INSTRUCTIONS FOR

METHANE FROM COMMUNITY WASTE SYSTEMS ANALYSIS (COWSA) MODEL

June 20, 1988

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ABBREVIATIONS

BMP	Biochemical Methane Potential
BOD	Biological Oxygen Demand
BVS	Biodegradable Volatile Solids
CMD	Command Mode Indicator (in Lotus 1-2-3)
COD	Chemical Oxygen Demand, a measure of total organics concentration, typically used for characterization of wastewater
COWSA	Community Waste Systems Analysis
CPI	Characters Per Inch
CSTR	Continuously Stirred Tank Reactor
ECH	Equipment Cost Handbook
ECSA	Energy Crop Systems Analysis
gpd	gallons per day
GRI	Gas Research Institute
HHV	Higher Heating Value
HRT	Hydraulic Retention Time
k	First order reaction rate coefficient
kwh	Kilowatt hour
MGD, mgd	Million Gallons per Day
MMBtu	Million British Thermal Units
MMscf	Million standard cubic feet
MSW	Municipal Solid Waste
NMVFR	Non-Mixed Vertical Flow Reactor
O&M	Operation and Maintenance
PDA	Process Development Allowance
Q	Wet Tons Feed Per Day
RDF	Refuse Derived Fuel
RS&H	Reynolds, Smith and Hills, A-E-P, Inc.
scf	Standard Cubic Foot, at 1 atmosphere (14.7 psi) and 0°C (32°F)
SNG	Substitute Natural Gas
SRT	Solids Retention Time
SS	Suspended Solids
STP	Standard Temperature and Pressure

TPD, tpd	Tons Per Day
TBtu	10^{12} British Thermal Units
TS	Total Solids
TSS	Total Suspended Solids
VS	Volatile Solids, or combustible solids
VSS	Volatile Suspended Solids
VSCE	Volatile Solids Conversion Efficiency
v/v/d	volume methane/unit reactor volume/day
VSLR	Volatile Solids Loading Rate (E.g.: lbs VS added/cu ft reactor volume/day, or grams VS/liter reactor volume/day
VDS	Volatile Dissolved Solids

INTRODUCTION

The Methane from Community Waste Systems Analysis (COWSA) model was developed using Lotus 1-2-3® Release 2 software. A basic knowledge of this software is required, and will allow the user to easily interact with the COWSA model. Macros have been integrated into the COWSA model to make it menu driven and relatively "user friendly". The user should also be familiar with the systems and terminology used for a community waste biogasification facility.

COWSATF1 is the first version of the COWSA model that calculates a tipping fee ($/ton MSW), whereby gas price is an input. There exists a parallel version (COWSAGC1) that calculates gas price; using tipping fee as an input.

The COWSA spreadsheet consists of seven sections arranged as shown in Figure 1, Community Waste Systems Analysis Model-Spreadsheet Map. These sections contain input and output areas, calculation and process flowsheet areas, and an area for the spreadsheet macros.

STARTING COWSA

Start the Lotus 1-2-3, Release 2 program using DOS Version 2.0, 2.1, 3.0, or 3.1 on an IBM PC, XT, AT® or compatible computer. When 1-2-3 is in the ready mode, type / File Retrieve (or /FR) COWSATF1 or COWSAGC1 and hit the ENTER (RETURN) key. File retrieval takes between 10 and 70 seconds, depending on the computer. When the file is retrieved, the initial screen as shown in Figure 2 should appear on the monitor.

MENU COMMANDS AND OPTIONS

The second line from the top of the initial screen contains the main menu commands. The COWSA model starts under macro control (as noted by the CMD indicator at the bottom of the screen) each time the file is initiated. As in 1-2-3, the COWSA menu commands can be selected by two methods.

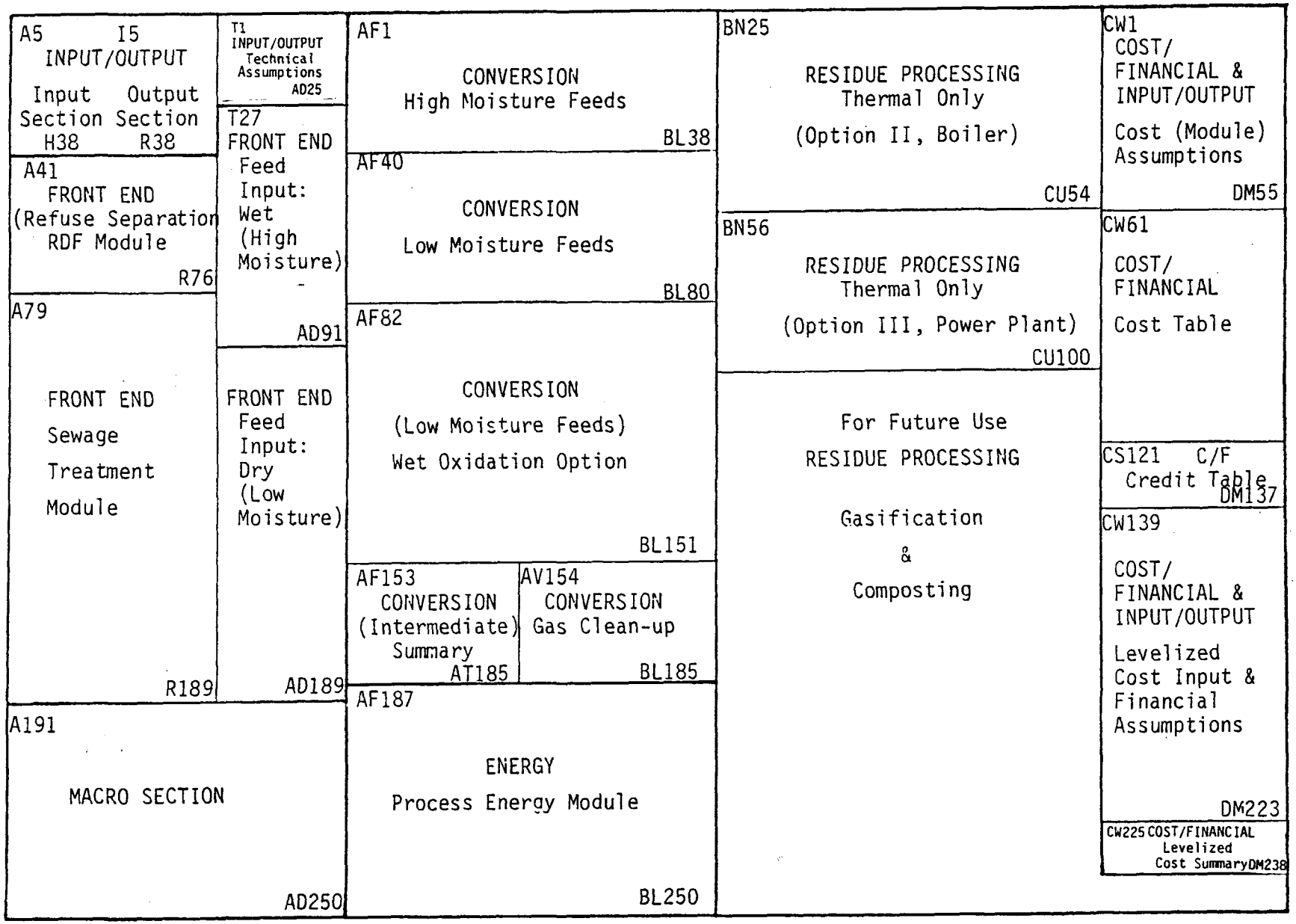

FIGURE 1 Community Waste Systems Analysis (COWSA) Model - Spreadsheet Map

```
A1: PR 'METHANE FROM COMMUNITY WASTE SYSTEMS ANALYSIS (COWSA)                MENU
INPUT  TRAVEL  PRINT  QUIT
Enter inputs into various sections of the model
        A          B          C         D         E         F          G          H
1   METHANE FROM COMMUNITY WASTE SYSTEMS ANALYSIS (COWSA)
2   FILENAME: COWSTF13
3   DATE: 16 JUNE 88
4
5                                  INPUT SECTION
6   ------------------------------------------------------------------------------
7   MGD sewage                                                          20 MGD
8   Tons per day MSW (7 days/wk)                                       600 tpd
9   % Total Solids MSW                                                74.0 %
10  % Volatile Solids (of TS) MSW                                     73.0 %
11  % Biodegradable Volatile Solids (of VS) MSW                       87.0 %
12  SNG sales price                                                  $3.00 /MMBtu
13  Solid residue processing option:                                    3
14      1 = Landfill
15      2 = Incinerate - recover process heat
16      3 = Power plant - recover process heat & generate power
17      4 = Wet Oxidation
18  Low, average or high cost estimate (L, A, H)                        A
19  Base year dollars (1980 - 1990)                                  1987
20                                          HIGH MOISTURE LOW MOISTURE
27-Jun-88  02:18 PM                            CMD
```

FIGURE 2. Initial Screen Display for COWSA

First, move the cursor using the right arrow and left arrow keys to highlight the desired command, then hit the ENTER key. The second method is to type the first letter of the desired command. If there are two or more menu commands that begin with the same letter, the second method will select the first command (from left-to-right in the menu) that begins with that letter.

During operation of the model, there are occasions when the user will be working out of macro control (the CMD indicator will be off). To return to macro control and call up the main menu hold down the Alt key and type M.

There are also menu options to be selected from within the main menu commands. These options as shown in Figure 3, can be selected by the same methods as previously described for menu commands. When viewing the Input, Travel, and Print Options menus, the user can use the Esc key to recall the main menu. The Commands available from the main menu are INPUT, TRAVEL, PRINT and QUIT.

INPUT Command: The INPUT command allows the user to enter or change input data into the various sections of the COWSA model. After the INPUT command has been selected, the INPUT Options menu is displayed. Figure 4 shows the INPUT Options and the selections available with these options. The five options available within the Input command are PRIMARY, SEWAGE TREATMENT, ASSUMPTIONS, COST/CREDIT, and FINANCIAL.

PRIMARY: This option, when selected, allows the user to enter or modify input data within the Primary Input Section. A sample Primary Input Section screen is shown by Figure 5.

SEWAGE TREATMENT: This input option allows the user to enter or modify input data to the Sludge/Water Hyacinth Module (adapted from Black & Veatch). This module contains three steps; Primary Treatment, Hyacinth Ponds, and Hyacinth Productivity. Step 2, Hyacinth Ponds, contains four options for determining effluent BOD & SS, retention time, loading rate, and surface area of ponds (in acres). Select the option that is a known parameter, enter the required values, and the spreadsheet will calculate the other three quantities.

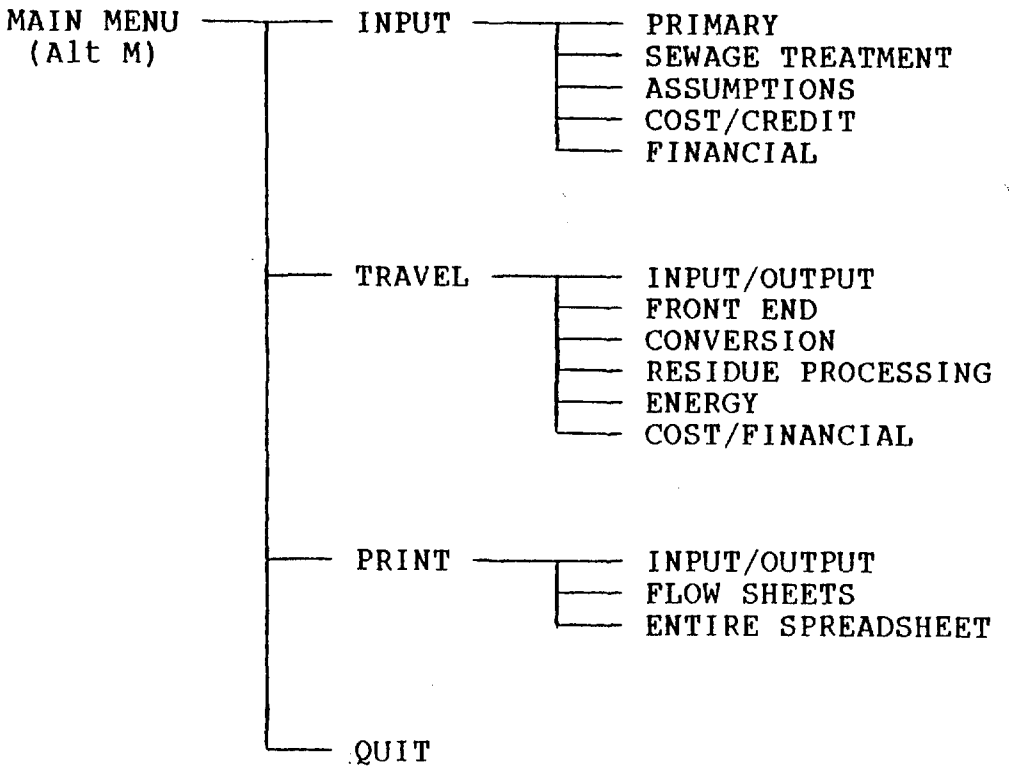

Figure 3. Main Menu Commands

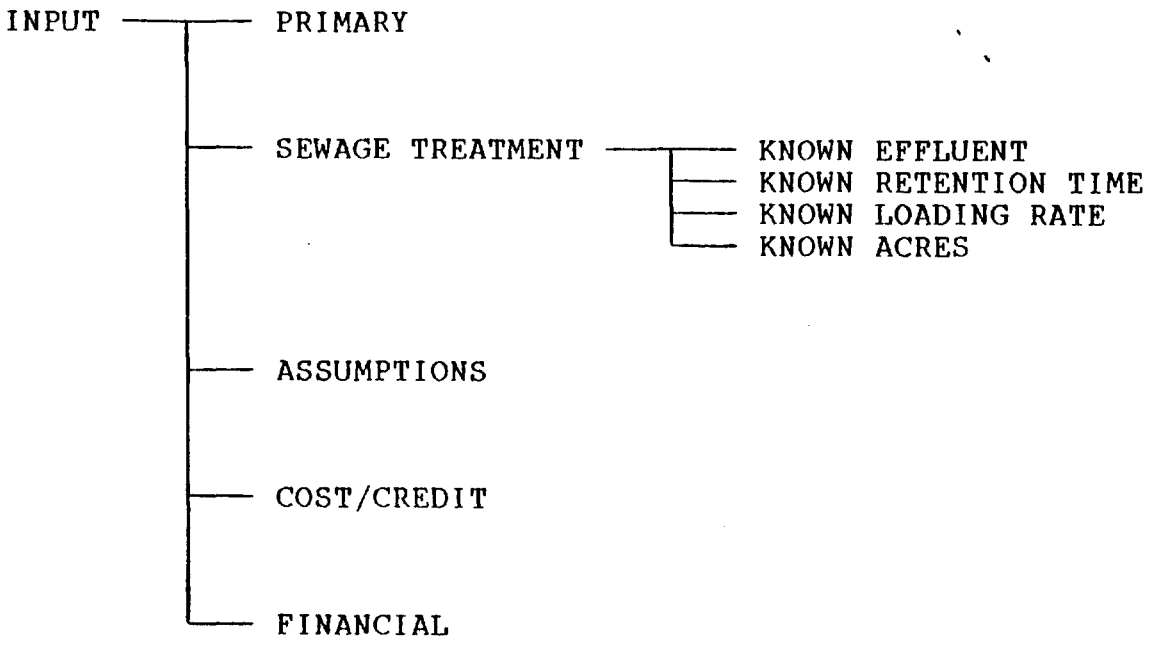

Figure 4. Input Command Options Flowchart

```
G24: U [W7] 140                                                    READY
Are all entries correct? (Y/N)

      A          B          C          D          E          F          G          H
5                                      INPUT SECTION
6    ------------------------------------------------------------------------------
7    MGD sewage                                                          20 MGD
8    Tons per day MSW (7 days/wk)                                       600 tpd
9    % Total Solids MSW                                                74.0 %
10   % Volatile Solids (of TS) MSW                                     73.0 %
11   % Biodegradable Volatile Solids (of VS) MSW                       87.0 %
12   SNG sales price                                                  $3.00 /MMBtu
13   Solid residue processing option:                                    3
14        1 = Landfill
15        2 = Incinerate - recover process heat
16        3 = Power plant - recover process heat & generate power
17        4 = Wet Oxidation
18   Low, average or high cost estimate (L, A, H)                        A
19   Base year dollars (1980 - 1990)                                  1987
20                                                  HIGH MOISTURE LOW MOISTURE
21   SRT                                                    10.00     20.00 days
22   SRT/HRT ratio                                           2.00      1.00
23   % CH4 in biogas (both 55% or 85%)                         55        55 %
24   Digester temperature                                      95       140 deg F
27-Jun-88  02:15 PM                              CMD
```

FIGURE 5. Primary Input Section Screen Display

ASSUMPTIONS: This option allows the user to modify the technical assumptions used in the COWSA model.

COST/CREDIT: This option allows the user to modify the cost and credit data within the Cost Module. The Cost Module contains the following seven categories: Refuse Separation, Sewage Treatment, Conversion, Gas Cleanup/Compression, Solid Residue Processing, Compostable Residue Processing, and Other.

FINANCIAL: This option allows the user to modify the financial assumptions used in the Levelized Cost Module.

When the desired input option has been selected, the macro will move the cursor to the corresponding input locations. Key in the desired value and then hit ENTER for each of the required input items. If the pre-existing value is acceptable, just hit ENTER to proceed to the next input item. Do not use the arrow keys to move the cursor during the input procedure, use only the ENTER key. If your system is too slow between entries, set it for manual recalculation by typing /WGRM.

After entering the final required value in any of the input options, the macro will prompt the user with "Are all entries correct? (Y/N)". If not, type N and hit ENTER to go through the input procedure again. If the values are all correct, type Y, and hit ENTER (or just hit ENTER) and the macro will advance to the Output Section. Press ENTER again and the Levelized Cost and Net Total Levelized Tipping Fee will be displayed as shown in Figure 6, and control is returned to the main menu.

TRAVEL Command: The TRAVEL command permits the user to move to, view and explore the various sections of the COWSA spreadsheet. When the TRAVEL command is selected, the TRAVEL Options Menu is displayed. There are six options available in the TRAVEL Options Menu that correspond to the six main sections of the spreadsheet. Refer to Figure 1, COWSA Model Spreadsheet Map. These options (sections) are INPUT/OUTPUT, FRONT END, CONVERSION, RESIDUE PROCESSING, ENERGY, AND COST/FINANCIAL.

```
I32: PR 'NET TOTAL                                                    MENU
INPUT  TRAVEL  PRINT  QUIT
Enter inputs into various sections of the model
        I        J     K         L          M        N        O        P       Q
13  vol. methane/vol. reactor/day                      1.78    2.10 v/v/d
14  Volatile Solids Loading Rate (VSLR)                0.44    0.43 lb VS/cf-day
15  % of gross methane production                       5.2    94.8 %
16
17
18            LEVELIZED COST                1987 $/ton          % of Total Cost
19  Refuse Separation                          $11.7735                  23.58%
20  Sewage Treatment                            $6.5961                  13.21%
21  Conversion - High Moisture                  $1.1034                   2.21%
22  Conversion - Low Moisture                   $7.3068                  14.63%
23  Gas Cleanup                                 $2.1649                   4.34%
24  Solid Residue Processing                   $20.9897                  42.03%
25  TOTAL COST                                 $49.9343                 100.00%
26
27  Gas Credit                                ($13.2366)
28  Sewage Credit                              ($6.6667)
29  Byproduct Credit                           ($4.6823)
30  TOTAL CREDIT                              ($24.5856)
31
32  NET TOTAL                                  $25.3487
27-Jun-88  02:16 PM                    CMD
```

FIGURE 6. Sample Output Section Screen Display

When one of the TRAVEL options (except ENERGY) is selected, the user will have a choice of destinations within that section. Figure 7, Travel Command, Options Flowchart shows the six TRAVEL options and the choice of destinations for each option. The ENERGY option has only one destination and therefore no additional selection is needed for "travel" to the Process Energy Module.

Once a TRAVEL option and destination have been selected, the cursor advances to the chosen destination. The spreadsheet is no longer under macro control. The user is now free to move around the spreadsheet using the arrow keys, page down, page up, tab, shift tab, and the goto (F5) key with a range name or cell address.

To recall the main menu and return to macro control, hold down the Alt key and type M.

PRINT Command: The PRINT command initiates macros to format and print various sections of the spreadsheet, or the entire spreadsheet. When the PRINT command is selected, the PRINT Options Menu is displayed. The available PRINT options are INPUT/OUTPUT, FLOW SHEETS, and ENTIRE SPREADSHEET. The PRINT Options and the selections available with them are presented in Figure 8. Examples of the INPUT/OUTPUT and FLOW SHEETS printouts are displayed in Figures 9 through 16.

INPUT/OUTPUT: Prints the primary Input Section and Output Section, 10 characters per inch (CPI), on 8½" x 11" paper.

FLOW SHEETS: Prints process flowsheets for the RDF Module, Conversion Module, Gas Clean-up Module and Residue Processing Module. The following list gives the minimum paper size (width x height) and specifies the CPI value for each Flow Sheet Option.

RDF Module	:	11"x 8½", 17 CPI
Conversion Module		
- High Moisture Feeds	:	11"x 8½", 17 CPI
- Low Moisture Feeds	:	11"x 8½", 17 CPI
- Wet Oxidation Option	:	14"x 11", 17 CPI
Gas Clean-up Module	:	11"x 8½", 17 CPI
Residue Processing Module		
- Thermal Only (Option II)	:	11"x 8½", 17 CPI
- Thermal & Power (Option III):		14"x 8½", 17 CPI

ENTIRE SPREADSHEET: Prints the entire COWSA spreadsheet, 17 CPI, on 25 sheets of 14" x 11" paper.

QUIT Command: This command macro removes the main menu, ends macro control of the spreadsheet, and returns the computer to the 1-2-3 READY mode. These same functions can be accomplished by pressing the Escape key when the main menu is displayed. The CMD indicator will be OFF. This allows the user to end the COWSA session or to move throughout the spreadsheet using the arrow, page down, page, tab, shift tab, and goto (F5) keys. To recall the main menu and return to macro control, hold down the Alt key and type M.

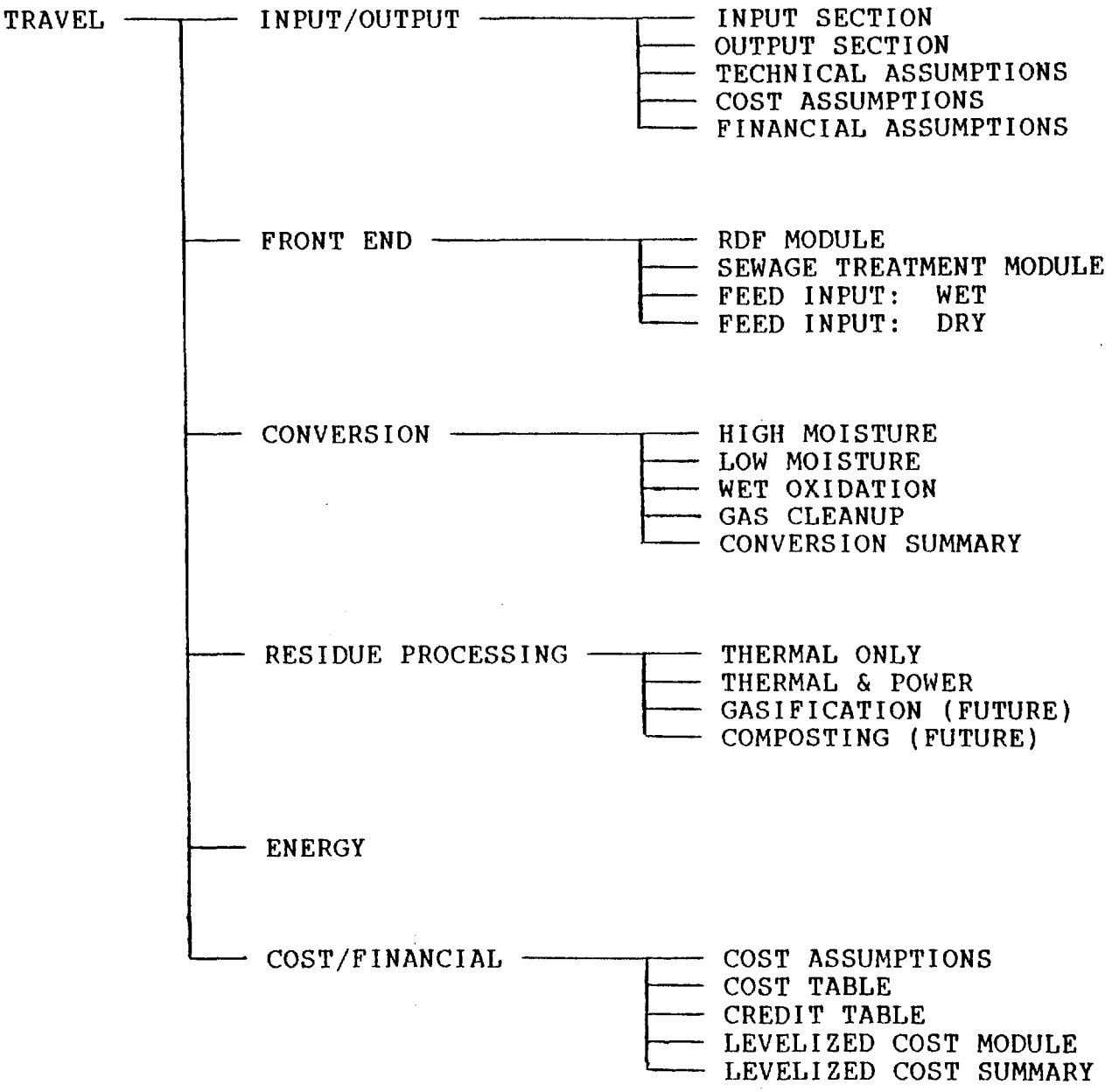

Figure 7. Travel Command Options Flowchart

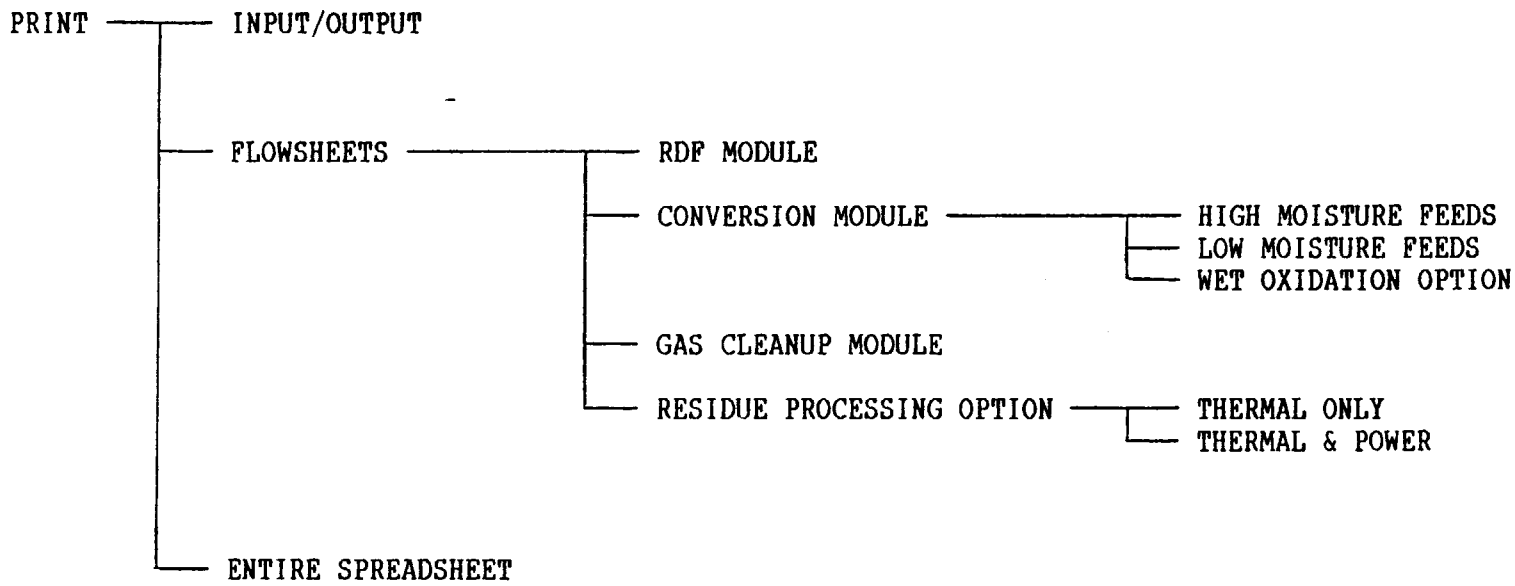

Figure 8. Print Command Options Flowchart

FIGURE 9. Input/Output, Print Example

INPUT SECTION

MGD sewage	20	MGD
Tons per day MSW (7 days/wk)	600	tpd
% Total Solids MSW	74.0	%
% Volatile Solids (of TS) MSW	73.0	%
% Biodegradable Volatile Solids (of VS) MSW	87.0	%
SNG sales price	$3.00	/MMBtu
Solid residue processing option:	3	
1 = Landfill		
2 = Incinerate - recover process heat		
3 = Power plant - recover process heat & generate power		
4 = Wet Oxidation		
Low, average or high cost estimate (L, A, H)	A	
Base year dollars (1980 - 1990)	1987	

	HIGH MOISTURE	LOW MOISTURE	
SRT	10.00	20.00	days
SRT/HRT ratio	2.00	1.00	
% CH4 in biogas (both 55% or 85%)	55	55	%
Digester temperature	95	140	deg F

OUTPUT SECTION

Net methane production per day	2.79	MMscf/day
Net energy production per year	0.97	10E12 Btu/yr
Pond area	163.5	acres

	HIGH	LOW MOISTURE	
Volatile Solids Conversion Efficiency %	54.26	69.48	%
Gross methane yield	4.08	4.87	scf CH4/lb VSa
vol. methane/vol. reactor/day	1.78	2.10	v/v/d
Volatile Solids Loading Rate (VSLR)	0.44	0.43	lb VS/cf-day
% of gross methane production	5.2	94.8	%

LEVELIZED COST	1987 $/ton	% of Total Cost
Refuse Separation	$11.7735	23.58%
Sewage Treatment	$6.5961	13.21%
Conversion - High Moisture	$1.1034	2.21%
Conversion - Low Moisture	$7.3068	14.63%
Gas Cleanup	$2.1649	4.34%
Solid Residue Processing	$20.9897	42.03%
TOTAL COST	$49.9343	100.00%
Gas Credit	($13.2366)	
Sewage Credit	($6.6667)	
Byproduct Credit	($4.6823)	
TOTAL CREDIT	($24.5856)	

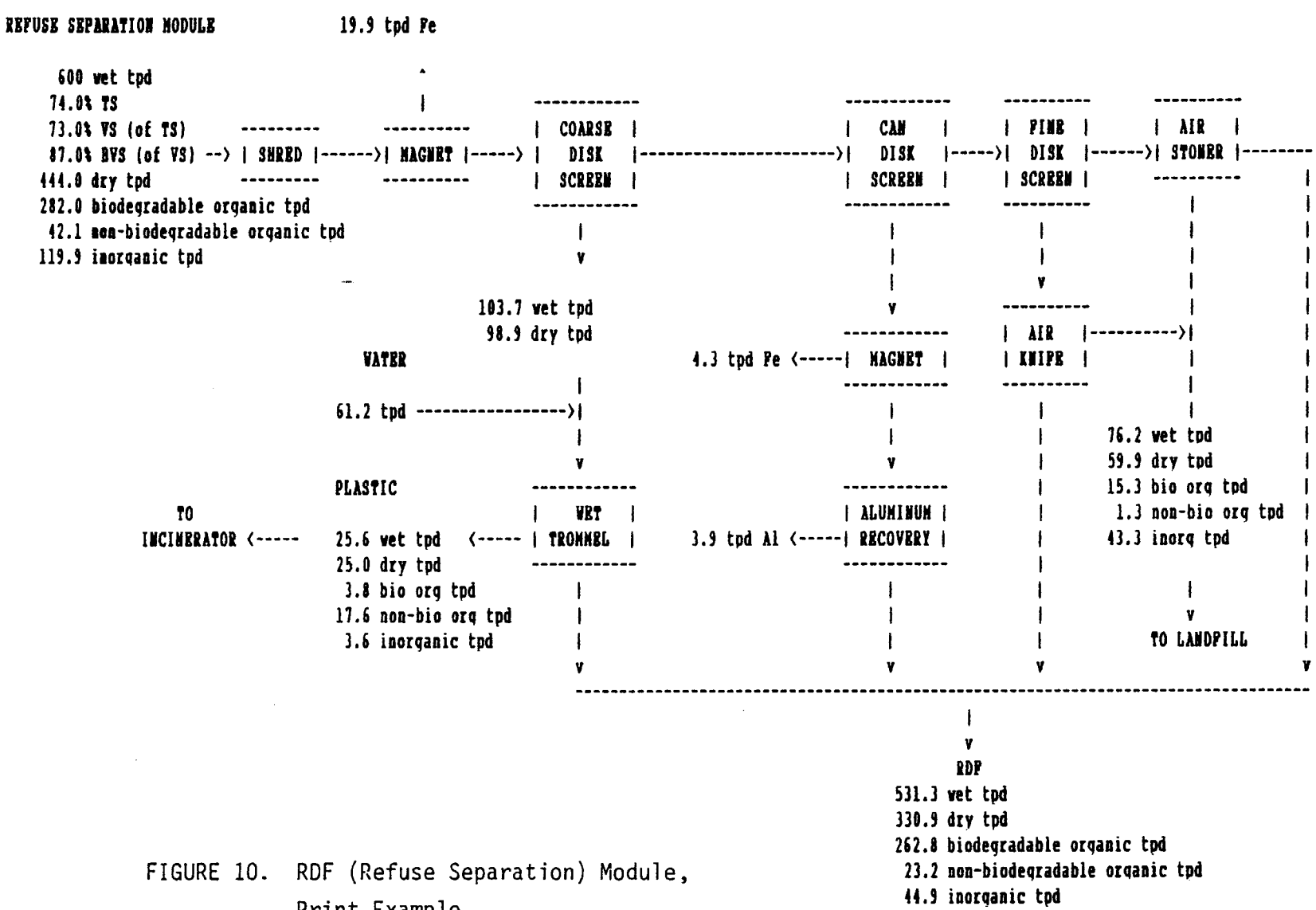

FIGURE 10. RDF (Refuse Separation) Module, Print Example

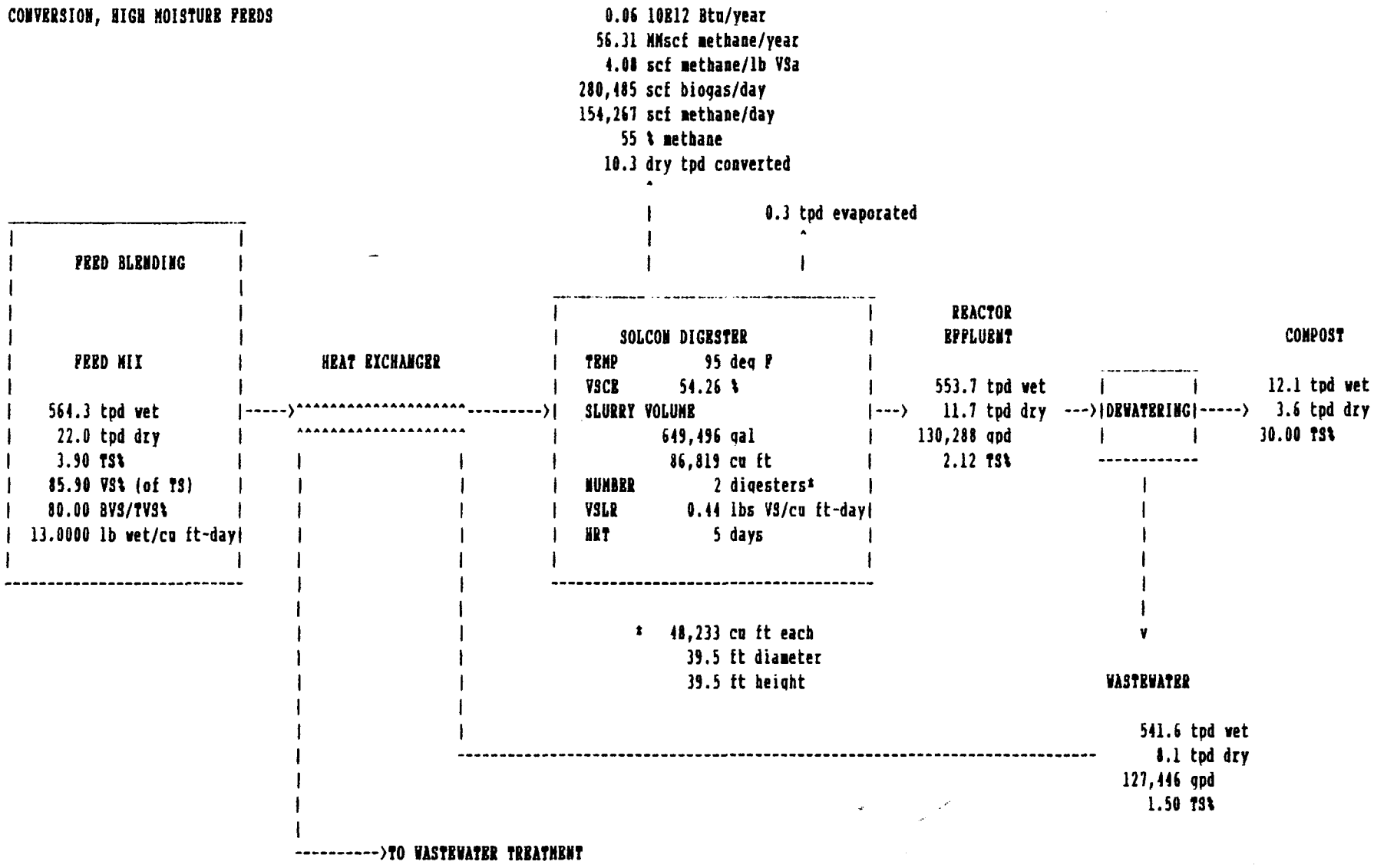

FIGURE 11. Conversion, High Moisture Feeds, Print Example

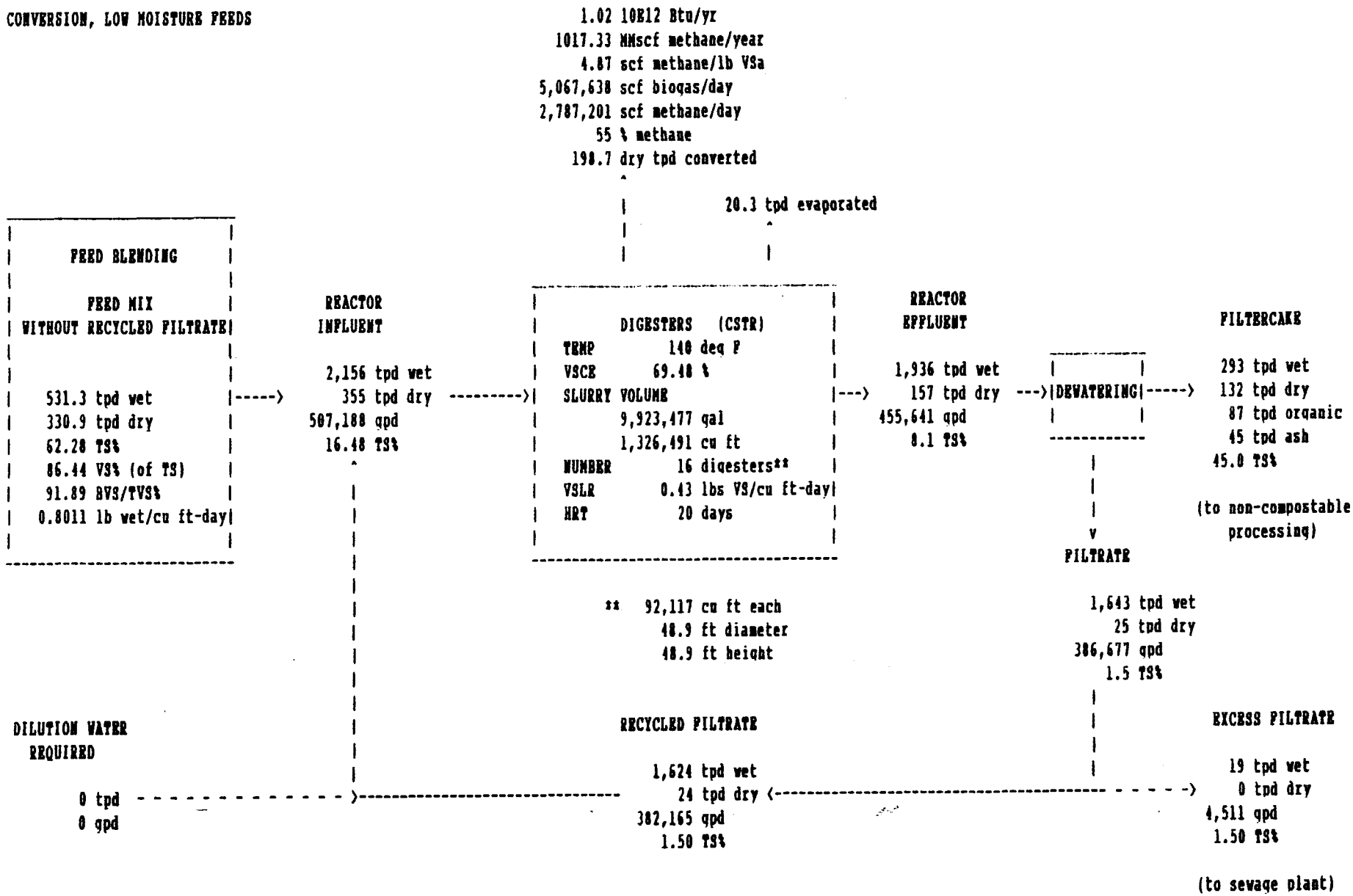

FIGURE 12. Conversion, Low Moisture Feeds, Print Example

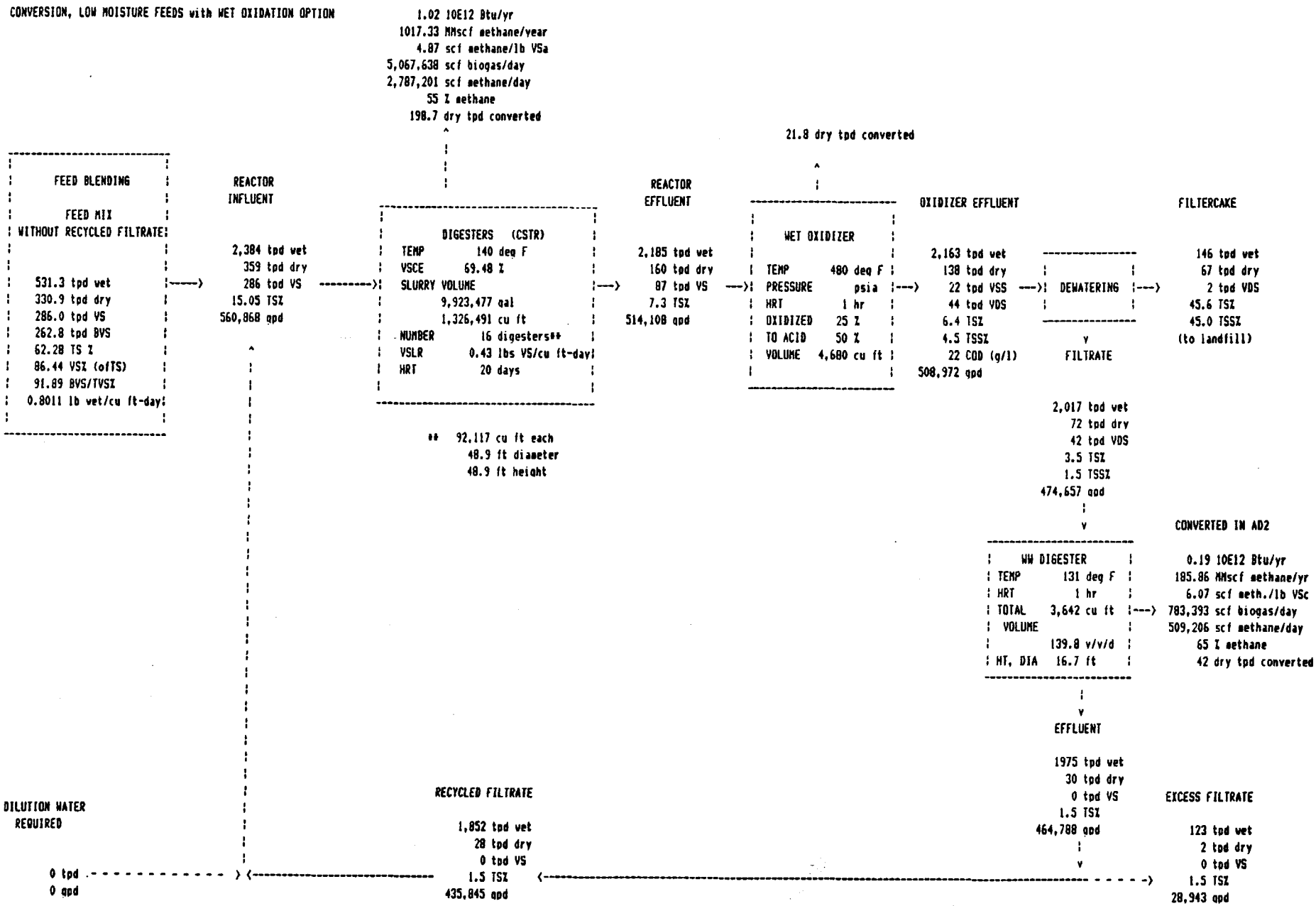

FIGURE 13. Conversion, Wet Oxidation, Print Example

GAS CLEANUP MODULE - PRISM MEMBRANE SYSTEM

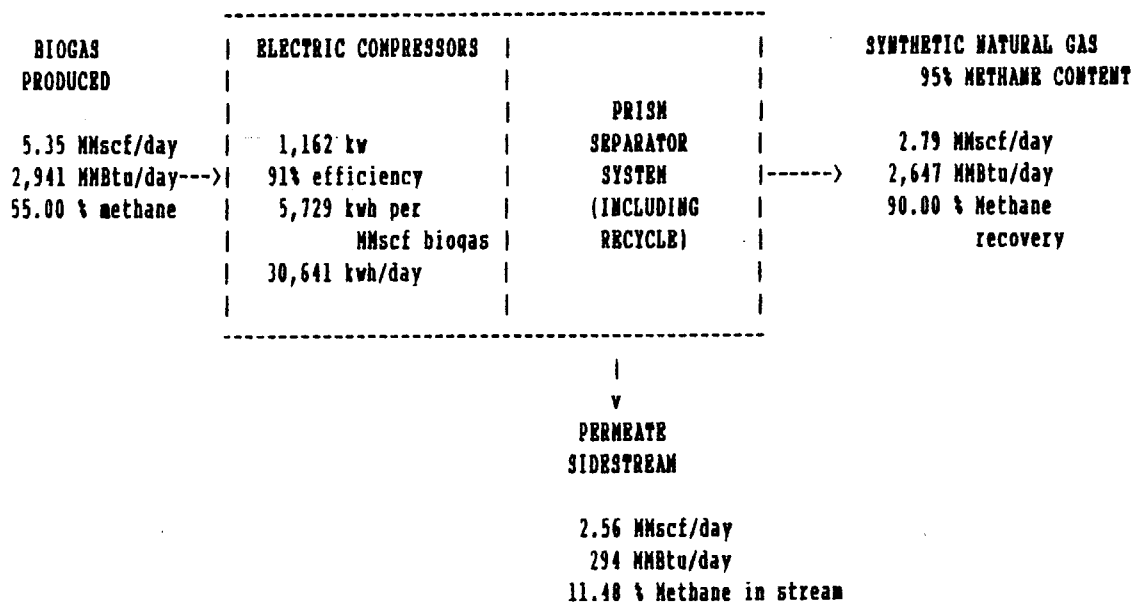

FIGURE 14. Gas Cleanup Module, Print Example

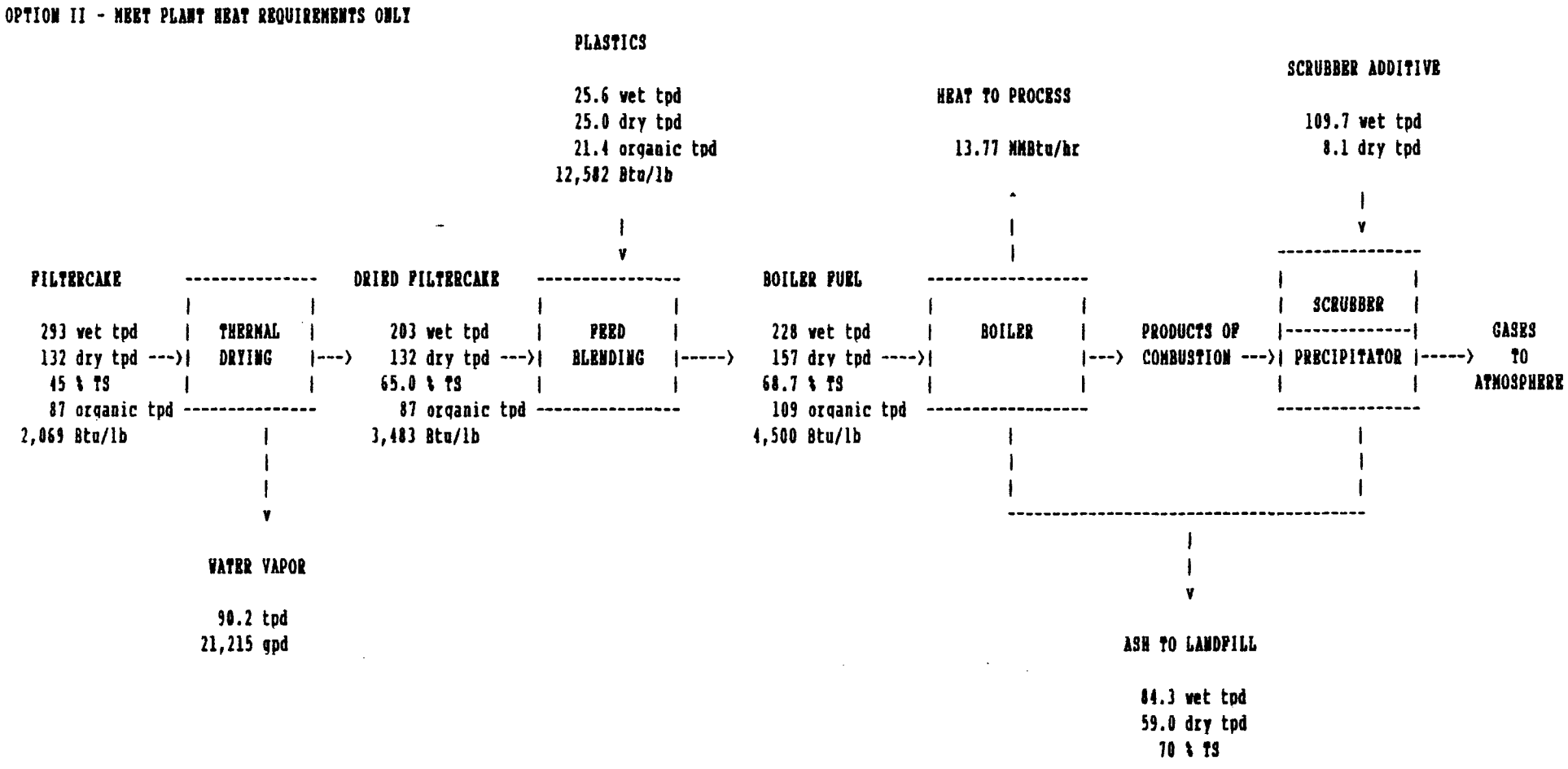

FIGURE 15. Residue Processing Thermal Only, Print Example

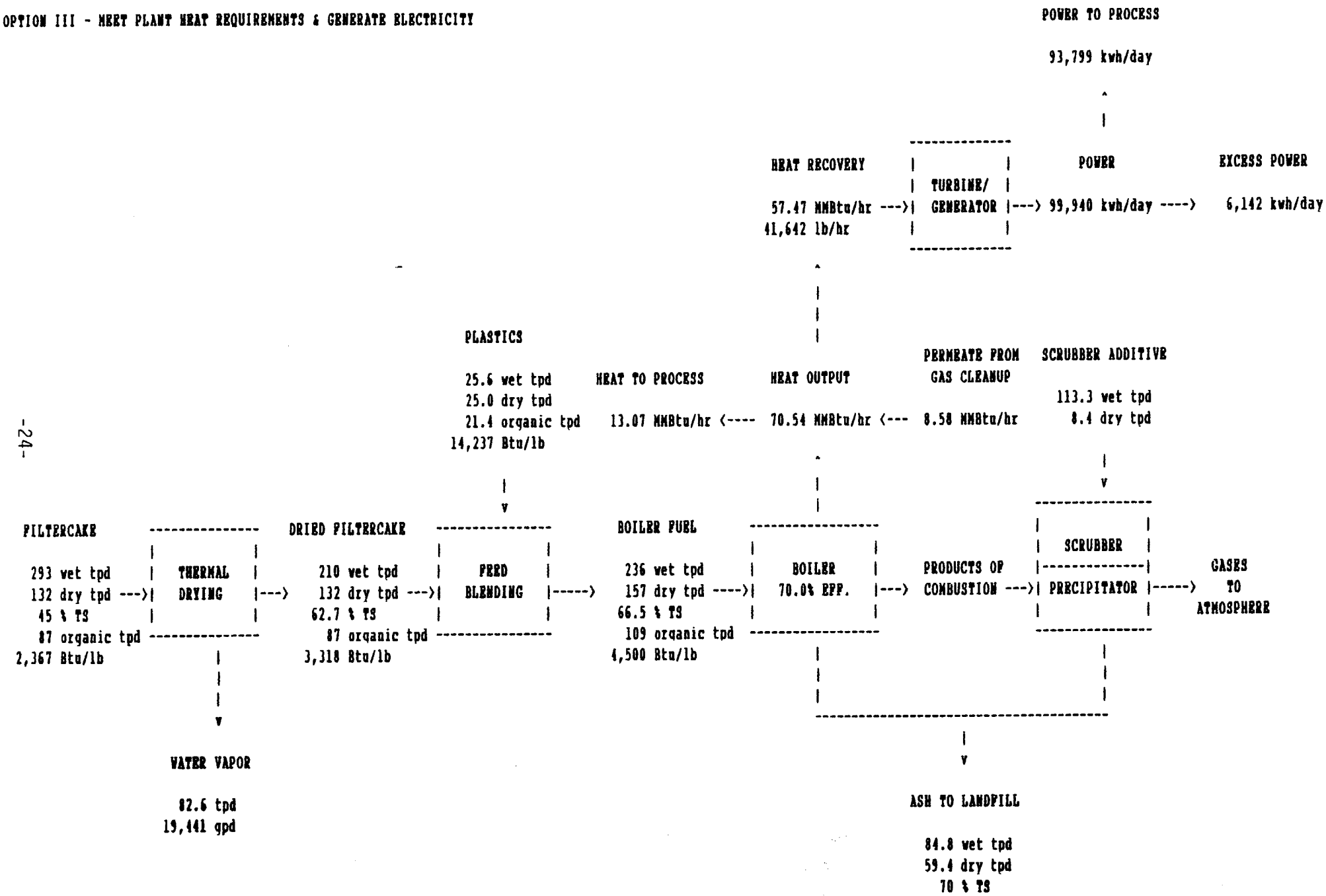

FIGURE 16. Residue Processing, Thermal & Power Print Example

LIST OF RANGE NAMES

Range Name	Cell Address	Range Name	Cell Address	Range Name	Cell Address
ADJ85	DM10	HARACRE	F177	PRAN5	CW1..DM253
ASSUMAC	B242	HIGHMO	AF1	PRIMINP	B207
ASSUMP	T1	IACRES	G119	PRINT	T196
AVTEMP	X15	IDAYS	G117	PRPMENU	T223
BIOMETH	AV164	IEFFBOD	G116	RDFBIO	L73
BLRBTU	AP171	IEFFTSS	G114	RDFDRY	L72
BLRIN	AP170	ILR	G118	RDFINORG	L75
CBMETH	AP6	INDEX1	B126	RDFNONBI	L74
CBSCF	AP4	INOUT	A5..R31	RDFWET	L71
CDIGTEMP	F24	INPUT	B202	REFBFLO	A48
CGCOUT	AG153	INTH	X17	REFDFLO	A47
CONTD1	U223	IOMENU	J227	REFIFLO	A50
CONVMENU	J235	IPDEPTH	G113	REFNFLO	A49
CORRECT1	H208	LEVCOIN	CW139	REFWFLO	A43
CORRECT2	H218	LEVCOUT	CW224	RPMENU	J239
CORRECT3	H243	LOADING	I81	RSMOD	A41..R76
CORRECT4	P196	LOWMO	AF40	SEWTPD	G7
CORRECT5	P204	MACROS	A190	SEWTRMAC	B217
COSTMAC	J196	MAINMENU	B196	SRTRATD	G22
COSTMENU	J243	MAXDC	W8	SRTRATW	F22
COSTRANG	G18	MAXDD	Y8	STEP2	A105
COSTTAB	CW61..DD136	MAXHC	W7	STEP3	A140
CREDTAB	CW121	MAXHD	Y7	SUMMRY	A170..F178
DBMETH	AP45	MINNOC	W9	SWHMOD	A79
DBSCF	AP43	MINNOD	Y9	TECHOP	X10
DDIGTEMP	G24	MSWTPD	G8	TEPO	G13
DESTEMP	X16	MTMENU	J222	TRAVEL	J218
ELCOST	DA51	OPT2	BN25	TREACRE	F176
ELECREQ	AI244	OPT3	BN57	TSHY	B168
ENTER	J215	OUTPUT	I5..R31	TSSLU	B100
FEMENU	J231	PCONMENU	T215	UNITCOST	CW1
FIMOD	T27	PEMOD	AG187..AM244	VSSLU	B101
FINANMAC	J204	PERINCR	T189	WETOX	AF82..BL141
FLOMENU	T205	PONDIN	A113..G119	YEAR	G19
FLOW	G87	PONDOPT	A233	\O	B193
FUELCOST	DA52	PRAN1	A1..S248	\E	AN150
GCMOD	AV154	PRAN2	T1..AE248	\M	B194
GCOPT	X25	PRAN3	AF1..BL248	\X	B217
GROSPROD	AP175	PRAN4	BM1..CV248		