SECTION 4.0

PLANT REQUIREMENTS

TVA Coal Gasification Demonstration Plant Project
Plant Based on Texaco Gasifiers

4.1 Summary of Feed and Products

TABULATION OF FEED AND PRODUCTS (4 MODULES)

Coal Feed Rate TPD as Rec'd	
Gasification	21,230
Boiler Plt	1,340
Excess Fines	0
Total	22,570
Oxygen Feed, 98%, TPD	18,120
Product Gas	
MM SCFD	1,234.6
HHV BTU/SCF	286.0
MMM BTU/DA	353.1
Composition, MOL%	
H_2	37.51
CO	50.04
CH_4	0.32
N_2 + Ar	1.39
CO_2	10.73
H_2O	0.01
C_2	–
By-products	
Sulfur LTPD	729
Ammonia, TPD	–
Phenols, TPD	–
Oil, BPD	–
Naphtha, BPD	–

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FOSTER WHEELER ENERGY CORPORATION

TVA Coal Gasification Study
Texaco Gasifiers

OVERALL MATERIAL & ENERGY BALANCE
(PER MODULE)

Input	Tons/Day	MMBTU/HR
Coal to Coal Handling	5,643	5,164.0
Air	20,860	8.7
Water	36,600	61.0
Limestone	91	-
Power	-	77.8
Total In	63,194	5,311.5

Output	Tons/Day	MMBTU/HR
Product Gas	8,260	3,714.1
Sulfur (ST/D)	207	68.2
Slag	760	23.5
Cooling Tower Evap.	15,027	1,214.2
Cooling Tower Losses	9,273	26.9
Air Plant Waste Gas	12,619	8.9
Vent Gases	8,500	14.4
Water Losses	8,250	13.6
Miscellaneous	298	227.7
Total Out	63,194	5,311.5

SECTION DESCRIPTION

4.2 STEAM BALANCE

A. Reference Material

- Process Flowsheets — FWEC Dwg. No. 54099-35-1-50-17
- Steam Balance Summary — FWEC Dwg. No. 54099-35-1-50-151
- Equipment Summary List

B. Description of Flow

Flow of steam generation and distribution may be followed on the Plant Steam, Condensate and Boiler Feed Water Diagram, Drawing No. 54099-35-1-50-151.

The Steam Header System consists of four steam levels:

High Pressure (H.P.)	900 psig,	1000°F
Medium Pressure (M.P.)	150 psig,	365°F
Low Pressure (L.P.)	85 psig,	460°F
Low Pressure (L.P.)	50 psig,	298°F

High pressure saturated steam is generated through waste heat recovery in the Radiant Cooler, E-313 and Convection Cooler, E-314. Most of high pressure steam is condensed or expanded through turbines driving Air Compressor, C-201, and the Oxygen Compressor, C-202. A small amount of H.P. steam is required for preheat in the Claus Sulfur Recovery Plant. Condensate from H.P. steam users is returned to the deaerator.

Medium pressure steam is generated in Claus Plant Section in the Waste Heat Boiler, E-601. Medium pressure steam is utilized principally in the Gasification Section 300.

85 psig steam is extracted from the oxygen compressor turbine. It is utilized principally in the H_2S Stripper Reboiler, E-403, in Acid Gas Removal Section 400. Other consumers of 85 psig steam are the H.P. Condensate Heater, E-1205, and Deaerator, DH-1201. Also, the Beavon Tail Gas Treating Unit, steam tracing and miscellaneous items utilize 85 psig steam.

50 psig steam is generated by flashing medium and high pressure steam condensate into Condensate Flash Drum, D-1208. Waste Heat Boiler, SG-1203, upstream of the Fluid Bed Boiler Superheater, SG-1202, also generates 50 psig steam by recovering heat from flue gas. Consumers of the 50 psig steam are: Deaerator, DH-1201; the Flash Drum, D-701; and Ammonia Stripper, T-701 in Section 700; Tail Gas Treating Unit and Sulfur Prilling Unit. Blowdown from various steam generating equipment is directed to the cooling tower as cooling tower makeup. L.P. condensate flows to the Condensate Storage Tank, TK-1203 and flashes to 15 psig steam. Final Sulfur Condenser, E-607, also generates 15 psig steam. Deaerator, DH-1201, utilizes all of the 15 psig steam generated within the plant. The condensate from the storage tank is pumped to the deaerator for subsequent use as boiler feed water. A BFW Booster Pump, P-1213, is provided in series with the M.P. BFW Pump, P-1205, to pump a portion of the deaerated condensate to the H.P. level.

Process flowsheet 54099-35-1-17 shows the Steam Generator, SG-1201, and the Fluid Bed Boiler Superheater, SG-1202. The Steam Generator is used during the plant startup. The Fluid Bed Boiler Superheater superheats the 900 psig saturated steam produced in the Gasifier. Limestone is injected into both the Steam Generator and Fluid Bed Boiler to reduce the sulfur emission. Approximately 90% of the sulfur in the coal is converted to calcium sulfite, recovered as ash and discharged to the slag pond.

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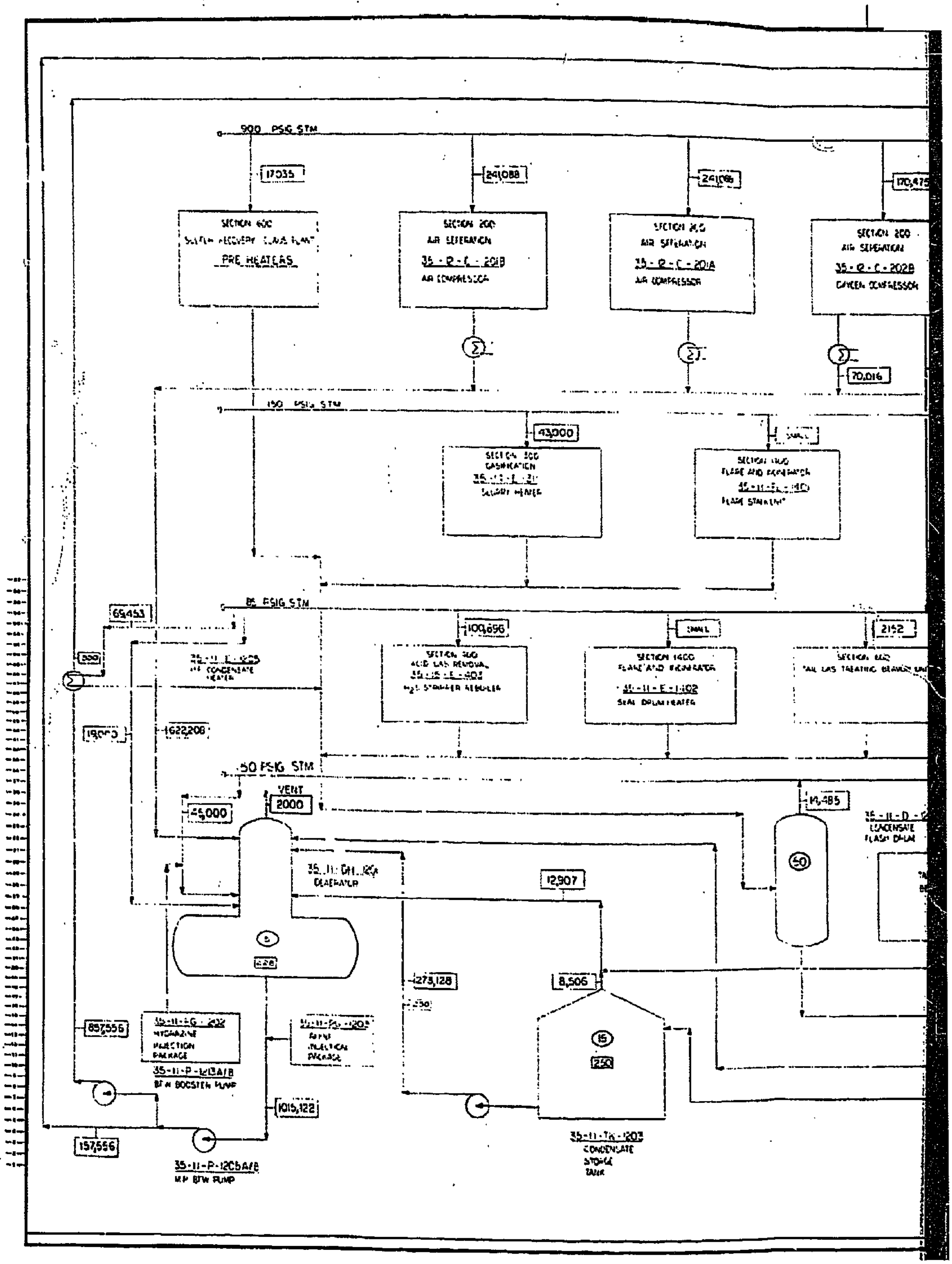
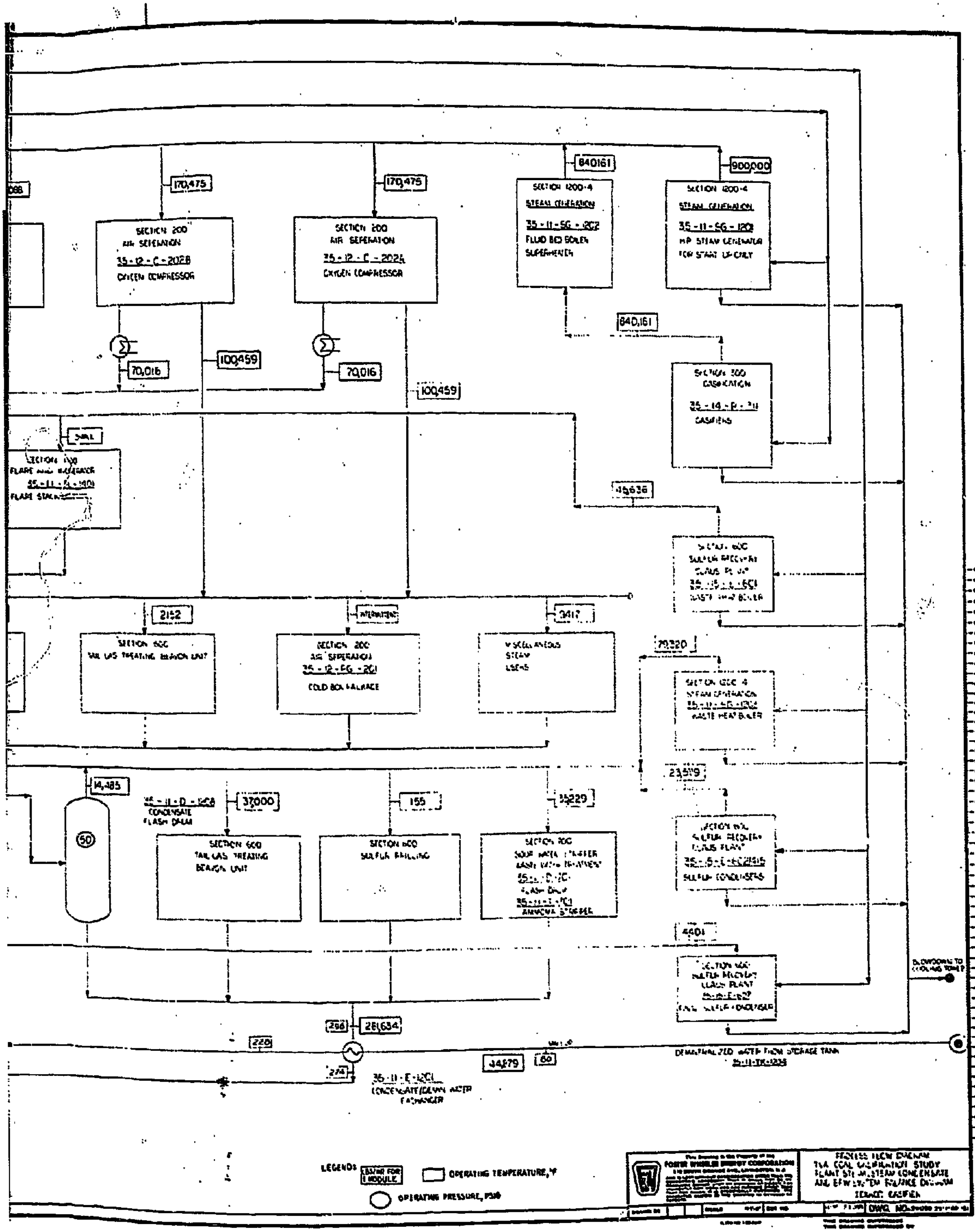


900 PSIG STM
17035
241088
241086
170,475
SECTION 600
SULFUR RECOVERY CLAUS PLANT
PRE HEATERS
SECTION 200
AIR SEPERATION
35-12-C-201B
AIR COMPRESSOR
SECTION 200
AIR SEPERATION
35-12-C-201A
AIR COMPRESSOR
SECTION 200
AIR SEPERATION
35-12-C-202B
OXYGEN COMPRESSOR
70,016
150 PSIG STM
43,000
SECTION 300
GASIFICATION
SLURRY HEATER
SECTION 1400
FLARE AND INCINERATOR
FLARE STACK
85 PSIG STM
69,453
100,656
2152
SECTION 500
ACID GAS REMOVAL
H2S STRIPPER REBOILER
SECTION 1400
FLARE AND INCINERATOR
35-11-E-1402
SEAL DRUM HEATER
SECTION 600
TAIL GAS TREATING
35-11-E-1205
AIR CONDENSATE HEATER
19000
1622,208
50 PSIG STM
VENT
2000
45,000
19,485
35-11-D-12
CONDENSATE FLASH DRUM
35-11-DH-1201
DEAERATOR
12,907
273,128
8,506
897,556
35-11-PG-1202
HYDRAZINE INJECTION PACKAGE
35-11-P-1213A/B
BFW BOOSTER PUMP
AMINE INJECTION PACKAGE
1015,122
157,556
35-11-P-1206A/B
H.P. BFW PUMP
35-11-TK-1203
CONDENSATE STORAGE TANK


170,475
SECTION 200
AIR SEPERATION
35-12-C-202B
OXYGEN COMPRESSOR
SECTION 200
AIR SEPERATION
35-12-C-202A
OXYGEN COMPRESSOR
840161
SECTION 1200-4
STEAM GENERATION
35-11-SG-1202
FLUID BED BOILER
SUPERHEATER
900,000
SECTION 1200-4
STEAM GENERATION
35-11-SG-1201
HP STEAM GENERATOR
FOR START UP ONLY
70,016
100,459
840,161
SECTION 300
GASIFICATION
GASIFIERS
45,636
2152
3417
SECTION 600
TAIL GAS TREATING BEAVON UNIT
SECTION 200
AIR SEPERATION
35-12-FG-201
COLD BOX FURNACE
MISCELLANEOUS
STEAM
USERS
79,320
14,485
35-11-D-1208
CONDENSATE
FLASH DRUM
37,000
155
35229
23,519
50
SECTION 600
TAIL GAS TREATING
BEAVON UNIT
SECTION 600
SULFUR PRILLING
4401
BLOWDOWN TO COOLING TOWER
256
281,654
226
274
34,879
60
35-11-E-1201
CONDENSATE/DEMIN WATER
EXCHANGER
DEMINERALIZED WATER FROM STORAGE TANK
LEGEND:
OPERATING TEMPERATURE, °F
OPERATING PRESSURE, PSIG
FOSTER WHEELER ENERGY CORPORATION
PROCESS FLOW DIAGRAM
TVA COAL GASIFICATION STUDY
TEXACO GASIFIER
DWG. NO.

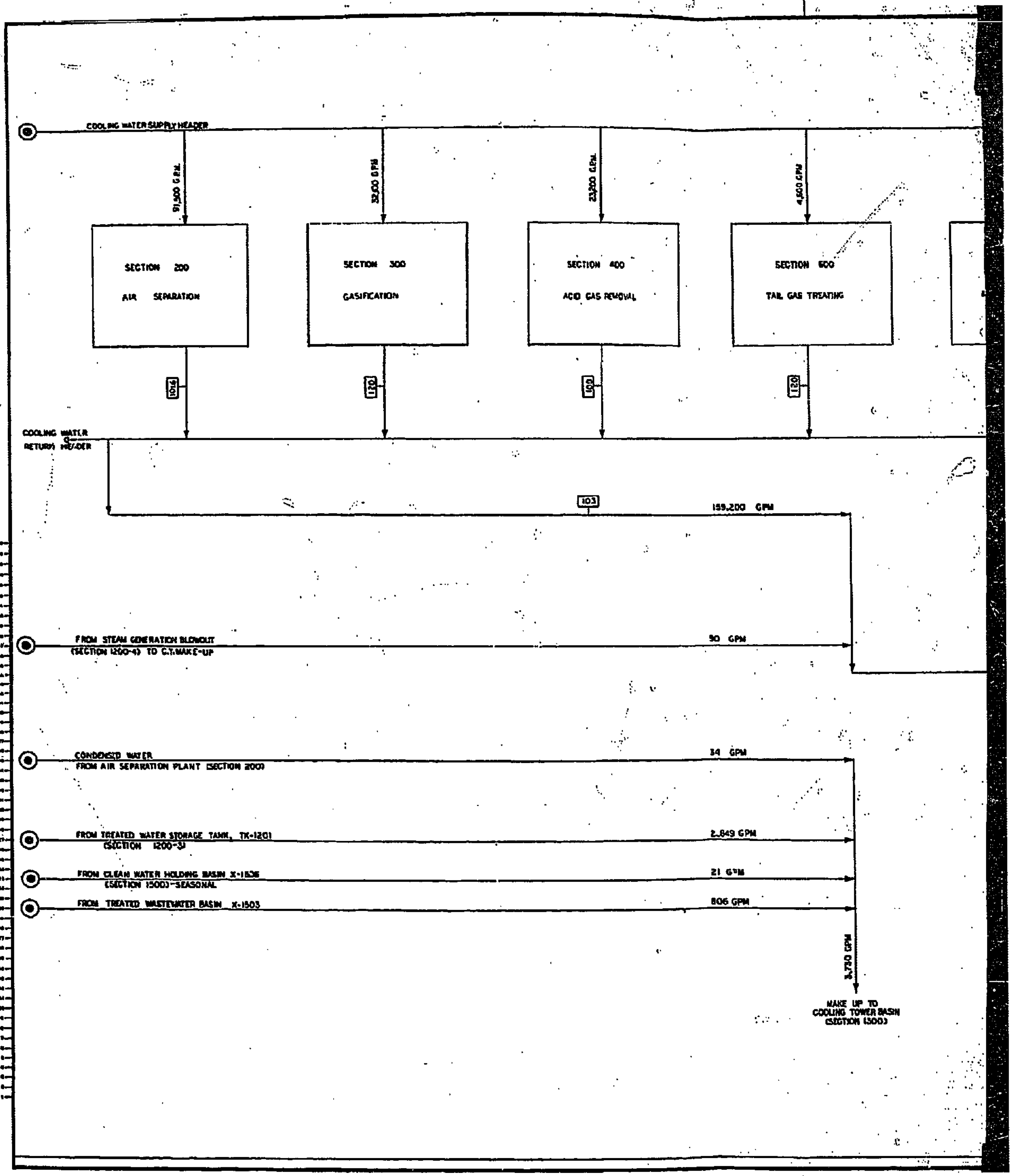
p

4.3 Cooling Water Usage

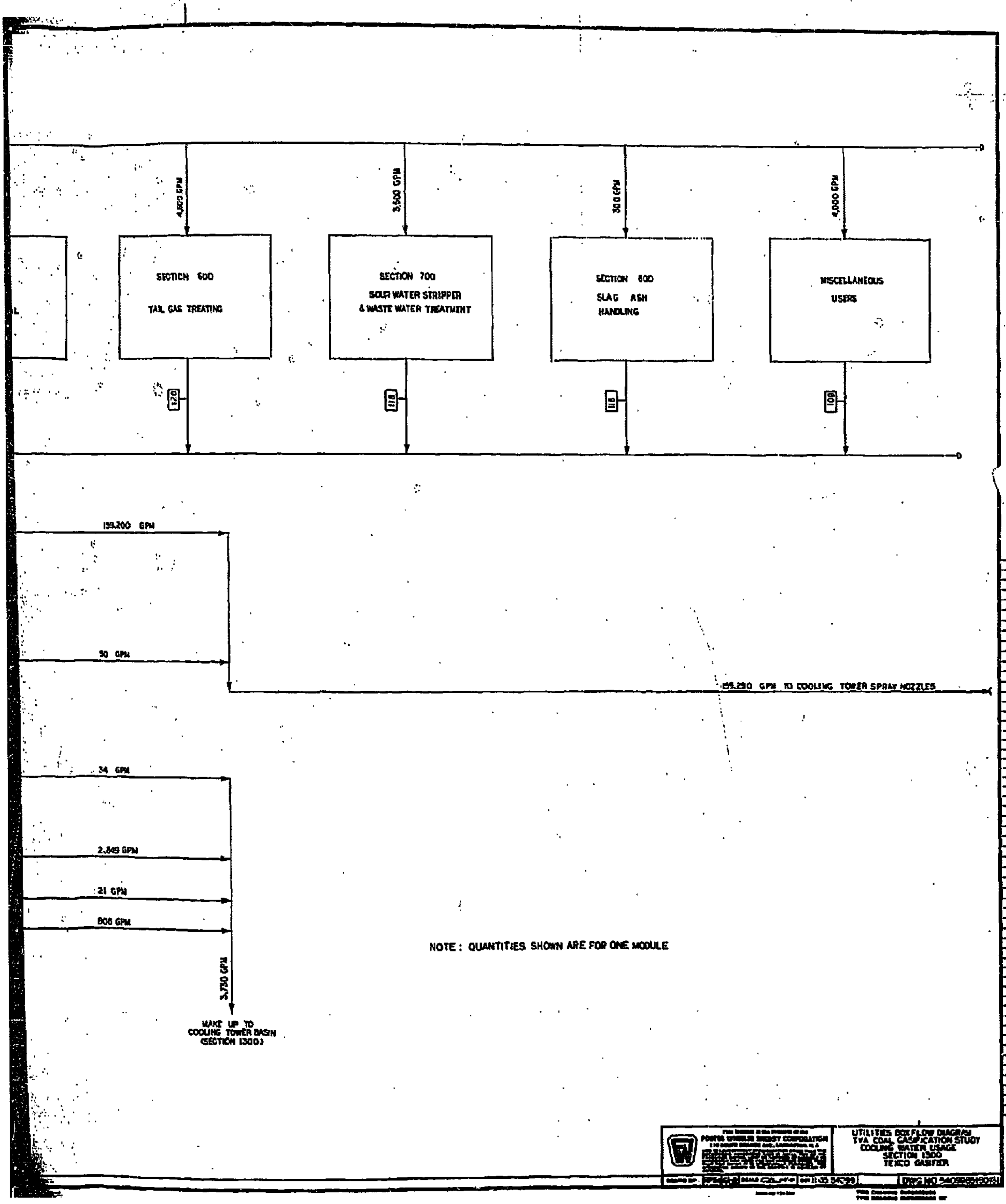
Utilities Box Flow Diagram

The cooling water users are indicated on Dwg. No. 54099-35-1-50-161. Major users are the turbine condensers in Sec. 200, Air Separation, for the Refrigeration Compressor in Sec. 400, Acid Gas Removal, and in Sec. 300, Gasification.

The average temperature rise is shown for each section. The cooling water return header discharges at the cooling tower spray nozzles. The cooling tower makeup of 3,730 gpm compensates for evaporation and windage losses at the cooling tower and for cooling tower blowdown (550 gpm).



COOLING WATER SUPPLY HEADER
91,500 G.P.M.
32,000 G.P.M.
23,200 G.P.M.
4,500 GPM
SECTION 200
AIR SEPARATION
SECTION 300
GASIFICATION
SECTION 400
ACID GAS REMOVAL
SECTION 600
TAIL GAS TREATING
1016
120
100
120
COOLING WATER RETURN HEADER
103
159,200 GPM
FROM STEAM GENERATION BLOWOUT (SECTION 1200-4) TO C.T. MAKE-UP
50 GPM
CONDENSED WATER FROM AIR SEPARATION PLANT (SECTION 200)
34 GPM
FROM TREATED WATER STORAGE TANK, TK-1201 (SECTION 1200-3)
2,849 GPM
FROM CLEAN WATER HOLDING BASIN X-1506 (SECTION 1500)-SEASONAL
21 GPM
FROM TREATED WASTEWATER BASIN X-1503
806 GPM
3,730 GPM
MAKE UP TO COOLING TOWER BASIN (SECTION 1500)


4,500 GPM
3,500 GPM
300 GPM
4,000 GPM
SECTION 600
TAIL GAS TREATING
SECTION 700
SOUR WATER STRIPPER
& WASTE WATER TREATMENT
SECTION 800
SLAG ASH
HANDLING
MISCELLANEOUS
USERS
120
118
116
109
199,200 GPM
90 GPM
199,290 GPM TO COOLING TOWER SPRAY NOZZLES
34 GPM
2,849 GPM
21 GPM
806 GPM
3,750 GPM
MAKE UP TO
COOLING TOWER BASIN
(SECTION 1300)
NOTE: QUANTITIES SHOWN ARE FOR ONE MODULE
UTILITIES BOX FLOW DIAGRAM
TVA COAL GASIFICATION STUDY
COOLING WATER USAGE
SECTION 1300
TEXCO GASIFIER

TVA Coal Gasification Study

Texaco Gasifiers

4.4 Power Requirements

Section	Name of Section	Plant Power Usage, Kw Gross	From Steam	Net
100	Coal Handling (Crushing, Feeding)	3100	---	3100
200	Air Separation	178,192	176,192	2000
300	Coal Grinding	11,928	---	11,928
300	Gasification and Gas Scrubbing	11,604	---	11,604
400	Acid Gas Removal (Selexol)	38,508	---	38,508
600	Sulfur Recovery - Claus Plant	1,792	---	1,792
600	Sulfur Recovery - Beavon Unit	3,972	---	3,972
600	Sulfur Prilling	120	---	120
700	Sour Water Stripping & Wastewater Treatment	768	---	768
800	Slag Handling	160	---	160
1200-1	Raw Water Treatment	800	---	800
1200-2	Condensate Treatment and Potable Water	1100	---	1100
1200-3	BFW Treatment	5600	---	5600
1200-4	Fluid Bed Boiler	500	---	500
1300	Cooling Water System	30,000	---	30,000
1400	Flare & Incinerator	1,000	---	1,000
1500	Wastewater Treatment	800	---	800
2000	General Facilities	900	---	900
2100	Buildings	450	---	450
2200	Dock Facilities	200	---	200
	TOTAL	291,494	176,192	115,302

4.5 Fuel Requirements - Texaco Gasifier System

The fuel required to produce the medium Btu product gas and provide the required quantity of process steam is coal.

Approximately 5,000 T/D of dried coal (containing 2.0 wt % moisture), 5,418 T/D as-is coal, is fed to each gasifier module. In addition, the fluid bed boiler superheater in each module will consume about 335 T/D of coal (as-is). There are no other normal fuel requirements.

SECTION 5.0

PLANT LAYOUT

5.0 PLANT LAYOUT

Introduction

The development of the Key Plot Plan requires the optimization of all facilities from the standpoint of accommodating the process steams, minimizing piping sizes and lengths, consilidating common facilities, access to coal storage and ash deposit areas, minimizing changes in the topography of the site, minimizing visual intrusions into the environment, etc.

As the plant is now envisaged, the major heavy structural loads would be situated where some twenty feet of overburden occurs over occasional outcroppings of Chickamauga limestone. This would provide excellent subsoil conditions for accommodating foundations for gasifier reactor vessels and other heavy rotating equipment and tanks.

A prominent feature of the Key Plot Plan is the cluster of four gasification modules. Each module contains in addition to the gasifier reactor, special coal preparation, raw gas cooling and compression (as may be required), extraction of by-products (when applicable) and treatment of the raw gas for removal of acidic compounds and sulfur.

Within the context of a conceptual design and level of detail expected in arriving at the cost estimate, the Key Plot Plan and elevation drawings, in two views of the entire plant, have been developed. The equipment and structures for the various process elements are representative of such units. The gasifier reactors and materials handling elevation views are fairly accurate representations of how the plant would actually appear.

The rationale and design philosophy for developing the Key Plot Plan and elevations is discussed below under the following headings.

Key Plot Plan & Elevation Views

Paragraph	Facility	Section No.
A.	Dock Facilities	2200
B.	Coal Storage, Handling & Preparation	100
C.	Coal Gasification	300
D.	Air Separation & Steam Generation	200, 1200
E.	Gas Treating & Removal of Sulfur	700, 600
F.	Waste Water Treatment	1500
G.	General Facilities	2000
H.	Flare & Incinerator	1400
I.	Ash Storage	2000
J.	Buildings	2100
K.	Cooling Water System	1300
L.	Elevation Views	

p

Key Plot Plan

A. Dock Facilities - A promontory on the N.W. shore of Murphy Hill has been selected for barge unloading as it incorporates the best features desired, considering -

1. Spillage of coal or water from coal into Guntersville Lake would be minimized.

2. There is minimal dredging required initially, and it is expected that future dredging of silt would be required on very infrequent intervals.

3. Docking and any movement of barges by tow boat, would be completely unhampered in this location. This is especially true in the event that 24 loaded and 24 unloaded b arges had to be moored, as stipulated in the Design Criteria (1.2.3).

4. The conveyor, from the dock area inland, would pass along a land area at the S.W. corner of Murphy Hill, which provides a convenient area for dead storage of coal to a height of approximately 50 feet.

A dock, auxiliary to the coal unloading facilities, is provided to accommodate the shipment of sulfur, either in a liquid state or as dry prills, by means of a barge. The auxiliary dock may also be utilized for the receipt of any bulk materials which would be necessary for the operation of the plant.

B. Coal storage, handling and preparation - The acreage required for the 90 day dead storage, stipulated, is seen to occupy a peninsula at the S.W. corner of Murphy Hill. Maximal use is made of an area having an irregular boundary. The proportions of the area are such that the encirculing roadway facilitates monitoring the coal pile to maintain compaction with a view to preventing fires and erosion of surface fines by the elements. One of the important benefits of the site selected or dead storage of coal is the latitude it provides, or coal conveying and treatment. When coal is withdrawn from dead storage, there are several stations for transfer and processing of the coal before entering the final feed device for the gasifier or the ancillary combustion equipment. The lineal distance provided between reclaim from dead storage and the gasifiers is ample to accommodate limits on elevation feasible with the belt conveyors as coal is fed to various stations and, ultimately, to the gasifier feed.

C. Coal Gasification - The arrangement of the reactor for coal gasification is closely intertwined with the coal feed system. As a consequence, the reactor vessels are aligned parallel to the conveyor for coal feed and the system for removal of ash or slag as it occurs at the reactor itself. The process systems, ancillary to the coal gasifiers, are arranged in close proximity for each module.

D. Air Separation and Steam Generation - These plants are situated contiguous to each other and in close proximity to the gasifier to minimize the length of high pressure steam piping to the compressor turbine drives of the air separation plant. The economic necessity of minimizing the length of oxygen piping from the air separation plant to the gasifiers dictates having the air separation plant in close proximity to the gasifiers. Coal, flux and ash conveying design condiserations have been a strong influence in determining the general location of the steam generation plant.

D. Gas Treating and Removal of By-products - The raw gas stream is processed to remove acidic compounds and to separate and concentrate H_2S as well as other compounds containing sulfur in trace amounts. Ammonia is also separated from the raw gas for disposal by burning in the SRU reaction furnace. The separated gas stream containing the concentrations of sulfur compounds are then diverted to a Claus sulfur recovery unit (SRU) to produce elemental sulfur. Inasmuch as each gasification module is provided with a separate gas treating and sulfur recovery system, all such units are contained in the plot area common to each module. A spare SRU is placed contiguous to the four modules.

F. Water Treatment - This area is for general service to the entire plant, exclusive of boiler feedwater treatment which is done in the utility area. The western area, adjacent to a cove S.W. of Murphy Hill, is a naturally low laying area at approximately 600 feet elevation. The principal reason for selecting this ares is that it allows for adequate head to drain oily waters and other liquid wastes for treatment. Considering the variety of ponds, tanks, clarifiers and separators, maximal utilization of the irregular terrain is possible with minimal requirements for grading. Inasmuch as the river flows from N.E. to S.W., overflow of treated wastewaters may be returned to the river, conveniently, at a location downstream of the fresh water intake from the N.W. face of Murphy Hill, as shown on the Key Plot Plan.

G. General Facilities - This area is reserved for the storage of various chemicals such as limestone, chemicals for the treatment of waste waters, catalysts, the storage of prilled sulfur ready for shipment and the sewage treatment plant. The grade is at approximately 600 feet elevation to accommodate the gravity flow of sewage to the treatment plant, and is otherwise centrally located to serve various process units and the waste water treatment area nearby.

H. Flare - A separate flare for each of the four modules is provided. The separate flare limits the maximum radiation from the flame of an emergency diversion of all process gas flows to the atmosphere. The flares are located S.E. of the process areas, to minimize the length of piping and yet provide isolation of radiation from the flame. Moreover, the terrain where the flares are situated are areas which need only be cleared and grubbed, avoiding costly cutting and filling.

I. Ash Storage - Terrain laying generally N.E. of the process areas has been reserved for the storage of ash. The ash or slag storage commences from an area S.E. of Murphy Hill and occupies the terrain between the process areas and the shoreline surrounding the cove S.E. of Murphy Hill. This arrangement results in maximul utilization of an irregularly shaped terrain for the very considerable quantity of ash and slag which may require storage during the life of the plant. The entire perimeter of the ash and slag storage area is accessible by roadway, which is built on an embankment constructed of rocky material from the plant site. At the foot of the embankment, a drainage system is to be provided to collect surface water runoff.

J. Buildings - Administration, maintenance, visitor's center, laboratory, control, environmental data and dock buildings are some of the more important facilities which are identified on the Key Plot Plan. At the level of detail required for this pahse of the study, additional buildings, stipulated in the Design Criteria, such as operator's shelters, weigh station instrument room, emergency first aid shacks, etc., are not shown but are otherwise included within the scope of the conceptual assessments.

Based on our preliminary estimate of ease of access to the site via either the connecting road running S.E. from the immediate exit of the plant, thence to Five Points or S.W. of the main entrance, access to the plant is well selected, in our opinion.

K. Cooling Water System - The cooling towers and water circulating pumps are shown, at present, at the extremity of each of four gasification modules and adjacent to the air separation plant to minimize piping costs and pumping losses. As the cooling towers are situated, there is some minimal diffusion of cooling tower plumes over either the process areas or the buildings. As the reader may be aware, the prevailing wind in summer is to the South when the cooling towers would be operating at, or near, full capacity. In the winter months, the prevailing wind direction is to the north.

During summer operation, underwindy conditions, cooling towers at the N.E. perimeter of the process areas would experience wind velocities which are flowing over the ash pile. The presence of the ash pile upstream of the cooling towers is not considered to have any measurable adverse impact on performance. This position appears to be confirmed by the results of tests on a tower-spoil hill configuration which duplicates, in almost every respect, the proposed design.

Form No. 130-17I

Reference is made to the report: "Hydrothermal Modelling of Browns Ferry Nuclear Plant Cooling Towers" by S.P. Jain and J.F. Kennedy, Report No. 219, Iowa Institute of Hydraulic Research, April 1979. The report, sponsored by TVA Water Systems Development Branch, makes the following statement in regard to the spoil hill upstream of the cooling towers.

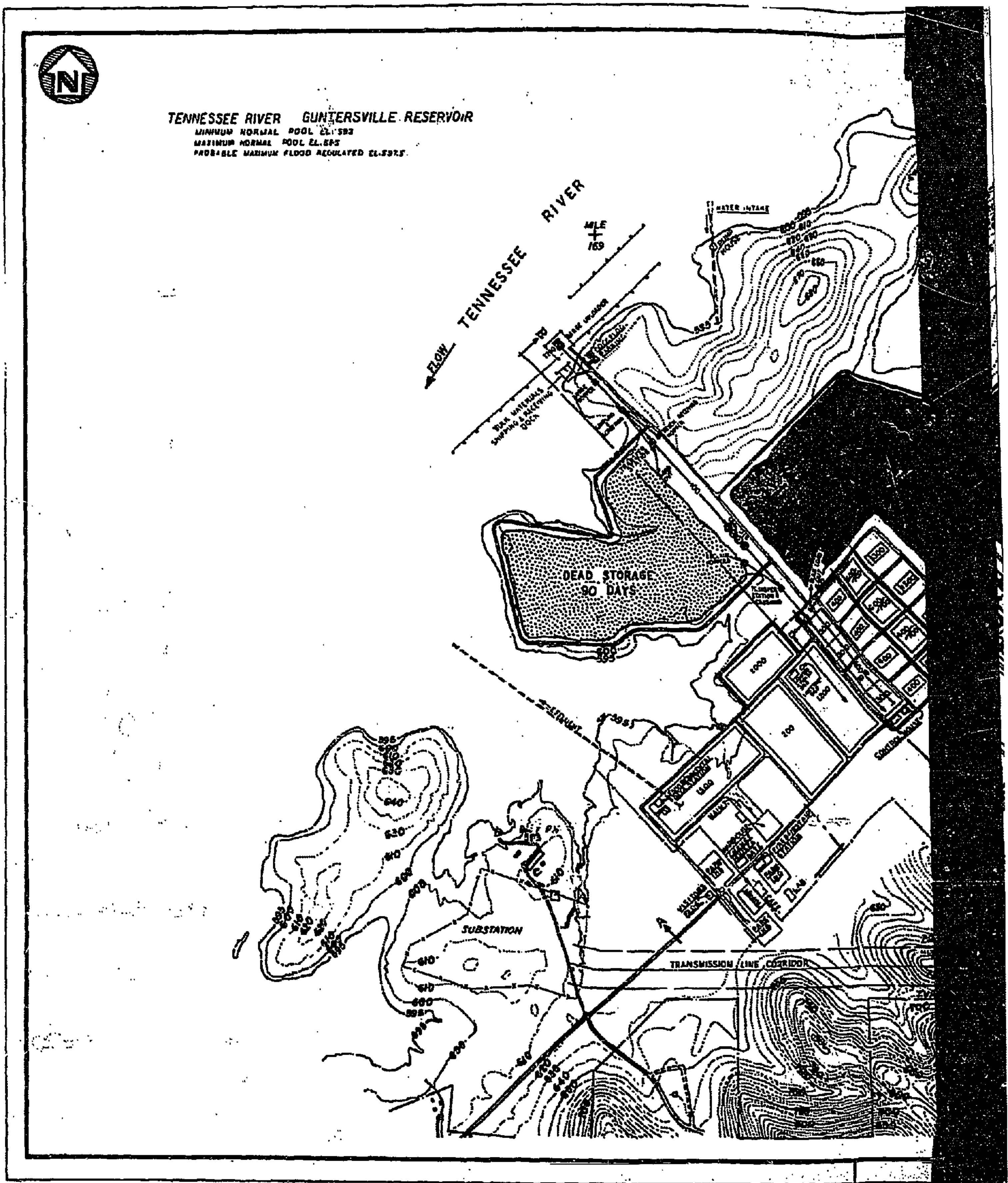
> "The influence of the spoil hill on $\bar{R}$ (the recirculation ratio of effluent air stream into the intake louvers) is significant, amounting to no more than ± 1%"

(Foregoing appears on p. 25, V I. Summary of Results)

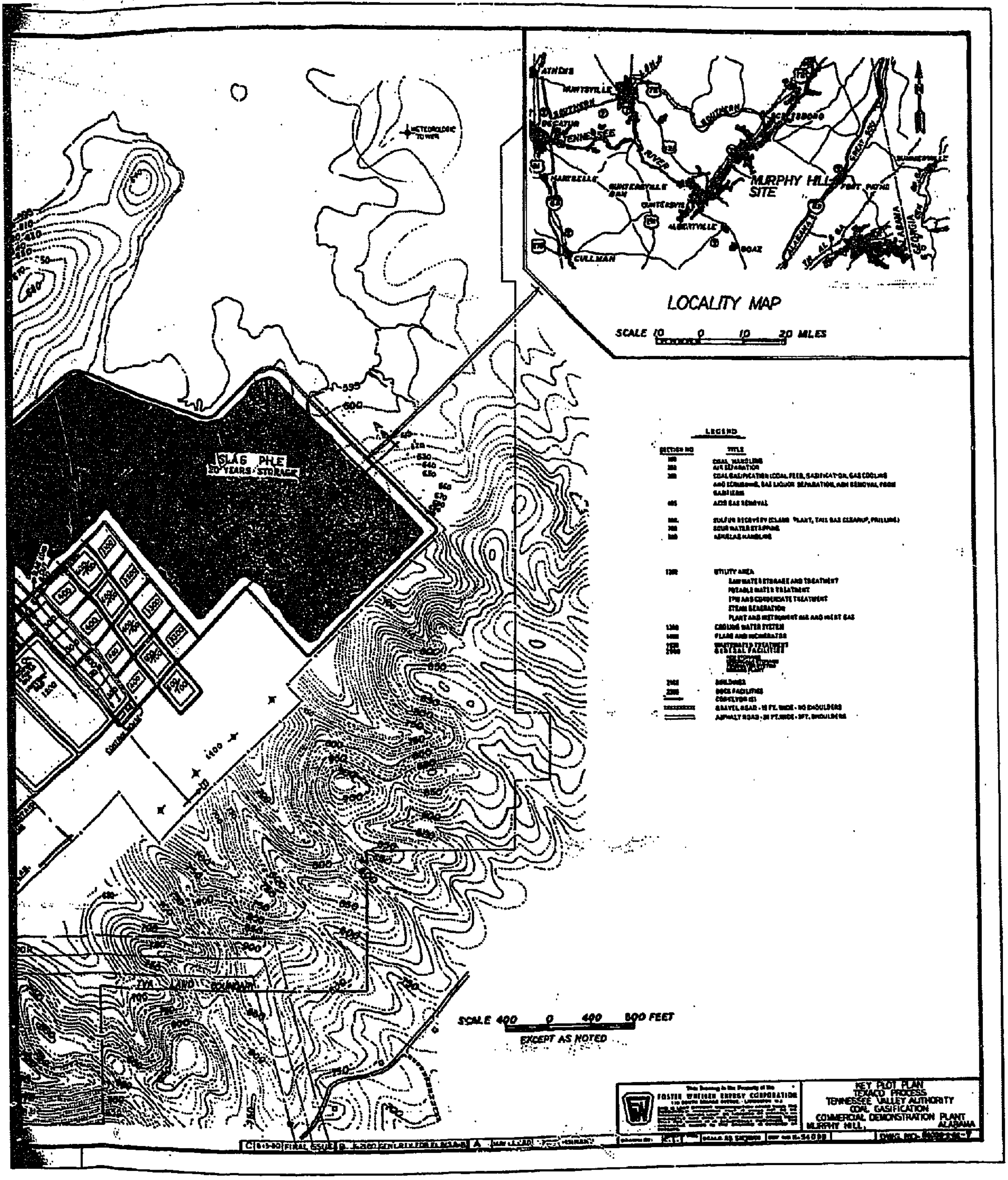
L. Elevation Views

I. Terrain - considering the rocky nature of the subsoil, based on extensive boring and seismic depth of rock determination, the plant areas have been terraced in order to minimize costly cutting and filling of excavated materials. The terraces shown are substantially those which form the basis of the cost estimates. As will be evident from the drawings, every effort has been made to limit differences in elevation to 15 feet. Wherever a greater difference in elevation occurs, a roadway for access of fire fighting equipment has been provided at the higher elevation, paralelling the main service road below.

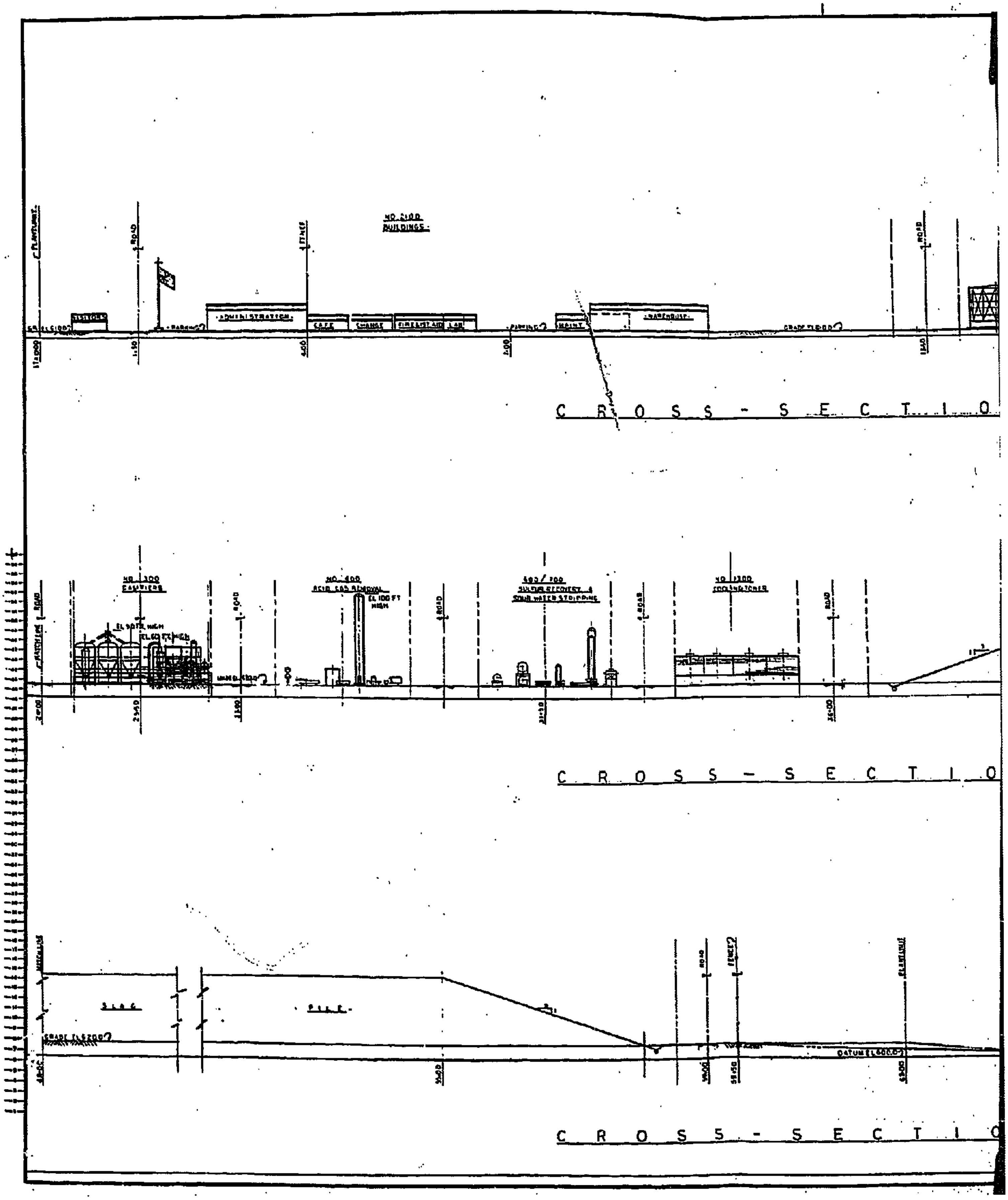
II. Process Units - The structures, towers and other equipment shown are representative of the type of equipment for a particular process. Where fairly detailed information on both the size and quantity of equipment was available, as an e xample, the gasifier reactors and ancillaries, the elevation views shown are substantially an accurate pictorial representation.

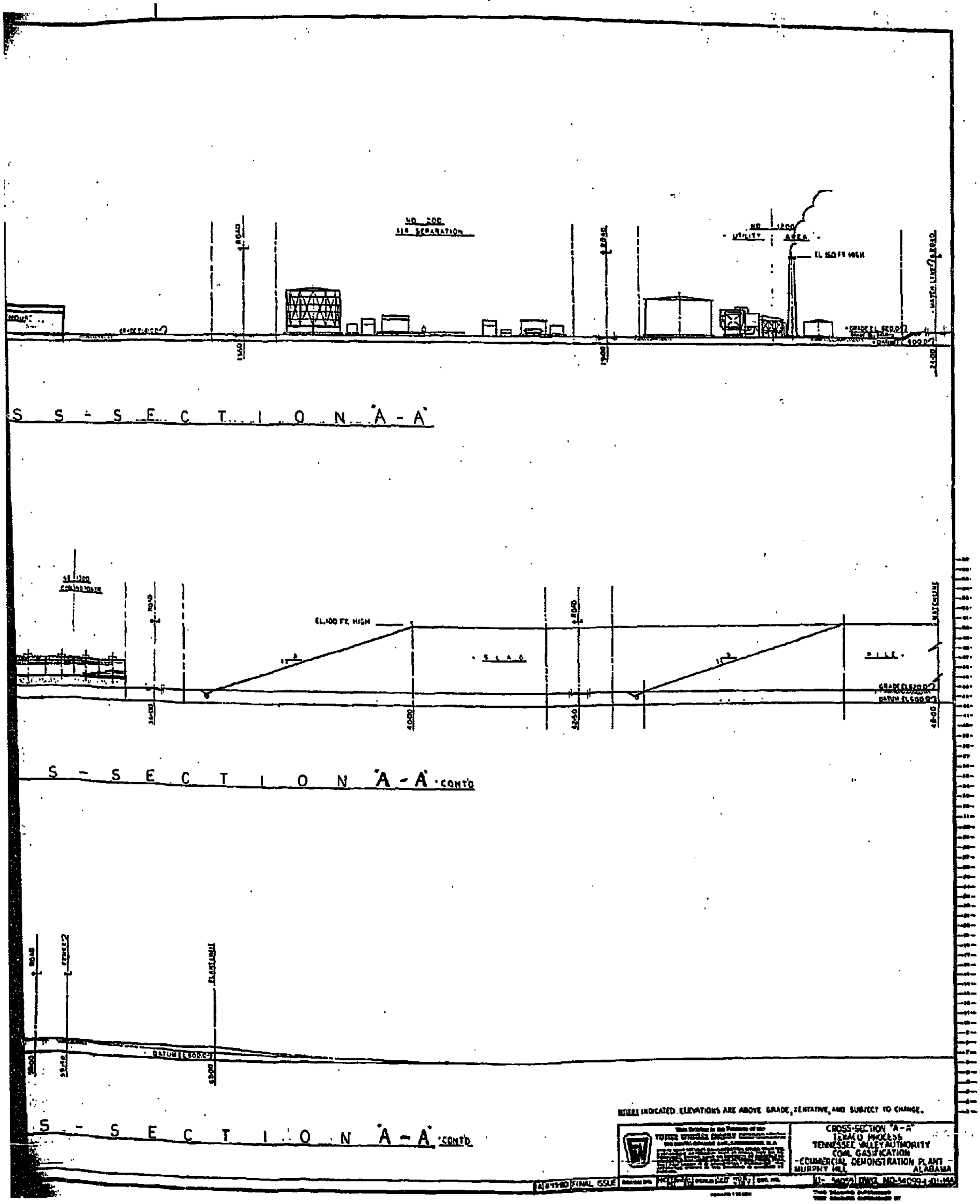


TENNESSEE RIVER GUNTERSVILLE RESERVOIR
TENNESSEE RIVER
FLOW
MILE 169
WATER INTAKE
DEAD STORAGE 90 DAYS
SUBSTATION
TRANSMISSION LINE CORRIDOR

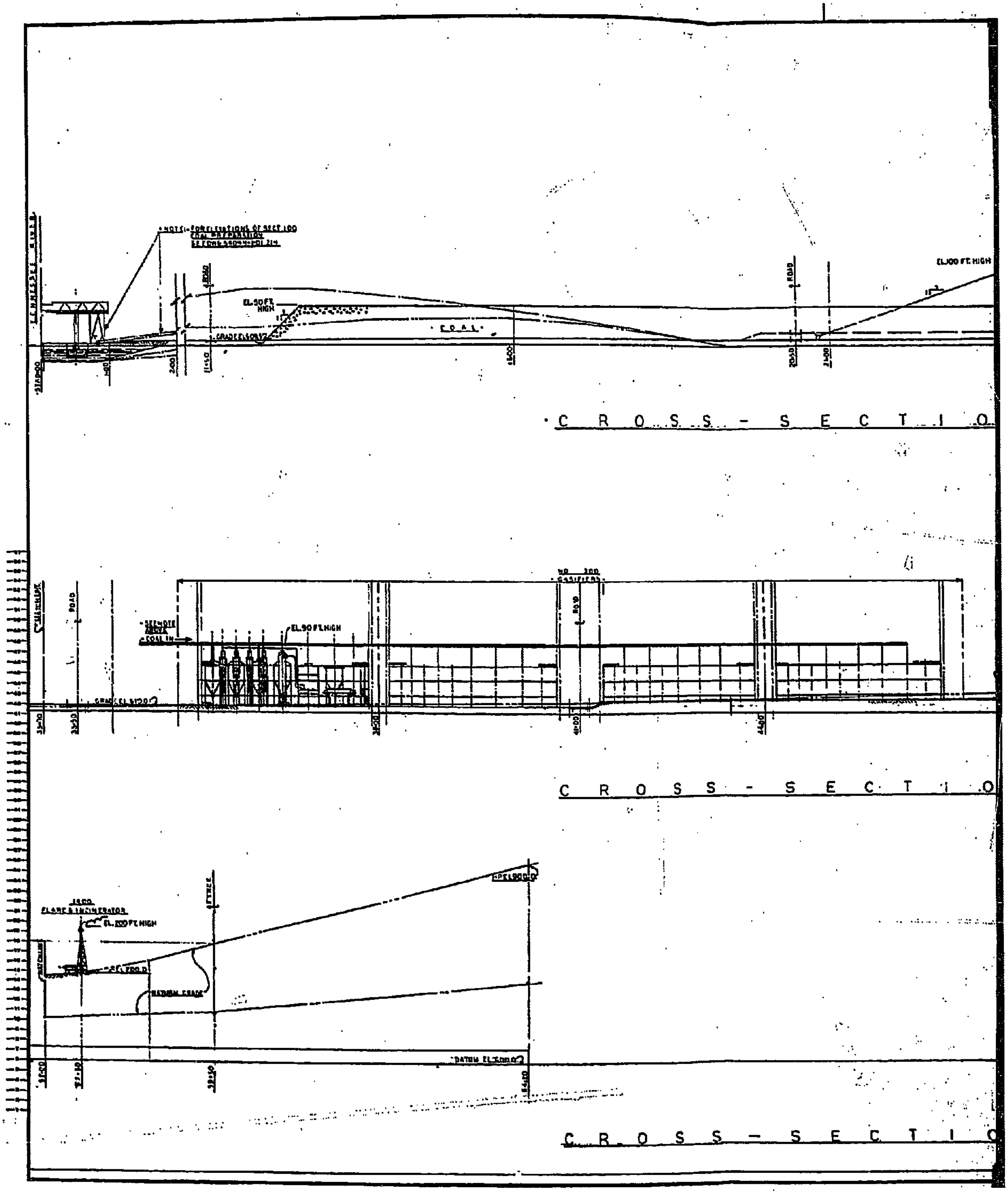


LOCALITY MAP
SCALE 10 0 10 20 MILES
ATHENS
HUNTSVILLE
DECATUR
TENNESSEE RIVER
HARTSELLE
GUNTERSVILLE
ALBERTVILLE
BOAZ
CULLMAN
SCOTTSBORO
FORT PAYNE
MURPHY HILL SITE
METEOROLOGIC TOWER
SLAG PILE
20 YEARS STORAGE
TVA LAND BOUNDARY
LEGEND
SECTION NO
TITLE
COAL HANDLING
AIR SEPARATION
ACID GAS REMOVAL
SOUR WATER STRIPPING
UTILITY AREA
STEAM GENERATION
COOLING WATER SYSTEM
BUILDINGS
DOCK FACILITIES
CONVEYOR (S)
SCALE 400 0 400 800 FEET
EXCEPT AS NOTED
FOSTER WHEELER ENERGY CORPORATION
KEY PLOT PLAN
TEXACO PROCESS
TENNESSEE VALLEY AUTHORITY
COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
MURPHY HILL, ALABAMA
FINAL ISSUE

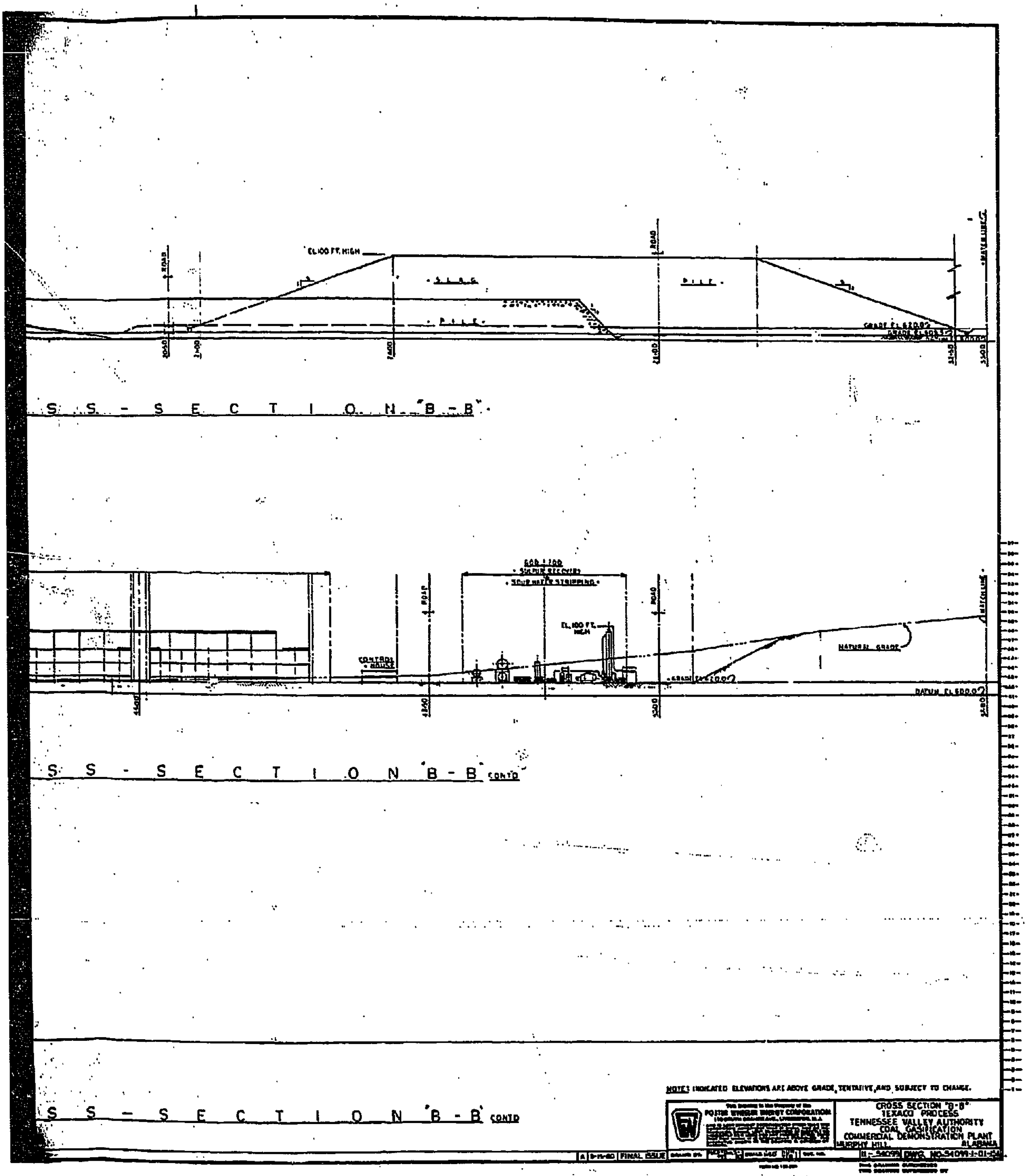

NO. 2100 BUILDINGS
ADMINISTRATION
CAFE
CHANGE
LAB
WAREHOUSE
C R O S S - S E C T I O
NO. 300 GASIFIERS
NO. 400 ACID GAS REMOVAL
EL 100 FT HIGH
ROAD
C R O S S - S E C T I O
SLAG
PILE
ROAD
C R O S S - S E C T I O



AIR SEPARATION
UTILITY AREA
ROAD
S - SECTION "A-A"
EL.100 FT. HIGH
SLAG PILE
S - SECTION "A-A" CONT'D
ROAD
PLANT LINE
S - SECTION "A-A" CONT'D
NOTES: INDICATED ELEVATIONS ARE ABOVE GRADE, TENTATIVE, AND SUBJECT TO CHANGE.
CROSS-SECTION "A-A"
TEXACO PROCESS
TENNESSEE VALLEY AUTHORITY
COAL GASIFICATION
-COMMERCIAL DEMONSTRATION PLANT-
MURPHY HILL ALABAMA
FINAL ISSUE



ROAD
EL.100 FT. HIGH
EL.50 FT. HIGH
COAL
CROSS - SECTIO
ROAD
EL.50 FT. HIGH
COAL IN
CROSS - SECTIO
EL.100 FT. HIGH
NATURAL GRADE
CROSS - SECTIO


EL.100 FT. HIGH
ROAD
SLAG
PILE
PILE
MATCH LINE
S S - S E C T I O N "B - B"
SULFUR RECOVERY & SOUR WATER STRIPPING
EL.100 FT. HIGH
CONTROL HOUSE
ROAD
NATURAL GRADE
DATUM EL.600.0
MATCH LINE
S S - S E C T I O N "B - B" CONT'D
S S - S E C T I O N "B - B" CONT'D
NOTE: INDICATED ELEVATIONS ARE ABOVE GRADE, TENTATIVE, AND SUBJECT TO CHANGE.
FOSTER WHEELER ENERGY CORPORATION
CROSS SECTION "B-B"
TEXACO PROCESS
TENNESSEE VALLEY AUTHORITY
COAL GASIFICATION
COMMERCIAL DEMONSTRATION PLANT
MURPHY HILL, ALABAMA
FINAL ISSUE
DWG. NO.

SECTION 6.0

ENVIRONMENTAL ASSESSMENTS

6.0 ENVIRONMENTAL ASSESSMENT

TVA Coal Gasification Study

Texaco Gasification Process

The emissions associated with a coal gasification plant involves possible gaseous and particulates contaiminants discharges to atmosphere. The waste water from the plant, including runoff and leachates from coal and ash piles, may contain water soluable, as well as insoluable liquids and solids. Additionally, thermal pollution may exist.

This gasification process, investigated for the TVA, uses cooling towers or air coolers so that thermal pollution from hot waste liquids to the rivers and streams is not a factor.

Most of the sulfur in coal is gasified in the form of H_2S and COS. These compounds together with particulates are removed by aqueous scrubbing followed by Acid Gas Treating (Selexol). Sour water produced during gas cleanup is sent to Waste Water Treatment Section 700, for removal of absorbed H_2S and NH_3, and clarifications for the removal of solids before being pumped to wastewater treatment, Section 1500. Ammonia in the sour gas is destroyed and elemental sulfur recovered from H_2S in the the Claus Unit. The fulsur Plant has a tail gas cleanup unit for the unconverted sulfur gases from the Claus Unit cslled a Beavon Unit. All the gas remaining after sulfur removal is vented to the atmosphere with less than 200 ppm (v) of sulfur.

The Texaco process produces negligible amounts of ammonia and nitrogen coupounds in the product gas are absorbed in the quench water and stripped in the wour water stripper. This stream is sent to the Fluidized Bed Superheater where it is combusted underconditions conducive to minimization of NOX formation. H_2S is stripped from the water before ammonia removal and recycled to the process.

Steam is superheated in a coal fired fluidized bed of limestone removing some 90% of the sulfur dioxide formed with the combustion of coal. The flue gas is then vented through a baghouse to minimize particulate discharge to the atmosphere.

Product gas is scrubbed with water in two stages of venturi scrubbers to remove particulates. The sour water from the scrubbers is stripped to remove dissolved acid gas and settled to remove char and then treated before discharge.

The principal gaseous emissions from this facility are the following:

a) Gas leaving the Beavon Sulfur Recovery Unit absorber
b) Gas vented from the Beavon Unit Oxidizer Pit

The Claus Unit and Beavon Tail Gas Treating Unit together convert almost all the sulfur from sour gases to elemental sulfur. The clean gas stream containing less than 200 ppmv of total sulfur, emission "a" listed above, is discharged to atmosphere from the absorber in the Beavon Unit (part of Sec. 600).

Emission "b" results from air which flows through the Beavon Unit Oxidizer Pit and oxidizes the sulfides to elemental sulfur. The licensor has stated that this emission "b" is contaminant-free and is essentially nitrogen and oxygen (air). The quantity of oxygen which reacts is small.

The gaseous emissions described above are listed in Table I for a single module. The gasification plant will have a total of four gasification modules.

In addition to the above gaseous emissions, the cooling tower will emit large quantities of water vapor as evaporative and windage losses.

The principal normal effluent stream quantity is cooling tower blowdown. This stream will be treated to reduce zinc and chromium to undetectable levels before being discharged.

Clean water streams, rinse and neutralization water from demineralization, ash pile leachate and stormwater runoff will be surged in a common basin, then used in ash handling or perhps fed to the cooling tower or discharged in part.

Coal pile runoff, service water and stripped sour water are combined and treated to precipitate chlorides and iron, then used as cooling tower makeup or alternatively they are discharged. BOD levels for coal pile runoff and service water are specified in Table III. The BOD level for stripped sour water is approximately equal to the suspended solids level or about 40 ppmw. The composite stream, after wastewater treating, will contain about 40 ppmw BOD.

Each of the above aqueous streams is described in Table III. Quantities indicated are per module and contaminants are our best estimates from engineering literature and past experience with similar or other gasification processes. Sanitary waste water, approximately 10,400 lbs/hr per module, is treated in a packaged biological system and is then discharged.

Modifications of the reported effluents may be expected based upon any additional information received from the process developer, from literature or from similar processes.

TABLE I

Emissions to Atmosphere

1. Vent Gas from Beavon Unit Absorber

Component	Mole Wt.	Mols/Hr	Lbs/Hr
Hydrogen (H_2)	2.016	2.402	4.84
Carbon Monoxide	28.011	—	—
Carbon Dioxide (CO_2)	44.011	336.759	14,821.1
Nitrogen (N_2)	28.014	1,075.025	30,115.75
Oxygen (O_2)	32.000	—	—
Hydrogen Sulfide (H_2S)	34.080	10 ppmv max.	0.46
Carbonyl Sulfide (COS)	60.075	195 ppmv	—
Total Dry Gas		1,414.187	44,942.15
Water		83.058	1,496.37
Total Wet Gas		1,497.245	46,439
Temperature, ^{o}F		95	

2. Vent Gas from Beavon Unit Oxidizer Pit T=100^{o}F

Component	Mols/hr	Lbs/Hr
N_2	177.75	4,979
O_2	47.30	1,514
Total Dry Gas	225.05	6,493
Water	15.54	280
Total Wet Gas	240.59	6,773

TABLE II

EFFLUENT STREAMS AND LOSSES

Source	Flow, Lbs, Hr	Net Aqueous Discharge, Lbs/Hr
Rinse and Neutralization	60,700	10,700
	(50,000 to Ash Handling)	Or to Cooling Tower
Service Water	100,000 to 303,000 to cooling tower	0
Cooling Tower Blowdown	440,000	440,000
Cooling Tower Evaporation	1,250,000	1,250,000
Cooling Tower Windage Loss	175,000	175,000
Air Separation Plant	(1,000,000)	(1,000,000)
Lime Sludge	16,000 Water	16,000
Aqueous Discharge		1,891,700 lbs/hr (3,783 gpm)

Net Aqueous Makeup

After Raw Water Treating = 3,050,000 lbs/hr = 6,100 gpm

TABLE III

EFFLUENT STREAMS BREAKDOWN

Streams	Discharge Flow Lbs/Hr	Estimated Quality
1. Rinse and Neutral-ization Water	10,700	TDS 6,000 mg/liter PH neutral
2. Ash Pile Leabhate	150,000 Intermittent Flow	TDS 500 mg/liter SS 200 mg/liter BOD 10 mg/liter
3. ISBL Stormwater Runoff	28,000 Intermittent Flow	TDS 100-150 mg/liter SS 50-100 mg/liter BOD 20 mg/liter

Streams 1. + 2. + 3. are pumped to the cooling tower or discharged. If discharged, flow = 188,700 Lbs/hr, TDS = 64.2 + 75.0 + 3.5 = 142.7 #/hr.

SS = 30 + 2.1 = 32.1 #/hr, BOD = 1.5 + 0.56 = 2.06 #/hr, PH 6.5

Streams	Discharge Flow Lbs/Hr	TO TRTG
4. Coal Pile Runoff	24,000 Intermittent Flow	TDS 500 mg./liter (12#/hr) SS 200 mg./liter (4.8#/hr) BOD 8 mg./liter (0.19#/hr) COD 10-20 mg./liter (0.24-0.48#/hr) PH 2.5

TABLE III

EFFLUENT STREAMS BREAKDOWN (Cont'd)

Stream	Discharge Flow Lbs/Hr	Estimated Quality
		TO TRTG
5. Service Water	100,000	TDS 200 mg/liter (20#/hr)
		SS 200 mg/liter (20#hr)
		BOD 50-150 mg/liter (5-15#hr)
6. Stripped Sour Water	303,000	TDS 7,000-8,000 (2,121-2,424#/hr)
		NH_3 20 mg/liter (6.1#hr)
		H_2S 5 mg/liter (1.6#hr)
		SS 40 mg/liter (12.1#hr)
		Cl 1,750 mg/liter (530#hr)

Streams 4 + 5 + 6 normally are pumped to the cooling tower. If discharged, flow = 24,000 + 100,000 + 303,000 - 16,000 = 411,000 Lbs/hr

water with lime sludge

		After TRTG
SS	30 mg/liter x 411,000	= 12.3 #/hr
COD	25 mg/liter x 411,000	= 10.3 #/hr
TDS	500 mg/liter x 411,000	=205.5 #/hr

Stream	Discharge Flow	TO TRTG
7. Cooling Tower Blowdown	440,000 Lbs/hr	Cr 12 mg/liter (3.3#/hr)
		Zn 8 mg/liter (2.2#/hr)
		TDS 1,000 mg/liter (275#/hr)

TABLE III

EFFLUENT STREAMS BREAKDOWN (Cont'd)

7. Cooling Tower (Cont'd)

LVG. TRTG

Cr	0.05 mg/liter (0.0137#/hr) undetectable
Zn	0.1 mg/liter (0.0275 #/hr)
TDS	1,000 mg./liter (275 #/hr)

TABLE IV

Composition Given to FW For Kentucky #9 Seam Coal

Component in Coal	Dry Wt%	As-Is Wt%
Carbon (C)	67.310	60.872
Hydrogen (H_2)	4.757	4.302
Nitrogen (N_2)	1.529	1.383
Oxygen (O_2)	6.343	5.736
Sulfur (S)	4.100	3.708
Ash	15.830	14.316
Chlorine (Cl_2)	0.131	0.119
H_2O	0	9.564
Total	100.000	100.000

Form No. 130-171

SECTION 7.0

SUGGESTIONS FOR FOLLOW-ON WORK

7.0 SUGGESTIONS FOR FOLLOW-ON WORK

In the event that TVA selects the Texaco Coal Gasification process for further consideration relative to the proposed Coal Gasification Demonstration Plant, the follow-on work described below is suggested:

A. Carry out bench scale and pilot plant tests of TVA candidate coals.

B. Carry out engineering studies to evaluate available data on waste heat boiler performance and assess potential waste heat boiler designs.

C. Identify and evaluate methods of increasing the coal slurry concentration fed to the Texaco Gasifier. This could increase the gasifier product gas heating value thus reducing the quantity of CO_2 removal required in the Acid Gas Removal System in order to meet the Product Heating Value Specification.

D. Conduct wet grinding test using TVA candidate coals.

E. Review and further optimize steam, cooling water and overall water usage in the plant.

F. Study interactions with other coal gasifiers in the event two different types of gasifiers are included in the Demonstration Plant.

SECTION 8.0

PROJECTIONS

8.0 PROJECTIONS

The Texaco Coal Gasification Process is a developing technology having recently progressed from the pilot plant to the demonstration plant stage. A demonstration plant has been in operation in Germany for about two years. The Texaco coal gasifier being installed by TVA in Muscle Shoal will represent a further demonstration of the process.

Continued development of the Texaco process in the long term is expected to demonstrate operation at pressures substantially above 500 psig. This would be an important advantage since all compression beyond oxygen compression would be eliminated.

SECTION 9.0

COST ESTIMATES

9.1 Investment Costs

The total capital investment required for the commercial coal gasification plant, based on Texaco entrained flow gasifiers, is estimated at $1.84 billion. Included in this total are the following capital related costs:

- Installed plant cost
- Initial catalyst and chemical inventory
- Cost of land at $3,000 per acre
- Plant start-up costs; taken as a percentage of the plant annual operating cost
- Required working capital; summarized in Table 9.7

The estimated installed plant cost, summarized in Table 9.1, is $1.67 billion. This represents a conceptual cost estimate, based on first quarter 1980 costs for an Alabama site, having an expected accuracy of +30%, -15%. The accuracy range specifically means that the upper limit has a value of 30% higher than the estimated cost and the lower limit is 15% below the estimated value.

In addition to the battery limits processing units and support facilities, the installed plant cost includes site preparation, spare parts, and a project contingency factor. Process engineering and license fees are included in the costs for the individual process units. Additional breakdown of the costs associated with the plant support facilities is given in Table 9.2. It should be noted that only about 10% of the total required site preparation cost is included in the installed plant cost. The remaining site preparation for ash disposal is treated as an operating expense over the life of the plant.

Items specifically excluded from the plant investment cost estimate are:

- Soil consultant expenses
- Environmental consultant expenses
- Craft training program
- Cost of all permits
- Import duties, if any
- Escalation from date of estimate
- Financing charges
- Construction camp facilities
- Sales and use tax

The estimated schedule of investment capital disbursements according to plant module is given in Tables 9.3 through 9.6. The disbursements corresponding to the erected plant cost were estimated according to Foster Wheeler's proposed overall project schedule shown in Fibure 9.1. Cost of land acquisition was charged in the year 1981 while the cost for the initial charge of catalyst and chemicals was charged during the last year of construction. Working capital and start-up costs were accounted during the year of plant start-up.

TABLE 9.1

PLANT BASED ON TEXACO GASIFIERS

Summary of Estimated Capital Investment
in Millions of Dollars (1980)

MODULE		1	2	3	4	TOTAL
ON-SITES						
SECTION	DESCRIPTION					
100	Coal Receipt and Preparation	32.6	0	0	0	32.6
200	Air Separation	83.7	77.4	77.4	77.4	315.9
300	Gasification	124.0	124.0	124.0	124.0	496.0
400	Acid Gas Removal	34.5	34.5	34.5	34.5	138.0
500	Product Gas Compression	-	-	-	-	-
600	Sulfur Recovery	25.2	12.5	11.5	11.5	60.7
700	Sour Water Stripper	4.3	4.2	4.2	4.2	16.9
800	Ash/Slag Handling	2.5	2.5	2.5	2.5	10.0
900	Phenol Recovery	-	-	-	-	-
1000	Ammonia Recovery	-	-	-	-	-
	SUB-TOTAL	306.8	255.1	254.1	254.1	1,070.1
	Offsites	159.5	79.5	56.3	56.2	351.5
	Spare Parts	7.1	4.8	4.7	4.7	21.3
	Site Preparation	9.9	0	0	0	9.9
	Contingency	72.2	48.2	48.2	48.1	216.7
	TOTAL INSTALLED PLANT COST	555.5	387.6	363.3	363.1	1,669.5
	Initial Catalyst & Chemicals	0.5	0.4	0.3	0.3	1.5
	Cost of Land	1.2	0	0	0	1.2
	Start-Up Cost	26.4	22.6	18.8	18.8	86.6
	Working Capital	21.6	19.7	19.3	19.2	79.8
	TOTAL CAPITAL INVESTMENT	605.2	430.3	401.7	401.4	1,838.6

TABLE 9.2

SUMMARY OF SUPPORT FACILITIES COST

TEXACO GASIFICATION

Section	Description	D & E Cost, MM$
1200	Utilities Area	
	Water Treatment	7.0
	Steam Generation	171.8
1300	Cooling Water System	42.8
1400	Flare System	3.2
1500	Waste Water Treating	20.0
2000	General Facilities	
	Storage	5.6
	Electric Power Distribution	17.0
	Lighting & Communications	2.5
	Roads & Fences	2.2
	Firewater System	5.0
	Inter-connecting Piping	61.9
2100	Buildings	10.5
2200	Dock Facilities	2.0
		351.5

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TABLE 9.3

PLANT BASED ON TEXACO GASIFIERS

ESTIMATED INVESTMENT CAPITAL DISBURSEMENTS SCHEDULE

MILLIONS OF 1980 $

MODULE #1

Year	Installed Plant Cost	Other * Investment	Working Capital	Yearly Total
1980	9.44	-	-	9.44
1981	33.04	1.20	-	34.24
1982	152.76	-	-	152.76
1983	234.43	-	-	234.43
1984	125.83	9.00	10.80	145.63
1985	0	17.90	10.81	28.71
TOTAL	555.50	28.10	21.61	605.21

* Other Investment = Cost of Land, Start-Up (Costs) and Initial Catalyst & Chemicals.

TABLE 9.4

PLANT BASED ON TEXACO GASIFIERS

ESTIMATED INVESTMENT CAPITAL DISBURSEMENTS SCHEDULE

MILLIONS OF 1980 $

MODULE #1 and 2

Year	Installed Plant Cost	Other * Investment	Working Capital	Yearly Total
1980	9.44	-	-	9.44
1981	33.04	1.20	-	34.24
1982	166.71	-	-	166.71
1983	294.73	-	-	294.73
1984	302.97	9.00	10.80	322.77
1985	136.21	18.24	10.81	165.26
1986	0	22.60	19.68	42.28
TOTAL	943.10	51.04	41.29	1,035.43

* Other Investment = Cost of Land, Start-Up (Costs) And Initial Catalyst & Chemicals.

TABLE 9.5

PLANT BASED ON TEXACO GASIFIERS

ESTIMATED INVESTMENT CAPITAL DISBURSEMENTS SCHEDULE

MILLIONS OF 1980 $

MODULE #1,2 and 3

Year	Installed Plant Cost	Other * Investment	Working Capital	Yearly Total
1980	9.44	-	-	9.44
1981	33.04	1.2	-	34.24
1982	166.71	-	-	166.71
1983	308.68	-	-	308.68
1984	370.51	9.0	10.80	390.31
1985	320.08	18.24	10.81	349.13
1986	97.95	33.73	39.00	170.68
1987	0	8.00	0	8.00
TOTAL	1,306.41	70.17	60.61	1,437.19

* Other Investment = Cost of Land, Start-Up (Costs) and Initial Catalyst & Chemicals.

TABLE 9.6

PLANT BASED ON TEXACO GASIFIERS

ESTIMATED INVESTMENT CAPITAL DISBURSEMENTS SCHEDULE

MILLIONS OF 1980 $

MODULE #1 thru 4

Year	Installed Plant Cost	Other * Investment	Working Capital	Yearly Total
1980	9.44	–	–	9.44
1981	33.04	1.20	–	34.24
1982	166.71	–	–	166.71
1983	308.68	–	–	308.68
1984	388.81	9.00	10.80	408.61
1985	410.13	18.24	10.81	439.18
1986	287.51	33.73	39.00	360.24
1987	65.19	27.13	19.20	111.52
TOTAL	1,669.51	89.30	79.81	1,838.62

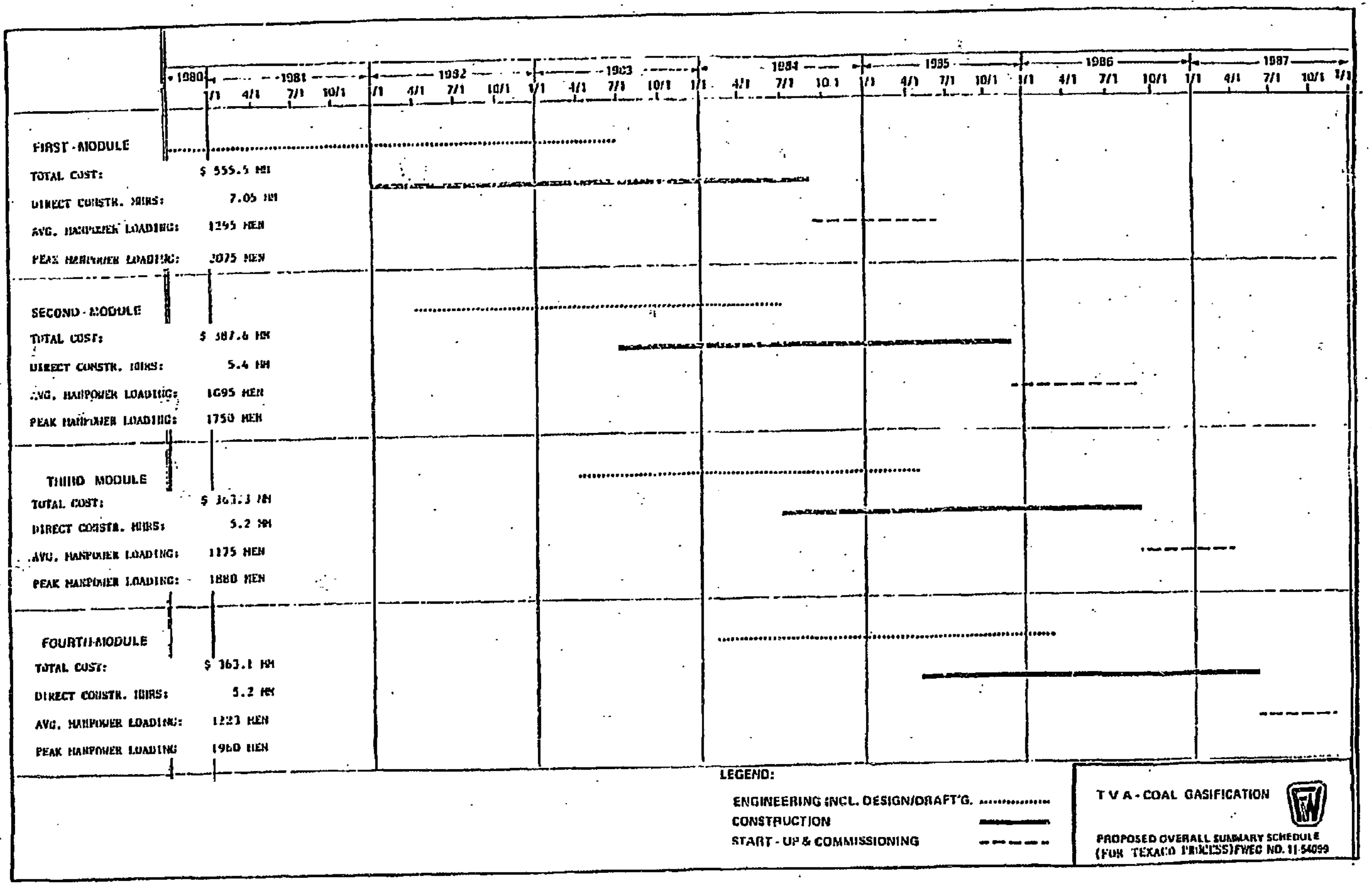
* Other Investment = Cost of Land, Start-Up (Costs) and Initial Catalyst & Chemicals.

TABLE 9.7

ESTIMATED WORKING CAPITAL (1980 DOLLARS)

TEXACO GASIFICATION

Plant Modules	1	2	3	4	TOTAL
Coal Inventory 90 days @ $1.25/MMBTU	13.94	13.94	13.94	13.94	55.76
Plant Materials and Supplies @ 0.9% installed cost	5.00	3.49	3.27	3.27	15.03
Plant Payroll @ 90 days	1.13	0.71	0.57	0.45	2.86
Catalyst and Chemicals @ 90 days	0.35	0.35	0.35	0.35	1.40
Electric Power Costs 90 days @ $0.024/KwH	1.19	1.19	1.19	1.19	4.76
TOTAL, MM$	21.61	19.68	19.32	19.20	79.81



1980
1981
1982
1983
1984
1985
1986
1987
1/1 4/1 7/1 10/1
FIRST-MODULE
TOTAL COST: $ 555.5 MM
DIRECT CONSTR. MHRS: 7.05 MM
AVG. MANPOWER LOADING: 1295 MEN
PEAK MANPOWER LOADING: 2075 MEN
SECOND-MODULE
TOTAL COST: $ 387.6 MM
DIRECT CONSTR. MHRS: 5.4 MM
AVG. MANPOWER LOADING: 1695 MEN
PEAK MANPOWER LOADING: 1750 MEN
THIRD MODULE
TOTAL COST: $ 363.3 MM
DIRECT CONSTR. MHRS: 5.2 MM
AVG. MANPOWER LOADING: 1175 MEN
PEAK MANPOWER LOADING: 1880 MEN
FOURTH-MODULE
TOTAL COST: $ 363.1 MM
DIRECT CONSTR. MHRS: 5.2 MM
AVG. MANPOWER LOADING: 1223 MEN
PEAK MANPOWER LOADING 1960 MEN
LEGEND:
ENGINEERING INCL. DESIGN/DRAFT'G.
CONSTRUCTION
START-UP & COMMISSIONING
T V A - COAL GASIFICATION
PROPOSED OVERALL SUMMARY SCHEDULE
(FOR TEXACO PROCESS) FWEC NO. 11-54099

FIGURE 9.1

9.2 Operating Costs

The annual production and operating requirements corresponding to the 4-module gasification plant, based on the Texaco gasifier, are summarized in Table 9.8. Values are given for 100% plant service factor. The service factor is the expected yearly production divided by the plant rated capacity for 365 days. A summary of the estimated plant service factors by module and year is given in Table 9.9.

Estimated annual operating costs, in 1980 dollars, for the 4-module plant are summarized in Table 9.10. The coal price used in this base calculation is 1.25 $/MMBTU as delivered, which corresponds to 27.45 $/Ton. No product credit is taken except for excess coal fines which are credited at 80% of the delivered coal price, i.e., 1.00 $/MMBTU.

The estimated plant staffing requirements are detailed in Tables 9.11 and 9.12. The salaries and wage rates employed follow the guidelines provided by TVA's design criteria (dated March, 1980).

Maintenance materials and subcontract labor were estimated as percentages of the erected plant cost. As requested by TVA, a corporate general and administrative expense of 1.0 percent of plant maintenance and operating cost, exclusive of coal, was included.

A separate operating expense designated as ash disposal costs is associated with the continuing site work required for stock piling the coal ash through the life of the project.

TABLE 9.8

SUMMARY OF ANNUAL OPERATING REQUIREMENTS

TEXACO GASIFIER CASE

BASIS: 4-MODULE PLANT @ 100% SERVICE FACTOR (365 DAYS/YEAR)

Item	Rate/Year	
Product Gas @ 353.1 MMMBTU/D	128.882×10^6	MMBTU
Coal Feed @ 22570 TPD	180.908×10^6	MMBTU
Limestone @ 91 TPD	33[illegible]76	Tons
Catalyst & Chemicals	5.170	MM$
Electric Power @ 91.2 Mw	798.912×10^6	KwH
By-Product Coal Fines	--	
By-Product Sulfur @ 842 TPD	307418	Tons
By-Product Ammonia	--	
By-Product Naphtha	--	
By-Product Light Oil	--	
By-Product Tar	--	
By-Product Phenol	--	

Table 9.9

Summary of Plant Service Factors

Bases: Percent of 4-Module Plant Operating 365 Days/Year

Module	1	2	3	4	Total
1984	0	0	0	0	0
85	7.5	0	0	0	7.5
86	20.0	5.0	0	0	25.0
87	22.5	20.5	13.0	0	56.0
88		22.5	22.5	18.75	86.25
89				22.5	90.0
1990					
91					
92					
93					
94					
95					
96					
97					
98					
99					
2000					
01					
02					
03					
04	22.5				90.0
05	9.25	22.5			76.75
06	0	16.75	22.5		61.75
07	0	0	5.5	22.5	28.0
2008	0	0	0	0	0

TABLE 9.10

ESTIMATED PLANT ANNUAL OPERATING COSTS (1980 DOLLARS)

TEXACO GASIFIER CASE

BASIS: 4-MODULE PLANT

No.	Item	Calcu :ion Basis for 100% Service Factor (S.F.)	Annual Cost, MM$ 100% SF	Annual Cost, MM$ 90% SF
1	Coal Feed	$180.908 \times 10^6 \times 1.25$ \$/MMBTU	226.13	203.52
2	Limestone	33076 x 13 \$/Ton	0.43	0.39
3	Catalyst/Chemicals	(Table 9.8)	5.17	4.65
4	Electric Power	$798.912 \times 10^6 \times 0.025$ \$/KwH	19.97	17.98
5	Plant Labor & Supervision	(Table 9.11 and 9.12)	14.42	14.42
6	Operating Supplies	At 30% of Labor & Supervision	4.33	4.33
7	Maintenance Materials	At 2.1% of Erected Plant Cost	35.09	35.09
8	Maintenance S/C Labor	At 55% of Maintenance Material	19.31	19.31
9	TVA G & A Overhead	At 1% of Items 2 through 8	1.00	1.00
10	Ash Disposal		4.10	4.10
11	Total Gross Operating Cost		329.95	304.79
12	By-Product Credits	At Zero Credit	0.00	0.00
13	Net Annual Operating Cost		329.95	304.79

TABLE 9.11

Estimated Plant Operating Staff

Basis: 4 - Module Plant

Position	Number	Annual * Salary/Wage, $	Annual Cost, $
Plant Superintendent	1	57936	57936
Plant Operating Supervisor	16	48990	783840
Shift Engineer	16	39192	627072
Ass't Shift Engineer	4	32092	128368
Unit Operator	80	28826	2306080
Ass't Unit Operator	48	24140	1158720
Auxiliary Operator	32	21726	695232
Yard Operations Supervisor	2	34080	68160
Plant Results Supervisor	1	48990	48990
Ass't Plant Results Supervisor	4	39760	159040
Instrument Unit Foreman	16	30672	490752
Instrument Mechanic	24	30160	723840
Instrument Mech. Apprentice	18	22880	411840
Mechanical Unit Foreman	16	30672	490752
Engineering Aide	16	23004	368064
Chemical Unit Foreman	4	30672	122688
Chemical Lab. Analyst	36	23004	828144
Materials Tester	12	23004	276048
Boilermaker Foreman	8	32234	257872
Boilermaker	16	27264	436224
Janitor (Senior)	16	20824	333184
Janitor	24	19170	460080
Coal Handling Foreman	2	29120	58240
Primary HEO	2	27040	54080
Apprentice HEO	2	22880	45760
Coal Tower Foreman	2	29120	58240
Coal Car Dump Operator	4	29120	116480
Track Foreman	2	29120	58240
Laborer	6	17680	106080
Total Operating Staff	430		11,730,046

* 1980 basis, includes fringe benefits

TABLE 9.12

Estimated Plant Maintenance Staff

Basis: 4 - Module Plant

Position	Number	Annual * Salary/Wage, $	Annual Cost, $
Mechanical Supervisor	1	48990	48990
Ass't Mechanical Supv.	4	39760	159040
Mechanical Engineers	28	22436	628208
Foreman: Asbestos	2	34320	68640
Electricians	7	32240	225680
Ironworkers	4	31200	124800
Machinists	5	28080	140400
Steamfitters	10	33280	332800
Painters	2	27040	54080
Truck Drivers	6	21840	131040
Journeymen: Electrician	7	30160	211120
Ironworkers	4	29120	116480
Machinists	5	26000	130000
Steamfitters	7	31200	218400
Painters	1	24960	24960
Truck Drivers	4	19760	79040
Total Maintenance Staff	97		2,693,678

* 1980 Basis, Includes Fringe Benefits

9.3 Sensitivity Analysis

In accordance with TVA's requirements, sensitivity analyses were conducted to assess the effects of the following parameters on the MBG production rate and levelized gas product cost:

- Coal cost at +50%
- Plant capital cost at +25%
- Plant operating cost at +50%
- Plant service factors at 80%, 70%, and 60%
- Byproduct values, specified as
  - sulfur @ 70 $/ton
  - ammonia @ 130 $/ton
  - naphtha @ 0.80 $/gal.
  - light oil @ 0.80 $/gal.
  - tar @ 0.60 $/gal.
  - phenols @ 0.75 $/gal.
- Design/construction period per module at ± one year
- Plant operating life at +5 years and +10 years
- Sulfur content in product gas at 1.0 ppm
- Product gas delivery pressure at 800 psi and 200 psi

All sensitivity analysis cases were conducted for the total 4-module plant concept only. The results of the sensitivity analyses for the plant based on Texaco gasifiers are summarized in Table 9.13.

TABLE 9.13

SENSITIVITY ANALYSIS SUMMARY

TEXACO GASIFIER - 4 MODULE PLANT

Case	Total Gas Production MMMM BTU	Relative Gas Cost
Base Case	2295.7	1.00
Coal Cost @ +50%	2295.7	1.22
Plant Cost @ +25%	2295.7	1.08
Operating Cost @ +50%	2295.7	1.11
Plant Service Factor @ 80%	2040.6	1.06
70%	1785.6	1.15
60%	1530.5	1.26
By-Product Credit	2295.7	0.96
Design/Construction @ +1 year	2295.7	1.08
-1 year	2295.7	0.92
Plant Life @ +5 years	2875.7	1.04
+10 years	3455.6	1.08
Sulfur @ 1.0 ppm	2295.7	1.02
Delivery Pressure @ 800 psig	2295.7	1.01
@ 665 psig	2295.7	1.00