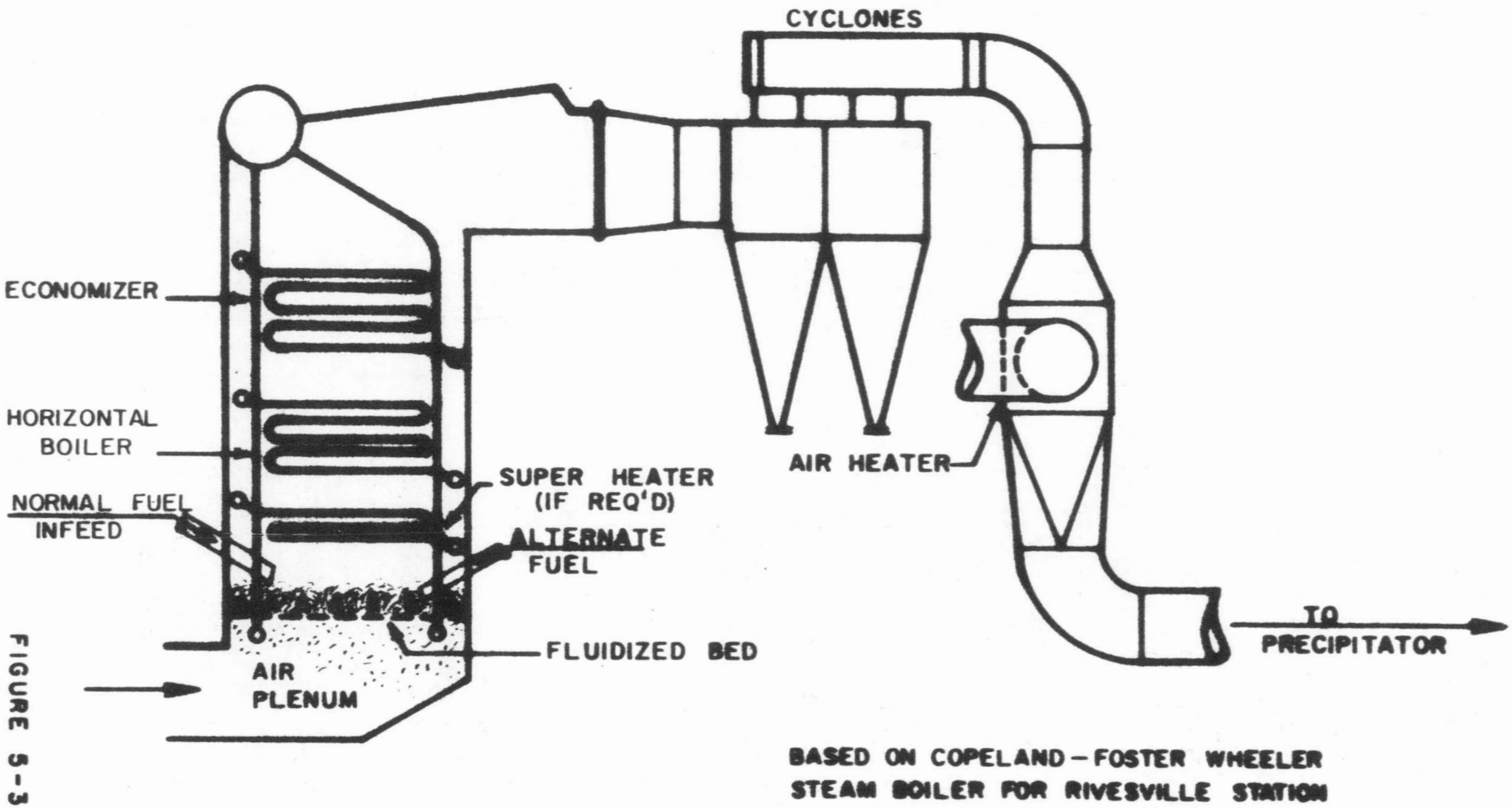


FIGURE 5-3

zone. The sand bed is a stable heat sink so variations in feed rate or heating value of the combustible material can be handled without system upset.

The gaseous products of combustion traverse the free board or separating zone at a reduced velocity which allows most of the entrained solids to drop back into the bed zone.

The fluidized bed process requires a system for successful operation which may contain the following components: cyclone separators on gas stream leaving fluidized bed vessel, heat recovery units to generate steam or hot water, air heater, and a particulate removal system. Auxiliary equipment required includes multi-stage centrifugal blower for fluidizing air supply, bed ash removal, make-up sand storage tank and injection system, start-up fuel system, and induced draft fan if balanced draft operation is required. The particulate removal system most commonly used to date has been the wet scrubber. However, a bag type filter unit or an electrostatic precipitator can also be used for particulate removal.

c. Fluidized Bed Furnace Steam Generator.

Fluidized bed units designed specifically for steam generation are commercially available. These units have advantages for burning waste type fuels, such as hog fuel and RDF, since fuel particle size and quality are not critical to unit operation.

A system designed for steam generation would contain the following components: rectangular fluidized bed furnace of two or more cells for capacity control, boiler unit with water wall tubes into fluidized bed furnaces, gas outlet cyclones for primary particulate removal and reinjection into bed zone, ash removal system from fluidized bed cells, air heater, bag type filter unit for final particulate removal, induced draft fan, and stack.

d. Fuel Handling Systems.

Fluidized bed combustion systems are capable of burning multiple fuels. Three general fuel categories are used and their use determines the type of feed system used. Fuel categories are liquid, semi-liquid, and solid. Summarized below is a general discussion of the fuel handling systems:

1. Solid fuels can be fed to the reactor with pneumatic conveyors, screw conveyors and belt conveyors. Pneumatic conveying systems generally discharge the solid fuel slightly above but directed towards the fluidized bed. Screw conveyors generally feed directly into the bed. Belt conveyors usually empty into hoppers or rotary feeders for subsequent discharge into the reactor.

   Solid fuels may be fed by gravity into the reactor when a balanced draft system is employed. With this feed system, the freeboard zone is operated under a slightly negative pressure with an induced draft fan. The fan is usually installed in the exhaust duct downstream of the scrubber. The induced fan complements the fluidizing air blower. Outputs are controlled to maintain furnace pressure and overcome the gas flow friction loss through the unit.

   When a heterogeneous mixture of solid waste is the input fuel the mixture should be evaluated to determine potential adverse impacts on the fluid bed combustion system.

2. Liquid waste fuels are usually pressurized and injected into the reactor. The injection point is based on the fuel's volatility and water content. If the waste fuel has a high water content and low heating value it may be fed through a single spray nozzle located at the top of the reactor. Fuels with high volatility, such as solvents and oils, can be injected directly on the bed (or into freeboard zone).

3. Dewatered semi-liquid wastes are usually injected into the freeboard zone similar to the low volatility high water content procedure described in the preceding paragraphs.

e. Case Histories.

Fluidized bed combustion has been an effective system for the disposal of sludges, chemical wastes and other materials that could not be disposed of in any other environmentally safe method. Fluidized bed combustion is a developing technology in comparison to conventional incinerator/water wall boiler combustion systems. Summarized below are case histories of three fluidized bed applications applicable to this project.

1. Thunder Bay, Canada

The Great Lakes Paper Company at Thunder Bay, Ontario uses a 22'-0" bed diameter fluid bed incinerator to dispose of bark, debris and clarifier sludge. This unit was designed by Copeland Systems, Inc., of Oak Brook, Illinois. When the system began operating, bark and wood debris were reduced to a 2x2x6 inch size using a hammer-mill. The milled material was pneumatically conveyed into the fluid bed reactor where it was incinerated. After the system had been in operation a few months, it became apparent that the cost of resurfacing the hammers was more expensive than originally anticipated. This was attributed to the large rocks, gravel and tramp metals which were mixed in with the waste bark stockpile.

The pneumatic feed system was replaced with a rotary feed valve installed in the freeboard zone near the top of the dome. It was designed to feed a 3-foot log. Sludge from the effluent clarifier is mixed with the wood waste and debris on the feed conveyor. These materials are fed through the rotary valve together with no effort to homogenize the mixture.

Municipal refuse was experimentally incinerated in the Thunder Bay fluid bed installation during June of 1974. During the course of the experiment, 30 tons of mixed municipal refuse and other solid wastes were combusted in the system. At one point, refuse feed rate was approximately 8 tons/hour while simultaneously feeding paper with sludge at a rate of about 3 tons/hour.

The sand bed was removed from the reactor approximately 48 hours after the refuse combustion experiment was concluded. The bed contained several electric motors, miscellaneous scrap iron, hundreds of can ends and one car muffler. Normal operating debris was also observed which included a large quantity of stones on the orifice plate and remnants of cans.

Results from this experiment were used as a basis of design for a sewage sludge incinerator at Duluth, Minnesota. It is proposed that the unit will use municipal solid waste as auxiliary fuel.

2. Duluth, Minnesota.

Two fluid bed reactor incinerators are under construction for the Western Lake Superior Sanitary District in Duluth, Minnesota. The two reactors are Copeland Systems, Inc., Models CRS-20. Each reactor has a 20 foot diameter inside the refractory walls of the combustion zone. Each reactor is designed for balanced draft operation. Each reactor is equipped with both a fluidizing air blower and an induced draft fan to maintain a slight negative pressure on the freeboard zone of the reactor.

Each reactor will burn approximately 136,000 lbs/day of waste primary and secondary sludge solids. These sludges will be fed at 20 percent dry solids, 65 percent volatile solids mixture containing 9825 Btu's/lb of volatile solids.

The reactors are designed to use either 375 gallons per hour of No. 2 fuel oil or 160 tons per day of prepared municipal solid waste as auxiliary fuel on a 24 hour per day basis. The solid waste will be shredded to a nominal 1-1/2 inch material size, subjected to magnetic separation for ferrous metal removal, and air classified prior to injection by a pneumatic conveying system. The prepared solid waste fuel is fed at 30 percent moisture and 65 percent combustible with an as fired heating value of 5500 Btu's/lb.

Waste heat produced by each reactor will pass through a downstream waste heat recovery boiler generating 45,000 lbs/hr of 280 psig saturated steam.

Particulate material will be removed in a two-stage system. Stack gases will be reheated to about 250°F for plume suppression. The reheating operation will be accomplished using a heat exchanger recycling boiler exhaust gases mounted downstream from the high energy wet venturi scrubbing system.

3. Longview, Washington

A fluid bed incinerator is currently being installed for Weyerhaeuser at their Longview, Washington facility. The unit has been designed by Combustion Power Company, Inc., of Menlo Park, California, a Weyerhaeuser Company. The fluidized bed reactor design was based on the Combustion Power CPU 400 pilot plant program. The reactor is 22 feet in diameter and is designed to burn approximately 240 tons per day of dry fiber material from log decks.

The Longview system is functionally similar to the Thunder Bay system. Both systems are designed primarily to burn high moisture content wood wastes. But, the Longview system has incorporated several innovative features such as a balanced draft operation and rock classification and removal system. Both a fluidizing air blower and an induced draft fan will be used to balance the pressure on the reactor freeboard. Because of this design feature, large pieces of wood waste up to 12 inches in diameter by 48 inches long can be fed into the unit. The nominal wood waste material will be 1/4 inch by 1/4 inch by 1 inch. A special orifice plate design has been incorporated to remove rocks and tramp metals from the reactor bed. The plate will cause oversize materials to migrate out of the reactor without disturbing or suspending the combustion process.

C. ENERGY DISTRIBUTION SYSTEMS

1. Introduction

In this section, the technology concerning underground energy distribution systems used in district heating is reviewed. Design considerations for the distribution systems including pipe sizing are discussed in the following paragraphs.

The existing steam distribution serving Tacoma's central business was described in Chapter 3, paragraph B of this report.

2. Steam Distribution System

a. General

An underground steam distribution system's basic components are an insulated steam pipe line, an insulated condensate return line and a protective conduit(s) (See Figure 5-4). These distribution and return lines are routed from the central energy plant to supply steam and return the condensed steam from the system customers. The distribution and return lines may be housed in the same or separate protective conduits. Provisions for thermal expansion of the piping system is made by dividing the pipelines into sections using anchor points and installing expansion loops when space is available or expansion joints when adequate space is not available. Adequate space for expansion loops is seldom available for piping installed under city streets. Isolating valves, expansion joints with anchors, and customer connections are installed in manholes for protection and access. The termination of the district heating system piping is usually the outlet of the shutoff valve on the building service lines just inside the wall of the building.

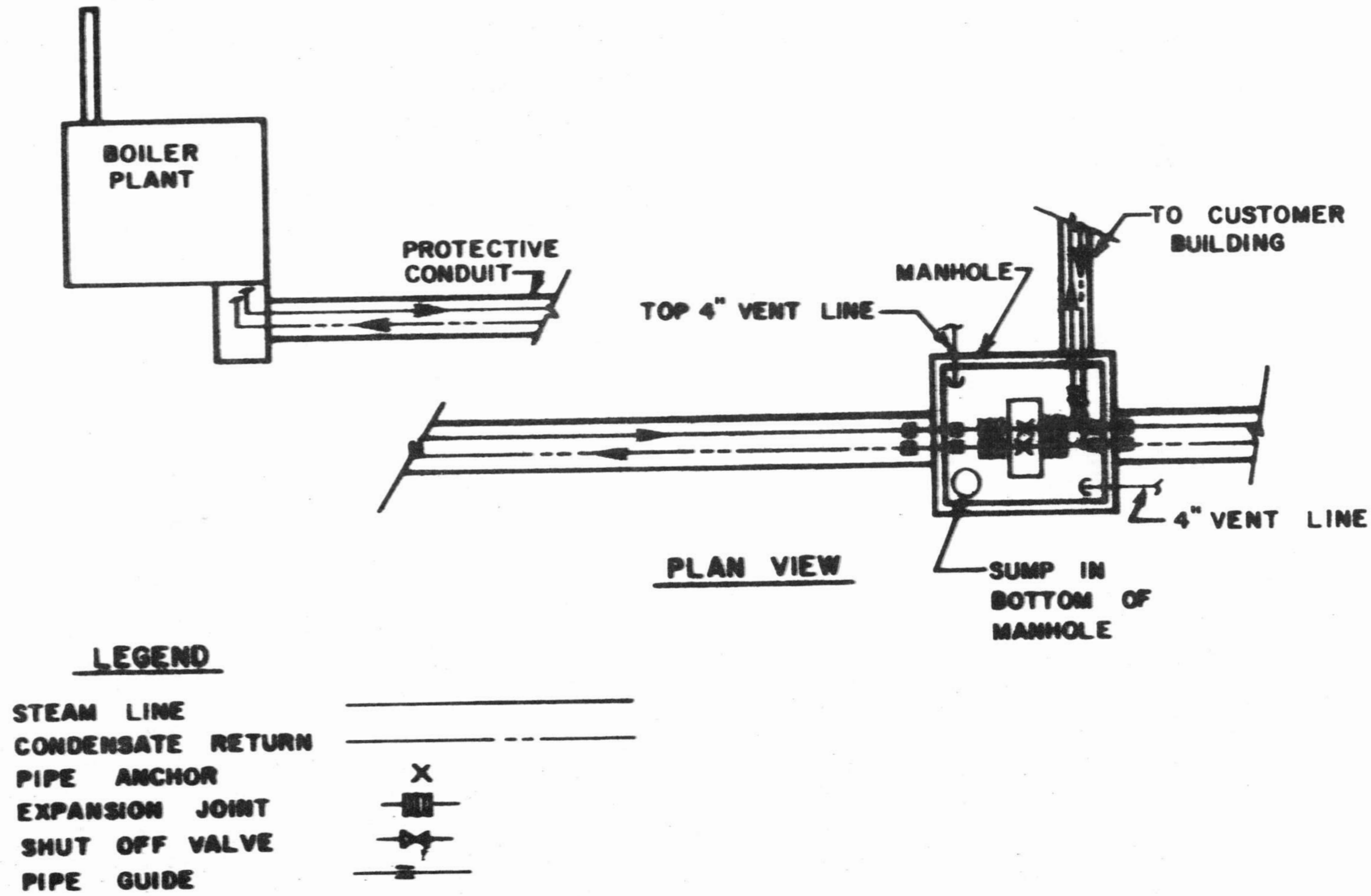
The flow metering equipment is normally owned and furnished by the district heating company to the customer for installation in the building steam main or condensate return main. Installation drawings are furnished by the district heating company. The meters are read and maintained by personnel of the district heating company.

b. Design Parameters

1. Pipe Sizing

a. Steam Lines

The connected load plus an increment for future expansion



TITLE: PARTIAL SCHEMATIC DIAGRAM FOR DISTRIBUTION SYSTEM

FIGURE 5-4

determines nominal pipe size required for steam lines. System pressure drops are analyzed to insure that customers having a process load are served with steam at a pressure adequate for their individual requirements. For instance, a dry cleaning-laundry facility requires 100 psig steam at the presses and a hospital requires a minimum pressure of 40 psig at sterilizers. Pipe size is selected to deliver the demand steam quantity to the buildings served at the required pressure. Flow velocities in the lines are checked and line size increased if necessary. Reasonable velocities for steam lines range from 2,000 feet per minute (FPM) for small lines of 1 1/2 or 2 inch size to 8-9,000 FPM for 10 inch size and larger at initial steam pressures of 125-150 psig. System allowable pressure loss will usually result in steam line velocities near the middle or lower part of the velocity range.

b. Condensate Lines

Condensate lines in almost all cases will be pumped returns from the buildings on the system. The condensate return temperatures can vary from about 180°F to 250°F, the saturation temperature of 15 psig steam, and is dependent on the type of heating system installed in the buildings. Therefore, the possibility of flashing fluid (two phase) flow in parts of return piping system exists. Good engineering practice dictates a conservative approach to pipe sizing with velocities limited to the range of 2 to 5 FPS according to pipe size. This reduces friction loss in the condensate lines and the probability of pressure loss reducing line pressure to the vapor pressure of the condensate which would cause flashing with attendant water hammer.

2. Pipe Material

a. Steam Lines

Pipe material usually specified for steam lines of district heating systems for typical system pressures of 100 to 250 psig is ASTM A53, grade B, or ASTM A106, grade B. Both grades are seamless carbon steel with a minimum tensile strength rating of 60,000 pounds per square inch. Wall thickness of pipe is specified by using ASNI standard B36.10. Schedule 40, standard weight, is adaquate for pipe sizes 10 inch and smaller. Standard weight pipe, 0.375 inch wall thickness, is adaquate for pipe sizes of 12 inch through 24 inches.

The ASNI standard B31.1, Code for Pressure Piping, governs pipe design.

b. Condensate Lines

Condensate lines are subject to internal corrosion if intrained air or carbon dioxide is present in the condensate. Carbon steel pipe with increased wall thickness, (Schedule 80) to provide a corrosion allowance has frequently been used. Type 304S. S has good resistance to the corrosion effects of entrained oxygen or carbon dioxide. However, it is subject to chloride corrosion attack, which has caused failure in some central heating systems resulting from the use of salt on streets for snow removal when salt containing water leaked into manholes or pipe conduits. Type 316S. S. has greater resistance to chloride corrosion than Type 304 S. S. Copper has good resistance to condensate containing extrained air and carbon dioxide and is not subject to chloride corrosion attack. The temperature limit for ASTM B42 copper pipe is 400 deg. F. which is seldom approached in condensate return lines of district heating systems. Careful investigation of local conditions is required to determine the pipe material most suitable for a particular project. Economics normally favor schedule 80 carbon steel pipe or copper pipe.

3. Thermal Expansion

The piping distribution system design incorporates methods to accommodate the thermal expansion of the piping from installation temperature to the operating temperature of the line. Carbon steel pipe expands 2.35 inches per 100 feet from a temperature of 60 deg. F. to a temperature of 350 deg. F. (the temperature of 125 psig Sat. steam). Austinitic stainless steels expand 2.01 inches per 100 feet of pipe and copper pipe 2.07 inches per 100 feet from 60 deg. F. to 250 deg. F.

Expansion loops in the piping are the preferred method of accommodating piping expansion, but district heating piping systems installed under city streets can seldom utilize expansion loops because of limited right-of-way and other utilities installed in the street. Therefore expansion joints are employed to accommodate pipe thermal expansion. The two types of commercially available expansion joints usually used are the packed type joint and the bellows or corrugated type with internal sleeves. Recent engineering practice has been to use the bellows type in lieu of the packed type joint to eliminate maintenance and alignment problems. A packed type joint is available that incorporates internal guiding and uses a special plastic type packing that allows re-packing under full line pressure. The stainless steel bellows of the packless joint is subject to chloride corrosion which has occurred when manholes have been flooded by street run-off water.

The expansion joints currently available are not suitable for direct burial and are installed in manholes for accessability. The exception is a piping system installed in tunnels which allows access to the piping and components.

4. Insulation

Insulation used on underground piping, in addition to good thermal efficiency, should have other properties as follows: resistance to moisture penetration, high wet strength, resistance to abrasion, and the ability to dry out after being wet by the heat from the pipe without sustaining physical damage. Pipe insulation materials used with a rating of some of the more important characteristics are listed in Table 5-2.

The type of protective conduit used also affects the choice of insulation. Light weight concrete and hydrocarbon fill material are used for the combination of protective conduit and thermal insulation. Protective conduits are discussed in the next part of this section. For piping installed in protective conduits and tunnels, calcium silicate type insulation is frequently specified, as its properties meet most of the required criteria for insulation on underground piping plus good thermal efficiency.

5. Customer Metering

Accurate metering is very important to both the district heating company and to the customer since the meters are the "cash registers" on which the billing for the energy supplied is based. One of the most accurate volumetric type meters measures the condensate flow utilizing a constant volume rotating bucket principal. The meter operates at atmospheric pressure so condensate temperature has to be reduced to a maximum of 212 deg. F. before entering the meter. This can result in steam loss due to flashing when higher pressure condensate is reduced to atmospheric pressure as the steam flashed will not be metered.

TABLE 5-2

INSULATION MATERIALS

Insulation	Dry k* value, 100 deg. F. Mean	Temp. Limit deg. F.	Recovery Drying	Density lb/cu. ft.	Stability Shrinkage
Calcium Silicate	0.33	1,200	Good	11-13	Good
Preformed Glass Fiber	0.24	370	Poor	3-4	Excellent
Cellular Glass	0.42	800	Good	9	Fair
Light Weight Concrete	0.60	1,800	Good	20-25	Good
Loose Fill, Mineral Wool or Glass Fiber	0.32	1,000	Poor	2-11	Excellent
Hydrocarbon Fill	0.6 to 1.2	300/460	Fair	30-60	Good

*k, thermal conductivity, BTU per hour per sq. ft. per deg.F. Temp. difference per inch thickness

Other types of liquid flow meters used to measure condensate flow are nutating disk types and propellor types designed for hot water measurement.

Pressure compensated steam flow meters of the pressure differential type having an orifice plate or ASME flow nozzles as the primary element are used when the quantity of steam supplied to a customer is sufficient to justify the rather high cost of this metering system. Meters of this type are accurate from 25 percent to 100 percent of design flow. If the load drops below this range in the summer, a parallel separate summer primary element pipe run is used or the orifice plate in the primary element is changed.

An integrator unit is standard on all meters. The Pressure differential steam flow metering system may also include a two pen chart recorder which records steam flow and steam pressure at the customers building. The thirty day strip chart recorder is most commonly used.

c. Pipe Installation

All steel pipe is connected by butt welding or socket welding. Copper pipe is jointed using a high temperature soldering technique. Screwed connections are seldom used and flanged connections are used very infrequently. Weldend valves and expansion joints are preferred to flanged connections to minimize points of potential leakage. Welding requirements are specified in the Code for Pressure Piping, ANSI B31. 1.

Proper alignment at expansion joints is critical. Pipe guides of the type, number, and spacing called for by the expansion joint manufacturer require careful installation. Most failures of expansion joints and anchors are the result of improper installation.

Pipe grade should be accurately maintained so the lines will drain to the low points. Generous drip legs on steam lines are required at low points. Traps of adaquate size and oversize strainers should be used to ensure complete removal of condensate. The oversize traps and strainers are particularily important during the initial start-up of a piping system when more of the steam is condensed than during normal operation and various foreign materials that have not been previously removed from the pipe line enter the strainers. A valved test connection should be provided on the discharge line of each trap and a valved blow down clean out line provided for each strainer to facilitate maintenance. The trap discharge line is connected to the condensate return line with a 45 degree or smaller angle lateral sloped in the direction of flow.

Service connections to the buildings are made in a manhole and are taken off the mains through top 45 degree or top vertical connections. Isolating valves are installed close to the mains. Service connections are installed adjacent to an anchor point to eliminate horizontal movement of the connection point.

d. Underground Pipe Protection

1. Tunnels

Reinforced concrete tunnels, properly waterproof, are the best protective conduits for underground piping and provide complete access to the piping and associated components. Other utilities such as potable waterlines, compressed air lines, and electrical distribution cables can also be installed in the same tunnels. This method has been widely used in the past for systems serving a college campus, a governmental building complex, and district heating systems. However, the large capital investment currently required to install a tunnel system has precluded their use except for short runs between buildings or special use situations.

2. Concrete Conduits

The reinforced concrete box type conduit, properly waterproofed, with poured in place or precast concrete removable covers provides good protection for the insulated pipe lines. Pipe supports of structural steel shapes are usually used with attachment plates provided in the bottom or side walls of the box. Anchor blocks for intermediate pipe anchors can be provided by increasing bottom slab thickness at the anchor points. Manholes are required for the installation of expansion joints, isolating valves and customer connections. Drainage lines or shallow trenches in the bottom slab can be provided to make the conduit self draining if water should leak into the conduit.

Lightweight aggregrate concrete, also called insulating concrete, has been used as a combination protective conduit and insulation for underground piping. A concrete base slab four to six inches thick is poured in the bottom of the trench. The top of the base slab is waterproofed. Precast insulating blocks are installed on about ten foot centers for pipe supports. Support spacing depends on pipe size. The pipe is installed and wrapped with a parting medium, usually one ply plain corrugated paper. Insulating concrete is then poured over the assembly to a minimum thickness of six inches on all sides of the pipe. A waterproof envelope over the insulating concrete completes the installation.

Another type of concrete conduit that has been used consists of a waterproofed concrete conduit with loose fill rock wool insulation surrounding the piping. A concrete slab with about six inch high side walls is poured in the bottom of the trench. Pipe supports, anchors, and piping are then installed. Loose fill rock wool insulation is placed over the piping to a minimum thickness of four inches. A waterproof membrane and wire mesh is placed over the insulation. A four inch concrete cover of semi-circular shape is poured over the assembly connecting to the side walls of the base slab. A drain line installed in the bottom slab provides water removal if a leak develops. This is a proprietory system installed by Permaduc International, Inc.

3. Steel Conduits

Several manufacturers produce a factory fabricated underground piping system using a steel protective conduit. The better units have an annular air space between the insulated pipe line and the protective conduit. The pipe material and insulation are supplied according to the specifications of the purchaser. The protective conduit of spiral welded steel pipe, smooth or corrugated, is fabricated from 10 gauge to 16 gauge steel. Exterior protection includes hot dipped galvanizing with an outer dipped and wrapped coating of fiberglass fabric and asphalt, catalytic epoxy coating, and PVC coatings. Cast iron pipe conduit is also available.

These systems are available with drain lines and sealed sections containing an inert gas for leak detection.

The layout of a system using the prefabricated steel conduit and pipe has to be carefully done, as field changes are difficult to make.

A large steel conduit is also manufactured that is used for a tunnel system. The pipe lines for installation in these tunnels can be purchased prefabricated to the purchasers specifications complete with pipe racks and pipe hangers or supports.

4. Hydrocarbon Granular Fill

Both natural occuring and synthetic hydrocarbon granular fill material is available for use as both a protective conduit and an insulating material for underground installation of hot pipe lines. The pipe line is installed in the trench upon steel angle or bent reinforcing rod pipe supports imbedded in concrete pads spaced at the proper interval to support the pipe size being used. The granular hydrocarbon fill is poured over the pipe or pipes in the trench, using temporary forms if necessary, with the width and amount of cover according to the manufacturers instructions. Material occurring hydrocarbon fill material (Gilsonite) is then cured by internal pipe heat from steam or hot water which forms a solid sintered layer of material around the pipe. The synthetic hydrocarbon fill materials do not usually require a cure period.

3. High Temperature Hot Water Distribution Systems

a. Design Parameters

The high temperature hot water (HTHW) system has a pressure pad on the system of 50-100 psig above the vapor pressure of the outlet water temperature in the central generating plant. Nevertheless, the hydraulic design has to be very carefully done to ensure that the pressure at any point in the piping distribution system never falls below the vapor pressure of the water flowing under all load conditions. The distribution piping is a constant flow system, so during low load periods, the water temperature in the return line approaches the supply water temperature. Excess line friction pressure drop could then drop line pressure below the vapor pressure of water flowing if the piping isn't correctly sized.

Pressures on HTHW systems require the use of 300 lb. class steel flanges and valves. Schedule 40 steel pipe size 10 inch and smaller or standard weight for large size pipe can usually be used. The Code for Pressure Piping, ASNI B31.1, District Heating Section governs system piping design and material selection.

b. Underground Piping Installation

The previous sections discussing the underground installation of steam and condensate piping apply to underground HTHW systems. The same type of thermal expansion joints, insulation, and underground pipe conduits are used on HTHW systems.

c. Building Service HTHW

Building service connections are provided on the HTHW supply and return mains in a manhole located in an adjacent street. Lines sized to supply the building design heating load, probably including the domestic water heating load, are installed underground in a protective conduit to the building, usually penetrating a basement wall below grade into the building. Isolating valves are installed on the service lines in the manhole and immediately inside the building wall.

A hot water type heating system using hot water supply temperatures in the range of 180 to 220 deg. F. is required for building heating. A shell and tube type heat exchanger (converter) with the 350 deg. F. HTHW in the tubes and building system water in the shell is used to produce the hot water for building heating. Domestic hot water heaters of the storage tank type are available with tube bundles designed for HTHW.

Temperature control valves used on HTHW equipment are the 3-way type installed in the HTHW return line. This type of control valve by-passes HTHW supply to the return line to control flow through the heat exchanger. The high pressure drop at low flows inherent in a throttling type control valve could cause the pressure to drop below the vapor pressure of HTHW causing flashing in the valve and immediately downstream.

Low pressure steam of pressures of 5 to 15 psig can be produced in limited quantities using a heat exchanger designed for this purpose. Sufficient steam for building humidification, for instance, can be economically produced utilizing HTHW as the heat source.

d. Converting to HTHW in Tacoma Central Business District

If the existing steam system in the CBD was replaced with a new HTHW system, each building served would need to install some new equipment to convert from steam to HTHW. Buildings now having hot water heating systems would require the least new equipment. The existing steam converter (heat exchanger) would be replaced with a new HTHW converter with new temperature controls. Piping revisions would be a minimum. The existing hot water circulating pumps could still be used if the new HTHW converter was selected with the same pressure drop as the existing steam converter.

For buildings with heating systems using steam directly in radiaters or steam heating coils in air handling units, the costs of conversion to HTHW would be significantly greater. The steam using components would have to be replaced with components designed for hot water in the temperature range from 180 to 220 deg. F. To accomplish such a conversion would include the following: HTHW converter, hot water circulating pumps, expansion tank, air separating device, new hot water heating coils, new control valves for heating coils, temperature controller for HTHW converter, and major piping revisions.

CHAPTER SIX

ALTERNATIVE SITES

A. INTRODUCTION

Three locations have been identified for the proposed central energy plant. They are all located in the area east of the City Waterway near the 11th Street Bridge (See Figure 6-1). These sites were suggested by the City of Tacoma because of their location and zoning.

The three sites have been identified by the consultant as Site A, Site B, and Site C. All sites are located on the Tide Flats and reasonable access is available to potential steam customers in downtown Tacoma.

Table 6-1 lists the site evaluation criteria used in the analysis.

TABLE 6-1
SITE EVALUATION PARAMETERS

A. LOCATION

B. PLANNING

1. Present use and contiguous uses
2. Future use and contiguous uses
3. Ownership of Site

C. DESIGN

1. Size
2. Utilities
3. Topography
4. Soils
5. Ground Water
6. Proximity to Street and Rail Service

D. ECONOMIC

1. Land Values
2. Proximity to Markets

B. SITE LOCATION AND DESCRIPTION

1. Site A

a. Location

Site A (Figure 6-2) is a small parcel located between East "F" Street and the Middle Waterway. Site A is adjacent to an existing Power Substation and 1510 feet West of the East 11th St. Bridge.

b. Planning

Site A is owned by the City of Tacoma. Site A is vacant and is zoned M-2. It is bordered on the East by Middle Waterway and on the other three sides by M-2 type industrial buildings. Present and future use indicates a continuation of M-2 industrial zoning usage.

c. Design

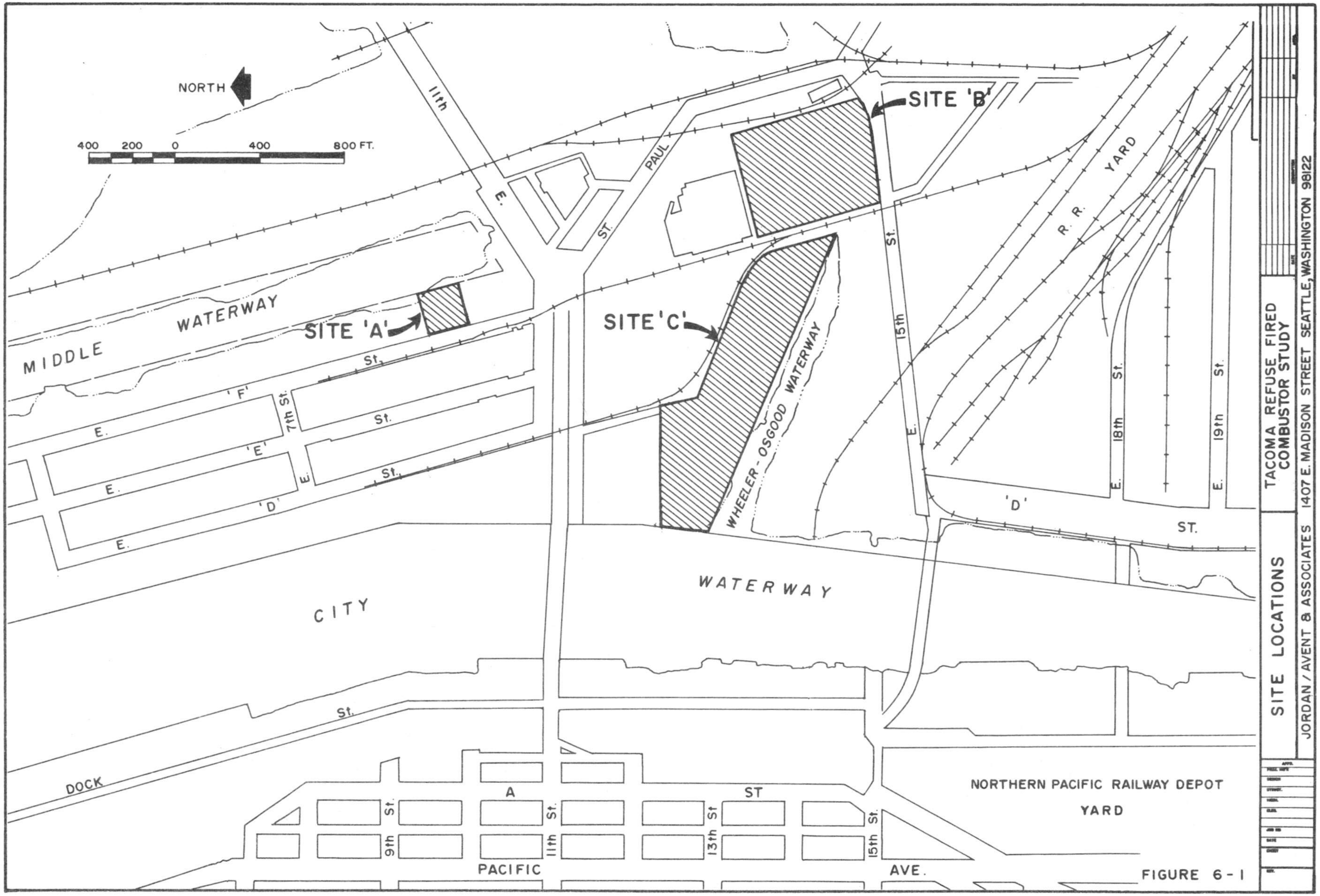
Site A is located on land reclaimed from the Puyallup River Delta. Site A contains 40,000 sq. ft. (0.92 acres) and is level. Electric power is available from the adjacent substation. An 8 in. cast iron water main fronts the site on East "F" Street and a 4 in. gas main is located 250 feet South of the property line on East "F" Street. A 12 in. sanitary sewer is located 500 feet from the Southwest corner of the Site under East 11th Street and a storm sewer is located 300 feet from the Southwest corner of the Site on East "F" Street.

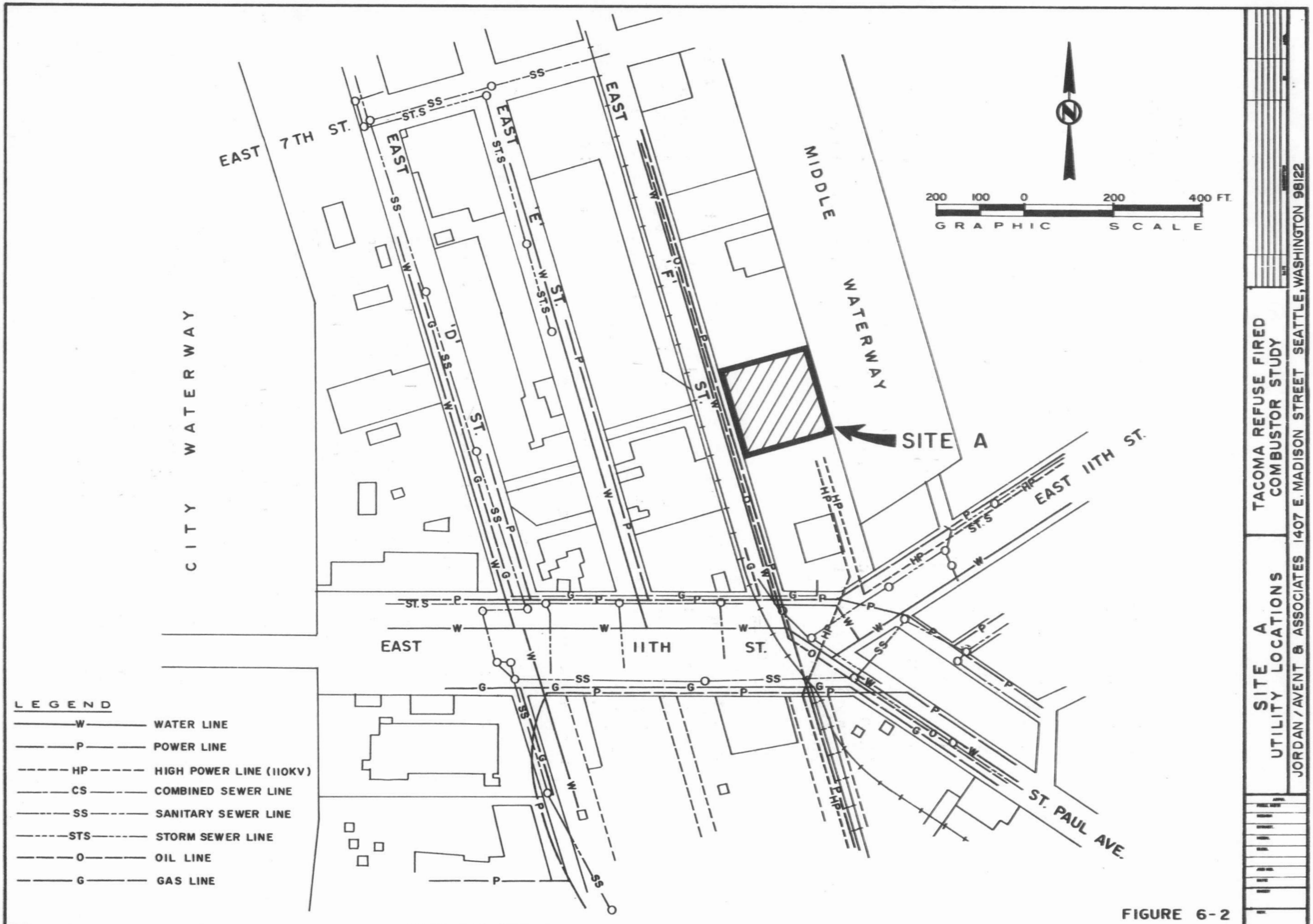
Soils are all fill material and borings indicate silty sand, localized pockets of clay intermixed with clam shells and wood chips. The water table was located between 8 and 9 feet below the surface and borings indicated no bedrock to the 70 feet level.

The site is accessable from East 11th Street to East "F" Street an active line rail is located on East "F" Street and the possibility of barge access exists via the Middle Waterway Canal.

d. Economic

Site A is owned by the City of Tacoma and is part of a parcel containing a fire station and power substation. Site A has an


NORTH
400 200 0 400 800 FT.
SITE 'A'
SITE 'B'
SITE 'C'
MIDDLE WATERWAY
WHEELER - OSGOOD WATERWAY
CITY WATERWAY
R. R. YARD
E. 11th ST.
ST. PAUL
15th St.
E. 'F' St.
E. 'E' St.
E. 'D' St.
E. 7th St.
E. 15th St.
E. 18th St.
E. 19th St.
'D' ST.
DOCK St.
A ST
9th St.
11th St.
13th St.
15th St.
PACIFIC AVE.
NORTHERN PACIFIC RAILWAY DEPOT YARD
TACOMA REFUSE FIRED COMBUSTOR STUDY
JORDAN / AVENT & ASSOCIATES 1407 E. MADISON STREET SEATTLE, WASHINGTON 98122
SITE LOCATIONS
FIGURE 6-1


EAST 7TH ST.
EAST 'D' ST.
EAST 'E' ST.
EAST 'F' ST.
MIDDLE WATERWAY
CITY WATERWAY
SITE A
EAST 11TH ST.
ST. PAUL AVE.
200 100 0 200 400 FT.
GRAPHIC SCALE
LEGEND
W WATER LINE
P POWER LINE
HP HIGH POWER LINE (110KV)
CS COMBINED SEWER LINE
SS SANITARY SEWER LINE
STS STORM SEWER LINE
O OIL LINE
G GAS LINE
TACOMA REFUSE FIRED COMBUSTOR STUDY
SITE A UTILITY LOCATIONS
JORDAN/AVENT & ASSOCIATES 1407 E. MADISON STREET SEATTLE, WASHINGTON 98122
FIGURE 6-2

assessed value of $66,200. An estimate of assessed value for the vacant portion has been placed at $26,000. Because Site A is city-owned,no taxes would be lost if the energy plant were constructed on the parcel.

2. Site B

a. Location

Site B (See Figure 6-3) is located on the North Side of East 15th Street about 200 feet West of St. Paul Ave and bounded on the East and West by the Burlington Northern RR and on the North by the National Blower and Sheet Metal Co. Site B is located approximately 2050 feet East of the east end of the 11th Street Bridge.

b. Planning

Site B is owned by the 15th Street Realty Co. Site B is currently vacant and is zoned M-3. It is bordered on the East and West by rail lines andon the North by industrial buildings and fronts on East 15th Street. Present and future use indicates a continuation of the M-3 industrial zoning usage. M-3 zoning is a more permissive zone than M-2. Summarized below is the definition of M-2 and M-3 zoning:

"M-2" HEAVY INDUSTRIAL DISTRICT

A building, structure, or land shall be used and a building or structure hereafter built, altered or enlarged shall be used for only the following permitted uses:

1. Any use permitted in the "M-1" Light Industrial District within or outside of a building or fence; provided, however, that all residential uses are prohibited in the "M-2" Heavy Industrial District except necessary quarters for caretakers and watchmen; provided further, that group care homes, day care centers and nursery schools are also prohibited from "M-2" Heavy Industrial Districts.
2. Alcohol manufacture or liquor distillery.
3. Asbestos products manufacture.
4. Asphalt manufacture and creosote manufacture and treatment plant.
5. Bag Cleaning.
6. Brick, tile, terra cotta and pottery manufacture.
7. Carborundum and abrasive manufacture.
8. Cloth, cord, rope and thread manufacture.
9. Chemicals manufacture but <u>excluding</u> acid manufacture.
10. Concrete and Concrete products manufacture.
11. Coke Ovens.

12. Felt manufacture.
13. Fish curing, smoking and canning.
14. Flour, feed and cereal manufacture.
15. Gutta percha, tar and rubber goods manufacture.
16. Iron, steel, brass, copper and other metals, foundry and fabrication (excluding smelter and blast furnace).
17. Lampblack, paint, varnish, oil and turpentine manufacture.
18. Linoleum and oil cloth manufacture.
19. Meat and food manufacture and processing but excluding the slaughter of animals and rendering of fat.
20. Mining, rock quarry and rock, sand and gravel cleaning, crushing and processing.
21. Railroad repair and classification yard.
22. Rolling mill.
23. Petroleum and petroleum products above ground storage in excess of 1,000 gallons.
24. Plastics manufacture.
25. Salt works.
26. Saw and planing mill.
27. Soap manufacture.
28. Ship yard.
29. Tobacco products manufacture.
30. Wool pulling or scouring.
31. Accessory uses when located on the same lot.

"M-3" HEAVY INDUSTRIAL DISTRICT

A building, structure or land may be used or a building or structure hereafter built, altered or enlarged, may be used for any use other than those uses which are excluded from the City of Tacoma by ordinance;

Provided, however, that all residential uses are prohibited in the "M-3" Heavy Industrial Districts except necessary quarters for caretakers and watchmen. Automobile house trailers and mobile homes are allowed for such caretaker and watchman quarters provided a special permit has been approved in accordance with Section 13.06.375; provided further, that group care homes, day care centers and nursery schools are also prohibited from "M-3" Heavy Industrial Districts. And further provided that yards for the storage or bailing of rags, paper, metal and junk and automobile salvage and wrecking yards shall be enclosed within a tight board or masonry fence or similar permanent structure not less than seven feet in height. Such fence shall be neutral in color and shall not be used for advertising purposes. Such enclosure shall not include required front or side yard.

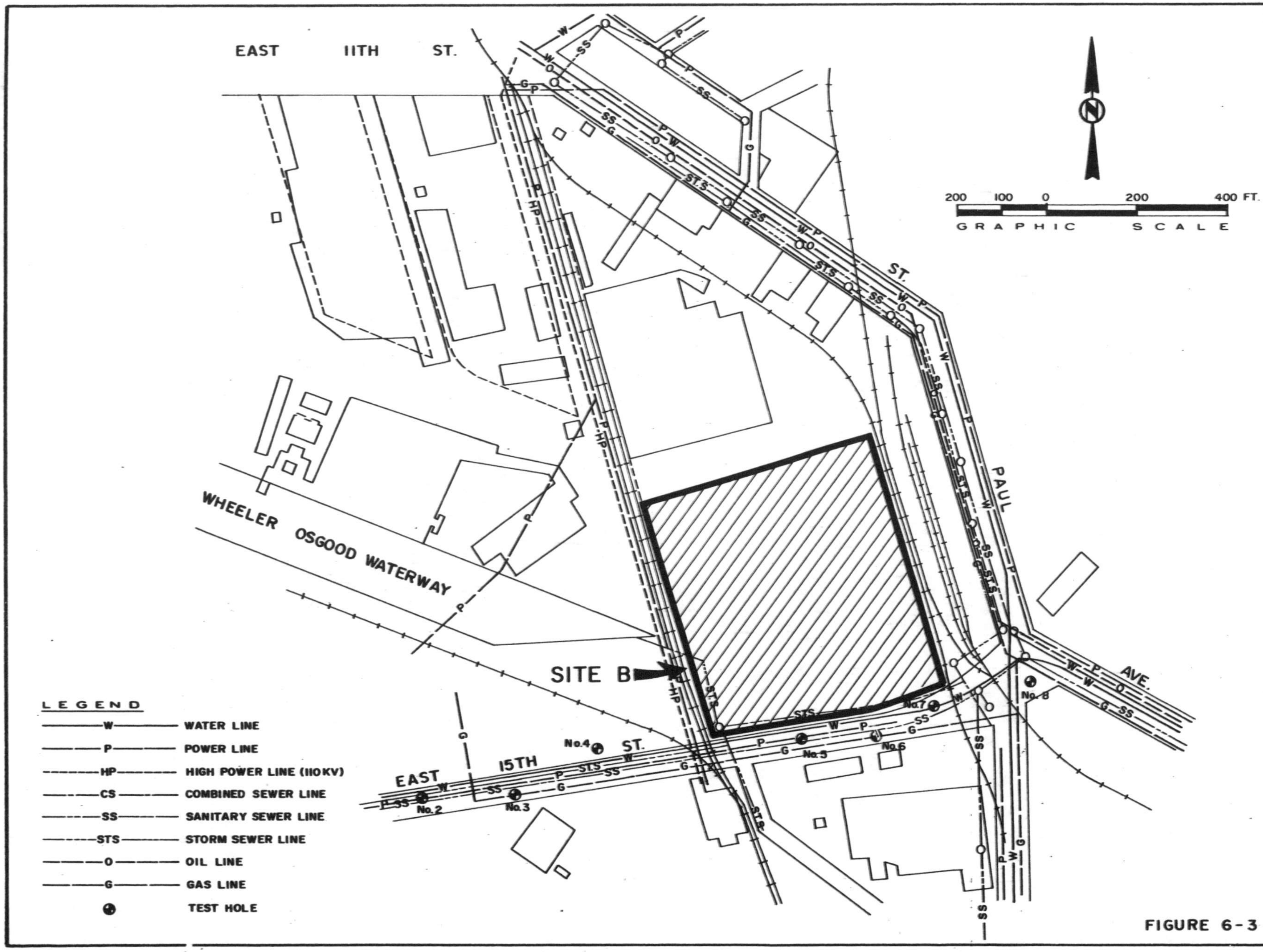
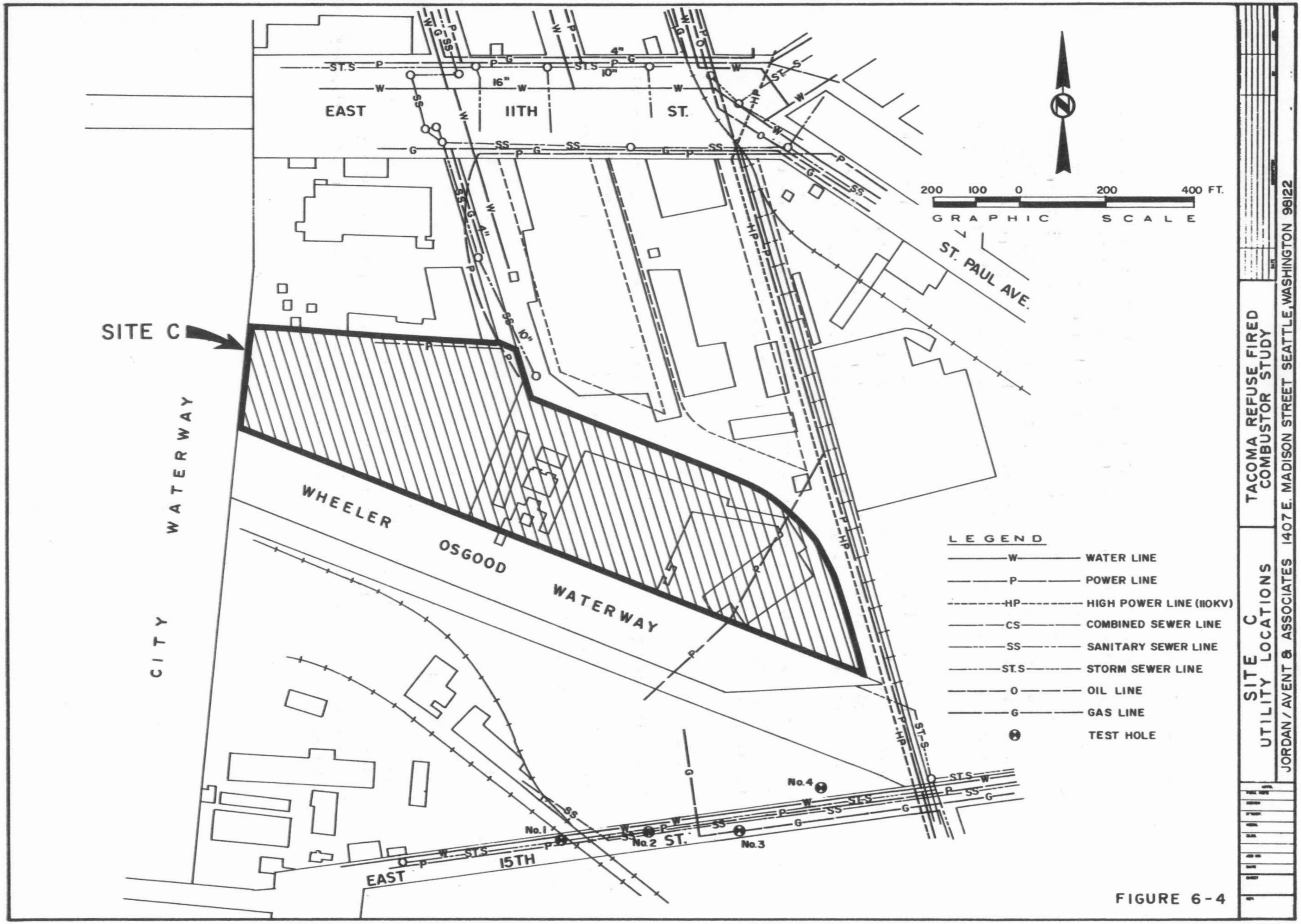


FIGURE 6-3

TACOMA REFUSE FIRED COMBUSTOR STUDY

SITE B UTILITY LOCATIONS

JORDAN / AVENT & ASSOCIATES 1407 E. MADISON STREET SEATTLE, WASHINGTON 98122



EAST 11TH ST.
ST. PAUL AVE.
SITE C
CITY WATERWAY
WHEELER OSGOOD WATERWAY
EAST 15TH ST.
200 100 0 200 400 FT.
GRAPHIC SCALE
LEGEND
W WATER LINE
P POWER LINE
HP HIGH POWER LINE (110KV)
CS COMBINED SEWER LINE
SS SANITARY SEWER LINE
ST.S STORM SEWER LINE
O OIL LINE
G GAS LINE
TEST HOLE
No.1
No.2
No.3
No.4
TACOMA REFUSE FIRED COMBUSTOR STUDY
SITE C
UTILITY LOCATIONS
JORDAN / AVENT & ASSOCIATES 1407 E. MADISON STREET SEATTLE, WASHINGTON 98122

FIGURE 6-4

c. Design

Site B, reclaimed from the Puyallup River Delta land, contains 7.24 acres and is level. Electric power is available from a 110 KV power line running along the railroad right-of-way. A 32 in. steel watermain fronts the site on East 15th Street and a 4 in. gas line runs under East 15th Street. An 8in. sanitary sewer runs under East 15th Street and a 36 in. storm sewer runs along East 15th Street and a portion of the West property line.

Soils in the vicinity of Site B are all fill material and borings along East 15th Street indicate a sandy soil with localized pockets of clay intermixed with clam shells and wood chips. The water table is located 11 feet below the ground surface.

The site is accessable from East 15th Street from the South, two active rail lines East and West and possibly from the Waterway on the West.

d. Economic

Site B is owned by the 15th Street Realty Co. and has an assumed assessment of $200,000. The current annual tax revenue of $5,000 would be lost to the City of Tacoma if this site were removed from the tax roles.

3. Site C

a. Location

Site C(See Figure 6-4) is located on the north side of the Wheeler Osgood Waterway east of the City Waterway. Site C is bounded on the North by St. Regis; Woodworth and Co. and lies approximately 480 feet due south of the 11th Street Bridge.

b. Planning

Site C is owned by the St. Regis Paper Co. and is approximately 70 percent occupied. Site C is zoned M-2. It is bounded on two sides by water and on the North by industrial buildings. Site C is located along the City Waterway and has been targeted for redevelopment into a recreation area.

c. Design

Site C, reclaimed from the Puyallup River Delta, contains approximately 12.4 acres consisting 10.2 acres of dry land and 2.2 of waterway. Site C is level. Electric power is available from a 110 KV power line running along the railroad right-of-way. A 6 in. cast iron water line is located 200 feet North of the Site on private property and a 4 in. gas line also lies 200 feet North of the property line on East "D" Street. A 10 in. sanitary sewer runs along East "D" Street a short distance from the North property line. There are no storm sewers in the vicinity of Site C as storm water flows by gravity into the City Waterway.

Soils are all fill material and borings along East 15th Street indicate a sandy soil with localized pockets of clay intermixed with clam shells and wood chips. The water table was located 11 feet below the ground surface.

Street access to the site is along East "D" Street. A rail line runs along a small strip of the property on the East. Barge access is good, but maybe incompatiable with the planned recreational development of the City Waterway.

d. Economic

Site C is owned by the St. Regis Paper Co. and has a land assessment of $362,460 and building assessment of $104,600. The vacant portion has an assumed value of $150,100. The current tax revenue of $12,000 assuming the whole site were taken, or $3,800, if only the vacant property were purchased would be lost to the City of Tacoma tax roles.

C. COMPARISON OF SITES

1. Similar Characteristics

Due to the close proximity of the three sites (all three are located within a half mile square area), some site parameters are similar for all three sites. Table 6-2 summarizes the site findings.

a. Terrain

All three sites are located on reclaimed Puyallup River Delta land. All three sites are flat.

b. Soil

Soils in the general area are fill material. Borings made along East 15th Street (some quite close to Site B) show a sandy soil with localized pockets of clay and such fill materials as clam shells and wood chips. The water table along East 15th Street is about 11 feet below the surface.

Roger Lowe and Associates conducted a soils study for Union Oil at 516 East "D" Street, which is a few block northwest of Site A. Their study showed the soil in this area to be generally ranging from silty sand to gravelly sand. Some shells, wood chips and other fill materials appear near the surface in some areas. The ground water table is between 8 and 9 feet below the surface. Two borings were made to 70 feet and bedrock was not encountered.

Three facts suggest that these general characteristics of the soil are quite homogeneous throughout this area:

1. Soils data (referred to above) obtained for two separate locations - one northwest and the other south of the three sites - are quite similar.

2. Borings made at a third location along Canal Street, which is east of the three sites, show similar soil conditions.

3. The entire area is reclaimed Puyallup River Delta land.

c. Zoning

The zoning in this area is for heavy industry. Sites A and C are zoned M-2 and Site B is zoned M-3. The primary difference

TABLE 6-2

SITE CHARACTERISTICS

PARAMETERS	SITE 'A'	SITE 'B'	SITE 'C'
Size (total) in acres (vacant)	0.92 0.92	7.2 7.2	10.2[A] 4.3[A]
Distance (to 11th St. Bridge)	1510 feet	2050 feet	480 feet
Terrain	flat	flat	flat
Soil	fill-sandy	fill-sandy	fill-sandy
Ownership	City of Tacoma	15th Str. Realty	St. Regis Paper
Assessed Value (total) (vacant)	$26,000 $26,000	$200,000 $200,000	$467,060[B] $150,000
Unit Land Value - $/ft^2	0.65	0.64	0.80[C]
Annual Tax (on vacant land)	0	$ 5,000	$ 3,800[C]
Zoning	M2-Heavy Industry not noxious, noisy or dangerous	M3- Heavy Industry	M2-Heavy Industry not noxious, noisy or dangerous
Roads	Good	Good	Immediate access questionable
Railway Access	Yes	Yes	Only to occupied side
Potential Barge Access	Yes	No	Yes
Water	8" CI WM	32" St. WM	6" CI WP 200' away
Gas (distance to)	200 feet	50 feet	200 feet
Oil (distance to)	20 feet	200 feet	1200 feet[D]
Power (normal) (high)	Yes Yes from power substation	Yes Yes	Yes Yes to occupied side
Sewers (sanitary) (storm)	12" line 500' away 12" line 300' away	Yes 8" Yes 36"	Yes 10" W.O. Waterway
Aesthetics	Negligible impact	Negligible impact	Effect on waterfront view
Fish & Wildlife	Negligible impact	Negligible impact	Negligible impact

A - Does not include water area
B - Includes value of buildings
C - Does not include buildings
D - Distance to vacant side

between M-2 and M-3 zoning is that M-2 zoning does not permit noxious, noisy or dangerous industries.

d. Power

All three sites can be serviced for normal power load. If high voltage is needed, a 110 KV power line runs from the power substation on East "F" Street, southeast along the railroad right-of-way. High voltage power could possibly be provided to Site A directly from the power substation, and to Site B and the occupied side of Site C from the aforementioned high voltage line.

e. Fish and Wildlife

No information has been collected concerning fish and wildlife species inhabiting this area. However, considering the types of industry present, it is expected that the proposed project would have little impact on the area.

2. Differing Characteristics

a. Size

If buildings are present on part of the site, the estimated size of the vacant portion of the site is included as well as the total area.

Site A - Total area = vacant area = 40,000 ft^2 = 0.92 acres
Site B - Total area = vacant area = 7.24 acres
Site B has been subdivided into four lots ranging in size from 1.63 acres to 2.05 acres
Site C - Total area = 12.37 acres
This figure apparently includes water surface area, as the legal property line of this parcel does right down the middle of the Wheeler Osgood Waterway. The total dry land area of Site C is 10.2 acres. The vacant dry land area of Site C is 4.3 acres.

b. Distance

The distances were measured from the centerline of the 11th Street Bridge where it just touches the east shore of the City Waterway, to the closest corner of the site.

Site A - Measured down the eastern edge of East "F" Street to the center line of East 11th Street and west to the bridge, the distance = 1510 feet.

Site B - Measured north along the eastern edge of the railroad right-of-way to the centerline of East 11th Street and west to the bridge, the distance = 2050 feet.

Site C - Measured north along the eastern shore of the City Waterway. (across the private properties of Woodworth and Co. Inc. and Petrich Marine Charters Corp.), the distance = 480 feet.

c. Ownership

Site A - owned by the City of Tacoma
Site B - owned by 15th Street Realty
Site C - owned by St. Regis Paper Co.

d. Assessed Value

Site A - The assessed unimproved land parcel value of the parcel owned by the City, including the power substation and the fire station as well as Site A is $66,200. Assuming the unit value of the land throughout this entire parcel is constant, the value of Site A alone would be about $26,000.

Site B - The assessed value of 6.39 acres of Site B (apparently another 0.85 acres was acquired since the last assessment was made) is $172,530. Again, using the assumption of constant unit land value, the total 7.24 acre parcel is worth about $200,000.

Site C - The land value of Site C was assessed at $362,460. The value of the buildings was assessed at $104,600, making the total improved value of Site C $467,060. Once again using the assumption of constant unit land value (unimproved) and ignoring the water area, the vacant portion of Site C should be worth about $150,000.

e. Unit Land Value

Dividing the assessed value of a parcel by its area in square feet, a unit land value was derived. Again, with Site C, only the land surface area was used, assuming that the value of the water surface area is negligible.

Site A - Unit land value = 65¢ per square foot
Site B - Unit land value = 64¢ per square foot
Site C - Unit land value = 80¢ per square foot

This last value may be high because the assumption that water surface area had negligible value may be incorrect. At any rate, considering all the assumptions and manipulations made to determine the assessed values, these figures are within 25 percent of each other.

f. Annual Tax

The 1977 property tax for these parcels was 2.5 percent of their assessed values.

Site A - Being city owned property, no tax assessment is made, so no tax revenue will be lost to the city if the facility is built here.

Site B - About $5,000 annually will be lost if this parcel is removed from the tax roles.

Site C - About $3,800 annually will be lost if only the vacant segment of this parcel is bought by the city. If the whole parcel, buildings and all, is removed from the tax roles, nearly $12,000 annually will be lost.

g. Transportation

Site A - Road access is good by East "F" Street, East 11th Street and Canal Street. Barge access may be possible up the Middle Waterway. As far as railway access is concerned, Burlington Northern owns the line running up East "F" Street to the Puget Sound Plywood Co. (just north of Site A). This line is in service.

Site B - Road access is good by East 15th Street, St. Paul Ave. and Canal Street. Railway access looks very promising as Burlington Northern and Union Pacific both operate lines skirting this property.

Site C - Immediate road access to Site C is very questionable. There could be possible access down a narrow road (continuation of East "D" Street - may be a private road) between St. Regis property and Petrich property. If East 11th Street can be reached by that road, from there East 11th and Canal Streets provide a good truck route. Railway access is also questionable. No railroad lines service the vacant side of Site C. However, Burlington Northern does operate a line along the eastern edge of the occupied side of Site C. Barge access to this site might be considered as an alternative.

h. Utilities

Water

Site A - An 8 in. cast iron water main runs under East "F" Street.

Site B - A 32 in. steel water main runs under East 15th Street.

Site C - A 6 in. cast iron water pipe runs under St. Regis property near the continuation of East "D" Street and comes within 200 feet of Site C.

Gas

Site A - A 4 in. gas line runs 70 feet along East "F" Street stopping short of Site A by about 250 feet.

Site B - A 4 in. gas line runs under East 15th Street.

Site C - A 4 in. gas line runs under the continuation of East "D" Street to within 200 feet of Site C.

Oil

There is a buried oil line running under St. Paul Ave. and East "F" Street.

Site A - Site A is adjacent to the pipeline.

Site B - The southeast corner of Site B is about 200 feet from the pipeline.

Site C - The vacant side of Site C is about 1200 feet from the pipeline, measured from the northeast corner along the continuation of East "D" Street and up East 11th. The occupied side of Site C is about 940 feet from the pipeline, taking the distance along the railroad right-of-way.

Sanitary Sewers

Site A - The closest sanitary sewer is a 12 in. pipe running under East 11th Street approximately 500 feet from the southwest corner of Site A.

Site B - An 8 in. sanitary sewer runs under East 15th Street.

Site C - A 10 in. sanitary sewer runs under the continuation of East "D" Street.

Storm Sewers

Site A - A storm sewer starts up East "F" Street from East 11th Street, coming within 300 feet of Site A.

Site B - A 36 in. storm sewer runs from East 15th Street along the railroad right-of-way and dumps into the Wheeler Osgood Waterway.

Site C - Lies adjacent to the Wheeler Osgood Waterway into which storm runoff is already being dumped.

i. Aesthetics

Judging from their locations, building a central energy plant on Sites A or B would probably have little effect on the aesthetics of the region. Site C, however, is located on the City Waterway. The effect of a steam plant here on the view from a proposed waterfront development project across the waterway may be of some concern.

D. RECOMMENDATIONS

The consultant would recommend serious consideration be given to the acquisition of Site B for the central energy plant project. Site B has the largest amount of vacant land and is zoned M-3vs.M-2 for both Sites A & C. Site B has road, rail, water, gas, sanitary and storm sewer service. Site A requires construction of gas, sanitary and sewer lines. Site C requires construction of water, gas and sanitary sewer lines and an entrance road way.

Site A lies next to present city facilities and would prevent any expansion of such facilities and Site C lies in the area of Waterway Redevelopment.

CHAPTER SEVEN

AREA WASTE RESOURCES

A. INTRODUCTION

The west coast area of the State of Washington has been a major timber and lumber producing area for over 100 years. In the processing of timber to produce lumber, plywood, particle board, and other wood products, a considerable amount of waste wood is also produced. The waste wood has traditionally been used as a fuel source by the wood products industry and other area industries to produce process steam. While the supply of waste wood fuel has declined in the last couple of decades, it is still commercially available in this area as a reliable fuel source.

A second source of waste material fuel will be available in limited quantity in the Tacoma area when the City of Tacoma solid waste processing plant, currently under construction, begins operations in April or May 1978. The heating value of refuse derived fuel (RDF) is approximately the same as wood waste fuels produced from green timber. Therefore, RDF can be used interchangeably with wood waste fuel.

B. WASTE FUEL PRODUCTION

1. Waste Wood Fuel (Hog Fuel)

Waste wood fuel is produced from the log residuals by processing in a horizontal shaft hammermill or knife type machine known in the industry as a "hog". Hence, the trade term for wood waste fuel is "hog fuel". Hog fuel is sold on a volume basis standard of 200 cubic feet which is commonly called a "unit". The weight of a unit is about one ton depending on wood species and moisture content.

Timber residuals available in the area for hog fuel production were much greater than the fuel market demand until the decade of the fifties. An expansion of pulp and paper making facilities in western Washington and Oregon created a market for pulp grade wood chips which had a market value three to four times that of hog fuel; i. e. $11 to $13 per ton vs. $2. 50 to $3. 50 per unit. Accordingly, most sawmills installed log barkers, chippers, and chip screens to produce pulp wood chips.

However, sufficient timber residuals are still hogged so that hog fuel continues to be a commercially available fuel source in the Tacoma area at $6.50 to $12.20 per unit.

Bone dry wood has a higher heating value of about 8,000 Btus per pound. However, the moisture content of moist hog fuel is from 30 to 50 percent which reduces its net heating value to approximately 5,000 Btus per pound.

2. Refuse Derived Fuel (RDF)

RDF is produced by shredding domestic and commercial solid waste to a particle size from four inches minus to one inch minus depending on type of boiler firing equipment, and removing the non-combustible materials by an air density classifier. The resulting RDF consists primarily of shredded paper and light plastic material with a higher heating value of 5,000 to 6,000 Btus per pound. Since the heating value of RDF is about the same as hog fuel, RDF can be used in place of, or in conjunction with hog fuel.

Presently, the only source of RDF in the area will be from the City of Tacoma solid waste processing plant scheduled for start up in April or May 1978.

RDF production from this plant will be about 2,000 tons per week. The price of RDF will be competative with hog fuel.

3. Other Sources of Waste Fuels

No other waste product fuels of any significance are available in the Tacoma area.

C. CONCLUSION

Wood waste fuel is still a commercial source of fuel in the Tacoma area and is expected to continue to be so.

CHAPTER EIGHT

ENVIRONMENTAL EVALUATIONS

A. INTRODUCTION

Evaluation of environmental concerns and the potential impact of steam plant development on the physical setting and local commercial-industrial-residential land use is an integral part of any new industrial development. Of particular interest is the potential impact of the steam plant on various physical media (air, water and land), and the social, political and economic effects on the proposed project area. Associated with the evaluation of environmental concerns is the preparation of various permits and completion of studies necessary in support of these permits.

The following section addresses these issues in a conceptual sense. Compliance with City, State and Federal regulations are summarized briefly for various portions of steam plant operation. A preliminary permits list is provided as a guideline for some of these areas of concern. Beyond the application of rules and regulations for the steam plant, are the issues of environmental and socio-economic impact. Since it is beyond the scope of this report to analyze specific impact in detail, an outline addressing these issues is provided.

B. LAND ORIENTED CONDITIONS

As has been previously stated, the proposed site is located to the east of the City Waterway in the industrial Port of Tacoma. This area is flat with little topographic relief and is referred to as the "tide flats" area of Tacoma. Comprised mainly of "made land", this area is developed on the low tidal marshes and the floodplain of the Puyallup River. Underlain by sands, silts and gravels deposited by the River as a delta and by subsequent reworking of the ocean, most of the existing terrain has been stabilized by deposition of fill materials and the establishment of bulkheads to control ocean erosion. As a result, soil borings in the vicinity of the site reflect varying thicknesses of man made detritus, earth fill and the naturally deposited deltaic and ocean sediments.

The potential impacts on the land conditions of the tide flats are considered to be minimal since no radical changes in the existing topography or underlying materials are expected.

C. WATER ORIENTED CONDITIONS

The proposed site is east of the City Waterway and northeast of the Wheeler-Osgood branch of the Waterway. The southwestern site boundary comes within 200 feet of the Waterway. The site grade is approximately 8 - 10 feet above the mean sea level and has a similar depth to ground water. The potential for flooding of the site is considered minimal.

The primary source of cooling and process water for the steam plant will be obtained from the City. The water would be withdrawn from the water system already existing on site, and used for cooling, boiler feed water and ash handling. Efficient reuse of water is planned to limit plant discharges and water requirements. Excess water will be treated and discharged to existing sewers in compliance with State standards.

Control of site runoff is an important part of the site development design. The runoff will be collected, allowed to settle and possibly be used for in-plant process water requirements. No water will be released unless it has been treated. Dewatered sludges generated during the treatment process will be disposed of in an environmentally acceptable manner.

The primary environmental consideration associated with plant water use will be related to the quality of the discharge. Evaluation of the treatment systems and overall plant water balance will be an essential part of the preliminary design. The design of such systems will be performed to meet State water quality standards. Compliance and approval of waste treatment systems is necessary for receipt of a Washington Waste Disposal permit.

Should, for some reason, discharge of waste waters into the City Waterway be required, the water quality standards for a Class C water body must be met (Table 9-1). The thermal mixing zone would have to be defined and agreed to by the State if an impact is anticipated. To comply with State administered regulations of the Federal Water Pollution Control Act Amendments of 1972, a National Pollution Discharge Elimination Permit (NPDES) would be required no matter where the point of discharge is.

In addition to the required discharge permits, construction of the facility near the City Waterway may require a Shoreline Management, Substantial Development Permit. As stipulated by the Washington Shoreline Management Act of 1971, the City of Tacoma has enacted a permit ordinance and shoreline management plan which has the approval of the Washington Department of Ecology. Under this program, any construction within 200 feet of a shoreline defined in the plan must be issued a permit to insure compatibility with the plan. Since

TABLE 8-1
CITY WATERWAY WATER QUALITY STANDARDS
CLASS C

1.	Characteristic Uses	Cooling water, commerce and navigation, fish passage, boating.
2.	Total Coliform Organizms	Shall not exceed medium values of 1000 when associated with any fecal source.
3.	Dissolved Oxygen	Shall exceed 4.0 mg/l or 50% saturation whichever is greater.
4.	Total Dissolved Gas	The concentration of total dissolved gas shall not exceed 110% saturation at any point of sample collection.
5.	Temperature	Water temperatures shall not exceed 72 degrees F. due in part to measurable (0.5 degrees F.) increases resulting from human activities; nor shall such temperature increases, at any time exceed t = 64/(T-29) where "t" represents the permissive increase and "T" represents the water temperatures due to all causes combined.
6.	pH	Shall be within the range of 7.0 to 9.0 with induced variation of less than 0.5 units.
7.	Turbidity	Shall not exceed 10 JTU over natural conditions.
8.	Toxic, Radioactive or Deleterious Material Concentrations	Shall be below those which adversely affect public health during the exercise of characteristic usages or which may cause acute or chronic toxic conditions to the aquatic biota or which may adversely affect characteristic water uses.
9.	Aesthetic Values	Shall not be interferred with by the presence of obnoxious wastes, slimes, or aquatic growths or by materials which will taint the flesh of edible species.

NOTES:
1. The City Waterway classification is found in WAC 173.201.080(29)
2. The Standards for Class C are found in WAC 173.201.030(4)

the proposed site comes within 200 feet of the City Waterway, a permit may be required. The need for such a permit will depend upon proposed construction activities and their proximity to the Waterway. Discussions with City officials (1) suggests that even if a permit were required, no major interferences with proposed plans and recreation developments would be anticipated. The permit would discuss the proposed action, define possible conflicts with the existing management plan and environmental conditions, and discuss means of mitigating those conflicts.

D. AIR RESOURCES

Tacoma, being located adjacent to Commencement Bay of Puget Sound and between the Olympic and Cascade Mountains, has a mid-latitude west coast climate modified somewhat by the imposing barrier of the Cascades, and to a lesser extent by the Olympic Mountains. This climate is characterized by equable temperatures, a pronounced, though not sharply defined, rainy season, and considerable cloudiness, particularly during the winter months. (2)

In general, the Tacoma area is one of the cloudiest in the country with precipitation being plentiful during the fall, winter and spring. July is the driest month and December is the wettest. Total yearly precipitation varies between forty and fifty inches per year. Winds are predominantly from the southwest and average between eight and nine miles per hour. During the summer months the winds are light and variable with northerly land and sea breezes forming during the afternoon due to the proximity to Puget Sound.

Temperature extremes in the area vary from a high near 100°F to near 0°F for a low. The daily temperature extremes will occasionally exceed 80°F and 32°F. The growing season is approximately 160 days. The proximity of the site to Puget Sound has a moderating effect on the climatic extremes.

Since the site is on the tide flats within the Puyallup River Valley, it is part of a localized climatic condition affecting the air dispersion characteristics of the area: the valley situation is conducive for stagnation conditions. The proximity of the site to Commencement Bay results in periodic fogging.

Air quality in the Tacoma area is monitored by the Puget Sound Air Pollution Control Agency (PSAPCA) and by the Port of Tacoma. The PSAPCA is the State approved regional agency responsible for monitoring, and permitting air pollution sources within the region. Discussions with officials of the PSAPCA (3) have indicated that the Tacoma portion of the region is classified as an "attainment" area subject to prevention of significant deterioration (PSD) standards as defined by the Federal Clean Air Act and its amendments. However, recent information received by the PSAPCA suggests that the Port of Tacoma area may be reclassified as a "non-attainment" area in the near future.[3]

As a new source of air emissions, the steam plant will receive increase attention from the State and local populace. The two products of combustion expected to receive the greatest attention will be particulates and SO_2. Because wood and refuse derived fuel (RDF) are proposed as the primary fuels for this steam plant, particulate emissions will be of most concern to the State. The conceptual design anticipates using a mechanical collector to capture the larger particulate particles and an electrostatic precipitator or bag filters to catch the finer materials. These systems have been found to work well for other wood burning boilers with respect to compliance with air quality standards. SO_2 emissions are not considered a major problem due to the low sulfur contents of the primary fuels.

Analysis of air emissions associated with steam plant development in the Tacoma area could include the establishment of a baseline and operational monitoring program. Evaluation of the type, suitability and locations of existing air quality monitors and local meteorological conditions will be made to determine the background conditions affecting dispersion.

Because of the proposed valley location of the steam plant, the data collected in the preceding monitoring programs conducted by PSAPCA and Tacoma can be used to model the meteorological conditions and evaluate the dispersion characteristics of the area. This will help establish the level of control technology required to comply with air quality standards (Tables 8-2 and 8-3).

If the Tacoma area remains an "attainment" area, the emissions from the steam plant would be subject to PSD regulations and standards (Table 8-4) of the EPA, and would require an operational permit. However, since PSAPCA officials anticipate reclassification of the Port of Tacoma area as non-attainment, the emission offset policies of the EPA would apply. Under this policy, new sources will be allowed only when an old source of greater pollution potential is retired. The PSAPCA has the authority to administer this policy, but has yet to receive any permit applications requiring the use of this policy. This suggests that the type of information required, the analysis time, and the negotiation procedures are not yet well known. In addition, officials of the PSAPCA are aware of 2 or 3 other industries in the Port of Tacoma area that are contemplating construction of new emission sources. This could affect the acceptability of later applications for construction permits, and suggests that only a certain amount of emissions will be allowed on a geographical basis. The first application received probably will have the best chance of being approved. Any permit applications received by the PSAPCA would be subject to EPA evaluation.

TABLE 8-2
AIR EMISSION STANDARDS

EMISSION	EMISSION LIMITATION	AUTHORIZATION
Visual	It is unlawful to allow emissions for a period or periods aggregating more than three (3) minutes in any one hour, which is, darker in shade than that designated as No. 1 (20% density) on the Ringleman Chart, as published by the U. S. Bureau of Mines. The density or capacity of an air contaminent shall be measured at the point of its emission.	Article 9 Section 9. 03
Sulfur Oxides	Greater than 2000 ppm.	Article 9 Section 9. 07
Particulates	It is unlawful for particulate matter to exceed the following weights at the point of discharge: 0. 05 grains for each cubic foot of exhaust gas calculated to 12 percent carbon dioxide for fuel burning equipment; and/or 0. 10 grains for each standard cubic foot of exhaust gas, adjusted or calculated to 12 percent carbon dioxide for full burning equipment utilizying wood residue.	Article 9 Section 9. 09 (b)
Odor	Effective control apparatus and measures shall be installed and operated to reduce odor-bearing gases or particulate matter emitted into the atmosphere to a reasonable minimum.	Article 9 Section 9. 12

NOTES:

1. All standards are taken from Regulation 1 of the Puget Sound Air Pollution Control Agency.

2. Sulfur content by weight shall not exceed: 2% for all oil except for Distillate No. 1 (0. 3%) and Distillate No. 2 (0. 5%) and 1% for coal. Article 9, Section 9. 07(d).

3. The particulate standard varies with the type of fuel used. Clarification of the applicable standard will be needed from the Puget Sound Air Pollution Control Agency.

TABLE 8-3
AMBIENT AIR QUALITY STANDARDS

POLLUTANT	AMBIENT LIMITATION			AUTHORIZATION
Sulfur Oxides	Concentration	Averaging Time	Frequency of Occurance	Article 9 Section 9.07
	1.0 ppm	5 min.	Once in any 8 consecutive hrs.	
	0.4 ppm	60 min.	Never to be exceeded	
	0.25 ppm	60 min.	Twice in any 7 consecutive days	
	0.10 ppm	24 hrs.	Never to be exceeded	
	0.04 ppm	30 days	Never to be exceeded	
	0.02 ppm	265 days	Never to be exceeded	
Suspended Particulate Concentration (SPC)	SPC averaged over any Twenty-four (24) hour period shall not exceed: 60 ug/M3 of air annual geometric mean; 150 ug/M3 of air not to be exceeded more than once per year.			Article 11 Section 11.03
Particulate Fallout (PF)	PF shall not exceed: 10 g/M^2/mo in an industrial area, or 5g/M^2/mo in an industrial area if visual observations show a presence of wood waste and the volitile fraction of the sample exceeds 70%; 3.5g/M^2/mo in residential and commercial areas is visual observations show the presences of wood waste and the volitile fraction of the sample exceeds 70%.			Article 11 Section 11.05
Carbon Monixide	CO concentrations shall not exceed: 10mg/M^3 (9ppm) maximum 8-hour concentration not to be exceeded more than once per year; 40 mg/M^3 (35 ppm) maximum one-hour concentration not to be exceeded more than once per year.			Article 11 Section 11.06
Photochemical Oxidants	The photochemical oxidant concentration measured in the ambient air shall not exceed 160 ug/M^3 (0.08 ppm) maximum onehour concentration not to be exceeded more than once per year.			Article 11 Section 11.07
Nitrogen Dioxide (NO_2)	The nitrogen dioxide concentration measured in the ambient air shall not exceed 100 ug/M^3 (0.05 ppm) annual arithmetic mean.			Article 11 Section 11.08
Hydrocarbons	The hydrocarbon concentration measured in the ambient air shall not exceed 160 ug/M^3 (0.24 ppm) maximum 3-hour concentration not to be exceeded more than once per year.			

NOTES:

1. All standards are taken from Regulation 1 of the Puget Sound Air Pollution Control Agency.

2. Abbreviations: ppm, parts per million; ug, micrograms; mg, milligrams; M^2, square meter; M^3, cubic meter; mo, month.

TABLE 8-4
FEDERAL AMBIENT AIR QUALITY STANDARDS FOR CLASS II AREAS

For any Class II area, the maximum allowable increase of sulfur dioxide and particulate matter over the baseline concentration of such pollutants shall not exceed the following amounts:

Pollutants	Maximum allowable increase (in micrograms per cubic meter)
Particulate matter:	
Annual geometric mean	19
Twenty-four-hour maximum	31
Sulfur Dioxide:	
Annual arithmetic mean.	20
Twenty-four-hour maximum	91
Three-hour maximum.	512

NOTES:

1. Baseline concentrations for SO_2 and particulates need to be established for the Tacoma area.

2. This portion of Washington has been given a Class II status.

3. The standards are listed in the Clean Air Act Amendments, PL 95-95.

Under the new Clean Air Act Amendments, chimney heights could require further scrutiny since heights are to be limited by good engineering practice, and are suggested to be no greater than two and one-half times higher than the highest local building. This provision could have a direct bearing on the dispersion of atmospheric emissions, and may require a variance from proposed Federal regulations, should a taller chimney be indicated by subsequent analysis.

Another item affecting chimney height is the visual impact and public acceptability. Determination of public opinion on this issue may be desirable. The chimney will be a structure capable of being seen from many directions, including from Commencement Bay. The rolling nature of the Tacoma area will do much to lessen its visibility, however, consideration of the visual views and vistas may be needed to help mitigate public concern.

While technically not an air quality parameter, noise could affect the overall acceptability of the steam plant. Affected by wind directions, temperatures and humidities, noise levels from existing and future sources will need evaluation to establish projected noise levels to assure compliance with proposed City noise regulations.

E. LAND USE

As previously noted, the proposed site is located in the Port of Tacoma just east of downtown Tacoma. The area is predominantly industrial with much of the immediate area being devoted to the pulp and paper industrial activity of the St. Regis Paper Company, various small warehouses and boat building enterprises. The area is served by City water, sewer and electric lines. A 32" steel watermain, an 8" sanitary sewer and a 36" storm sewer border the site on the south. A 110 KV electric transmission line is located along the western boundary of the site. Gas and oil lines are also located in the immediate area.

Proposed plans[4] for the area surrounding the site are related primarily to the City Waterway. The primary intended use for the Waterway will be for recreational purposes. A series of marinas, walkways, restaurants and small commercial businesses are planned. The transition to a recreational use will be slow and dependent upon the closing of industries currently on the Waterway. Future developments on the Waterway will be controlled by the Shoreline Management permit process. No plans currently exist for controlling development outside of the 200 foot buffer around the Waterway. Construction of a steam plant at the proposed site is not anticipated to be in conflict with the Waterway development plan.

F. TRANSPORTATION/CIRCULATION

Highway and street access to the site are of vital importance since the RDF and hog fuel will be brought to the site by truck. Although railroad spurs are found on both the east and west sides of the site, rail transportation of hog fuel appears not to be practical for this project. This means that the approximately 650 tons/day fuel requirement for the steam plant must be supplied by truck. Assuming that the fuel can be brought to the site in 18-20 ton loads, a total of 30 to 35 trucks per day would be required. Since the combustion waste products (ash) must also be removed, 4-5 truck loads of ash will add to the truck circulation.

Trucks carrying fuel would most likely follow a route from Interstate 5, to Portland Avenue,to St. Paul Avenue and then to the site. An evaluation of ingress and egress of the impact of the additional truck loading on existing traffic patterns may be desirable to determine possible socio-economic implications.

Although not directly related to vehicular transportation and circulation patterns, the distribution of steam to the heating district does have some transportation implications. The downtown heating district can be connected to the steam plant by routing the steamline under the City Waterway or by providing an overhead route along the 11th Street Bridge. The underwater route would require dredging of the City Waterway and permits from the City of Tacoma, the Washington Departments of Fisheries and Game, and the U. S. Corps of Engineers. Considering difficulties in construction, dredging and maintenance, this option is not as favorable as the overhead option. The use of the overhead route along the 11th Street Bridge provides a more accessible and more easily maintained steamline that would not involve construction seriously affecting the City Waterway. The major problem with using the 11th Street Bridge is that it is currently an operational vertical lift bridge; the steamline would have to be routed up and over the superstructure of the bridge so as not to interface with bridge operation.

Permits for construction of the steamline across the bridge would be required from the Washington Highway Department and the U. S. Coast Guard. Projected impacts on the environment, recreational plans, transportation patterns (on the bridge) and navigation are considered minimal for the overhead steamline route.

G. ENVIRONMENTAL IMPACT ASSESSMENT PROCEDURES

Since the plans for the construction and operation of the steam plant will be reviewed with respect to the potential impact on the environment, an Environmental Assessment Form (EAF) will have to be completed in accordance with Washington law and reviewed by the pertinent departments of the City of Tacoma. After 15 days, the City must rule as to whether potential impacts are significant or whether a negative declaration should be issued. If the potential for significant impacts are considered to be present, the City will recommend that an Environmental Impact Statement (EIS) be written. The appropriate departments of the

State will review the EIS for its adequacy. The results of the EIS will have bearing on the approval of project permits, since the EIS process can take up to a year before all sensitive issues are resolved and final approvals are given.

H. SUMMARY

Potential impacts associated with the construction of the plant will be primarily related to the air emissions and associated control technology, the use and discharge of water, and the ingress and egress problems of fuel supply and ash disposal. The plant site in the industrial Port of Tacoma area makes it compatible with existing land use. No interference with recreational development plans of the City Waterway is anticipated and the use of the overhead steamline route is considered much more favorable than placing the steamline under the Waterway.

Primary disruption of the area will occur during construction of the steam plant, but this is considered to be temporary.

Other important areas will be related to permit acquisition. A construction permit for a new emission source could take from one to two years if the emission offset policy is invoked. The EIS preparation and evaluation, if required, could also take a year, thereby affecting the issuance of other permits. A preliminary permits list is provided in Table 8-5.

For each of the functions previously described, a series of environmental considerations were described. Table 8-6 summarizes these aspects of the project. It should be noted that the need for special environmental evaluations and the amount of detail required should be resolved during the preliminary design phase. The exact nature of such re-evaluation will depend on further discussions with appropriate regulatory agencies, and will be influenced by the public view and acceptance of the overall project.

TABLE 8-5
PERMIT REQUIREMENTS
(Preliminary List)

A. FEDERAL PERMITS

Agency		Description	Authorization
U. S. Army Corps of Engineers	1.	Construction in a Navigable Waterway: Permits could be required for any construction affecting the City Waterway. This would include intake or discharge structures on the waterway, and placement of a steamline under the waterway.	33CFR, Sec. 209.120
U. S. Coast Guard	1.	Construction of Overhead Pipeline: Should the steamline from the new facility be placed over the City Waterway then a Coast Guard permit may be required.	

B. STATE PERMITS

Agency		Description	Authorization
Washington Department of Ecology	1.	Waste Disposal Permit: Permit will be required to discharge effluent into a receiving waterbody.	WAC 90.48.160
	2.	National Pollution Discharge Elimination System (NPDES): These requirements pursuant to the Federal Water Pollution Control Act (PL 92-500) are administered by Washington and must be met before a Waste Disposal Permit is granted. Provisions for analysis of intake and outfall (thermal) impacts are included.	WAC 173.220.020
	3.	Shoreline Management, Substantial Development Permit: The Shoreline Management Act requires local governments to develop policy plans and ordinances for protection and classification of waterways. Permits for construction activities along shorelines are administered by the local government but must be approved by the State.	WAC 173.14.020
	4.	Environmental Impact Statement (EIS): Should the City of Tacoma determine that a potential for significant impact exists then an EIS must be completed and approved.	RCW 43.21 C
Washington Department of Natural Resources	1.	Review of Overhead Steamline: A review of plans and specifications for an overhead steamline is required and administered by the Division of Marine and Land Management.	
Washington Department of Fisheries and the Department of Game	1.	Hydraulics Project Approval: Should the steamline go under the City Waterway approval from both Department would be required.	
Highway Department	1.	Application for Franchise: A review	

TABLE 8-5 (cont.)
PERMIT REQUIREMENTS
(Preliminary List)

B. STATE PERMITS Con't.

Agency		Description	Authorization
		of plans and specifications for an overhead steamline is required and managed by the Bridge Division.	
C. REGIONAL PERMITS			
Project Sound Air Pollution Control Agency	1.	Notice of Construction: The Agency must be notified and must approve plans, and specifications for a new air contaminant source. Approval is granted on projected compliance with air quality standards.	Article 6 Section 6.03
D. CITY-COUNTY PERMITS			
City of Tacoma	1.	Shoreline Management, Substantial Development Permit: The City Planning Department (Land Use Administration Division) administers the permit process allowing construction in, along or within 200 feet of a waterway. Any construction along the City Waterway will require a permit.	Ordinance No. 20931
	2.	Environmental Assessment Form (EAF): This form summarizing the proposed project and the environmental condition surrounding the project must be submitted to the Land Use Administration Division of the City Planning Department for interdepartmental review.	RCW 43.21 C
	3.	Environmental Impact Statement (EIS): Should review of the EAF indicate significant environmental problems, then an EIS will be required. The City Department reviews the draft EIS and submits it to the Washginton Department of Ecology for approval.	RCW 43.21 C

TABLE 8-6
POTENTIAL ENVIRONMENTAL CONSIDERATION
AND FUTURE STUDY AREAS

Resource	Area of Consideration	Study Description
Air Related	New Source Emissions	1. Baseline ambient air quality study; review existing air quality monitoring data.
		2. Establishment of meteorological monitoring station.
		3. Investigate existing available models.
		4. Using data collected from the above, model the dispersion characteristics of the area.
	Chimney Height	1. Determine height necessary to sufficiently disperse pollutants and meet air quality standards.
		2. Evaluate visual-aesthetic impact.
	Noise	1. Evaluate ambient noise patterns.
		2. Review Tacoma's noise standards.
		3. Evaluate steam plant operational noise levels.
Water Related	Discharge	1. Determine waste treatment processes required to meet chemical-biological standards.
		2. Determine existing water quality of City Waterway.
		3. Determine point of discharge and need for water quality and thermal plume studies into receiving waters.
Land Related	Ingress-Egress	1. Evaluate social effects of wood and RDF delivery.
		2. Evaluate increased traffic patterns due to transportation of fuels to the site.
	Socio-Economics	1. Evaluate socio-economic aspects of steam plant development.
		2. Evaluate impacts on land-use and recreation plans.

REFERENCES

1. Personal communication with Katie Mills and Kevin Foley, Land-Use Administration Division Planning Department, City of Tacoma, October 13, 1977.

2. National Oceanic and Atmospheric Administration, National Climatic Center, "Local Climatologic Data" Seattle-Tacoma and Olympia, Washington.

3. Personal communication with Jim Pearson, Puget Sound Air Pollution Control Agency, December 1, 1977.

4. City of Tacoma Inter-Departmental Communication from Ron Nelson, Waterfront Development Manager to Erling O. Mork, City Manager; Subject: "Status Report - City Waterway Redevelopment", August 25, 1977.

CHAPTER NINE

CONCEPTUAL DESIGN

A. INTRODUCTION

This chapter will describe the conceptual design of the alternatives applicable to meet the current and future heating demands of the central business district (CBD) of Tacoma. The alternatives described below will include; steam production and distribution, co-generation (steam and electric) production and steam distribution, high temperature hot water (HTHW) production and distribution and a combination of all three.

CHAPTER FOUR reported the findings of the market analysis. There are markets for steam and electrical energy. A potential market exists for high temperature hot water (HTHW) if the existing steam distribution system was replaced with a HTHW distribution system and the building owners made the required modifications to their individual heating system. Because of the climatic conditions present in Tacoma, there is not an adequate market for chilled water for air conditioning use in the CBD. The market values of these energy products presented in CHAPTER FOUR will be used in the subsequent feasibility analysis presented in CHAPTER TEN.

The market analysis revealed that two plant capacities should be developed because of the variable markets available in the CBD and the adjoining industrial area. The CBD has a peak demand of approximately 67,000 lbs/hr based on 1977 conditions, but this demand is projected to be approximately 115,000 lbs/hr in the year 2000. Therefore, the consultant proposes a 125,000 lbs/hr generating capacity. The facility will serve the CBD on a firm basis with any excess energy produced sold to industrial customers on an interruptible basis.

As an option to the 125,000 lbs/hr facility, the consultant proposes a central energy plant with a 200,000 lbs/hr generating capacity. The 200,000 lbs/hr facility will serve the CBD and one industrial customer on a firm basis. Because unused generating capacity may be available during the year, a second industrial customer could be served on an interruptible basis.

CHAPTER FIVE discussed the technology concerning combustion systems and energy distribution systems. The combustion system evaluation reported the general applicability of firing waste fuels in either a conventional boiler (traveling grate spreader stoker boiler) or a fluidized bed system. The energy distribution analysis reported the characteristics of supplying steam or high temperature hot water (HTHW) to a central business district.

Therefore, to test the feasibility of the boiler and energy distribution options conceptual design of these alternatives will be presented below describing in detail the major characteristics and components of each.

B. OUTLINE OF ALTERNATIVES

Listed below are the applicable alternatives with a brief description of each:

Alternative 1: A new steam plant with a 125,000 pounds per hour (lbs/hr) waste fuel fired boiler generating steam at 150 psig sat. to serve the CBD district heating system and industrial customers. Standby capability will be provided by the CCHC 120,000 pph boiler relocated to the new facility.

Alternative 2: A new steam plant with a 125,000 lbs/hr waste fuel fired boiler delivering steam at 600 psig/750°F to an extraction type turbine generator. Steam will be extracted at 150 psig to serve the steam loads. The electricity produced will be sold to Tacoma City Light. Standby capability will be provided by the CCHC 120,000 pph boiler.

Alternative 3: A new steam plant with a 200,000 pph waste fuel fired boiler to serve the district heating system and industrial customers. An existing oil fired packaged boiler owned by the St. Regis Lumber and Plywood Division and the existing CCHC boiler will provide standby capacity.

Alternative 4: A new steam plant with a 200,000 lbs/hr waste fuel fired boiler delivering 600 psig/750°F steam to an extraction type turbine-generator for electric generator. Steam will be extracted at 150 psig to serve the CBD and industrial steam loads. The electricity generated will be sold to Tacoma City Light. Standby capacity will be furnished by the existing CCHC boiler and existing oil fired package boiler currently owned by St. Regis.

Alternative 5: A new plant with the same conditions as Alternative 1, except the primary boiler will be a waste fuel fired fluidized bed unit.

Alternative 6: The same plant as described for Alternative 2, except for the use of a fluidized bed boiler in place of a conventional waste fuel fired unit.

Alternative 7: The same plant as described in Alternative 3 with the exception of a waste fuel fired fluidized bed boiler replacing the convention boiler.

Alternative 8: A new plant as outlined in Alternative 4, with a new fluidized bed unit replacing the conventional boiler for primary service.

Alternative 9: A new high temperature hot water generating plant and distribution system to serve the downtown business district with the same heating capacity as the existing CCHC plant. Hot water is produced by direct fired generators.

Alternative 10: A plant and distribution system based on high temperature hot water generated in a steam heat exchanger. Steam is supplied by a plant that can produce steam for industrial customers and/or electricity, as in Alternatives 1-8.

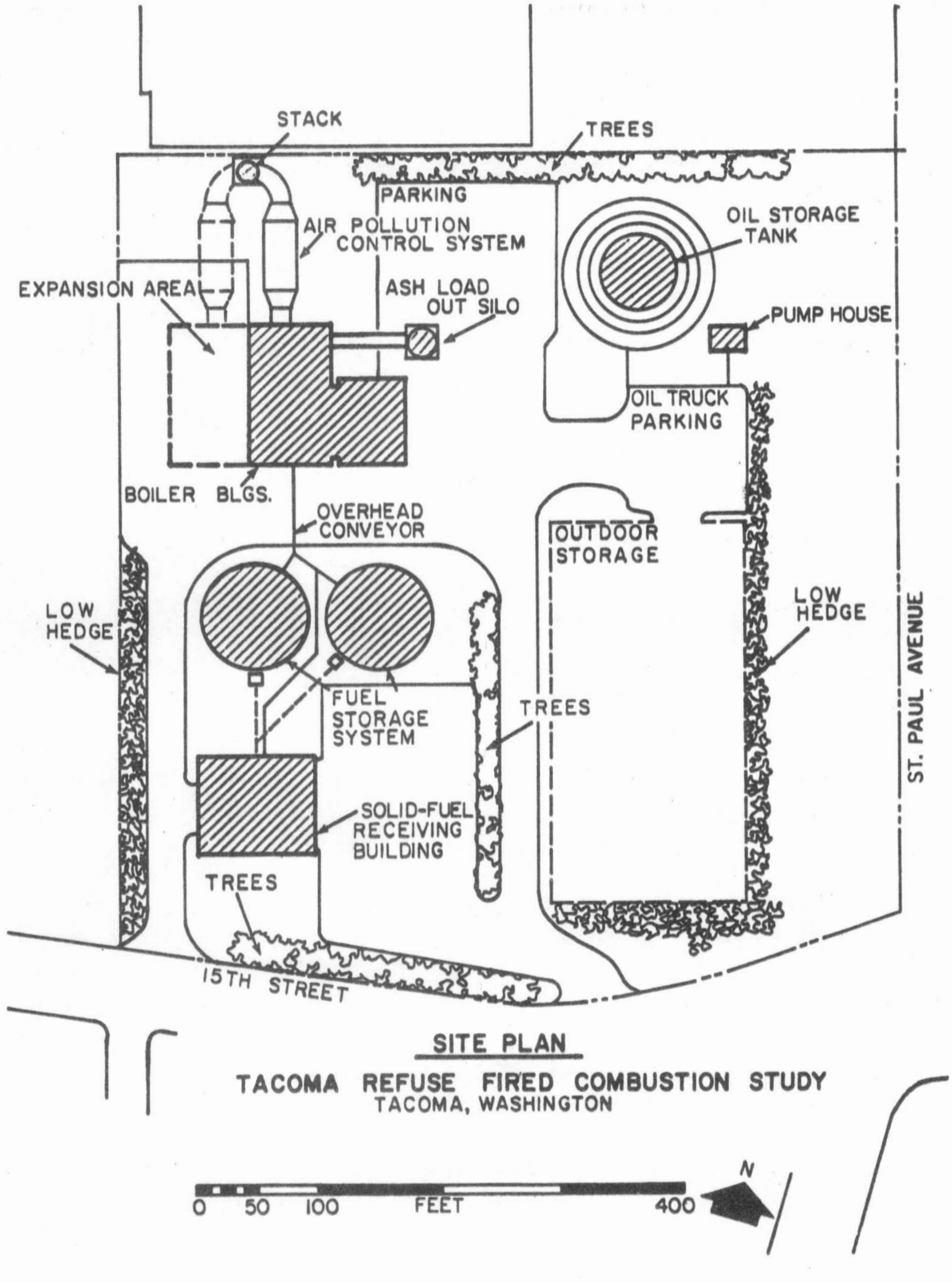
Alternative 11: Steam supplied to the district heating system to the steam plant of the St. Regis Paper Company, Lumber & Plywood Division.

C. CONVENTIONAL COMBUSTION PLANT DESCRIPTIONS

The primary boiler for each of Alternatives 1-4 is of conventional design. The boilers are water walled units with spreader stokers and horizontal traveling grates designed specifically for burning processed refuse and wood waste fuels. They have balanced draft furnaces with forced and induced draft fans and air heaters. These boilers have an estimated combustion efficiency of approximately 70 percent.

Figure 9-1 shows the site layout of a conventional boiler facility based on the utilization of Site B. Solid waste fuel will be unloaded inside the solid fuel receiving building and pneumatically conveyed to the fuel storage bins. An overhead pneumatic system can feed the boiler metering bin either directly from the receiving building or from the intermediate storage system.

Environmental regulations were discussed in CHAPTER EIGHT. Principal concerns are potential air quality impacts and the disposal of residues. The air pollution control system is designed to meet all federal, state, and local air quality regulations. Ash residue generated from solid fuel combustion will be stored for loadout and transport to a sanitary landfill. On a dry basis, the ash quantity is estimated to be 15 percent by weight of the input solid fuel quantity.



SITE PLAN

TACOMA REFUSE FIRED COMBUSTION STUDY
TACOMA, WASHINGTON

FIGURE 9-1

TITLE:
CONVENTIONAL COMBUSTION SYSTEM

Wastewater discharges produced will be collected on site and disposed into the city sewage system. The major wastewater source is the boiler blowdown effluent. Blowdown of boiler water is required to maintain the solids concentration of the water in the boiler at recommended levels. ABMA allowable total solids concentrations are 3,500 PPM for steam pressures from 0-300 psig and 2,000 PPM for steam pressures from 601-750 psig. Blowdown effluent quantities should average less than five percent of the steam produced on a weight basis. It is anticipated that cooled discharges of blowdown effluent will not have an adverse impact on the city sewage disposal system.

1. Alternative 1

Alternative 1 has one 125,000 lbs/hr waste fuel fired conventional steam boiler. Steam is generated at 150 psig sat. to be compatible with industrial users' specifications. The 120,000 pph oil fired packaged boiler of CCHC will be obtained for standby service. Figure 9-2 is a schematic diagram of Alternate 1.

The primary boiler is designed to burn refuse derived fuel and hog fuel. No. 6 fuel oil will be used as a secondary fuel. Two waste fuel storage silos are provided with a nominal capacity of 900 tons each, adequate to sustain the plant for a three day period without additional receipts of waste fuel.

Waste fuel will be pneumatically conveyed to the metering bin at the boiler. The solid fuel will be fed through a swing spout into the boiler with sufficient air to burn the lighter materials in suspension while the heavier materials fall and burn on the traveling grate. A 560,000 gallon (22 day supply) storage tank with a suction heater and two transfer pumps will be provided to store No. 6 fuel oil. The tank is 50 feet in diameter and 42 feet high. A day tank with a duplex fuel oil pump and heating set supply fuel oil to the boilers.

The new primary boiler will have spreader stoker equipment to accommodate future coal firing. Space has been allocated on the site for coal storage, although no coal handling equipment has been included in the conceptual design.

Water required will be purchased from the City of Tacoma municipal system. In plant water treatment system consisting of zeolite softeners for 100 percent makeup supply will be provided. Treated makeup water will be combined with the condensate returned from the industrial customers in the condensate receiver. Two condensate pumps (one electric, one steam driven) will supply the feedwater to the deaerator for heating and deaeration. Two electric

TITLE: ALTERNATIVE I
RDF FIRED STEAM PLANT, 125M LBS./HR.

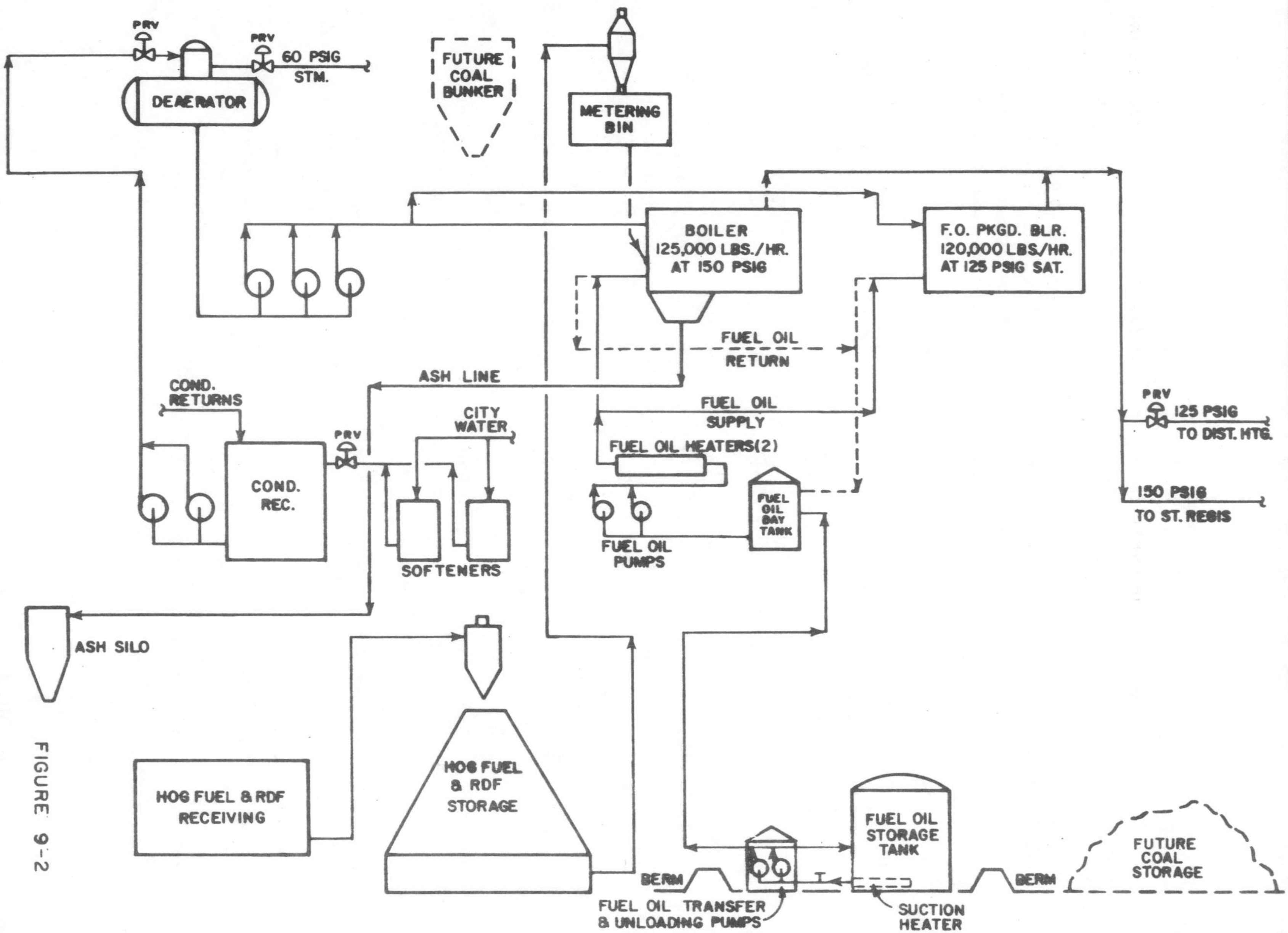


FIGURE 9-2

feedwater pumps and one steam driven feedwater pump will serve the boilers. Each of the three feedwater pumps is rated at 55 percent of one boiler's design capacity.

The air pollution control system will consist of a multi-cyclone mechanical separator and an electrostatic precipitator. The separator is designed to remove from 85 to 90 percent of the large suspended particulates. The electrostatic precipitator will be the final air pollution control component before the flue gases are emitted to the atmosphere via a 165 foot high stack.

Boiler ash will be handled by a wet system. Wet ash will be pumped to a collection tank and subsequently dewatered and stored for truck transport to Tacoma's sanitary landfill.

2. Alternative 2

The facility conceptually designed for Alternative 2 has the same boiler capacity as Alternative 1, however, the primary boiler will supply 600 psig/750°F steam to a 10 MW turbine generator with 150 psig steam extraction for direct use by the CBD. The same standby boiler will be used as described in Alternative 1. Added plant auxiliaries required for electrical generation are a steam condenser, condensate pumps, circulating water pumps and a cooling tower. Figure 9-3 schematically depicts Alternate 2.

Alternate 2 will use the same fuel handling systems described for Alternative 1. Makeup water treatment will be provided by a two train demineralizer.

Environmental regulations may permit using water from Commencement Bay for condenser cooling, eliminating the need for a cooling tower. This possibility is not considered for this conceptual design.

The plant of Alternative 2 can also serve the district heating system directly from the high pressure boiler by using the pressure reducing and desuperheating station should the turbine generator become inoperable.

Air pollution control and ash handling equipment are the same as described for Alternative 1.

TITLE:

ALTERNATIVE 2

RDF FIRED STEAM PLANT WITH ELECTRIC GENERATOR, 125M LBS./HR.

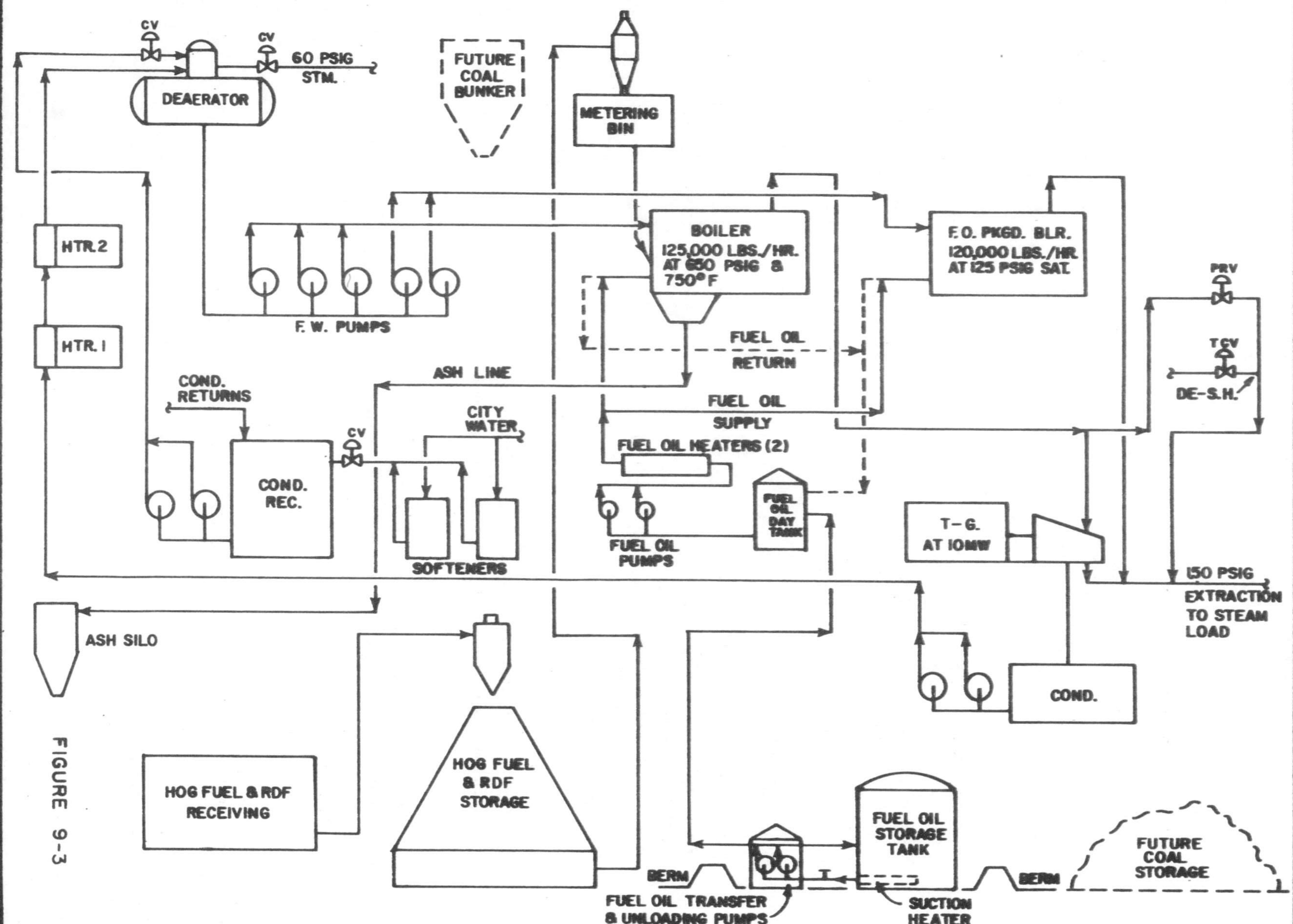


FIGURE 9-3

3. Alternative 3

The schematic diagram of Alternative 3 is shown in Figure 9-4. The primary waste fuel fired boiler will be a 200,000 lbs/hr unit, generating steam at 150 psig. The standby system will consist of the 120,000 pph CCHC packaged boiler and the St. Regis 70,000 pph packaged boiler.

The two waste fuel storage silos will have nominal capacities of 1200 tons each and will be able to supply fuel for three days based on continuous plant operation. The 560,000 gallon fuel oil storage tank will provide for 14 days of full load operation. Auxiliary plant equipment for Alternative 3 will be the same as the Alternative 1, but will be larger.

4. Alternative 4

Alternative 4 is a 200,000 lbs/hr steam and electricity generating facility based on the same conceptual guidelines discussed in Alternative 2. Figure 9-5 is a schematic diagram of Alternative 4. Steam for district heating and industrial customers will be either extracted from the 20 MW turbine generator at 150 psig or supplied through the pressure reducing and desuperheating station. The standby packaged boilers will be of the same configuration discussed in Alternative 3. The standby boilers can supply steam at 150 psig, and cannot be integrated into the electricity generation system because of their lower pressure and temperature operating characteristics.

The quantities, placement, and description of the auxiliary plant equipment for Alternative 4 will be identical to those for Alternative 2 with the exception of increases in equipment size. The fuels handling systems will be the same as those discussed for Alternative 3.

D. FLUIDIZED BED COMBUSTION PLANT DESCRIPTIONS

The primary boilers for Alternatives 5-8 are fluidized bed combustion units. The combustion efficiency for fluidized bed boilers is quoted to be 75 percent by their manufacturer.

The site layout of a fluidized bed boiler facility as it would appear at proposed site B is shown on Figure 9-6. The fuels storage and handling systems are the same as those of a conventional boiler plant (Alternatives 1-4).

TITLE: ALTERNATIVE 3
RDF FIRED STEAM PLANT, 200M LBS./HR.

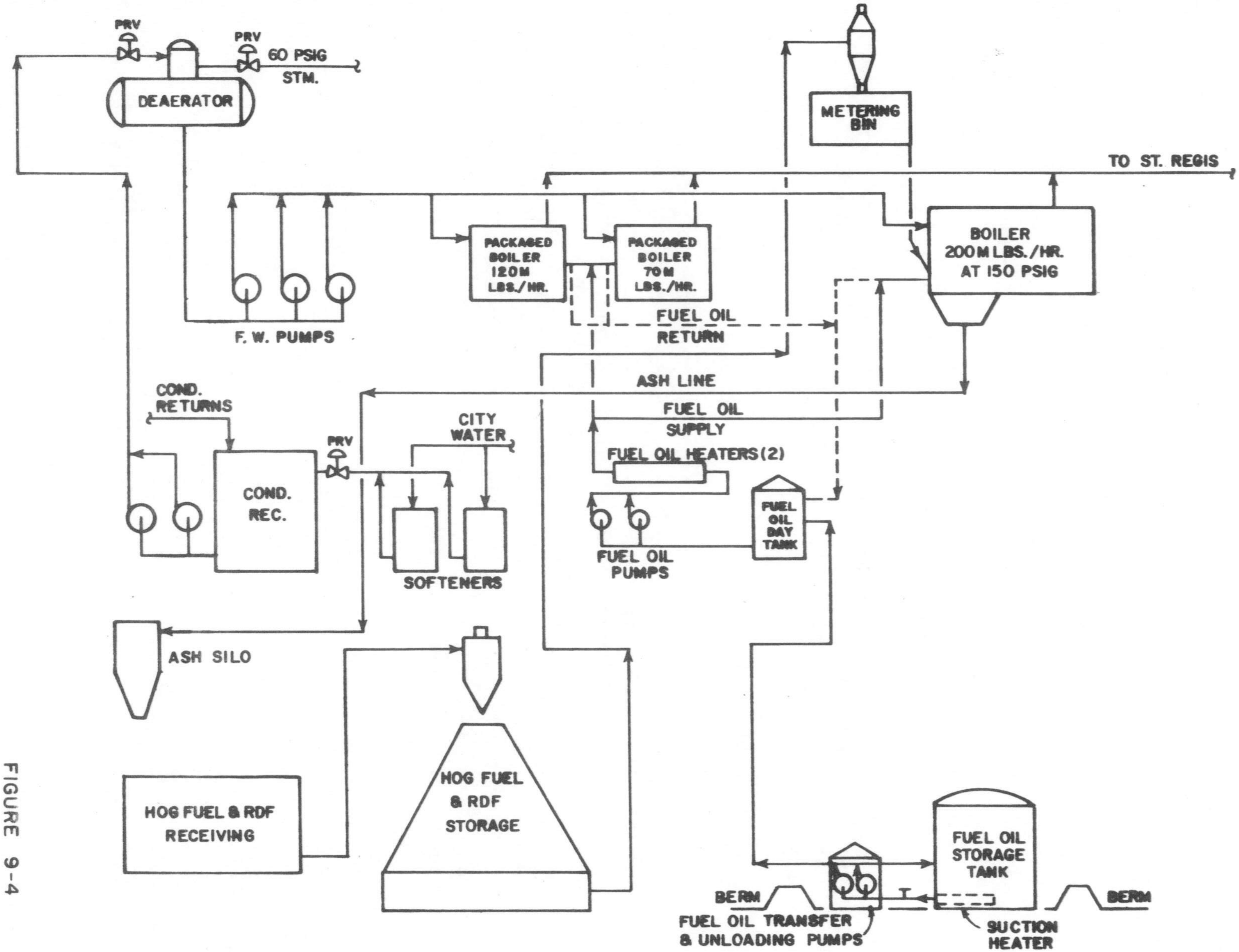


FIGURE 9-4

TITLE: ALTERNATIVE 4
RDF FIRED STEAM PLANT WITH ELECTRIC GENERATOR, 200M LBS./HR.

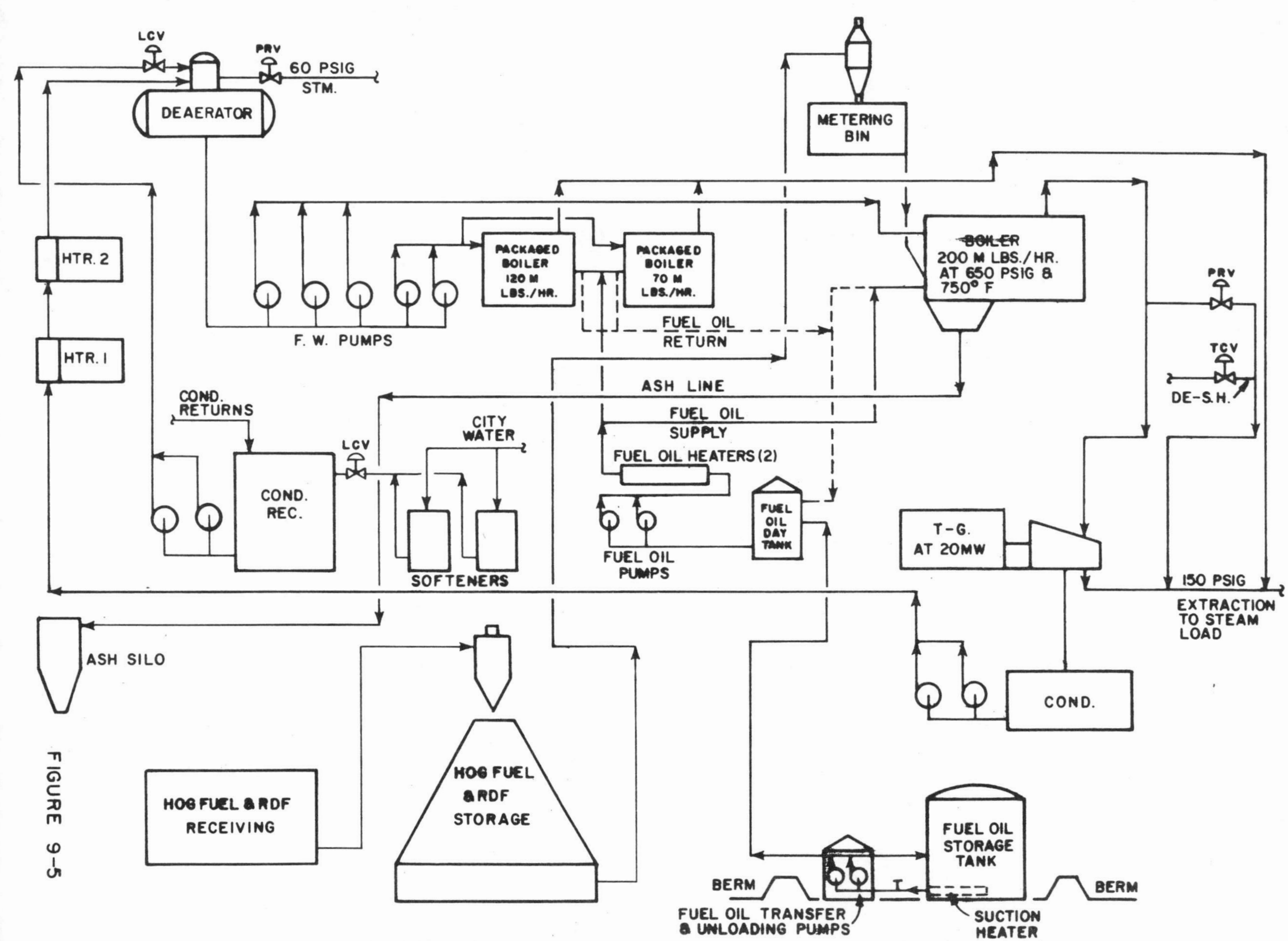
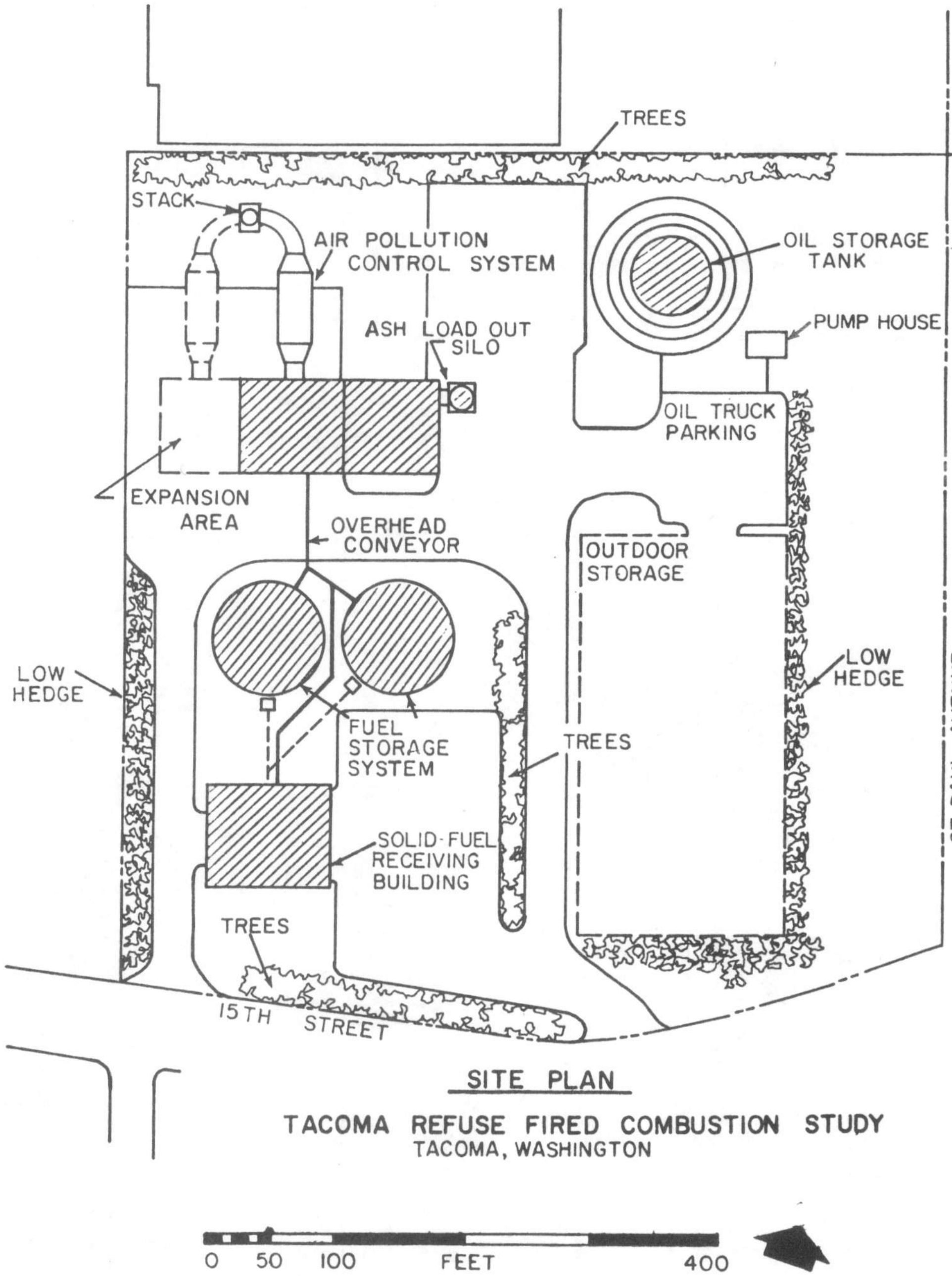


FIGURE 9-5



SITE PLAN

TACOMA REFUSE FIRED COMBUSTION STUDY
TACOMA, WASHINGTON

FIGURE 9-6

TITLE: FLUIDIZED BED COMBUSTION SYSTEM

Plant cycles for Alternatives 5-8 are identical of those of Alternatives 1-4 respectively, with the exception of differences in fuel combustion efficiency and combustion by-product treatment. Flue gases will pass through a multi-cyclone unit and bag filters for air quality control. The ash handling system for a fluidized bed combustion boiler is a dry system. The ash storage facility provided will store the dry ash produced during one day of plant operation.

Figures 9-7 through 9-10 are flow diagrams for Alternatives 5-8.

E. STEAM LINE DESCRIPTION

The steam line from a new plant located on site B to the existing CCHC distribution system will be approximately 3400 feet long. The proposed line will be a 12 inch diameter standard weight insulated pipe enclosed in a concrete box conduit. The exterior of the insulation will be covered with a waterproof wrap. Expansion joints will be provided where necessary. Because the existing CCHC system does not have condensate return lines, no condensate will be returned to the plant. The steam line will be routed to the CBD over the City Waterway via the existing 11th Street bridge or, if this is not permitted, by a pipe bridge.

Steam sales to St. Regis Paper Company will require the construction of a new 1100 foot steam line to tie into their existing system. Pipeline construction will include the installation of a steam supply line and a condensate return line.

F. HIGH TEMPERATURE HOT WATER SYSTEM DESCRIPTIONS

1. Alternative 9

The high temperature hot water (HTHW) system based on direct fired generators will have a central generating plant capable of producing 115 million Btus/hr. This heat output is equivalent to Alternative 1 (125,000 lbs/hr steam system). The facility layout for this alternative is the same as Figure 8-1.

Two HTHW generators will be provided, each capable of generating 57.5 million Btus/hr. The generators have conventional spreader stoker type furnaces. The fuel handling systems, ash handling system, and air pollution control equipment are identical to those described for Alternative 1, with one exception, a separate waste fuel metering bin for each HTHW generator.

TITLE: ALTERNATIVE 5
FLOW DIAGRAM FLUIDIZED BED UNIT, 125M LBS./HR.

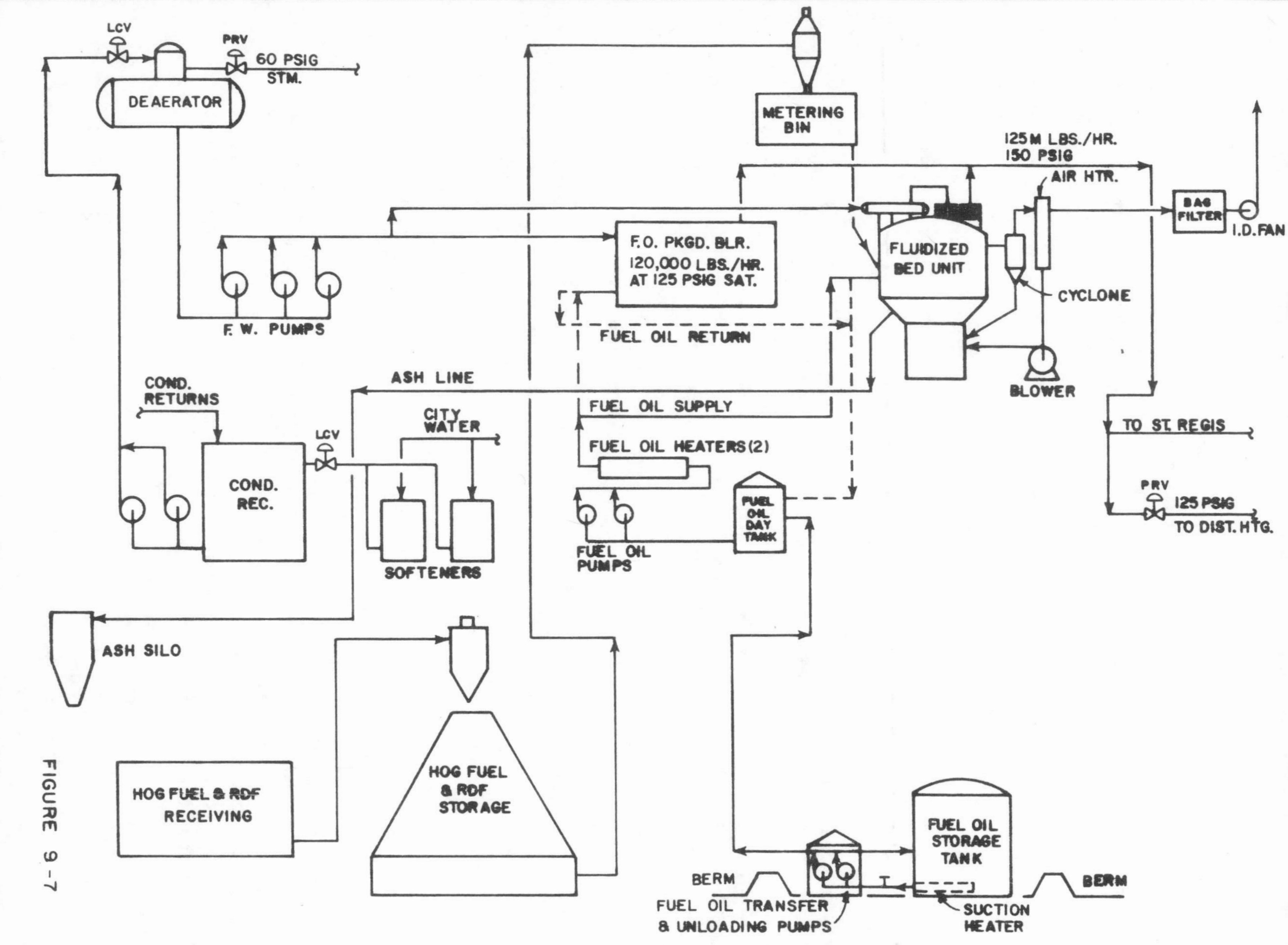


FIGURE 9-7

TITLE: ALTERNATIVE 6
FLOW DIAGRAM FLUIDIZED BED UNIT, 125M LBS./HR.

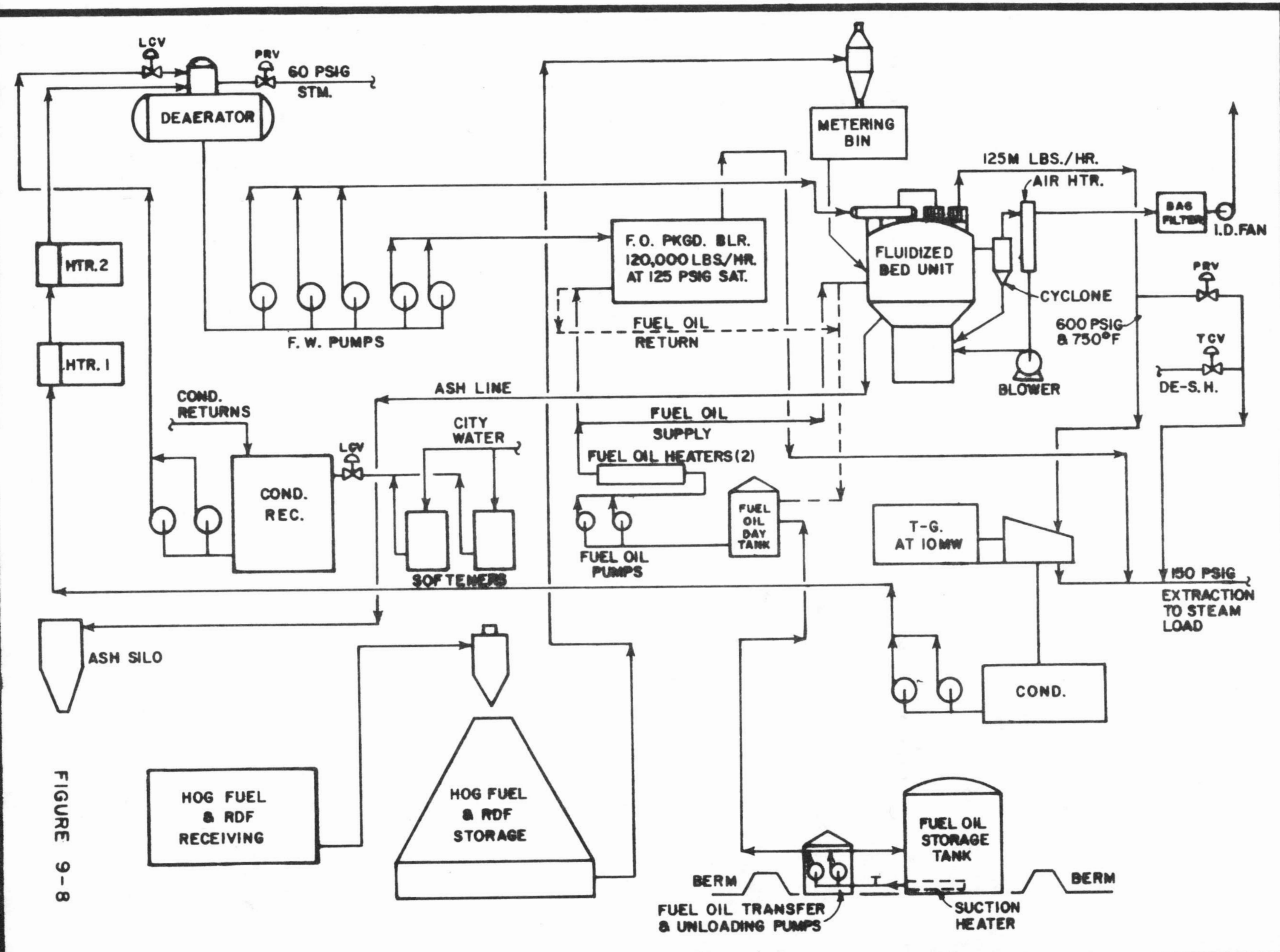


FIGURE 9-8

TITLE: ALTERNATIVE 7
FLOW DIAGRAM FLUIDIZED BED UNIT, 200M LBS./HR.

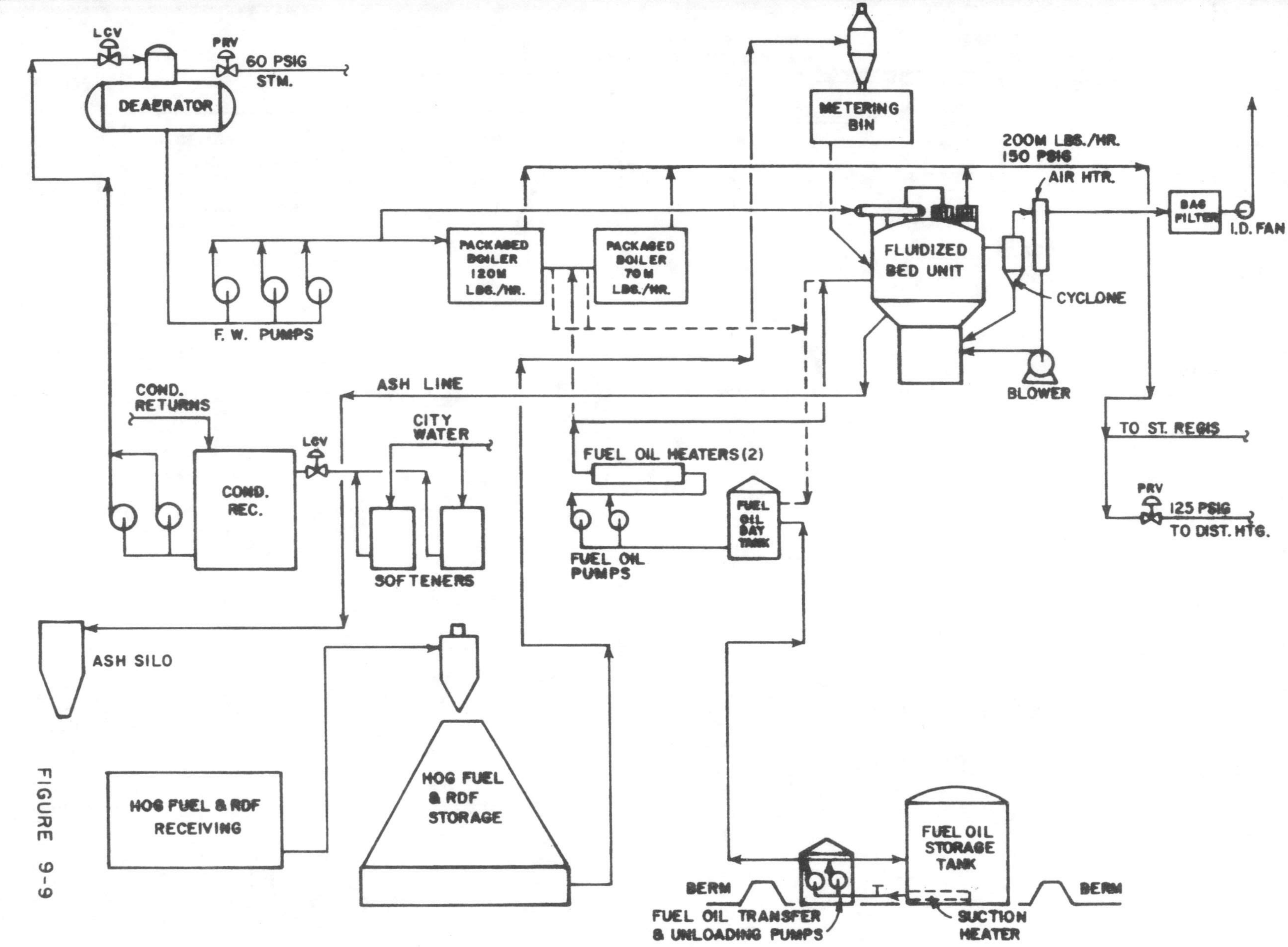


FIGURE 9-9

TITLE: ALTERNATIVE 8
FLOW DIAGRAM FLUIDIZED BED UNIT, 200M LBS./HR.

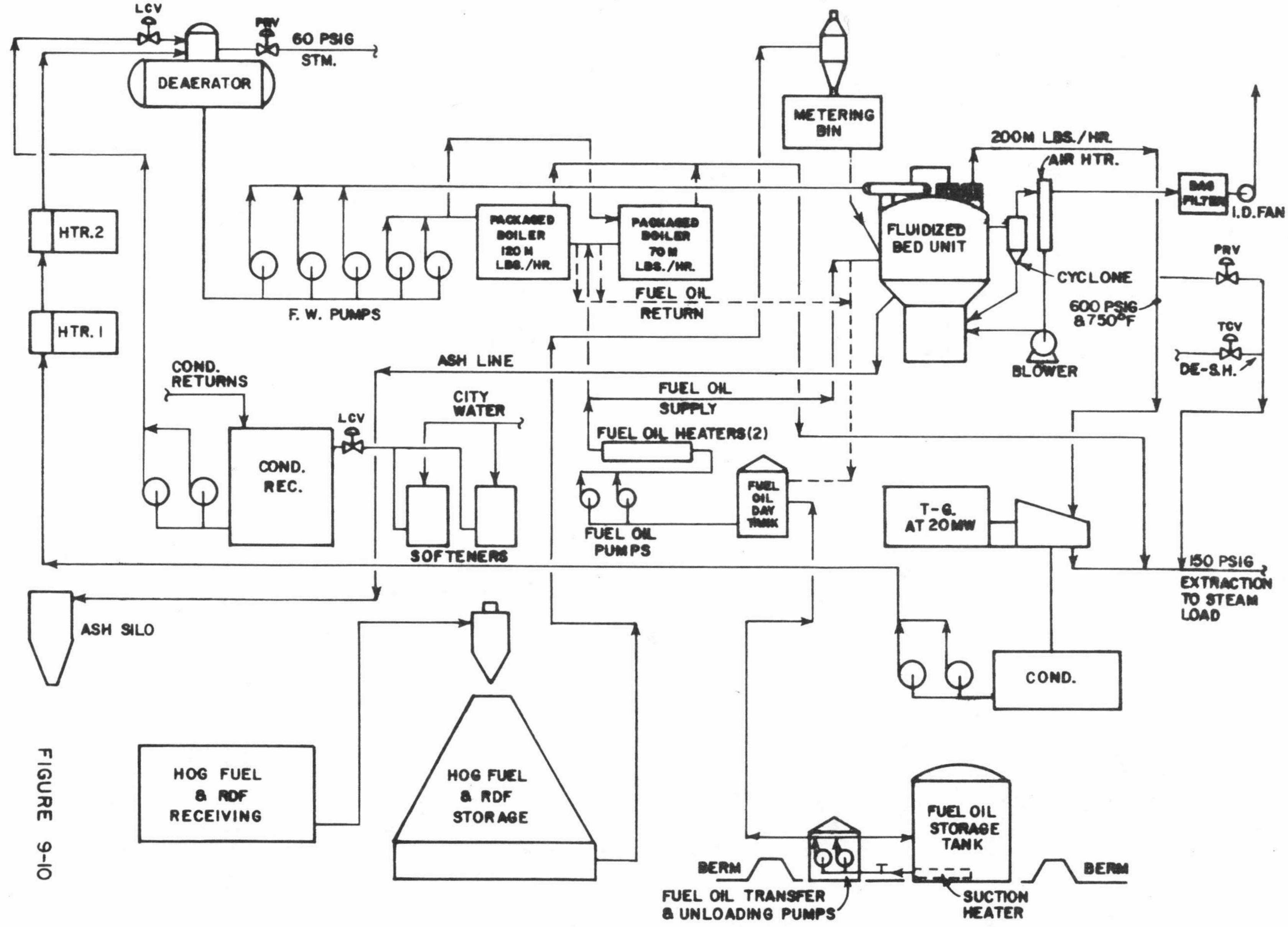


FIGURE 9-10

Figure 9-11 is a schematic diagram of Alternative 9. Three 55 percent circulation pumps will pump water through the generators. The distribution piping system will be pressurized by an inert gas supply in the expansion tank connected to the return main. Three 55 percent distribution system circulation pumps will supply the HTHW to the distribution system. Pumps designed for high pressures and temperatures will be required to withstand the extreme operating conditions of the circulation system. Supply water conditions for this system will be 350°F/500 psia; the water will return at 250°F/350 psia. Flow through the distribution system at peak demand is estimated to be 2200 gallons per minute.

2. Alternative 10

The HTHW system of Alternative 10 produces 350°F high temperature hot water via a heat exchanger from 150 psig saturated steam. This system can be connected to any of the steam plants discussed in Alternatives 1-8. Excess steam production can be sold to industrial customers and/or used for electrical generation. The HTHW equipment can be remotely located, but there is no advantage to not having it at the central plant.

The hot water side of this system is shown in Figure 9-12. Makeup water will be treated, stored and subsequently mixed with return water on the suction side of the circulation pumps. Minimum system pressure will be maintained by a pressure pad of inert gas in the expansion tank connected to the return main. Two of three 55 percent distribution circulation pumps return water through one of the heat exchangers and to the distribution system. At peak heating demand 87,000 lbs/hr of 150 psig sat. steam is required to produce the HTHW.

3. HTHW Distribution System

Figure 9-13 depicts the HTHW distribution network conceptually designed to satisfy the heating requirements of the Tacoma CBD. The network is applicable to either of Alternatives 9 and 10. Each line shown represents a supply and return line of the size indicated.

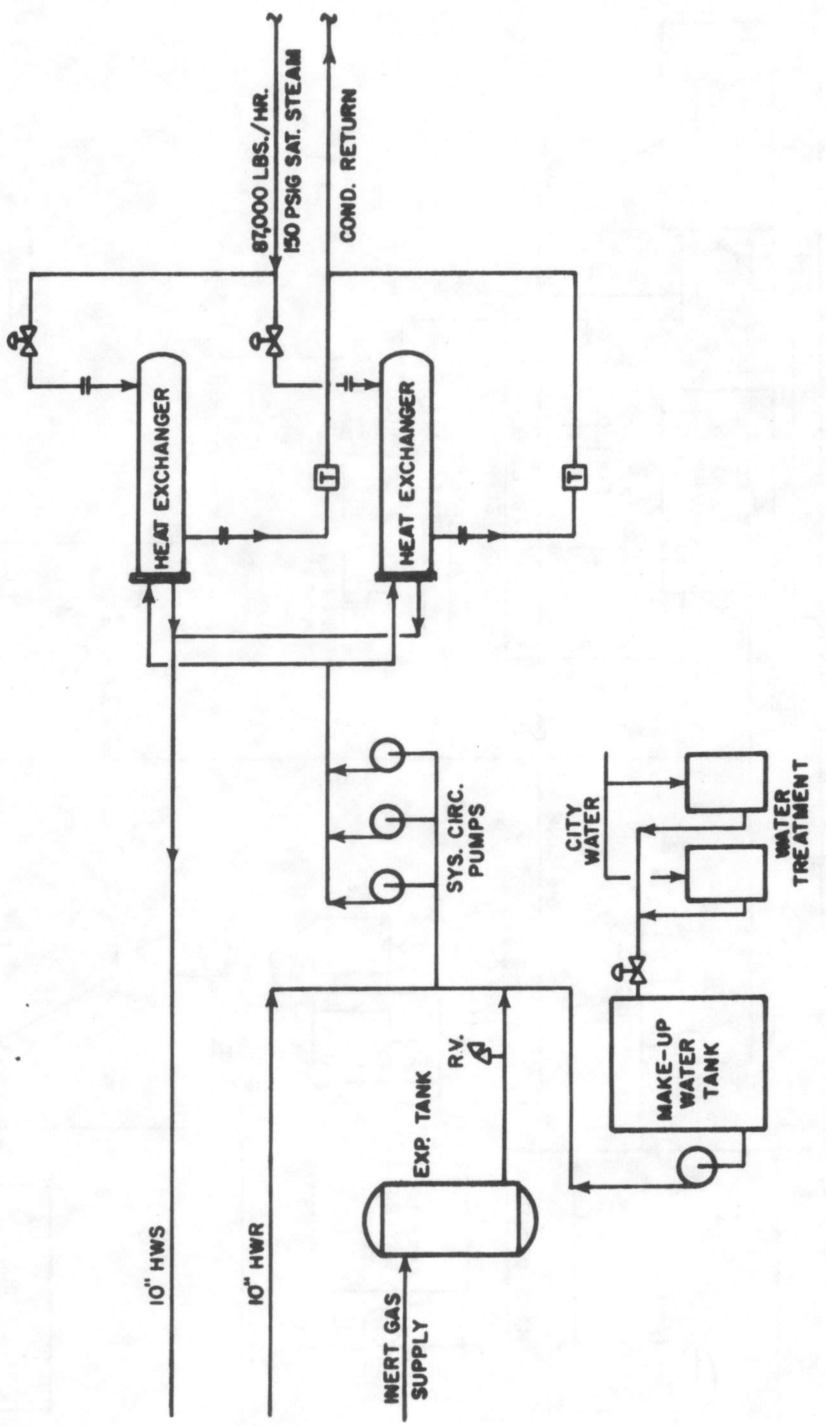
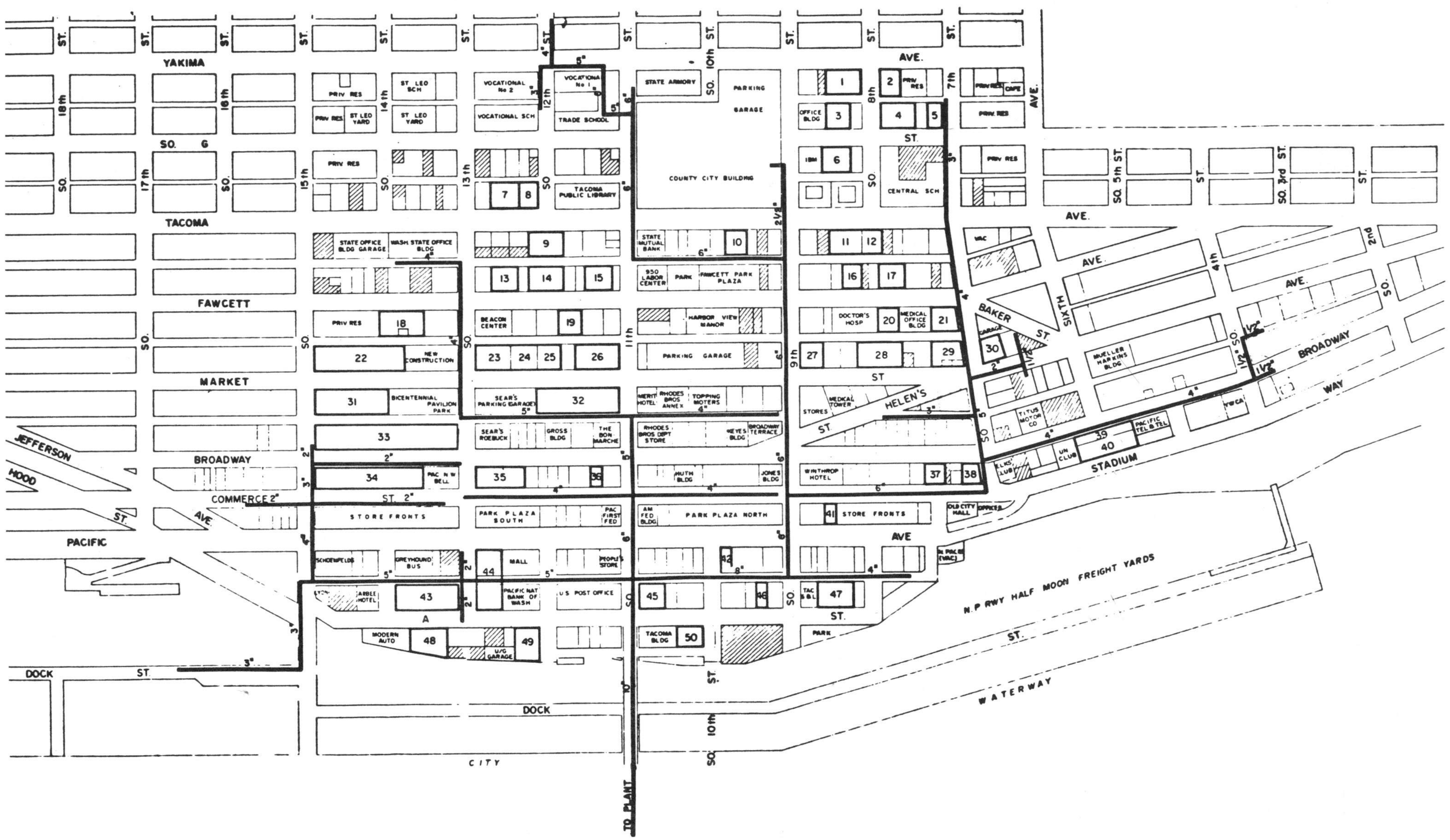


FIGURE 9-12

TITLE: ALTERNATIVE 10
SATELLITE HIGH TEMPERATURE HOT WATER PLANT FLOW DIAGRAM



1. VACANT LOT
2. SURFACE PARKING
3. SURFACE PARKING
4. SURFACE PARKING (CENTR. SCH)
5. SURFACE PARKING
6. SURFACE PARKING
7. VACANT LOT
8. SURFACE PARKING
9. SURFACE PARKING
10. VACANT LOT
11. SURFACE PARKING (TELEPH. CO.)
12. SURFACE PARKING (TAC. SCH.)
13. VACANT LOT
14. VACANT LOT
15. SURFACE PARKING
16. SURFACE PARKING
17. SURFACE PARKING (HOSP.)
18. VACANT LOT (BBQ)
19. SURFACE PARKING
20. SURFACE PARKING (MOB)
21. SURFACE PARKING (MOB)
22. VACANT LOT
23. VACANT LOT
24. SURFACE PARKING
25. VACANT LOT
26. VACANT LOT (FOR SALE-CITY TAL.)
27. SURFACE PARKING
28. SURFACE PARKING
29. SURFACE PARKING (VACANT BLDGS)
30. VACANT (STOREFRONTS)
31. SURFACE PARKING
32. SURFACE PARKING
33. SURFACE PARKING
34. SURFACE PARKING
35. VACANT LOT (FOR SALE-CITY TAL.)
36. SURFACE PARKING
37. VACANT LOT (BEV. PARKING)
38. SURFACE PARKING
39. VACANT LOT (HILLSIDE)
40. SURFACE PARKING
41. SURFACE PARKING
42. SURFACE PARKING
43. SURFACE PARKING
44. SURFACE & U/G PARKING
45. SURFACE PARKING
46. SURFACE PARKING
47. SURFACE PARKING
48. SURFACE PARKING (PUGET SOUND)
49. SURFACE PARKING
50. SURFACE PARKING

FIGURE 9-13

TACOMA REFUSE FIRED COMBUSTOR STUDY

HIGH TEMPERATURE HOT WATER DISTRIBUTION SYSTEM

HENNINGSON, DURHAM & RICHARDSON

G. STEAM FURNISHED BY ST. REGIS PAPER COMPANY, LUMBER & PLYWOOD DIVISION

1. Alternative 11

During the latter part of this project, meetings were held between the City of Tacoma and representatives of the St. Regis Paper Company, Lumber & Plywood Division concerning joint development of a central energy plant to serve the CBD and the St. Regis load on a firm basis. An alternative discussed included, St. Regis could install air pollution control equipment on their two hog fuel fired dutch oven boilers. With this modification, the two boilers could be operated at their rated capacity, Unit 13-60,000 lbs/hr and Unit - 80,000 lbs/hr. Furthermore, a hog fuel gasification facility is being actively discussed to supply gaseous fuel to their existing 70,000 lbs/hr B&W gas/oil fired packaged boiler as a St. Regis R&D project. The steam plant would then have a total generating capacity of 210,000 lbs/hr. This would potentially be sufficient to supply steam for the plant requirements of the St. Regis Paper Company, Lumber & Plywood Division and to the district heating system on a firm basis up to a maximum demand of 100,000 lbs/hr. This system would adequately serve the current district heating load, but would be capacity limited and unable to accommodate any significant growth of the heating load.

2. District Heating System Administration

A new entity will have to be created to administer and maintain the district heating system and to finance the 14 inch steam line required to connect the distribution piping system to the St. Regis Paper Company, Lumber & Plywood Division steam plant. This could be a new Corporation created by the present customers of the consumers Central District Heating Company or a new Utility unit formed by the City of Tacoma. This function could also be assigned to one of the existing utilities of the City of Tacoma.

CHAPTER TEN

FEASIBILITY ANALYSIS

A. INTRODUCTION

Many considerations contribute to the determination of the feasibility of generating energy products from the burning of waste fuels. These considerations could be grouped into the following four general catagories:

- Economic
- Technical
- Political
- Environmental

The environmental considerations were reviewed in CHAPTER EIGHT. The political considerations are beyond the scope of this study, but they must be recognized by the decision-makers. Based on the technical considerations presented in CHAPTER FIVE, eleven alternatives were developed in CHAPTER NINE to determine the viability of converting waste fuels into more useful forms of energy. The purpose of this chapter is to present the economic analysis of these alternatives.

Because each alternative converts waste fuels into a more useful energy form, the consultant selected the following procedure: All alternatives will be compared in a static comparison (current costs vs anticipated revenues based on a one year time frame) using 1978 dollars. The costs computed will be the "break-even" net facility energy value which includes capital amortization, operation and maintenance costs including the transportation and disposal of all ash residues. This break-even energy value is the price per unit of energy which must be charged by the steam plant in order to exactly offset all net costs. This static (one year) comparison is based on the assumption that changes in costs over the study period will affect each alternative equally so that the relative difference between alternatives will remain approximately equal. After the best waste fuel fired alternatives have been identified, they will be compared to the concept of converting the heating load to an all-electric system. Because the relative impact of higher electric energy rates will impact the alternatives differently, a dynamic cost analysis will be computed over a specific time frame (1980-2000). A financial analysis computer program will be used to determine the "break even" energy value required in each year for each of the alternatives. The capital costs of each alternative are escalated to 1980 dollars and amortized initially at eight percent over twenty years.

All other cost factors will be based on 1978 estimates escalated at a fixed percent per year to each respective year between 1980 and 2000. After the best alternatives have been selected, a sensitivity analysis will be computed as the final step in assessing fiscal feasibility for the first ten alternatives. Alternative 11 will be analyzed separately as it is not directly comparable to the first ten alternatives.

B. ECONOMIC ANALYSIS

1. Static Comparison

The ten alternatives are variations of the basic combustion facility that converts such fuels as hog fuel, RDF and fuel oil into more useful energy products, i. e. steam, high temperature hot water and/or electricity. The following discussion documents the economic costs of the first ten alternatives identified in CHAPTER NINE. The procedure used in comparing the alternatives is to calculate the "break-even net facility cost" ($/unit of energy) using 1978 base year dollars.

The net facility cost is made up of the following components:

a. Capital costs amortized over a twenty year time frame (1980-2000).

b. Annual O&M Costs.

A. The Capital Costs include:

1. Land
   The cost of its acquisition.

2. Equipment
   Buildings, steam or steam/turbogenerator system, storage, piping, controls, spare parts, handling equipment, pumps and associated equipment.

3. Steam Distribution System
   Pipes, controls, excavation, backfill.

4. Sales Tax
   5.5% of the Equipment Costs.

5. Fees
   Engineering, Legal and Administrative Fees - Estimated to be 10 percent.

6. Financing Cost
   Based on a review of similar type projects financed through the revenue bond method, a 30 percent average

financing charge was selected as an expected cost of financing. This financing costs include:

a. Bond Discount
b. Capitalized interest during construction.
c. Capitalized principal and interest (1st year)
d. Start-up costs (6 months of estimated O&M costs)

Minus

Interest earned on

1. Capitalized interest during construction
2. Start-up costs
3. 1st year principal & interest

This cost must be added to the construction costs to adequately finance the facility.

B. The Annual Operating and Maintance Costs include:

1. Fuel
   The facility may operate on hog fuel, wood chips, RDF, fuel oil or on a combination of the above. Market values used in the analysis are $0. 72/mmBtus of RDF hog fuel and wood chips and $2. 15/mmBtus for fuel oil.

2. Electricity
   Purchased from the City of Tacoma using Schedule D.

3. Water
   Purchased from the City of Tacoma using their variable rate Schedule (e. g., $0. 10/ccf)

4. Water Treatment
   Such internal treatment as required for the removal of corrosive elements. Liquid effluents generated by the facility will be discharged to the City of Tacoma sewerage system.

5. Labor
   Includes supervision, operation and maintenance personnel to man the facility on a 24 hour basis.

6. Maintenance
   Includes parts, vehicles and equipment for the combustion system and energy distribution system.

7. Ash Disposal
   Includes transportation and disposal costs for all residues. The City of Tacoma sanitary landfill is assumed to be the disposal site.

Capital and operating costs of the alternatives are shown in Appendix C. Table 10-1 summarizes the static cost comparison. Assumptions used in computing these costs are listed as notes on Table 10-1. The capital and annual costs presented in Table 10-1 are based on early 1978 dollars and reflect quotations from equipment vendors and the consultants prior experience in designing similar type projects.

The "break-even" energy costs listed on Table 10-1 for all alternatives with the exception of Alternative 9 are based on full load operating annual conditions. Alternative 9 (HTHW System) is designed to serve the heating load of the CBD only. It does not have the capability of serving industrial customers with steam. To reflect projected average demand conditions, Alternative 9's break-even costs were computed for 50 mmBtu's/hr service even through the design capacity is 115 mmBtu's/hr to accommodate future peak demands. This also matches the capacity of the existing central plant.

The static comparison (one-year) presented in Table 10-1 indicated three significant findings:

- The fluidized bed combustion systems have a lower net energy cost than equivalent boiler systems. The lower costs are the result of a smaller building requirement and higher combustion efficiency for fluidized bed systems.

- The cogeneration systems have a higher net energy price than the steam only systems when electrical revenues (1978 dollars) are based on one cent per kilowatt hour.

- Operating at full load, the larger capacity (200,000 lbs/hr) units had lower net energy costs than comparable systems with smaller capacity (125,000 lbs/hr). This finding is based on the assumption that adequate markets can be developed to sell the excess steam produced by the larger unit.

- The break-even cost of the HTHW system, Alternative 9, is not competitive with the other heating alternatives because of lower annual consumption.

Because a firm market committment has not been obtained from the industrial customers, the impact of reduced loads were computed for the 125,000 lbs/hr and 200,000 lbs/hr fluidized bed systems.

TABLE 10-1

COST SUMMARY OF ENERGY ALTERNATIVES
(Static Comparison)

	Conventional Boiler				Fluidized Bed Boiler				Conventional Boiler	Fluidized Bed
	Alternative 1 125,000 pph Steam	Alternative 2 125,000 pph Steam/Electric	Alternative 3 200,000 pph Steam	Alternative 4 200,000 pph Steam/Electric	Alternative 5 125,000 pph Steam	Alternative 6 125,000 pph Steam/Electric	Alternative 7 200,000 pph Steam	Alternative 8 200,000 pph Steam/Electric	Alternative 9 HTHW* Serves the CBD only	Alternative 10 Steam/HTHW
1978 Project Cost Includes										
Capital & Financing	$18,788,000	$26,909,000	$24,060,000	$34,185,000	$18,287,000	$25,630,000	$23,054,000	$33,002,000	$25,216,000	$30,382,000
1980 Project Costs (1978 Project Cost escalated to 1980 - 7%/2 years)	21,510,000	30,808,000	27,547,000	39,138,000	20,913,000	29,216,000	26,395,000	37,784,000	28,870,000	34,784,000
O&M 1978	2,002,600	2,332,700	2,915,700	3,468,800	1,974,300	2,296,000	2,830,500	3,386,800	1,010,500	2,662,900
Amortization (1978$) (8% - 20 years)	1,913,600	2,740,700	2,451,000	3,482,000	1,859,500	2,610,400	2,348,000	3,362,000	2,568,000	3,094,400
Annual Cost (1978$)	3,916,200	5,073,400	5,366,200	6,950,800	3,833,800	4,906,400	5,178,500	6,748,800	3,578,500	5,757,300
Steam Cost/1000 # (1)	$4.77	$6.16	$4.08	$5.28	$4.67	$6.97	$3.94	$5.14	$9.08	$4.06
Steam Cost/1000 # with Elect Credit (2)	---	5.74	---	4.84	---	5.55	---	4.69	---	---

Note:

(1) Steam sales are based on obtaining revenues for 75 percent of the steam generated by the facility operating 8760 hours per year.

(2) Co-generation alternatives include sale of electrical energy obtained from topping turbines. Revenue based on $0.01/KWH and 8400 hrs/yr operation.

* HTHW system has 115 mmBtus/hr capacity to accommodate peak demand, annual cost are computed on serving the projected average demand (50 mmBtus/hr). Capital costs listed do not include user modifications to use HTHW in lieu of low pressure steam.

(3) The cost per 1000 lbs. is an average value and that actual costs to individual users will vary with consumption quantities.

Figure 10-1 illustrates graphically the cost comparison per 1000 lbs. of steam sold for the "steam only" and two co-generation cases (electric revenues at 1¢/KWH and 1.5¢/KWH) using the 125,000 lbs/hr fluidized bed system. Figure 10-2 depicts the same comparison for the 200,000 lbs/hr fluidized bed system.

As was the case with the full-load comparison (Table 10-1), the co-generation cases had a higher break-even steam cost than the "steam only" system. To be competitive with the "steam only" system, the sale of electrical energy from the co-generation system would have to be approximately 27 to 30 mills per kwh based on 1978 dollars. The average current price for electrical energy to large users in the Tacoma area is less than 10 mills.

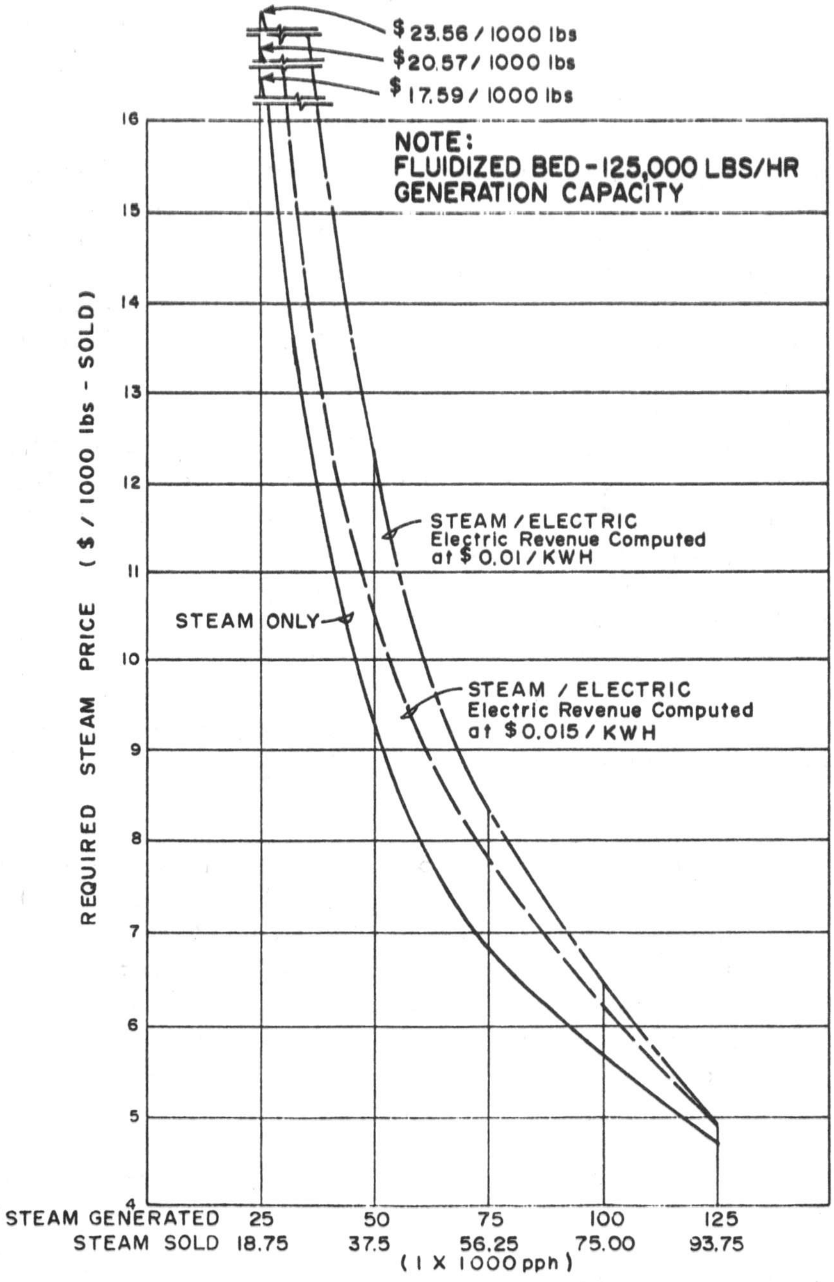
By inspection of Figures 10-1 and 10-2, the break-even cost per 1000 lbs. increases dramatically as the quantity of steam sold is reduced. For example, at full load, the 200,000 lbs/hr system has a break-even steam cost of $3.94/1000 lbs compared to $4.67/1000 lbs. for the 125,000 lbs/hr system. But if the demand is reduced to 75,000 lbs/hr steam sold, the 200,000 lbs/hr system break-even cost is $6.70/1000 lbs versus $5.80/1000 lbs for the 125,000 lbs/hr system. At a lower demand, the cost differential becomes even larger. For example when 50,000 lbs/hr of steam are generated for sale by both systems, the 125,000 lbs/hr system break-even cost is $9.20/1000 lbs versus $10.80/1000 lbs for 200,000 lbs/hr system.

Based on the static comparison the steam only systems have the lowest break-even cost for both design capacities (125,000 lbs/hr and 200,000 lbs/hr) evaluated. Furthermore, because the required electric revenues in 1978 dollars would have to be approximately three times larger (30 mills compared to 10 mills), the continued evaluation of co-generation in the dynamic cost analysis does not appear to be warranted. Therefore, a dynamic analysis will be conducted for both design capacities (125,000 lbs/hr and 200,000 lbs/hr) for the steam only system.

The two steam generating capacities were selected based on the following criteria:

1. 125,000 lbs/hr facility would serve primarily the central business district of Tacoma and have adequate reserve capacity to serve the central business district to the year 2000, any excess steam generated would be sold to industrial customers on an interruptable basis.

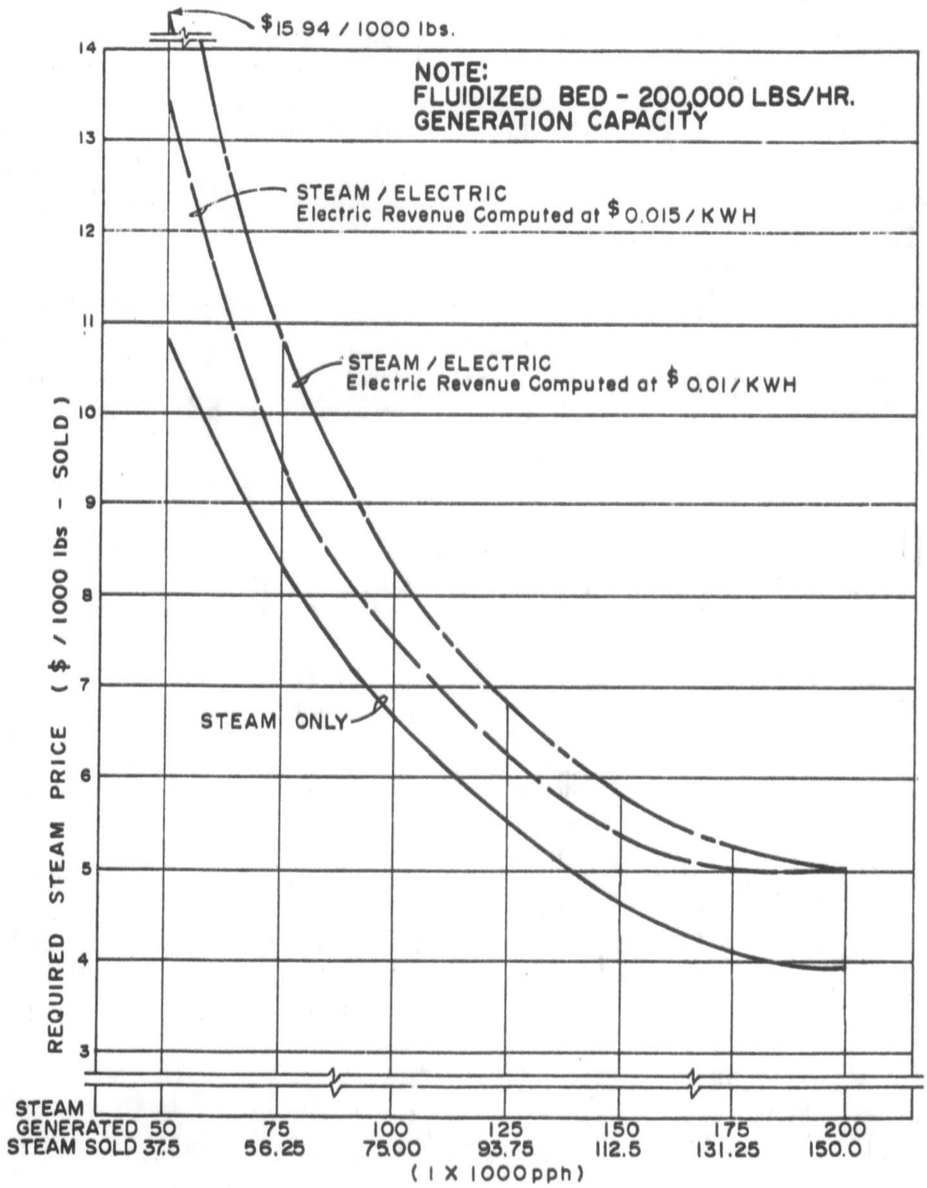
2. The 200,000 lbs/hr facility would have the capacity to serve the central business district and local industrial customers on a firm basis through the year 2000.



REQUIRED STEAM PRICE Vs STEAM SOLD
COMPARISON OF STEAM Vs. CO-GENERATION ALTERNATIVES

TACOMA REFUSE FIRED COMBUSTOR STUDY

FIGURE 10-1



REQUIRED STEAM PRICE Vs STEAM SOLD
COMPARISON OF STEAM Vs.
CO-GENERATION ALTERNATIVES

TACOMA REFUSE FIRED COMBUSTOR STUDY

FIGURE 10-2

3. The consultant further assumes sufficient users can be attracted from the central business district area to make the facility viable.

The previous analysis indicated that a "steam only" fluidized bed system would be the most attractive energy alternative if a central energy plant were constructed to serve the CBD. The options available to building owners in the CBD are to use the central system or convert individually to an all-electric heating system. Because the calculation of the capital cost of such a conversion for each building is beyond the scope of this project, the consultant has estimated the typical conversion costs that would be incurred on an individual basis.

Table 10-2 lists the typical cost of electrode boilers applicable to buildings in the central business district. The boiler costs listed do not include installation costs. In general terms the installation costs could range from 50 to 200 percent of the boiler costs.

TABLE 10-2

Representative Electrode Steam Boiler Prices
(Rated to 60 psig Pressure)
(Jan 1978 $)

Steam Output (lbs/hr)	KWD 480 Volt	Control Steps	Wt. (lbs)	Cost ($)
1080	360	5	2870	10,100
1620	540	7	4150	12,900
2520	864	12	6300	20,600
3060	1008	14	6500	22,800

Source: Patterson-Kelly, Inc.

Table 10-3 lists the steam costs per 1000 lbs based on one, two and three cents per kilowatt hour. Electric rate assumptions used to compute the unit steam cost include:

1 HP-Hr - 2544 Btu
1 HP-Hr - 0.746 kwhr
1 Btu - 0.000293 kwhr

1000 lbs. of steam equates to 1,007,000 Btu
Electrode boiler efficiency is 98 percent
All other non-power costs of steam production are $0.05/1000 lbs.

TABLE 10-3

Unit Steam Costs - Electrode Boilers
(1978$)

Cost (¢/kwhr)	Power Costs ($/1000 lbs)	Other Costs ($/1000 lbs)	Total Cost ($/1000 lbs)
1	3.01	0.05	3.06
2	6.02	0.05	6.07
3	9.03	0.05	9.08

In the subsequent dynamic cost analysis because of the unknown electrode boiler capital cost and the long term amortization rates used with the waste fired systems (8% - 20 years), the consultant will use the operational cost as the average annual unit cost of an all-electric heating system.

2. Dynamic Cost Analysis

To reflect long term conditions, a dynamic life-cycle analysis was computed for the following alternatives:

- 125,000 lbs/hr capacity fluidized bed steam generator
- 200,000 lbs/hr capacity fluidized bed steam generator
- Individual electrode boiler system serving the CBD

Assumptions used in the analysis were:

- Estimated capital costs (1978$) would escalate seven percent per year with construction completed in 1980.
- Operation and maintenance costs would escalate seven percent annually through the project period (1980 to 2000).
- The typical 1980 electric rates would be between 15 to 20 mills per kilowatt hour.
- Various levels of service would be computed for two fluidized bed alternatives.

Findings of the dynamic analysis will be discussed in the subsequent paragraphs. Computer summary reports of the two waste fired alternatives can be reviewed in Appendix C.

Figure 10-3 depicts the "break-even" energy cost of the small fluidized bed system operating at various levels of service along with the escalated electric boiler energy cost for the study period. Figure 10-4 graphically illustrates the same analysis for the large fluidized bed system.

Because the demand of the industrial market is unknown as well as the 1980 cost of electric energy, the life cycle analysis presented in Figure 10-3 and 10-4 indicate two obvious findings:

- A larger energy market yields the lower "break-even" energy cost.
- The cross over point where the waste fuel fired alternatives have a lower break-even energy price then the electrode boiler is strongly dependent on the initial electric rates.

C. SENSITIVITY ANALYSIS

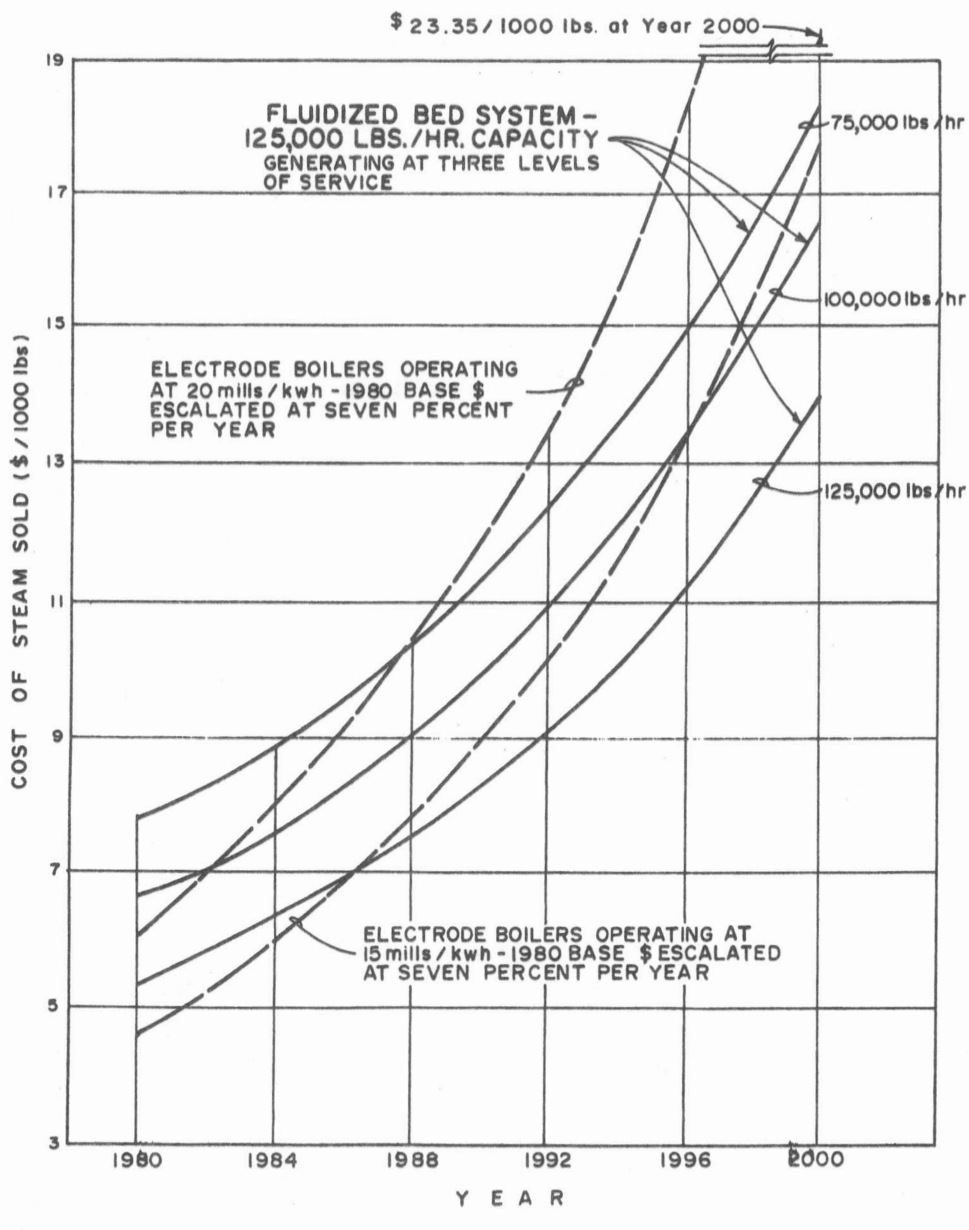
The static and dynamic cost comparison presented previously were based on certain assumptions that impact significantly on the feasibility analysis of this project. These assumptions will be discussed in the following paragraphs.

1. Capital Amortization

An eight percent capital amortization rate was used to compare annual costs of all alternatives. This rate reflects prevailing revenue bond financing cost. A lower rate would reduce the required break-even energy cost of each alternative. To test the impact of reduced capital interest rates, a six percent rate will be computed dynamically (20 year period) for the steam only alternatives, 125,000 lbs/hr and 200,000 lbs/hr.

2. Annual Escalation Rates

The dynamic cost analysis was based on the assumption that annual costs, excluding fixed amortized capital costs, would escalated at seven percent per year. This assumption was selected to reflect the anticipated inflation rate over the study period. While inflation is a determinant, it is significant when comparing various alternatives with differing fixed and variable costs over a life-cycle period.

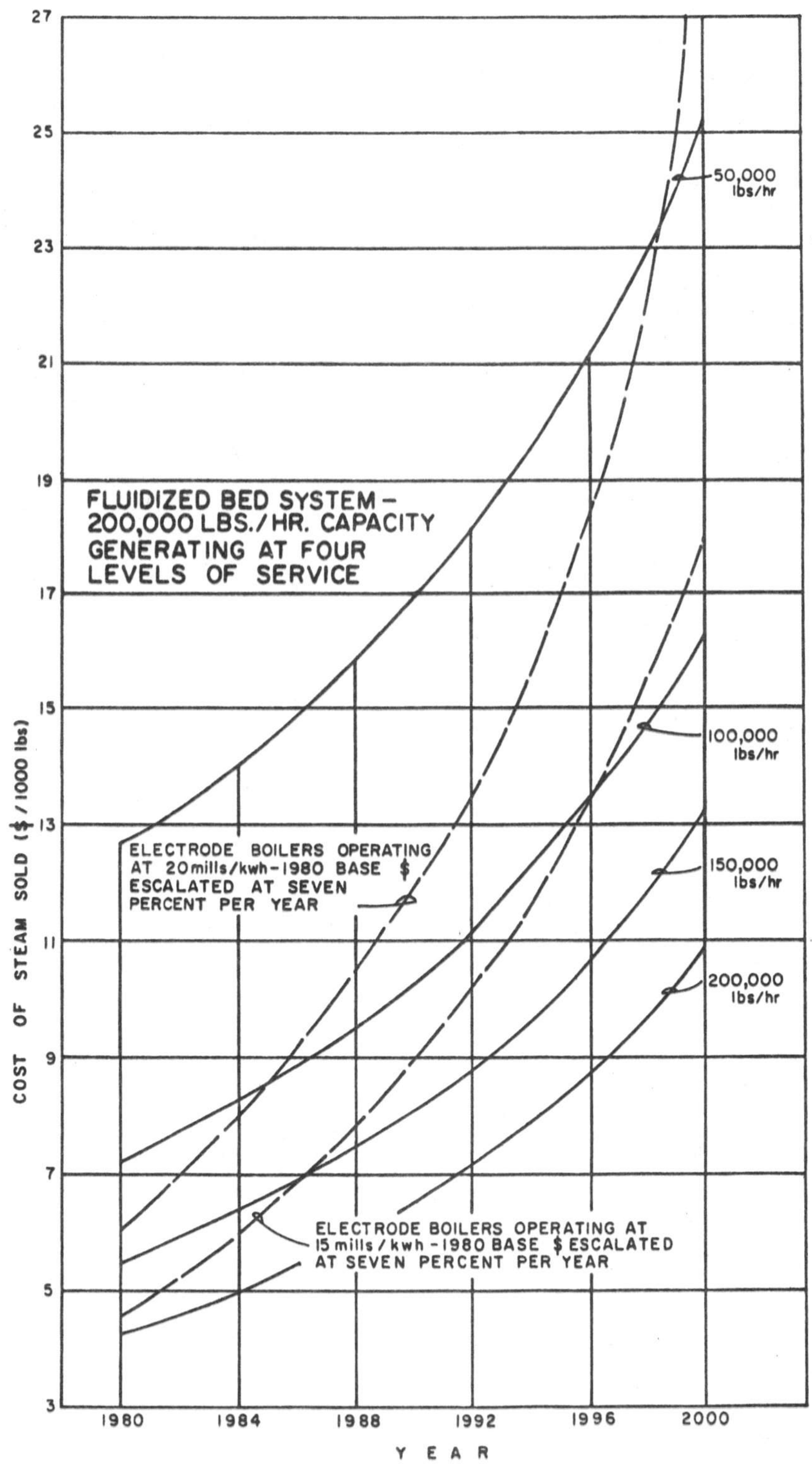


LIFE CYCLE COST ANALYSIS

COMPARISON OF STEAM ONLY Vs. ELECTRODE BOILER SERVICE

TACOMA REFUSE FIRED COMBUSTOR STUDY

FIGURE 10-3



LIFE CYCLE COST ANALYSIS

COMPARISON OF STEAM ONLY
Vs. ELECTRODE BOILER SERVICE

TACOMA REFUSE FIRED COMBUSTOR STUDY

FIGURE 10-4

For this project a seven percent annual rate was used to escalate the variable costs of each alternative. To determine the long term impact of a lower and higher escalation rate, a dynamic cost comparison will be computed for the two fluidized bed steam alternatives using a six percent and an eight percent annual escalation rate.

3. Sensitivity Analysis

Figures 10-5 and 10-6 graphically illustrate the sensitivity analysis superimposed on the break-even electrode boiler costs presented previously in the dynamic cost comparison.

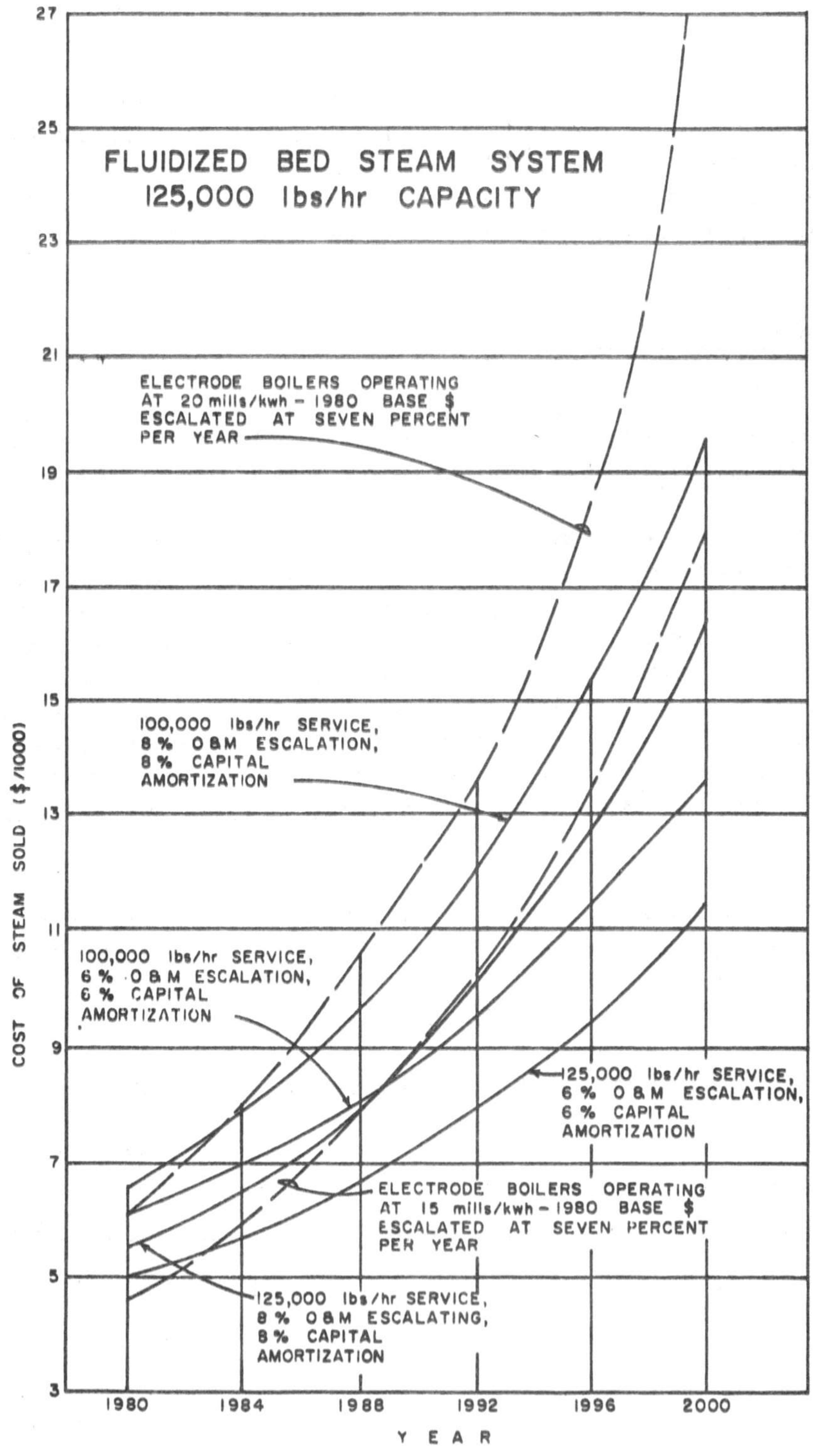
To illustrate the range of costs, cost envelopes are depicted to indicate the break-even cost at different service levels of the two alternatives. For example, a projected cost is computed for a six percent capital amortization rate six percent annual escalation rate and an eight percent capital amortization rate - eight percent annual escalation rate for the two steam alternatives based on 1978 dollar cost estimates. Certainly, a six percent capital amortization rate with an eight percent annual escalation rate could be incurred by the project owner, but its projected cost would be within the upper and lower break-even cost extremes depicted on Figures 10-5 and 10-6.

Findings of this analysis for the 125,000 lbs/hr are summarized in Table 10-4. Summary reports for each alternative are listed in Appendix C.

TABLE 10-4

Summary of 125,000 lbs/hr Sensitivity Analysis

Output lbs/hr	Amortization %	Escalation %	1980	YEAR 1990 ($/1000 lbs)	2000
125,000	6	6	4.99	7.25	11.31
	8	8	5.46	8.90	16.34
100,000	6	6	6.06	8.75	13.57
	8	8	6.63	10.73	19.56
75,000	6	6	7.10	9.92	14.96
	8	8	7.83	12.12	21.37

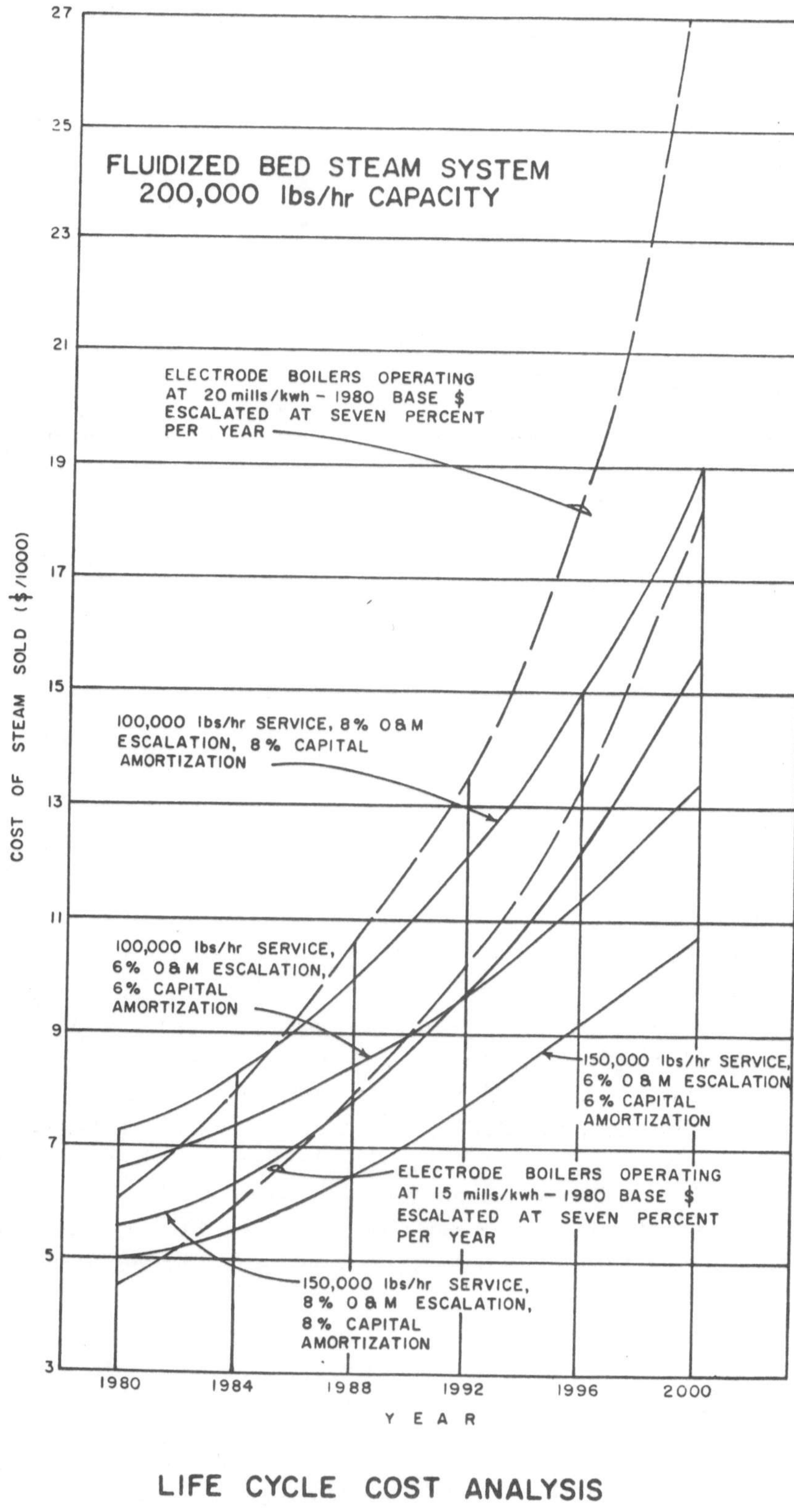


LIFE CYCLE COST ANALYSIS

SENSITIVITY ANALYSIS OF 125,000 LBS./HR. SYSTEM USING VARYING AMORTIZATION AND O&M ESCALATION RATES

TACOMA REFUSE FIRED COMBUSTOR STUDY

FIGURE 10-5



LIFE CYCLE COST ANALYSIS

SENSITIVITY ANALYSIS OF 200,000 LBS./HR. SYSTEM USING VARYING AMORTIZATION AND O&M ESCALATION RATES

TACOMA REFUSE FIRED COMBUSTOR STUDY

FIGURE 10-6

Table 10-5 summarizes the 200,000 lbs/hr sensitivity analysis presented graphically in Figure 10-7. Computer summary reports of this analysis can be reviewed in Appendix C.

TABLE 10-5

Summary of 200,000 lbs/hr Sensitivity Analysis

Output lbs/hr	Amortization %	Escalation %	1980	YEAR 1990 ($/1000 lbs)	2000
200,000	6	6	3.98	5.73	8.88
	8	8	4.35	7.03	12.81
150,000	6	6	4.99	7.09	10.85
	8	8	5.48	8.68	15.57
100,000	6	6	6.58	9.02	13.38
	8	8	7.29	11.00	19.00

Figures 10-5 and 10-6 and Tables 10-4 and 10-5 show that the relative impact of lower amortization and escalation rates is not significant until the later project years. For example, using the 125,000 lbs/hr system operating at full load, the 1980 six percent amortization - six percent escalation case has a break-even cost of $4.99/1000 lbs compared to $5.46/1000 lbs for the eight percent amortization rate and eight percent escalation case (a 9.4 percent difference). In the year 2000, based on the same full-load conditions, the six percent amortization, six percent escalation case has an estimated break-even cost of $11.31/1000 lbs versus $16.34/1000 lbs for the eight percent amortization - eight percent escalation case, (a 44.5 percent difference). Similar type cost increases are projected for varing levels of service for the two alternatives.

D. SUMMARY, FIRST 10 ALTERNATIVES

The feasibility analysis was computed for ten alternatives developed to serve the heating load of Tacoma's central business district. The alternatives were initially compared statically based on 1978 dollars and 1978 operating costs for full load conditions. The alternatives were then compared at different operating service levels (e.g. 75,000 lbs/hr, 100,000 lbs/hr, etc) to determine this impact on their respective break-even costs. The final analysis determined the dynamic cost of the most cost-effective alternatives identified from the static comparison and the sensitivity of reduced capital amortization rates and annual escalation rates on the break-even energy costs of the two alternatives.

The central energy alternatives are all highly capital intensive projects. The 125,000 lbs/hr fluidized bed steam system had the lowest capital cost, $18.257 million (1978$) and lowest construction cost $20.813 million (1980$). The 200,000 lbs/hr conventional boiler co-generation system had the highest capital cost, $34.185 million (1978$) and highest construction cost, 39.138 million (1980$). From the viewpoint of acquiring capital to construct the central energy complex, the smaller fluidized bed system would be the most attractive provided it had adequate capacity to serve the contracted energy market.

Based on the full load analysis presented in Table 10-1 (static comparison), the fluidized bed steam system had the lowest break-even energy cost for both design capacities. The 125,000 lbs/hr fluidized bed system had an estimated break-even cost (1978$) of $4.67/1000 lbs versus $3.94 /1000 lbs for the 200,000 lbs/hr fluidized bed steam alternative. The other alternative that approach the same competitive range of these two alternatives was Alternative 10, a 200,000 lbs/hr fluidized bed combustion system selling firm steam to the St. Regis Company and HTHW for heating purposes to the CBD. Alternative 10 had a break-even energy cost of $4.06/1000 lbs, but this cost did not include capital costs required for HTHW user modifications. This added cost would increase the break-even cost. Alternative 10 was judged not competitive with the fluidize bed alternative and eliminated from further consideration.

The co-generation alternatives were not competitive with the steam systems because the electric revenues did not offset the increased capital and annual costs incurred in the generation of electrical energy.

The dynamic cost analysis projected the break-even energy cost by year for the two fluidized bed steam systems. These costs were compared to the concept of serving the CBD's heating load with individual electrode boilers. The dynamic cost analysis indicated that an industrial customer is definitely required to supplement the CBD heating load. If adequate steam could be sold on an annual basis to both an industrial customer and the CBD, the CBD could be competitively served by a central energy plant provided the 1980 electric rates were a least 15 mills/KWH and escalated at seven percent rate per year. At a higher 1980 base year electric rate, the feasibility of the steam systems improves significantly.

The sensitivity analysis indicated the impact of a lower capital amortization and annual escalation rates on the break-even steam cost. Simply stated, lower rates equates to a reduced break-even energy cost.

Of the two steam alternatives developed, the 200,000 lbs/hr system would be the most attractive. It would have adequate capacity to serve both the CBD and the St. Regis Lumber and Plywood Division on a firm basis. The 125,000 lbs/hr system would be capacity-limited and would be unable to accommodate both markets during peak demand periods or accommodate future growth in the CBD.

In summation, the feasibility of serving the CBD heating load with a central energy plant is predicated on serving the industrial market of St. Regis. If St. Regis will not participate, the CBD would be served more cost effectively with individual electrode boilers. If St. Regis participates, the fluidized bed steam alternatives are the most cost-effective options for serving the CBD.

E. ALTERNATIVE 11

1. General

The St. Regis Paper Company, Lumber & Plywood Division would furnish steam on a firm basis to the district heating system under this alternative. However, the meter reading, customer billing, other administration functions and steam distribution piping maintenance will have to be performed by others. One possibility is that the City of Tacoma would assign these functions to one of their existing utilities or create a new utility for this purpose. Another possibility is to establish a new private corporation by the steam customers of the district heating system to perform the required administration and maintenance of the system.

The basic costs incurred in performing the administrative and maintenance functions will be essentially the same whether done by a municipal utility or a corporation, taxes and profit excluded. Accordingly, the operating cost estimates in the following parts of this section do not include any taxes or profits.

2. Steam Cost

According to City of Tacoma officials, the St Regis Paper Company, Lumber & Plywood Division is estimating a steam selling price to be competitive with other energy systems used to generate steam.

3. Operating Costs

The personnel requirements to perform the administrative and maintenance functions for the district heating system, based on the staff of the Consumers Central District Heating Company are as follows: one manager on a part time basis, one bookkeeper, one billing clerk, and one maintenance man-meter reader. A maintenance allowance has to be included in the rate to cover major piping replacement, when such is required, by a piping contractor. The annual cost of repaying the capital required to install the required 14 inch steam to connect the distribution piping system to the steam plant of the St. Regis Paper Company, Lumber & Plywood Division is based on borrowing the estimated sum of $950,000 at eight percent interest for twenty years. Other costs are office space rent and insurance. Office space was estimated on 800 square feet at an annual cost of $6.50 per square foot. These costs are listed below in Table 10-6. For estimating purposes annual steam sales are assumed to be 175,000,000 pounds. (Actual 1976 steam sales were 171,722,000 pounds).

TABLE 10-6

Estimated Annual Operating Costs Alternative No. 11

Item	Estimated Cost 1978 Dollars
Labor	52,000
Maintenance	45,000
Other Costs	10,200
Taxes @ 90% Gross Earnings	14,000
Capital Repayment	96,800
TOTAL	218,000

With steam sales of 175,000,000 lbs. (now only 121,000,000 lbs) per year, the cost per 1,000 lbs steam sold is $1.25.

4. Estimated Steam Cost

The steam selling price given by St. Regis will be competitive with other generation systems on a per thousand pounds of steam basis. The range of district heating heating system administration and maintenance costs is $1.25 to $1.80 per thousand pounds of steam sold. The total cost per thousand pounds of steam will be competitive with other energy sources used to generate steam.

CHAPTER ELEVEN

FINANCIAL & IMPLEMENTATION PLAN

A. INTRODUCTION

A central energy plant serving Tacoma's central business district and/or industrial customers is a highly capital intensive project requiring the sale of bonds to adequately finance the venture. The cost of financing the central energy plant is a substantial cost factor. The financing cost incurred is predicated on the risks associated with the project and the financing mechanisms used. Bond holders who invest their money in this type of project will look for security and an adequate return on their investment.

For this project, a financing cost of 30 percent was added to the capital cost to finance the project. This money was allocated to cover:

Bond Discount

Capitalized Interest During Construction

Capitalized 1 year Principal & Interest

Interest Earned on Investment Funds

Good technical plans and the best possible planning is of little value if the project is not financially feasible. Due to the high capital intensive cost of waste fuel fired energy systems most must be initially financed by borrowed money or bond funds. In addition to the best of technical plans and competent planning a good long term financial picture must be developed. The financial picture must include capital costs, expected operating costs, product sale guarantees (customers), secure sources of primary materials and a mechanism for deficient absorption.

There are five potential options available for financing and four options for operation of this project. They will be summarized in the following paragraphs. The ultimate method of financing of the project will be dependent upon the type of owner/operator selected and the degree of participation of other private entities in the study area. In addition the project, if undertaken as a joint public/private or private venture only, must comply with Internal Revenue Code and its regulations.

B. FINANCING ALTERNATIVES

There are five basic financing mechanisms available to provide the funds required for the construction of a central energy plant. The ultimate method of financing will depend upon the method of ownership/operation selected.

The various types of financing mechanisms are discussed in the following paragraphs. Each method is described and the consultant has commented on their respective applicability for this project.

1. General Indebtness Bond
2. Revenue Bond
   - Municipal
   - Industrial
   - Pollution Control
   - Waste Disposal Facility
3. Corporate
4. Leasing
5. Commercial Bank Loan
6. Federal & State Grants

1. General Indebtedness Bonds.

General Indebtedness Bonds are long-term tax exempt debt service instruments that are offered for sale on a competitive basis by municipalities. These obligations are backed by the full faith and credit of the public entity and voter approval is required prior to the issuance of General Indebtedness Bonds. This bond offers the lowest possible interest rate and is tax exempt. Currently, their interest rates vary from 5 to 7 percent. The interest rate is usually tied to the credit rating of the municipality.

For this project, financing by the route of Municipal General Indebtedness Bonds could be accomplished with approval of city authorities and a voter referendum. Their advantage would be the lowest interest cost of capital financing to the project.

2. Revenue Bonds.

Revenue Bonds are long-term lien instruments which are payable from the revenues that are generated through rentals, fees or rates of the project. Revenue Bonds are secured by the projects technology and its predicted ability to generate revenue. Revenue Bonds may be issued by any political entity in the State of Washington. Interest rates will vary dependent upon the project, the type of issue and the issuing authority. Generally interest rates range from 6.5 to 8. 5 percent on Revenue Bonds.

Revenue Bonds may be issued as Municipal Revenue Bonds, Industrial Bonds or Pollution Control Bonds. Revenue Bonds may be issued by the entity for its own project or in connection with a leased operation. Revenue Bonds are not an obligation of the City like General Indebtness Bonds. The project must stand on its merit to receive a favorable rating and subsequent bond sale. Revenue Bonds are tax exempt. A disadvantage of Revenue Bond financing is that long-term contracts are needed.

3. Corporate Bonds.

Corporate Bonds are bonds floated by private corporations to raise money for capital intensive projects. The debt is secured by the financial history of the issuing entity. Standard corporation laws govern the issuance of such bonds and no new ground must be covered. Bond interest of this type would be approximately 7-10 percent today and is constantly changing. They are not tax exempt. This type of financing is available for the Tacoma project if a private corporation or utility were to be owner/operator of the facility.

4. Leasing.

Leasing is defined as a contract by which one party (owner) gives another (user) the use and possession of lands, buildings and equipment for a specified period of time and for fixed payments. Although lease financing may involve complex arrangements, it is basically a revenue bond technique.

Important characteristics of leasing are:

a. Investment tax credit is not allowed on property used or leased by state or local agencies.

b. Demand on municipal investment is reduced, i.e., general obligation debt capacity is not consumed.

c. Lease financing can be instituted rather quickly.

d. Current leasing rates are higher than other methods of public financing.

e. Upon termination of the lease, the local government will neither own nor control the facility.

In Washington today, there are several different types of leasing contracts. The following narrative describes these methods:

a. Non-profit corporate leaseback contract organized for a public purpose can issue federal tax-exempt bonds for a solid waste project. The agency leaseback payments would be the guarantee for the purchasers of the revenue or corporate bonds. These bonds have a high rate and are not state tax-exempt.

b. Lease-purchase agreements may be yearly renewable contracts with the governmental agency whereby the lender can receive a portion of the lease payment as tax-free interest. The agency assumes title at completion of the lease.

c. True lease is a yearly lease agreement with the agency whereby the lessor receives tax depreciation but does not relinquish title or equity in the property.

d. Leverage leasing is a method of leasing whereby both the lessor and the lessee (government agency) provide capital. The lessor furnishes 20 to 30 percent of the project cost and the lessee finances the remaining 70 to 80 percent with a bond issue. The government agency enjoys the advantage of a lower net interest rate, normally below the G. O. rate, which in turn reduces agency out-of-pocket expenses. The lessor receives the advantages of an ownership tax shelter. The replacement of the funds is from the lessee to the lessor and then to the financial institution. At the end of the leasing period, however, the lessor becomes the owner of the facility.

At the present time, cities and counties in Washington may lease for periods not to exceed fifty years (RCW 35.42.010-200).

5. Commercial Bank Loans.

Commercial Bank Loans are standard financial sources for industry and business. Short and long-term borrowing occurs constantly in the market. The sum that one or more banks will lend is totally dependent on the project, the revenues generated from the project and the firms credit rating. This type of money is expensive as current interest rates vary from 10 to 14 percent. To a political entity rates are lower due to tax exempt status.

This method of financing is documented only to show the higher costs that might be involved if the project were to be financed totally by a private capital obtained by borrowing through commercial loans only. Furthermore, large long term loans are not available due to bank lending limits.

6. Federal Grants.

The Resource Conservation and Recovery Act of 1976 (Public Law 94-580) outlined the guidelines for participation by the Federal Government in Solid

Waste Management projects. Public Law 94-580's financial aid provisions are considered more in the nature of "seed money" and supplemental support of solid waste to energy resource recovery projects rather than the massive public works funding associated with wastewater treatment projects. In lieu of published statements by governmental officials currently developing an implementation strategy, the probability of Federal Grants to construct a large scale resource recovery system in Tacoma, Washington is judged doubtful by the Consultant. In general, the Federal government wants to provide the economic incentive without their actual participation in the construction, ownership and operation of such project.

7. State Grants.

The State of Washington passed a Waste Disposal Facilities Bond Issue (RCW 43.83A) in 1972 for the purpose of issuing grants or loans to public bodies. The loans or grants are to encourage long-range development plans for the integration of disposal of liquid and solid wastes. In addition Washington futures (authorized under RCW 70-95) will consider up to 50 percent grants to public bodies for the construction of physical facilities to process wastes into useful materials. Conservatively central energy plant burning refuse derived fuel could be a logical extension of the resource recovery disposal concept. If this project is judged feasible, grant money provided by the State of Washington should be completely investigated.

C. OWNERSHIP AND OPERATION ALTERNATIVES

1. General

There are four basic owner/operator alternatives available for consideration. This section will describe these methods and discuss the various combinations available to Tacoma. The methods of owner/operator are as follows:

- Municipal Owned - Municipal or Private Operation
- Private Owned - Private or Municipal Operation
- Authority Owned - Authority or Private Operation
- Public Utility

2. Municipal Ownership and Operation

A Municipal entity by virtue of its direct authorization of project funding through either General Indebtness Bonds or Municipal Revenue Bonds, may elect to build, own and operate its own facility. The entity would obtain the necessary financing, contract for the engineering, let construction contracts and provide operating personnel. It would thus own the facility, assume the bond indebtedness and operational responsibility for the facility. It also would set rates and make such rules and regulations as are necessary for efficient operations. An operation of this type would usually fall under a department within the municipal structure such as the Public Works Department.

Advantages of the Municipal owner/operator concept include total control of operation and the elimination of contractor operational profits. The major disadvantage may be the lack of municipal experties in such operations and the fact that the municipality bears full fiscal responsibility.

3. Municipal Owned/Other Operators

As discussed in Municipal Ownership/Operation the entity would authorize funding of the project through either General Indebtness Bonds or Municipal Revenue Bonds and would elect to build and own the facility. Once built the entity may elect to lease the facility to either a private company or to an municipally formed authority. The entity would receive a lease fee that would cover all debt service payments and expenses incurred by the entity for the project. It would also be in a position to exercise some control over the operation and its rates. Ownership of the facility would remain in the municipality.

The advantage of this system of operation lies mainly in the knowledge and experience of the contractor and his flexibility. Disadvantages include entity loss of control, potential disruption of service due to contractor failure, contractors profit and potential misunderstanding about repairs, etc. of the facility.

4. Quasi-Public/Private Corporation

An entity set up by the City on a non-profit basis having the power to issue tax exempt revenue bonds is called a Quasi-Public Corporation. Quasi is latin for "As if". The corporation directors are appointed by the City and conduct operations "as if" it were a private corporation.

Advantages are that it enjoys certain tax advantages, relieves the City of the long-term capital expense, is able to issue tax free revenue bonds and the facility reverts back to City ownership upon retirement of the revenue bonds.

Public Utility is an extension of the Quasi-Public Corporation on a profit motive basis. It is set-up as a private corporation and operated under state law being regulated by the City and State regulatory commissions. Such Public Utilities are common and the City of Tacoma is an example. If they were interested the City could lease or sell the project to them for operation.

The advantages of this method is that a public utility can move within its framework faster than the City and being profit motivated could be more efficient than strictly a municipal operation. Disadvantages to the City are loss of control and possible additional cost due to profits due the utility.

5. Private Ownership

A project of this type may be attractive enough to promote private ownership. A private entity with available financing and experience may elect to build, own and operate a facility of this type for the purpose of generating a profit. A prerequisite to this type of ownership would, of necessity, be long-term contracts or operating subsidies. The public entity should maintain some form of control over the rates to be charged.

The advantage of this operation is that it would eliminate the need of public entity financing, utilization of private experience and the investment tax credits available to private entities.

Potential disadvantages are loss of control of operation, disruption of service due to strikes or bankruptcy, additional costs incurred due to contractor profit and the wisdom of being locked into a long-term contract.

D. IMPLEMENTATION ALTERNATIVES

Important roles are available for both the Public and Private sector to participate in the implementation of this project. To date, the Tacoma project has been funded by the City of Tacoma.

The implementation of the Tacoma project will require strong public participation to insure a cost effective system. The Consultant assumes that the City of Tacoma together with strong participation from downtown Tacoma business, will act as a local catalyst in the implementation of the recommended central energy facility.

1. Conventional A/E Approach

a. City Owned-City Operated

The conventional A/E approach is the traditional method used by local government to procure public buildings and other projects. In this approach, the first step is to hire an Architect/Engineer consultant to design the facility and develop detailed drawings and specifications. The second step is to obtain the construction, material and equipment through competitive bidding. Although this method gives local government full control of the project, it places the responsibility of system implementation, including initial process performance on the local governmental agency. Ames, Iowa, utilized this implementation alternative in developing their resource recovery facility.

b. City Owned - Contract Operated

The lead public entity may employ a modification of the conventional A/E approach by awarding a management contract to a private firm for operation of the central energy facility. The operator may be paid a management fee based on a percentage of the annual operating and maintenance costs. The percentage fee (normally 10 - 12%) is a negotiable factor. Hiring and training personnel, plant supervision and routine operation and maintenance are tasks performed by the hired operator. The management contract reduces the public sector involvement in the daily plant operation, although it does not diminsh their overall responsibility for the project.

Another modification of the conventional A/E approach would place total responsibility for plant operation and maintenance on the private operator. In this alternative, the private operator is brought in for consultation with the A/E during the design phase. The public sector guarantees the dump fee and minimum tonnage which will be delivered to the facility. This becomes the basis for a "put or pay" contract, where the public sector must pay an established annual dump fee to the operator whether or not the required minimum tonnage is delivered. Compensation for the private contractor is negotiable but normally averages 25 percent of the operating and maintenance costs.

2. Modified A/E With Construction Management

The principal difference between this alternative and the conventional A/E approach is that in the Modified A/E approach, a construction manager is retained to shorten the implementation period. The construction manager is involved in the planning phases of the project through construction. It is the construction manager's responsibility to contribute construction expertise to early design decisions made by the project team. Knowledge of local availability of labor and materials, recommendations regarding procurement of long lead time items, and advice on contract packaging to facilitate construction phasing are expected to come from the construction manager. In this approach, construction contracts will be awarded before final designs are complete. Thus, a considerable degree of decisiveness is required by public sector in the early design phase since construction will begin before the designs are finalized. The construction cost of the project will essentially be about the same as conventional A/E; however, the completion date may be four to five months sooner, thus saving costs due to inflationary increases and also from revenues being generated sooner.

3. Turnkey Approach

In this approach, a system contractor is hired to design and implement the central steam plant system in one package. The contractor is selected through the negotiated procurement method. This approach is accompanied by public ownership, but alleviates their responsibility for system implementation.

The public sector can assume responsibility for plant operation or may choose among the private operating alternatives described for the conventional and modified A/E approach. In addition to assigning sole responsibility for the project to a single party, it provides the public sector some assurance regarding initial process performance. If the plant fails to operate as specified, the public sector is not obligated to accept it. This approach was used to implement the Monsanto resource recovery system in Baltimore, Maryland and the Raytheon Refuse Derived Fuel Complex in Rochester, New York.

4. Full Service Approach

In the full service approach, the system contractor is responsible for design, implementation and operation of the facility. Ownership may be 100 percent public. Both public and private financing can be utilized depending on ownership arrangement. In reality, the full service contractor is offering the public sector a service in return for public guarantee of a market or subsidy. This agreement becomes the basis for a "put or pay" contract. Examples of the full service approach are Bridgeport, Connecticut -- 100 percent publicly owned, Hempsted, New York -- 100 percent privately owned and the Americology Resource Recovery Plant in Milwaukee, Wisconsin -- 100 percent privately owned.

E. RISK ANALYSIS

Identification and evaluation of risks associated with this project is an integral part of project implementation. Reducing risks to an acceptable level must be an overriding objective throughout the project. However, all project risks can never be eliminated. Those risks remaining and their potential effects must be allocated between the project participants in an equitable manner. Risks are accepted in anticipation of receiving economic benefits. The transfer of risks to another project participant (i. e., private industry) requires that he be adequately compensated. This naturally raises the cost to the ultimate user.

1. Risk Identification

Major risks in this project fall into several general categories: fuel stream, facility construction, performance, and markets. Each risk can have a direct impact on project economics and system reliability. Risk considerations which apply to this central steam plant project are discussed below.

a. Fuel Stream

Changes in fuel composition and heating value can affect projected revenues.

b. Facility Construction

Delays in completion of construction and start-up can cause cost overruns and result in higher net cost requiring more revenues. Unforeseen inflation during the facility construction phase can increase capital requirements and impair the overall project economics.

c. Facility Operations

Inefficient operation as a result of unproductive labor, selection of improper equipment, or poor maintenance or design of the facility can have a negative impact on project revenues. Inability to operate to design specifications would force the project to breach its contracts with the energy purchasers.

d. Markets

Cancellation or non-renewal of contracts for the sale of energy products due to changing specifications by the purchaser or economic conditions can jeopardize project revenues.

2. Risk Evaluation

Risk evaluation entails consideration of many subjective factors which are difficult to analyze in isolation. The relative importance of risks determined qualitatively may be a more meaningful form of comparison than a quantitative evaluation. However, the sensitivity of certain project economics to changes in several key variables could be a factor in determining the significance of individual risks.

A sensitivity analysis was performed on several risk categories of the Conventional A/E Approach (used as a baseline) to determine their efforts on project economics. Each analysis discusses the impact of variation in a single parameter. Sensitivity of variable factors as determined for the A/E approach should reflect a proportional impact on project economics for other implementation alternatives and give an indication of their tendency and magnitude.

a. Risk Analysis for Conventional A/E Approach With Public Implementation (Baseline Case)

1. Risk of General Project Delay

The project economics will be adversely affected by delaying implementation. The capital cost reported in CHAPTER TEN includes a seven percent, two year escalation factor. If the project were delayed an additional year, the required 20 year steam price of would be increased by 10¢/1000 lbs to cover the additional escalated capital cost.

2. Risk of Cost Overruns in Construction and Capital Cost Variation

Assuming that all construction is performed under fixed price contracts, the responsibility for cost overruns is assumed by the construction contractor and thus constitutes a low risk factor to the public agency. In estimating the capital requirements for this project, conservative estimates extracted from similar type construction projects were used. These estimates are subject to economic conditions which are difficult to predict. The public agency can reduce the risks associated with the capital cost variation by minimizing project delays and utilizing experienced consultants and contractors to generate the "best possible, phases of implementation".

3. Risk of Insufficient Waste Fuel Supply

Project economics are adversely affected by fluctuations in waste-fuel quantities (tonnages) available.

4. Risk of Marketing Energy

Markets for energy and steam must be negotiated. Under the Conventional A/E Approach, the public agency is responsible for marketing the energy product. The consultant has identified potential markets and the public agency can reduce the marketing risks by contracting with specific consumers for guaranteed quantities of the commodity (i. e., energy or steam).

5. Risk of Default Bonds

The public agency will incur obligations associated with floating bonds to finance the project. It is highly unlikely that the sponsoring agency would default on its obligations to bondholders. Project economics and technical feasibility will have to be established before any bonds may be sold. Application of proven technology by reputable and experienced consultants should result in successful implementation of the facility. Adequate revenues can be generated to meet the obligations to bondholders over the 20-year period. In the event of short term system shutdowns, the bond debt reserve fund will serve to insure that bondholders are paid, in accordance with the terms of financing.

6. Risk of System Not Performing to Design Specifications

Under the Conventional A/E Approach, the consultant is responsible for system failures which result from errors in design or specifications. Equipment systems which fail to meet specifications are the responsibility of equipment vendors. Reliance upon proven technology and experienced consultants should make this a low-risk factor.

b. Risk Analysis for Other Implementation Approaches

The following describes the major risk considerations for the other implementation approaches.

1. Inflationary capital cost increases incurred due to delays in deciding to implement the project is a risk of the study area in all implementation approaches.

2. Once a construction contract has been signed by the sponsoring agency, the risk of facility capital cost overruns is the contractor's responsibility.

3. The risk associated with bond default is the responsibility of:

    a. Public agency in all approaches except full service, leveraged leasing or shared equity full service.

    b. Full service contractor in full service.

    c. Public agency to the extent of their debt percentage in the leverage leasing and full service shared equity.

4. The risk associated with equipment or facility failures due to faulty design specifications is the responsibility of the design consultant, turnkey or full service contractor depending upon implementation approach.

5. The risk associated with equipment failures due to faulty equipment not meeting design specifications, is the responsibility of the equipment vendor in all implementation approaches.

6. In all cases involving a public agency operating the central energy plant or with a private operational management contract, the public agency assumes the risk of:

    a. Insufficient waste fuel quantities and fluctuations in the steam demand.

    b. Operational cost variations.

    c. Operation and maintenance of equipment and any subsequent equipment failures due to misuse.

7. In those implementation approaches involving full service or variations of full service having guaranteed operational fees the full service contractor assumes responsibility for:

    a. Operational cost variations.

    b. Operation and maintenance of equipment and any subsequent equipment failure due to misuse.

    c. Variations in revenues derived from fluctuations in the steam demands.

    d. The public agency assumes the risk of "take-or-pay" for a minimum quantity of steam to the full service contractor.

F. TACOMA OPTIONS

1. General

The previous paragraphs of CHAPTER ELEVEN have addressed the general financing, implementation and risk factors applicable to this project. In the final analysis, what are the best options available to develop a long-term cost-effective, environmentally sound central heating system for the central business district of Tacoma? Central energy planning must be implementation oriented. In short a policy must be developed if the City of Tacoma deems the project to be feasible.

In the consultants opinion, this project will be financed and implemented via municipal and private participation. State participation is a possibility.

The mechanism used will be dependent upon the individual assessments made by the project participants.

Figure 11-1 depicts the status of this project in terms of implementation. The long-term feasibility of this project is dependent upon many variables that have not been completely resolved, such as: (1) the future cost of electrical energy in study area and (2) the price the principal industrial customers would be willing to pay for the steam energy generated by a central energy plant serving the CBD.

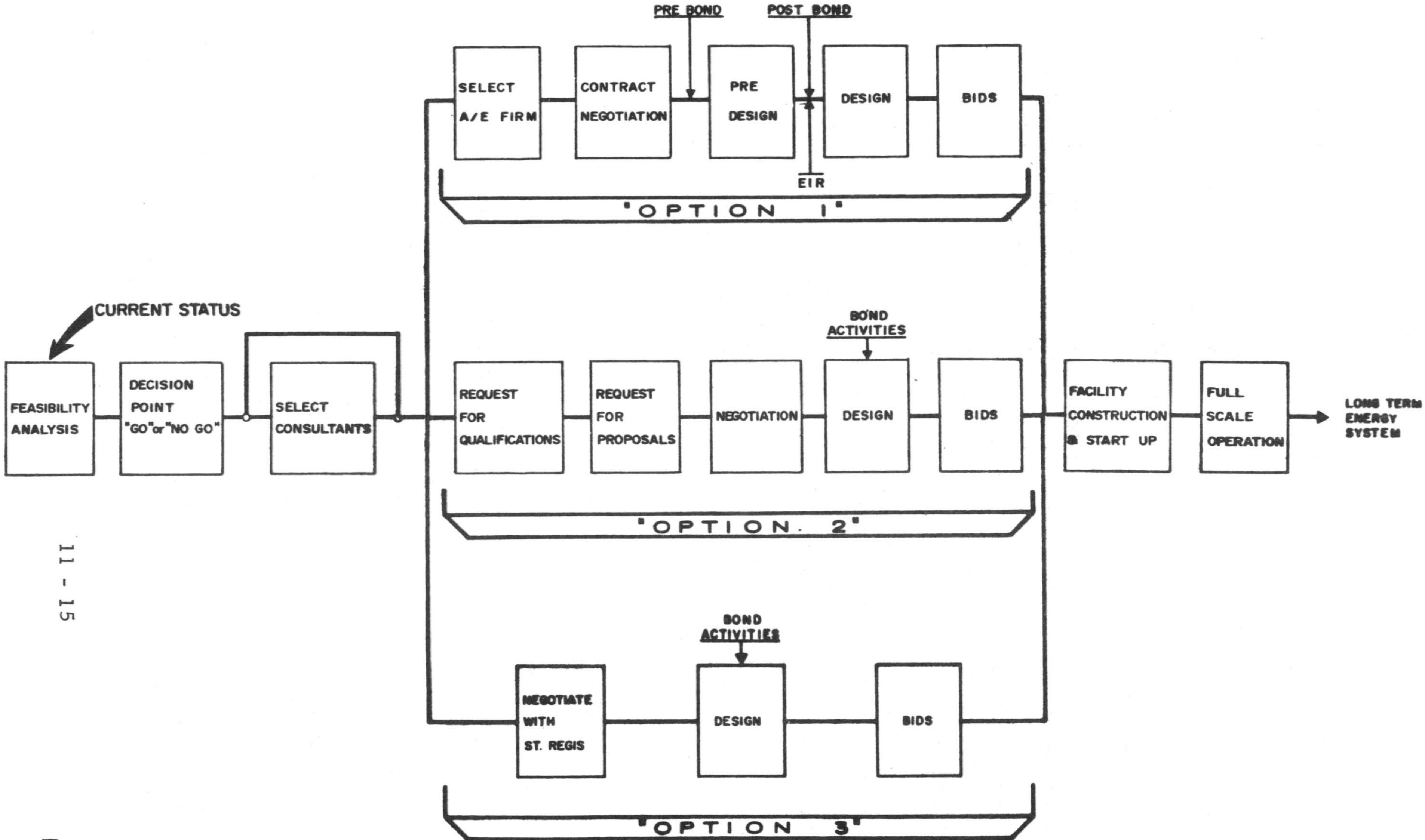
The options available to implement this project are predicted by a "Go" or "No Go" committment by the decision makers in the local study area. This decision may require the appropriation of financial and manpower resources to move the project to implementation. The options are:

Option 1: The City of Tacoma could proceed bilaterally with the State of Washington being a potential source of project revenue. The energy market could include the CBD and one or more industrial customers.

Option 2: The City of Tacoma could request, receive and evaluate proposals from private entities outside the study area who want to provide a service to the community for monetary profit. Negotiations would allocate the risks and benefits based on the participation. The markets would be same as Option 1.

Option 3: The City of Tacoma could participate with the St. Regis Company in a joint development of this project. The central business district could be served fulfilling the City of Tacoma's interest at the same time a new environmentally sound source of energy would be available for St. Regis.

Each of these options could successfully implement this project. All options would most likely require revenue bond financing. If Options 2 or 3 are selected, the private sector would be expected to provide some or all of the funding required to construct the facility.



IMPLEMENTATION OPTIONS APPLICABLE

FIGURE II-1

The selection of the appropriate option will be dependent the negotiation process. The City of Tacoma can issue a revenue bond by creating a Special Fund for the sole purpose of defraying the bond. The revenue bond does not require voter approval. The project must, however, be able to generate adequate revenues to meet all amortized capital and operating expenses plus the cost of bond defrayment (RCW Code 35. 67. 120). Furthermore, the City of Tacoma can lease facilities for periods not to exceed fifty years. (RCW) 34. 42. 010-200) Because of this flexibility the City of Tacoma and a private corporation could jointly finance own and operate the facility. The City would be obtaining a service while private corporation would be obtaining a long term source of energy or monetary profit for their investment.

A private corporation could also take full advantage of ownership not available to the public sector owner. Their tax advantages include.

a. Investment Tax Credit

A private corporation can deduct from his Federal Tax payments, ten percent of the total allowable capital cost of the facility.

b. Depreciation

A private corporation can take a pre-tax deduction in earnings for depreciation of the capitalized facility. This deduction can be accelerated in the initial years of operation to provide a substantial cash flow to the private participant.

c. Interest Cost Deduction

A private corporation can take a pre-tax deduction in earnings for the share of the lease attributable to interest payments.

2. Summary of Impact on Cost of Public vs. Private Financing

Public and private funding alternatives have been discussed. Both methods could be used to implement this project. Public funding is restricted to general indebtedness bonds and revenue bonds. The general indebtedness bonds require an election which is considered a substantial liability by the consultant. Outside the common local sources for public fundings, State grants are the most probable source available.

The private financing mechanism is restricted to standard corporate issues. The leasing options available to the City of Tacoma make the tax advantages of private financing attractive concerning this project.

G. IMPLEMENTATION ACTIVITIES

The implementation of this project will be determined by the role of the City of Tacoma undertakes in the post feasibility activities. Depending upon the mechanism selected, implementation will be divided into three phases.

1. Negotiation to Select the Most Feasible Project.

2. Pre-Bond Activities.

3. Post-Bond Activities.

The negotiation phase is required to complete the feasibility analysis and determine if the project should be implemented. With the interest shown by the City and St. Regis, it is assumed that the project will be implemented.

The pre-bond issue phase includes permit approvals, preparation of preliminary engineering, preparation of an environmental impact assessment or statement and report, preparation for bond issue and sale of the bonds.

The post bond issue phase includes award of equipment contracts, acquisition of a site and right-of-ways, final engineering, award the construction contract, construction period and start-up.

1. Phase I - Negotiations to Select the Most Feasible Project

Subsequent negotiations will depend upon the mechanism selected to implement the project. If the public agencies (Option 1) elect to implement the project, the negotiations can commence with the potential energy markets identified, CBD and St. Regis Company.

If Option 2 is selected by the City of Tacoma, a request for proposal will have to be issued and negotiation and evaluation will center around selecting the most attractive offer submitted by the private sector outside the City of Tacoma.

Option 3 is a combination of the first two options. Option 3 would require cooperation between the City of Tacoma with St. Regis to implement this project. Option 3 combines the largest energy user with the municipal entity in a joint venture.

The negotiations concerning all three options will consider the amount of revenue required, the organizational structure that will own and operate the project and the financing method to be employed.

The consultant recommends the City of Tacoma select a negotiation team. because of the special expertise required and the amount of work involved, the City may want to retain special consultants to assist in the negotiations. It is contemplated that the negotiations would continue until a letter of intent has been agreed upon or a contract signed. This document would cite all elements necessary for subsequent implementation activities, including: the degree of participation of the parties, the basic organizational structure to finance, construct, own and operate the project; basic methods of financing the interim and long-term capital requirements, costs and revenues, methods of implementation, and participation in the implementation.

2. Phase II - Pre-Bond Activities

The participants in the Phase II activities will be predicated by the Option (1 or 2) selected for implementation. If Option 1 (Public Implementation) is used, the subsequent items discussed will be accomplished by them. If Option 2 (Private Implementation) is employed, the private entity will complete the pre- and post-bond activities. If Option 3 is used, activities common to one and two will be incurred.

In the Pre-Bond Issue Phase (Phase II) the following general tasks will be accomplished:

a. Review of Phase I negotiation by City of Tacoma.

b. Authorization for funds to pay the costs of the pre-bond issue activities.

c. Preliminary engineering including:

    1. Preliminary plans and cost estimates required to support the bond issue.

    2. Plans and specifications for purchase of long lead time major items of equipment.

    3. Accept bids on long lead time major equipment items but delay the bid awards until after the bonds are sold.

    4. Support in matters relating to the bond issue.

    5. Acquisition of the site.

    6. Formalization of contracts for the sale of energy.

7. Developing contracts (if required) for the operation of the facility.

8. Support in matters related to regulatory authorities, such as state and local permits and environmental regulation requirements.

9. Retention of a financial consultant to prepare the plan to finance the project.

10. Formalize all contracts.

11. Sell the bonds.

3. Phase III - Post-Bond Activities.

In Phase III, the following tasks will be completed:

a. Award contracts for long lead equipment items.

b. Engineering work, including:

1. Plans and specifications for construction of facilities and installation of major equipment.

2. Services during construction and start-up.

3. Support in matters relating to contracts for the sale of energy.

4. Support in matters relating to the operation of the facilities.

5. Advertise for bids and award contracts for construction and start-up.

6. Execute contracts for the sale of energy and materials.

7. Execute contract for operation of facilities.

8. Construction period.

9. Start-up period.

4. Schedule

Approximately two years (24 months) will be required to implement Phases II and III described in the preceding discussion. This includes engineering,

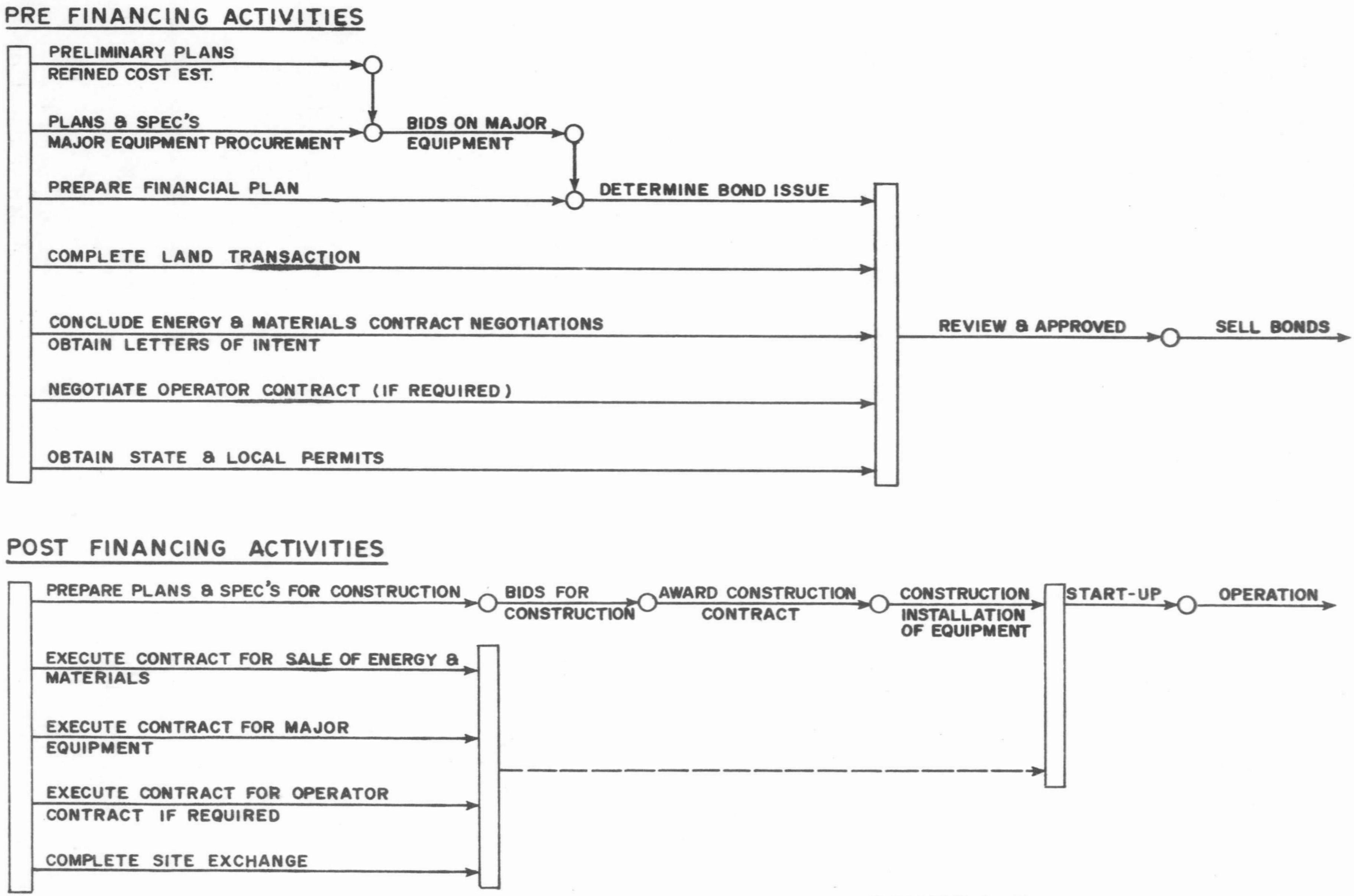


FIGURE II - 2

SCHEDULE OF ACTIVITIES
TACOMA REFUSE FIRED COMBUSTOR STUDY

acquisition of major equipment, construction and start-up. In addition to the two year period, time must be scheduled for the Phase II negotiation and activities. No estimate is made at this time for Phase I. See Figure 11-2 for a graphical representation of the schedule of activities.

CHAPTER TWELVE

OPERATION AND MANAGEMENT

Four methods of owner/operator for the proposed central energy plant have been documented in CHAPTER ELEVEN. They are briefly outlined as follows:

1. Municipal Owned
   Municipal Operated
   Private Operation under Contract

2. Private Owned
   Private Operation
   Municipal Operation under Contract

3. Authority Owned
   Authority Operation
   Private Operation under Contract

4. Public Utility

For the purposes of this chapter the report will cover only a municipal type operation. The Consultants primary activities were solely involved in the municipal aspect of the operation.

The bulk of this report covers the feasibility of an energy facility to supply steam to the central business district of downtown Tacoma and to adjoining industries. The types of organizational structures available to the City of Tacoma to operate such a system can be found in the state statues.

In the State of Washington there are several methods of creating structures or agencies for the conduct of public business. Examples are listed as follows with State Law Reference No's (RCW).

1. Airport Authority (RCW 14.08.120)
   a. Created by city ordinance or resolution.
   b. Five resident taxpayers appointed by City Council resolution or ordinance.
   c. Is reponsible to Council.

2. City Department or Utility (RCW 35.18.080)
   a. Recommended by City Manager.
   b. Creation by City Council.
   c. Is responsible to City Manager.

3. Planning Commission (RCW 35.63.020)
   a. Created by City Council action.
   b. Mayor appoints members (3 to 12)
   c. Members confirmed by Council
   d. Is responsible to Council

4. Public Utility or Authority (RCW 35.92)
   a. The City may own construct & operate
   b. Set-up by ordinance
   c. May be authorized by charter
   d. If not by voter approval
   e. Is responsible to City

5. Port Districts (RCW 54.04.020)
   a. Set-up by election by petition of County Commissioners
   b. Voter approval
   c. Is a Municipal Corporation of State
   d. 3 Commissioners elected from Districts
   e. Is responsible to Voters

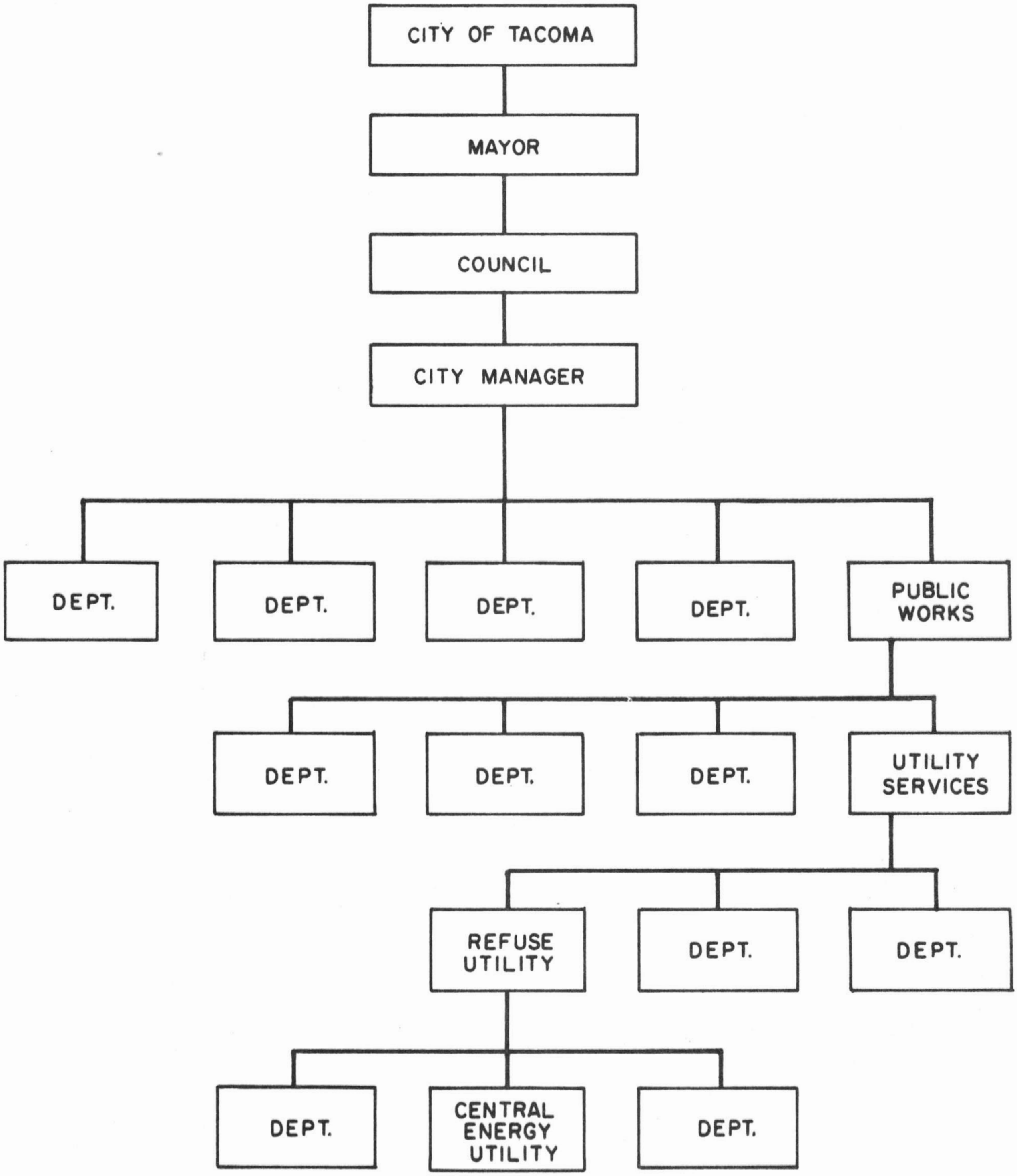
Based on a review of the Revised Code of Washington the Consultant has found no section that prohibits the City of Tacoma from the construction and operation of a central steam generation plant. RCW Chapter 35.92 defines cities authority to own, operate, construct, purchase, etc. various public systems including solid waste and electrical utilities.

The consultant would recommend that of the previously described options that only #2 & #4 and variations be investigated for the supervision and operation of the proposed steam plant.

The City of Tacoma may therefore choose a method of operation for the proposed energy facility from one of the following three alternatives:

1. <u>Place Operation Under an Existing City Department</u>

   This option would take advantage of the municipal personnel already on the city payroll. Their office functions are now functional and procedures have been established. The additional personnel required would be primarily in the operational area. Control of the operation is maintained under the City Manager through the existing Department Head. See Figure 12-1 for graphic description. The City of Tacoma now uses this principal with their Refuse Utility Division.



STEAM UTILITY PLACED UNDER EXISTING DEPARTMENT

FIGURE 12 - 1

2. <u>Create a New Department within the City Structure</u>

A new department of this type would require the appropriate staffing including a department supervisor, assistants, office personnel as well as plant operating manpower. The creation of a new department has the advantage that it serves only the energy facility and its customers and does not divide its time between other city functions. Control of the operation is maintained within the city structure. The department head would report directly to the City Manager. (See Figure 12-2.)

This concept was used by the City of Tacoma through the Tacoma Utilities Department and the City of Ames, Iowa in their Electric Utility Department.

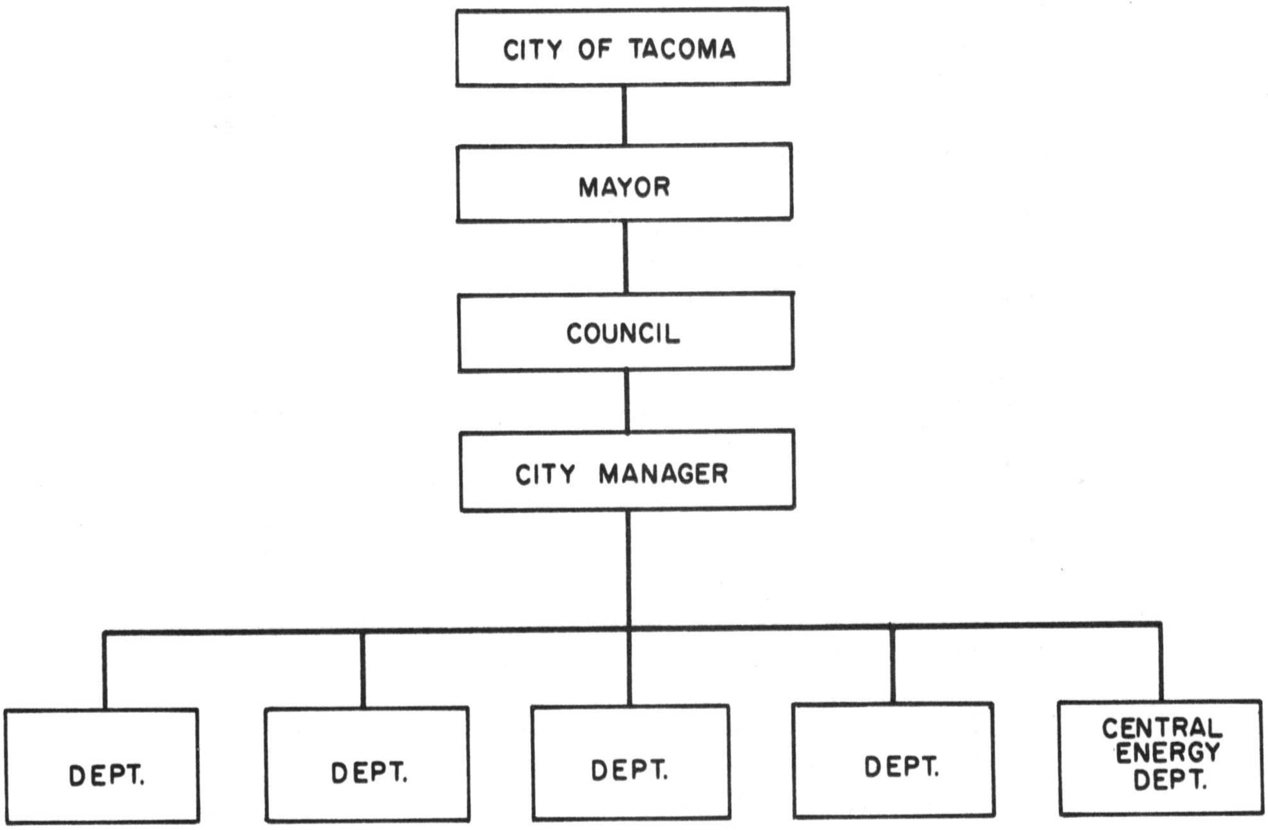
3. The City may chose to create a new authority to control and operate the central energy facility. This route would add another authority to the city. However, it would relieve the city of some the associated financial obligations. It also removes the direct operational control from the city. The City will however, maintain regulatory powers as the authority is responsible to the City Council and the Council can exercise some control over the rates and maintain economic control. (See Figure 12-3).

This concept was used by the City of Nashville Tenn. in the formation of the Nashville Thermal Corp, in Jamestown, N. Y. with the Jamestown Electric Utility and in Springfield, Mo. in the formation of their Electric Utility Authority.

If the City were to form a new department or section within an existing department its office responsibilitieswould include personnel for general supervision, customer contact, customer billings, engineering and business development.

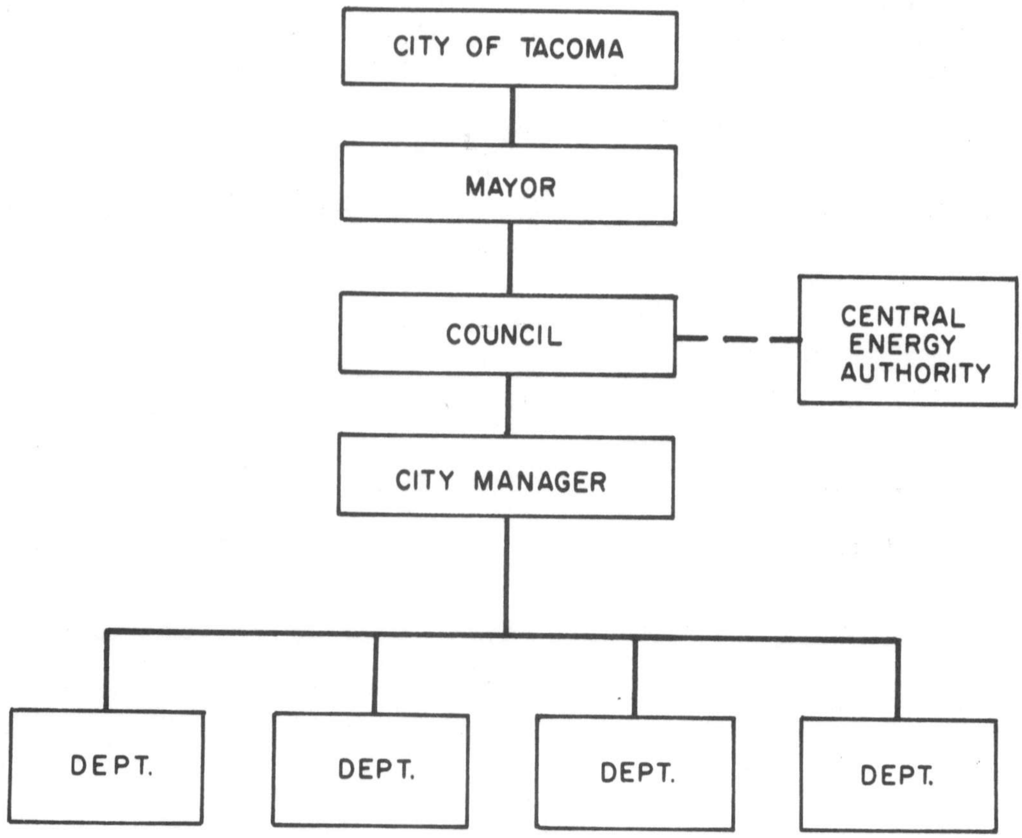
It is assumed that a continous ongoing sales and business development department will be of value to the central energy plant.

The potential least cost energy to its customers is from a City owned and operated energy plant. The plant if City owned would pay no taxes, be able to purchase its utilities at City rates and purchase its materials and supplies through the City purchasing department. Care must be exercised to insure the most efficient operation is being conducted and that management practices do not become lax or the advantage is lost.



STEAM UTILITY AS A NEW DEPARTMENT

FIGURE 12-2



STEAM UTILITY AS A NEW AUTHORITY

TACOMA REFUSE FIRED COMBUSTOR STUDY

FIGURE 12-3

As plans are formulated and the project gets underway it will be necessary for the City to secure customers for the energy facility. Discussions with potential customers resulting in a letter of committment for a stipulated unit of energy will be necessary. Once loads are known a decision on the facility size can be established and a rate structure can be generated. Before an energy contract can be finalized with a consumer contracutural intent must be indicated and an agreement developed, With the intent commitment, facility costs can be finalized and a rate structure can be established which will be based upon a cost apportionment of quantities of energy sold.

A sample agreement for use by the City of Tacoma and an energy user is as follows:

AGREEMENT

THIS AGREEMENT, Made and entered into this ____________ day of __________________, 197_, by and between the City of Tacoma Washington a Washington Municipal Corporation, party of the first part, hereinafter designated the City, and __________________________________ __________________, party of the second part, hereinafter designated as the customer.

WITNESSETH: WHEREAS, The City desires to operate a municipally - owned steam heating plant, located in Tacoma, Washington, for the generation of steam with a steam distribution system consisting of steam and condensate lines, and desires to sell and deliver to the customer its steam requirements and the customer desires to purchase from the City, said steam requirements as herein provided when said plant distribution system is complete.

NOW, THEREFORE, In consideration of the premises and the mutual covenants herein contained, the parties hereto agree as follows:

1. Conditioned upon the City's completing the construction of a steam generating plant, having a rated steam generating capacity of ______________ pounds and installing the steam distribution system the City agrees to sell and the customer agrees to purchase steam at a nominal pressure of _______psig.

2. The Customer shall purchase annually a minimum of ________________ and shall pay an annual charge of _______________ per month plus ____ per thousand pounds of steam purchased up to a total of ________________ pounds of steam per annum. Any amount purchased over this shall be at the rate of _____ per 1,000 pounds of steam purchased.

3. The City shall deliver to and meter the steam by a condensate meter located at a point nearest the City's steam main. The Customer shall provide a suitable condensate receiver and pump in order to return the condensate back to the City condensate return mains.

4. The City shall furnish, operate and maintain suitable shut-off steam and condensate valves at the entrance of the lines to the Customers building together with a suitable condensate meter for measuring the steam delivered by the City to the Customer.

5. The Customer shall own and maintain a suitable condensate receiver and pump adequate to receive and pump back into the City's condensate line all the condensate from the Customers steam system.

The Customer shall also own and maintain a steam system to and condensate system from all steam consuming equipment on its premises without leaks and capable of returning all condensate to the condensate receiver.

6. The City shall make routine tests of its metering equipment normally once every____ years to maintain its accuracy. However, tests may be made at any time at the expense of the party requesting the tests, if it appears that there is an inaccuracy of the metering equipment. Representatives of both parties shall be afforded reasonable opportunity to be present at such tests.

If after such tests any of the meters are found to be more than two percent (2%) inaccurate either way, the quantities measured thereby for and during the period sixty (60) days prior thereto shall be adjusted in accordance with the percentage of inaccuracy so found.

The meters shall be read at the end of each calendar month during the period that steam is furnished by the City. The City shall bill the Customer within ____(__) days for the steam used.

7. The rates contained herein are based upon fuel delivered to the City's plant costing not more than ________ dollars, nor less than ________ dollars per million Btu. For each one cent per million Btu the fuel cost

increases above or decreases below these costs, the price of steam shall be increased or decreased ____________ per 1,000 pounds sold.

8. The Customer shall pay the City for steam delivered by the City on or before the ____day of the month following the month in which the steam was delivered.

9. In the event that the customer desires to take no steam from the City for a period of time, the minimum charge will be _________ per year.

10. The Customer shall provide and maintain from its property line, at its expense, the steam and condensate lines from the City's mains to the Customers point of entry.

11. Each party shall exercise due diligence and reasonable care and foresight to maintain continuity in the delivery and receipt of steam and the return of condensate as provided for herein, but neither party shall be considered to be in default in respect of any obligation hereunder if prevented from fulfilling such obligation by reason of uncontrollable forces or by reason of outages of facilities for repair, replacement or inspection, provided due diligence be used to limit such outages, and provided such outages, except in emergencies, be conducted upon a reasonable pre-arranged schedule; the term "uncontrollable forces" shall be deemed for the purposes of this agreement to mean earthquake, storm, lightning, flood backwater cause by flood, fire, epidemic, accident, failure of facilities, war, riot, civil distur-

bance, strike, labor disturbance, restraint by court or public authority, or other causes beyond the control of the party affected, which by exercise of due diligence and foresight such party could not reasonable have been expected to avoid. Any party rendered unable to fulfill any obligation due to any of the foregoing described reasons will exercise due diligence to remove such disability with dispatch.

12. This Agreement shall extend for a period of _________ years from the first of the month following the date on which the City's plant is placed in commercial operation.

IN WITNESS WHEREOF, The parties hereto have executed this Agreement in duplicate as of the day and year first above written.

WITNESSETH:

CITY OF TACOMA, WASHINGTON
(A Municipal Corporation)

By_______________________________

(SEAL)

By_______________________________

____

By_______________________________

It's_______________________________

(SEAL)

By_______________________________

It's_______________________________

APPENDIX A

GENERAL INFORMATION

COPELAND SYSTEMS Incorporated
2000 SPRING ROAD, OAK BROOK, ILLINOIS 60521

November 11, 1977

Henningson, Durham & Richardson, Inc.
Consulting Engineers
8404 Indian Hills Drive
Omaha, Nebraska 68114

Attention: Mr. Ralph Freeman

Reference: Tacoma, Washington

Dear Ralph:

This is to confirm information given to you by telephone on the afternoon of November 8, 1977.

This project involves generating steam at 150 psig for central heating with the City, or a 850 psig with 150 pound backpressure in a combination of electrical generation and sale of steam to the City. Various combinations of refuse-derived fuel, hog fuel and oil are being considered, and you requested that we provide budget quotations for 200,000 lbs/hr of steam and 125,000 lbs/hr of steam. Both of the budget quotations given below are based on Copeland rectangular fluid bed reactors with integral Foster Wheeler boilers.

The 200,000 lbs/hr unit would be based on a heat release of 266 MM Btu's/hr with 75% efficiency. This requires a 600 square foot reactor with two (2) bed cells, each 20 feet by 15 feet. The operating power draw would be 1300 HP, 80% of connected. Fluidizing air blower would be 42,000 scfm, total 4 psig through the unit, split 60/40 through the I.D. fan and the fluidizing air blower. Approximately 40 feet maximum height clearance is required for the equipment, and the lowest point of the ceiling in this area should be 45 feet. Less than 10,000 ft^2 would be required for the boiler and its accessories. Accessories include fluidizing air blower, I.D. fan, dry cyclones, baghouse and exhaust stack. The estimating price on this equipment is $4.0 million.

COPELAND SYSTEMS Incorporated

Mr. Ralph Freeman
Henningson, Durham & Richardson

November 11, 1977

For a similar installation at 125,000 lbs/hr with 75% efficiency and 166 MM Btu's/hr heat release, we would use a single 300 ft^2 reactor with one (1) cell 20 feet by 15 feet. Operating power draw would be 650 HP, fluidizing air blower flow 20,000 scfm, building and equipment heights per above, less than 8,000 ft^2 required. The estimating price of this unit is $2.5 million.

We certainly appreciate this opportunity to work with you and will be happy to get into greater details when you need them. Enclosed for your reference are xerox copies from a 300,000 lb/hr unit which we quoted recently to an industrial client. The layout and arrangements for the Tacoma project would be quite similar.

Yours very truly,

M. H. Saxer /mjh

M. H. Saxer, P.E.
Sales Manager

MHS/mjh
Enclosures

cc: Mr. R. Bell
Mr. M. S. Campbell
Mr. A. A. Zahner

December 9, 1977

Mr. Richard Bell
Henningson, Durham & Richardson
8404 Indian Hills Drive
Omaha, Nebraska 68114

Atlas Systems
CORPORATION

Reference: Atlas Storage and Retrieval Systems
City of Tacoma Project

Dear Dick:

This will confirm those cost estimates which I transmitted to you during our telephone conversation of November 21, 1977.

The budget prices for the two units, as listed below, are based upon a total discharge rate of 22 -1/2 tons per hour of prepared refuse. The estimates include equipment, field erection, mechanical installation, electronic control system, DC motors and SCR power units, etc. The prices do not include any state or local sales or use taxes, foundation, field painting or field touch-up of shop primer, or field electrical work. Incidentally, the foundations for these particular units are quite simple since there is only one discharge conveyor extending all the way across the floor of the silo. Therefore, the foundation can be built for considerably less money than one with a four point discharge such as the one at Ames, Iowa (or the eight point discharge system at Milwaukee, Wisconsin).

A. Estimated Cost for One (1) #21TP = approximately $800,000 to $900,000.

B. Estimated Cost for One (1) #25TP = approximately $950,000 to $1,050,000.

Dick, I hope that this information is adequate for the present. However, please let us know any time that you would like to have us furnish you with any additional information, etc.

Very truly yours,

W. B. Hickman, P.E.
Executive Vice President

APPENDIX B

TYPICAL COMPLETED MARKET QUESTIONNAIRES

CITY OF TACOMA, WASHINGTON

STEAM DISTRIBUTION SYSTEM STUDY QUESTIONNAIRE

October, 1977

OWNERSHIP

	Building Owner	Tenant
Name	City of Tacoma	Various
Mailing Address	Medical Arts Bldg.	
	740 St. Helens Ave. Tacoma, WA. 98402	

BUILDING

Building Name	Medical Arts Building
Address of Building	Same as Above
Heated Floor Area, Total	110,000 Sq. Ft.
Number of Floors	15 plus basement
If future building additions are planned, please give estimated heated floor area and approximate dates.	None Planned
Number of Employees	2

STEAM USAGE (for Present Steam Customers)

Annual use in 1976, lbs. x 1000	7,359
Maximum Monthly Use in 1976, lbs. x 1000	1,051
Minimum Monthly Use in 1976, lbs. x 1000	230
Percentage of steam returned as condensate	0

AIR CONDITIONING

Type of existing cooling equipment - absorption or electrical.	Electrical
Size of cooling equipment in tons of capacity total.	Third Floor Only
Do you plan to add steam operated cooling equipment in the future? If so, give size of equipment and date.	No
If an economical centrally operated chilled water supply were available, would you convert existing systems to utilize a centrally supplied chilled water?	No

FUEL USAGE (for Potential New Customers)

GAS:

Annual Use, 1976, MCF	Minimal - For One
Maximum Monthly Use, 1976, MCF	Tenant Use Only
Minimum Monthly Use, 1976, MCF	

OIL:

Annual use 1976, gallons	N/A
Maximum Monthly Use, 1976, gallons	N/A
Minimum Monthly Use, 1976, gallons	N/A

INTEREST IN CONVERSION

If an economical central steam supply becomes a available to you, would you convert existing heating or cooling systems so that the centrally supplied steam could be used?	No

EXISTING STEAM GENERATION FACILITIES

Do you presently generate steam?	Yes
If so, please state size of boilers and operating pressure.	75 KW - Approx. 8 - 10lbs.

REMARKS

CITY OF TACOMA, WASHINGTON

STEAM DISTRIBUTION SYSTEM STUDY QUESTIONNAIRE

October, 1977

OWNERSHIP

	Building Owner	Tenant
Name	City of Tacoma	Same as Owner
Mailing Address	930 Tacoma Ave. So.	
	Tacoma, WA 98402	

BUILDING

Building Name	Bicentennial Pavillion
Address of Building	1313 Market
Heated Floor Area, Total	37,000 Sq. Ft.
Number of Floors	2
If future building additions are planned, please give estimated heated floor area and approximate dates.	NA
Number of Employees	5+

STEAM USAGE (for Present Steam Customers)

Annual use in 1976, lbs. x 1000	11.06.10
Maximum Monthly Use in 1976, lbs. x 1000	433.20
Minimum Monthly Use in 1976, lbs. x 1000	6.50
Percentage of steam returned as condensate	None

AIR CONDITIONING

Type of existing cooling equipment - absorption or electrical.	Absorption
Size of cooling equipment in tons of capacity total.	2 ea. 50 ton+ 2 ea. 5 ton +
Do you plan to add steam operated cooling equipment in the future? If so, give size of equipment and date.	No
If an economical centrally operated chilled water supply were available, would you convert existing systems to utilize a centrally supplied chilled water?	No

FUEL USAGE (for Potential New Customers)

GAS:

Annual Use, 1976, MCF	None
Maximum Monthly Use, 1976, MCF	N/A
Minimum Monthly Use, 1976, MCF	N/A

OIL:

Annual use 1976, gallons	None
Maximum Monthly Use, 1976, gallons	N/A
Minimum Monthly Use, 1976, gallons	N/A

INTEREST IN CONVERSION

If an economical central steam supply becomes a available to you, would you convert existing heating or cooling systems so that the centrally supplied steam could be used?	N/A

EXISTING STEAM GENERATION FACILITIES

Do you presently generate steam?	No
If so, please state size of boilers and operating pressure.	N/A

REMARKS

APPENDIX C

COST ESTIMATES

	Cost Summary	Alternative 1
1.	Land	$ 300,000
2.	Steam Plant	11,502,000
3.	Steam Distribution System	900,000
		12,702, 000
4.	Sales Tax (5.5% - $7,932,000)	436,000
		13,138 000
5.	Fees (10%)	1,314,000
		14,452,000
6.	Financing (30%)	4,336,000
	Project Cost (1978$)	$18,788,000
	Escalated Project Cost (1980$)	$21,510,000

	Operation and Maintenance	Alternative 1
1.	Fuel	$1,225,000
2.	Electricity	51,200
3.	Labor	361,000
4.	Water	11,100
5.	Water Treatment	43,300
6.	Maintenance	175,000
7.	Ash Disposal	136,000
	Annual Cost	$2,002,600

	Plant Capital Costs	Alternative 1
1.	Site Work	$ 150,000
2.	Piling	325,000
3.	Building - Boiler Plant	1,418,000
4.	Equipment Installation	250,000
5.	Plant Piping	900,000
6.	Electrical Equipment	80,000
7.	Electrical Installation	700,000
8.	Relocating Existing Boiler	25,000
9.	RDF & Hog Fuel Receiving Station, Pneumatic Conveyors & Metering Bin	1,000,000
10.	Atlas Bin Fountains	500,000
	General Contract	$ 5,348,000
	Owner Furnished Equipment	5,108,000
		$10,456,000
	Contingencies (10%)	1,046,000
		$11,502,000

	Equipment Capital Costs		Alternative 1
1.	Boiler: 125,000 lbs/hr, 150 psig stoker for RDF, Hog Fuel, Coal & Oil		$2,625,000
2.	Deaerator: 15 psig, 145,000 lbs/hr		36,000
3.	Boiler F. W. Pumps - 3 @ $3,000.		9,000
4.	Deaerator Supply Pumps - 3 @ $1,200		3,600
5.	Water Softener: zeolite, 2 train		45,000
6.	Fuel Oil Pump and Heating Set		20,000
7.	Fuel Oil Day Tank		2,000
8.	Fuel Oil Storage Tank		75,000
9.	Fuel Oil S. T. Suction Heater		3,000
10.	Fuel Oil Transfer Pumps 2 @ $2,500		5,000
11.	(2) Atlas Bins		1,800,000
12.	Air Compressor		18,000
13.	Tank Suction Heater		10,000
14.	Condensate Receiver		6,000
15.	Ash Handling System		450,000
			$5,107,600
	Boiler	Use	5,108,000

	Cost Summary	Alternative 2
1.	Land	$ 300,000
2.	Steam/Turbogenerator System	16,797,200
3.	Steam Distribution System	900,000
		17,997,200
4.	Sales Tax (5.5% - $14,910,000)	819,800
		18,817,000
5.	Fees (10%)	1,882,000
		20,699,000
6.	Financing (30%)	6,210,000
	Project Cost (1978$)	$26,909,000
	Escalated Project Cost (1980$)	$30,808,000

	Operation and Maintenance	Alternative 2
1.	Fuel	$1,434,000
2.	Electricity	78,700
3.	Labor	361,000
4.	Water	28,200
5.	Water Treatment	43,400
6.	Maintenance	225,000
7.	Ash Disposal	162,400
	Annual Cost	$2,332,700

	Plant Capital Costs	Alternative 2
1.	Site Work	$ 150,000
2.	Piling	360,000
3.	Building - Boiler Plant & Turbine Bldg.	1,850,000
4.	Equipment Installation	1,000,000
5.	Plant Piping	880,000
6.	Electrical Equipment	180,000
7.	Electrical Installation	800,000
8.	Relocating Existing Boiler	25,000
9.	RDF & Hog Fuel Receiving Station, Pneumatic Conveyors & Metering Bin	1,000,000
10.	Atlas Bin Fountains	500,000
	General Contract	$ 6,745,000
	Owner Furnished Equipment	8,525,200
		$15,270,200
	Contingencies (10%)	1,527,000
		$16,797,200

	Equipment Capital Costs	Alternative 2
1.	Boiler: 125,000 lbs/hr, 600 psig/750°F stoker for RDF, Hog Fuel, Coal & Oil	$2,875,000
2.	Deaerator: 60 psig, 145,000 lbs/hr	40,000
3.	Boiler F. W. Pumps - 3 @ $14,000	42,000
4.	Deaerator Supply Pumps 3 @ $1,400	4,200
5.	Turbine Generator: 12.5 MW	2,470,000
6.	Condenser	190,000
7.	Condensate Pumps - 2@ $2,500	5,000
8.	Cooling Tower	250,000
9.	Cuc. Water Pumps - 2 @ $27,500	55,000
10.	Turbine Room Crane	70,000
11.	Demineralizer	135,000
12.	Other Equipment per Alternative 1	2,389,000
		$8,525,200

Cost Summary	Alternative 3	
1.	Land	$ 300,000
2.	Steam Plant	15,052,000
3.	Steam Distribution System	900,000
		16,252,000
4.	Sales Tax (5.5% - $10,428,000)	573,000
		16,825,000
5.	Fees (10%)	1,683,000
		18,508,000
6.	Financing (30%)	5,552,000
	Project Cost (1978$)	$24,060,000
	Escalated Project Cost (1980$)	$27,517,000

Operation and Maintenance	Alternative 3	
1.	Fuel	$1,960,000
2.	Electricity	64,500
3.	Labor	387,500
4.	Water	15,500
5.	Water Treatment	69,400
6.	Maintenance	230,000
7.	Ash Disposal	188,800
	Annual Cost	$2,915,700

	Plant Capital Costs	Alternative 3
1.	Site Work	$ 150,000
2.	Piling	396,000
3.	Building - Boiler Plant	2,278,000
4.	Equipment Installation	208,000
5.	Plant Piping	850,000
6.	Electrical Equipment	85,000
7.	Electrical Installation	750,000
8.	Relocating Existing Boilers	35,000
9.	RDF & Hog Fuel Receiving Station, Pneumatic Conveyors & Metering Bin	1,160,000
10.	Atlas Bin Fountains	600,000
	General Contract	$ 6,512,000
	Owner Furnished Equipment	7,172,000
		$13,684,000
	Contingencies (10%)	1,368,000
		$15,052,000

	Equipment Capital Costs	Alternative 3
1.	Boiler: 200,000 lbs/hr, 150 psig stoker for RDF, Hog Fuel, Coal & Oil	$4,000,000
2.	Deaerator: 15 psig, 220,000 lbs/hr	42,000
3.	Boiler F. W. Pumps - 3 @ $4,000	12,000
4.	Deaerator Supply Pumps - 3 @ $1,500	4,500
5.	Water softener: zeolite, 2 train	53,000
6.	Fuel Oil Pump and Heating Set	24,000
7.	Fuel Oil Day Tank	2,500
8.	Fuel Oil Storage Tank	90,000
9.	Fuel Oil S. T. Suction Heater	3,500
10.	Fuel Oil Transfer Pumps - 2 @ $2,500	5,000
11.	(2) Atlas Bins	2,400,000
12.	Air Compressor	21,750
13.	Tank Suction Heater	5,600
14.	Condensate Receiver	7,500
15.	Ash Handling System	500,000
		$7,171,350

Cost Summary	Alternative 4	
1.	Land	$ 300,000
2.	Steam/Turbogenerator System	21,835,000
3.	Steam Distribution System	900,000
		23,035,000
4.	Sales Tax (5.5% - $15,827,000)	870,000
		23,905,000
5.	Fees (10%)	2,391,000
		26,296,000
6.	Financing (30%)	7,487,000
	Project Cost (1978$)	$34,185,000
	Escalated Project Cost (1980$)	$39,138,000

Operation and Maintenance	Alternative 4	
1.	Fuel	$2,294,800
2.	Electricity	99,900
3.	Labor	387,500
4.	Water	32,400
5.	Water Treatment	69,400
6.	Maintenance	325,000
7.	Ash Disposal	259,800
	Annual Cost	$3,468,800

	Plant Capital Costs	Alternative 4
1.	Site Work	$ 150,000
2.	Piling	436,000
3.	Building - Boiler Plant & Turbine Bldg.	2,500,000
4.	Equipment Installation	1,490,000
5.	Plant Piping	1,100,000
6.	Electrical Equipment	225,000
7.	Electrical Installation	950,000
8.	Relocating Existing Boilers	35,000
9.	RDF & Hog Fuel Receiving Station, Pneumatic Conveyors, & Metering Bin.	1,160,000
10.	Atlas Bin Fountains	600,000
	General Contract	$ 8,046,000
	Owner Furnished Equipment	11,804,000
		$19,850,000
	Contingencies (10%)	1,985,000
		$21,835,000

	Equipment Capital Costs	Alternative 4
1.	Boiler: 200,000 lbs/hr, 600 psig/750°F stoker for RDF, Hog Fuel, Coal & Oil	$ 4,400,000
2.	Deaerator: 60 psig, 220,000 lbs/hr	48,000
3.	Boiler F. W. Pumps - 3 @ $17,000	51,000
4.	Deaerator Supply Pumps - 3 @ $1,760	5,300
5.	Turbine Generator: 20 MW	3,435,000
6.	Condenser	228,000
7.	Condensate Pumps - 2 @ $3,000	6,000
8.	Cooling Tower	280,000
9.	Cuc. Water Pumps - 2 @ $35,000	70,000
10.	Turbine Room Crane	70,000
11.	Demineralizer	150,000
12.	Other Equipment per Alternative 3	3,059,850
		$11,803,150

Cost Summary	Alternative 5	
1.	Land	$ 300,000
2.	Steam Plant	11,170,000
3.	Steam Distribution System	900,000
		12,365,000
4.	Sales Tax (5.5% - $7,314,000)	402,000
		12,767,000
5.	Fees (10%)	1,277,000
		14,044,000
6.	Financing (30%)	4,213,000
	Project Cost (1978$)	$18,257,000
	Escalated Project Cost (1980$)	$20,813,000

Operation and Maintenance	Alternative 5	
1.	Fuel	$1,164,400
2.	Electricity	68,400
3.	Labor	361,000
4.	Water	11,100
5.	Water Treatment	43,400
6.	Maintenance	200,000
7.	Ash Disposal	126,000
	Annual Cost	$1,974,300

	Plant Capital Costs	Alternative 5
1.	Site Work	$ 150,000
2.	Piling	300,000
3.	Building - Boiler Plant	760,000
4.	Equipment Installation	210,000
5.	Plant Piping	825,000
6.	Electrical Equipment	85,000
7.	Electrical Installation	750,000
8.	Relocating Existing Boiler	25,000
9.	RDF & Hog Fuel Receiving Station, Pneumatic Conveyors & Metering Bin	1,000,000
10.	Atlas Bin Fountains	500,000
	General Contract	$ 4,605,000
	Owner Furnished Equipment	5,108,000
		$ 9,713,000
	Contingencies (15%)	1,457,000
		$11,170,000

	Equipment Capital Costs	Alternative 5
1.	Boiler: 125,000 lbs/hr, 150 psig fluidized bed unit	$2,600,000
2.	Deaerator: 15 psig, 145,000 lbs/hr	36,000
3.	Boiler F. W. Pumps 3 @ $3,000	9,000
4.	Deaerator Supply Pumps 3 @ $1,200	3,600
5.	Water softener: zeolite, 2 train	45,000
6.	Fuel Oil Pump and Heating Set	20,000
7.	Fuel Oil Day Tank	2,000
8.	Fuel Oil Storage Tank	75,000
9.	Fuel Oil S. T. Suction Heater	3,000
10.	Fuel Oil Transfer 2 @ $2,500	5,000
11.	(2) Atlas Bins	1,800,000
12.	Air Compressor	18,000
13.	Tank Suction Heater	10,000
14.	Condensate Receiver	6,000
15.	Ash Handling System	475,000
		$5,107,600

Cost Summary	Alternative 6	
1.	Land	$ 300,000
2.	Steam/Turbogenerator System	15,923,200
3.	Steam Distribution System	900,000
		17,123,200
4.	Sales Tax (5.5% - $14,455,500)	800,000
		17,923,200
5.	Fees (10%)	1,792,000
		19,715,200
6.	Financing (30%)	5,914,800
	Project Cost (1978$)	$25,630,000
	Escalated Project Cost (1980$)	$29,218,000

Operation and Maintenance	Alternative 6	
1.	Fuel	$1,363,800
2.	Electricity	101,100
3.	Labor	361,000
4.	Water	28,300
5.	Water Treatment	43,400
6.	Maintenance	250,000
7.	Ash Disposal	148,400
	Annual Cost	$2,296,000

	Plant Capital Costs	Alternative 6
1.	Site Work	$ 150,000
2.	Piling	330,000
3.	Building - Boiler Plant & Turbine Bldg	922,000
4.	Equipment Installation	1,200,000
5.	Plant Piping	920,000
6.	Electrical Equipment	210,000
7.	Electrical Installation	850,000
8.	Relocating Existing Boiler	25,000
9.	RDF & Hog Fuel Receiving Station, Pneumatic Conveyors & Metering Bin	1,000,000
10.	Atlas Bin Fountains	500,000
	General Contract	$ 6,100,000
	Owner Furnished Equipment	8,375,200
		$14,475,200
	Contingencies (10%)	1,448,000
		$15,923,200

	Equipment Capital Costs	Alternative 6
1.	Boiler: 125,000 lbs/hr, 600 psig/750°F fluidized bed unit	$2,700,000
2.	Deaerator: 60 psig, 145,000 lbs/hr	40,000
3.	Boiler F. W. Pumps - 3 @ $14,000	42,000
4.	Deaerator Supply Pumps - 3 @ $1,400	4,200
5.	Turbine Generator: 12.5 MW	2,470,000
6.	Condenser	190,000
7.	Condensate Pumps - 2 @ $2,500	5,000
8.	Cooling Tower	250,000
9.	Cuc. Water Pumps - 2 @ $27,500	55,000
10.	Turbine Room Crane	70,000
11.	Demineralizer	135,000
12.	Other Equipment	2,414,000
		$8,375,200

Cost Summary	Alternative 7	
1.	Land	$ 300,000
2.	Steam Plant	14,378,000
3.	Steam Distribution System	900,000
		15,578,000
4.	Sales Tax (5.5% - $9,887,500)	544,000
		16,122,000
5.	Fees (10%)	1,612,000
		17,734,000
6.	Financing (30%)	5,320,000
	Project Cost (1978$)	$23,054,000
	Escalated Project Cost (1980$)	$26,395,000

Operation and Maintenance	Alternative 7	
1.	Fuel	$1,862,700
2.	Electricity	88,400
3.	Labor	387,500
4.	Water	15,500
5.	Water Treatment	69,400
6.	Maintenance	250,000
7.	Ash Disposal	157,000
	Annual Cost	$2,830,500

	Plant Capital Costs	Alternative 7
1.	Site Work	$ 150,000
2.	Piling	400,000
3.	Building - Boiler Plant	886,000
4.	Equipment Installation	225,000
5.	Plant Piping	850,000
6.	Electrical Equipment	125,000
7.	Electrical Installation	800,000
8.	Relocating Existing Boilers	35,000
9.	RDF & Hog Fuel Receiving Station, pneumatic Conveyors, & Metering Bin	1,160,000
10.	Atlas Bin Fountains	600,000
	General Contract	$ 5,231,000
	Owner Furnished Equipment	7,272,000
		$12,503,000
	Contingencies (15%)	1,875,000
		$14,378,000

	Equipment Capital Costs	Alternative 7
1.	Boiler: 200,000 lbs/hr, 150 psig fluidized bed unit	$4,000,000
2.	Deaerator: 15 psig, 220,000 lbs/hr	42,000
3.	Boiler F. W. Pumps - 3 @ $4,000	12,000
4.	Deaerator Supply Pumps - 3 @ $1,500	4,500
5.	Water softener: zeolite, 2 train	53,000
6.	Fuel Oil Pump and Heating Set	24,000
7.	Fuel Oil Day Tank	2,500
8.	Fuel Oil Storage Tank	90,000
9.	Fuel Oil S. T. Suction Heater	3,500
10.	Fuel Oil Transfer Pumps - 2 @ $2,500	5,000
11.	(2) Atlas Bins	2,400,000
12.	Air Compressor	21,750
13.	Tank Suction Heater	5,600
14.	Condensate Receiver	7,500
15.	Ash Handling System	600,000
		$7,271,350

Cost Summary	Alternative 8	
1.	Land	$ 300,000
2.	Steam/Turbogenerator System	21,031,000
3.	Steam Distribution System	900,000
		22,231,000
4.	Sales Tax (5.5% - $15,407,500)	847,000
		23,078,000
5.	Fees (10%)	2,308,000
		25,386,000
6.	Financing (30%)	7,616,000
	Project Cost (1978$)	$33,002,000
	Escalated Project Cost (1980$)	$37,784,000

Operation and Maintenance	Alternative 8	
1.	Fuel	$2,176,000
2.	Electricity	149,700
3.	Labor	387,500
4.	Water	32,400
5.	Water Treatment	69,400
6.	Maintenance	335,000
7.	Ash Disposal	236,800
	Annual Cost	$3,386,800

	Plant Capital Costs	Alternative 8
1.	Site Work	$ 150,000
2.	Piling	440,000
3.	Building - Boiler Plant & Turbine Bldg	1,038,000
4.	Equipment Installation	1,550,000
5.	Plant Piping	1,200,000
6.	Electrical Equipment	250,000
7.	Electrical Installation	1,000,000
8.	Relocating Existing Boilers	35,000
9.	RDF & Hog Fuel Receiving Station, Pneumatic Conveyors & Metering Bin	1,160,000
10.	Atlas Bin Fountains	600,000
	General Contract	$ 7,423,000
	Owner Furnished Equipment	11,696,000
		$19,119,000
	Contingencies (10%)	1,912,000
		$21,031,000

	Equipment Capital Costs	Alternative 8
1.	Boiler: 200,000 lbs/hr, 600 psig/750°F fluidized bed unit	$ 4,200,000
2.	Deaerator: 60 psig, 220,000 lbs/hr	48,000
3.	Boiler F. W. Pumps - 3 @ $17,000	51,000
4.	Deaerator Supply Pumps - 3 @ $1,760	5,300
5.	Turbine Generator: 20 MW	3,435,000
6.	Condenser	228,000
7.	Condensate Pumps - 2 @ $3,000	6,000
8.	Cooling Tower	273,000
9.	Cuc. Water Pumps - 2 @ $35,000	70,000
10.	Turbine Room Crane	70,000
11.	Demineralizer	150,000
12.	Other Equipment	3,159,850
		$11,696,150

Cost Summary	Alternative 9	
1.	Land	$ 300,000
2.	HTHW Plant	11,820,000
3.	HTHW Distribution System	4,942,000
		17,062,000
4.	Sales Tax (5.5% - $10,400,000)	572,000
		17,634,000
5.	Fees (10%)	1,763,000
		19,397,000
6.	Financing (30%)	5,819,000
	Project Cost (1978$)	$25,216,000
	Escalated Project Cost (1980$)	$28,870,000

Operation and Maintenance	Alternative 9	
1.	Fuel	$229,000
2.	Electricity	36,000
3.	Labor	345,400
4.	Water	500
5.	Water Treatment	5,000
6.	Maintenance	97,000
7.	Ash Disposal	25,300
	Annual Cost	$738,200

	Plant Capital Costs	Alternative 9
1.	Site Work	$ 150,000
2.	Piling	350,000
3.	Building - HTHW Plant	1,200,000
4.	Equipment Installation	230,000
5.	Plant Piping	350,000
6.	Electrical Equipment	85,000
7.	Electrical Installation	675,000
8.	Relocating Existing Boiler	25,000
9.	RDF & Hog Fuel Receiving Station, Pneumatic Conveyors & Metering Bins	1,100,000
10.	Atlas Bin Fountains	550,000
	General Contract	$ 4,715,000
	Owner Furnished Equipment	5,563,000
		$10,278,000
	Contingencies (15%)	1,542,000
		$11,820,000

	Equipment Capital Costs	Alternative 9
1.	HTHW Generators - (2) 57 x 10^6 Btu/hr stoker for RDF, Hog Fuel, Coal & Oil	$3,000,000
2.	Generator Circ. Pumps - 3 @ $6,100	18,300
3.	System Circ, Pumps - 3@ $10,500	31,500
4.	Expansion Tank	3,500
5.	Demineralizer	110,000
6.	Makeup Water Tank & Pump	7,500
7.	Chemical Pump & Tank Set	2,500
8.	Fuel Oil Pump & Heating Set	20,000
9.	Fuel Oil Day Tank w/Suction Heater	7,000
10.	Fuel Oil Storage Tank	75,000
11.	Fuel Oil S. T. Suction Heater	5,600
12.	Fuel Oil Transfer Pumps - 2 @ $2,500	5,000
13.	(2) Atlas Bins	1,800,000
14.	Air Atomizing Air Compressor	9,500
15.	(2) Plant Air Compressors	18,000
16.	Ash Handling System	450,000
		$5,563,400

Cost Summary	Alternative 10	
1.	Land	$ 300,000
2.	Steam/HTHW Plant	14,995,000
3.	HTHW & Steam Distribution Systems	5,242,000
		20,537,000
4.	Sales Tax (5.5% - $12,891,000)	709,000
		21,246,000
5.	Fees (10%)	2,125,000
		23,371,000
6.	Financing (30%)	7,011,000
	Project Cost (1978$)	$30,382,000
	Escalated Project Cost (1980$)	$34,784,000

Operation and Maintenance	Alternative 10	
1.	Fuel	$1,755,000
2.	Electricity	95,700
3.	Labor	387,500
4.	Water	5,000
5.	Water Treatment	12,700
6.	Maintenance	250,000
7.	Ash Disposal	157,000
	Annual Cost	$2,662,900

Plant Capital Costs	Alternative 10
General Contract - Steam Plant (Alt. 7)	$ 5,231,000
General Contract - HTHW System	309,000
General Contract	$ 5,540,000
Owner Furnished Equipment	7,500,000
	$13,040,000
Contingencies (15%)	1,955,000
	$14,995,000

Equipment Capital Costs	
Steam Plant (Alt. 7)	$7,272,000
HTHW Equipment	228,000
	$7,500,000

COMPUTER SUMMARY
125M lbs/hr
8% - 8%

TACOMA CONSUMERS CENTRAL HEATING (100,000PPH)

SUMMARY REPORT - STEAM
PLAN: STEAM

PLANNING ITEM					
	1980	1981	1982	1983	1984
	1985	1986	1987	1988	1989
	1990	1991	1992	1993	1994
	1995	1996	1997	1998	1999
	2000				
125,000 PPH COSTS X $1000					
42 TOTAL COSTS	4480	4676	4887	5114	5360
	5626	5913	6223	6558	6919
	7310	7731	8187	8678	9209
	9783	10403	11072	11794	12575
	13418				
44 COST PER 1000 LB STEAM	5.46	5.69	5.95	6.23	6.53
	6.85	7.20	7.58	7.98	8.43
	8.90	9.41	9.97	10.57	11.21
	11.91	12.67	13.48	14.36	15.31
	16.34				
100,000 PPH COSTS X 1000					
62 TOTAL COSTS	4359	4545	4745	4961	5195
	5448	5721	6015	6333	6677
	7048	7448	7881	8348	8853
	9398	9987	10623	11310	12051
	12852				
64 COST PER 1000 LB STEAM	6.63	6.92	7.22	7.55	7.91
	8.29	8.71	9.16	9.64	10.16
	10.73	11.34	12.00	12.71	13.48
	14.30	15.20	16.17	17.21	18.34
	19.56				
75,000 PPH COSTS X 1000					
82 TOTAL COSTS	3860	4006	4163	4333	4517
	4715	4929	5160	5410	5680
	5971	6285	6625	6992	7388
	7816	8278	8778	9317	9899
	10528				
84 COST PER 1000 LB STEAM	7.83	8.13	8.45	8.79	9.17
	9.57	10.00	10.47	10.98	11.53
	12.12	12.76	13.45	14.19	14.99
	15.86	16.80	17.81	18.91	20.09
	21.37				

COMPUTER SUMMARY
125M lbs/hr
6% - 6%

TACOMA CONSUMERS CENTRAL HEATING (100,000PPH)

SUMMARY REPORT - STEAM

PLAN: STEAM

PLANNING ITEM					
	1980	1981	1982	1983	1984
	1985	1986	1987	1988	1989
	1990	1991	1992	1993	1994
	1995	1996	1997	1998	1999
	2000				
125,000 PPH COSTS X $1000					
42 TOTAL COSTS	4096.7	4237.8	4387.4	4545.9	4714.0
	4892.1	5080.9	5281.1	5493.2	5718.1
	5956.5	6209.2	6477.1	6761.0	7062.0
	7381.0	7719.1	8077.6	8457.5	8860.3
	9287.2				
44 COST PER 1000 LB STEAM	4.99	5.16	5.34	5.54	5.74
	5.96	6.19	6.43	6.69	6.95
	7.25	7.56	7.89	8.23	8.60
	8.99	9.40	9.84	10.30	10.79
	11.31				
100,000 PPH COSTS X 1000					
62 TOTAL COSTS	3979.8	4113.9	4256.1	4406.7	4566.4
	4735.7	4915.2	5105.4	5307.0	5520.7
	5747.3	5987.4	6241.9	6511.8	6797.8
	7100.9	7422.3	7762.9	8124.0	8506.7
	8912.4				
64 COST PER 1000 LB STEAM	6.06	6.26	6.48	6.71	6.95
	7.21	7.48	7.77	8.08	8.40
	8.75	9.11	9.50	9.91	10.35
	10.81	11.30	11.82	12.37	12.95
	13.57				
75,000 PPH COSTS X 1000					
82 TOTAL COSTS	3499.4	3604.7	3716.2	3834.5	3959.9
	4092.8	4233.6	4383.0	4541.2	4709.0
	4886.8	5075.4	5275.2	5487.0	5711.5
	5949.5	6201.8	6469.2	6752.6	7053.1
	7371.6				
84 COST PER 1000 LB STEAM	7.10	7.32	7.54	7.78	8.04
	8.31	8.59	8.89	9.22	9.56
	9.92	10.30	10.71	11.14	11.59
	12.07	12.59	13.13	13.70	14.31
	14.96				

COMPUTER SUMMARY
200M lbs/hr
6% - 6%

TACOMA CONSUMERS CENTRAL HEATING (200,000PPH)

SUMMARY REPORT - STEAM PAGE 10
PLAN: STEAM

PLANNING ITEM					
	1980	1981	1982	1983	1984
	1985	1986	1987	1988	1989
	1990	1991	1992	1993	1994
	1995	1996	1997	1998	1999
	2000				
200,000 PPH COSTS X $1000					
42 TOTAL COSTS	5223	5399	5585	5782	5991
	6212	6447	6695	6959	7238
	7535	7849	8182	8534	8908
	9305	9725	10171	10643	11143
	11674				
44 COST PER 1000 LB STEAM	3.98	4.11	4.25	4.40	4.56
	4.73	4.91	5.10	5.30	5.51
	5.73	5.97	6.23	6.50	6.78
	7.08	7.40	7.74	8.10	8.48
	8.88				
150,000 PPH COSTS X 1000					
62 TOTAL COSTS	4917	5074	5240	5417	5604
	5802	6012	6235	6471	6721
	6986	7267	7565	7881	8216
	8571	8947	9346	9768	10216
	10691				
64 COST PER 1000 LB STEAM	4.99	5.15	5.32	5.50	5.69
	5.89	6.10	6.33	6.57	6.82
	7.09	7.37	7.68	8.00	8.34
	8.70	9.08	9.48	9.91	10.37
	10.85				
100,000 PPH COSTS X 1000					
82 TOTAL COSTS	4325.2	4446.8	4575.4	4711.8	4856.5
	5009.8	5172.3	5344.6	5527.2	5720.9
	5926.0	6143.5	6374.0	6618.4	6877.4
	7152.0	7443.1	7751.6	8078.7	8425.3
	8792.8				
84 COST PER 1000 LB STEAM	6.58	6.77	6.96	7.17	7.39
	7.63	7.87	8.13	8.41	8.71
	9.02	9.35	9.70	10.07	10.47
	10.89	11.33	11.80	12.30	12.82
	13.38				

COMPUTER SUMMARY
200M lbs/hr
8% - 8%

TACOMA CONSUMERS CENTRAL HEATING (200,000PPH)

SUMMARY REPORT - STEAM PAGE 10
PLANT STEAM

PLANNING ITEM					
	1980	1981	1982	1983	1984
	1985	1986	1987	1988	1989
	1990	1991	1992	1993	1994
	1995	1996	1997	1998	1999
	2000				
200,000 PPH COSTS X $1000					
42 TOTAL COSTS	5722	5965	6227	6510	6815
	7146	7502	7887	8303	8753
	9238	9762	10329	10939	11599
	12312	13082	13913	14811	15781
	16828				
44 COST PER 1000 LB STEAM	4.35	4.54	4.74	4.95	5.19
	5.44	5.71	6.00	6.32	6.66
	7.03	7.43	7.86	8.32	8.83
	9.37	9.96	10.59	11.27	12.01
	12.81				
150,000 PPH COSTS X 1000					
62 TOTAL COSTS	5404	5621	5856	6109	6383
	6678	6998	7342	7715	8117
	8551	9020	9527	10074	10665
	11303	11992	12736	13540	14408
	15346				
64 COST PER 1000 LB STEAM	5.48	5.70	5.94	6.20	6.48
	6.78	7.10	7.45	7.83	8.24
	8.68	9.15	9.67	10.22	10.82
	11.47	12.17	12.92	13.74	14.62
	15.57				
100,000 PPH COSTS X 1000					
82 TOTAL COSTS	4789	4957	5139	5335	5547
	5775	6022	6289	6577	6888
	7224	7587	7979	8403	8860
	9354	9887	10463	11085	11756
	12482				
84 COST PER 1000 LB STEAM	7.29	7.55	7.82	8.12	8.44
	8.79	9.17	9.57	10.01	10.48
	11.00	11.55	12.15	12.79	13.49
	14.24	15.05	15.93	16.87	17.89
	19.00				

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