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Municipal Environmental Research
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Research and Development

Short Course Proceedings Applications of Computer Programs in the Preliminary Design of Wastewater Treatment Facilities

Section II
Users' Guide and Program Listing

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Short Course Proceedings

APPLICATIONS OF COMPUTER PROGRAMS IN THE PRELIMINARY DESIGN OF WASTEWATER TREATMENT FACILITIES

Section II: Users' Guide and Program Listing

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DISCLAIMER

FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimonies to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution, and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems to prevent, treat, and manage wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research--a most vital communications link between the research and the user community.

The information presented here is a users' guide for the Executive Program. This computer program provides the quantitative expressions for calculating the performance and cost of wastewater treatment systems as a function of the nature of the wastewater to be treated and the design criteria associated with the individual unit processes that comprise the system. As such, it can be a valuable tool to the design engineer for determining the most cost-effective system for achieving any specific wastewater treatment goal.

Francis T. Mayo
Director, Municipal Environmental
Research Laboratory

ABSTRACT

This document contains a portion of the material used for the Short Course on the Applications of Computer Programs in the Preliminary Design of Wastewater Treatment Facilities. The short course lectures appear in Section I of the report, under separate cover.

Section II, contained herein, contains the users' manual and program listing for the Executive Program for Preliminary Design of Wastewater Treatment Systems. The users' manual describes the use of the program and subroutines. Several examples show appropriate input and expected output for a variety of applications. In addition, the theoretical basis for the calculations are shown in the form of conventional mathematical and equivalent fortran equations.

The program listing includes the fortran listing for the main program (EXECMAIN) and each of the 27 subroutines, representing different treatment processes, energy consumption, and cost calculations. The program listings include extensive documentation and can be easily related to the theoretical equations in the users' manual.

This report was submitted in partial fulfillment of Grant Number R-805134-01 by the Pritzker Department of Environmental Engineering at the Illinois Institute of Technology under the sponsorship of the U. S. Environmental Protection Agency. This report covers a period from May 23, 1977 to June 22, 1978 and work was completed as of June 22, 1978.

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SECTION 1

Main Program, EXECMAIN

INTRODUCTION

The Executive Program is a digital computer program which can be used to compute the quasi-steady-state performance and cost of wastewater treatment systems. Groups of conventional and advanced wastewater treatment processes arranged in any logical configuration can be simulated using this program. Table 1 gives a listing of the 24 unit process models that are presently included in the program along with the subroutine name and identification number for each process. Each unit process is handled as a separate subroutine, which makes it possible to add additional process models to the system as they are developed.

Initial development began on the Executive Program in 1967 and has continued until the present time. The program is written in FORTRAN IV. The complete FORTRAN source card listing of the computer program is included in this section. The system presently consists of the main program, entitled EXECMAIN, 24 process subroutines (each subroutine computes the performance and the costs associated with building and operating the unit process), and 3 additional subroutines entitled COST, PRINT, and ENGY. EXECMAIN reads the input data to the program, handles the iteration for system recycle streams, and calls the proper subroutines to perform the needed calculations. The COST subroutine sums and updates (by means of cost indicies) the costs of the individual processes and adds additional charges for yardwork, land, engineering, legal-fiscal-administrative services, and interest during construction. PRINT simply prints out all of the pertinent input and output data in a prescribed format. ENGY computes and prints out the energy requirements (electrical power, fuel oil, natural gas, etc.) associated with operating each unit process.

The Executive Program can be used as a valuable preliminary design tool by the consulting engineer or planner. The performance of existing and proposed wastewater treatment plants can be simulated along with providing cost estimates for building and operating these plants. It is also possible to mathematically optimize a particular treatment system by varying design parameters and noting the effect on performance and cost.

Subroutine Name	Identification Number
PREL, preliminary treatment	1
PRSET, primary sedimentation	2
AERFS, activated sludge-final settler	3
MIX, stream mixer	4
SPLIT, stream splitter	5
DIG, single stage anaerobic digestion	6
VACF, vacuum filtration	7
THICK, gravity thickening	8
ELUT, elutriation	9
SBEDS, sand drying beds	10
TRFS, trickling filter-final settler	11
CHLOR, chlorination-dechlorination	12
TFLOT, flotation thickening	13
MHINC, multiple hearth incineration	14
RWP, raw wastewater pumping	15
SHT, sludge holding tanks	16
CENT, centrifugation	17
AEROB, aerobic digestion	18
POSTA, post aeration	19
EQUAL, equalization	20
DIG2, second-stage anaerobic digestion	21
LANDD, land disposal of liquid sludge	22
LIME, lime additional to sludge	23
RBC, rotating biological contactor-final settler	24

Table 1 Unit processes contained in the executive program

Furthermore, alternate treatment systems can be compared with respect to performance and cost. Cost-effectiveness studies along these lines are becoming increasingly important because of the soaring construction costs that are now being experienced.

PROGRAM DESCRIPTION

The first step in using the Executive Program is to draw a system flow diagram showing the processes to be used and the connecting and recycle streams. The process symbols are shown in each of the Subroutine Users Guides. An example system flow diagram is shown in Figure 1. Each process and stream is assigned a number by the program user. Any stream can be numbered 2 through 30, and any process can be numbered 1 through 20. However, the principal influent stream to the system must always be assigned the number one (1). The number zero (0) must always be given to the processes that require no input decision data. Only the stream mixer (MIX) and the stream splitter (SPLIT) need no input data. Notice that the volume of the split stream must be supplied by a downstream process, such as gravity thickening, flotation thickening or sludge elutriation.

The program reads the influent stream characteristics and stores them with all the computed stream characteristics in the stream matrix (SMATX) which has 20 rows and 30 columns. One stream vector is stored in each column of SMATX corresponding to the user assigned stream number on the system diagram. A temporary stream matrix (TMATX) with 20 rows and 30 columns is used internally by the program to store newly computed stream vectors until they can be compared with the previously computed values during the program's recycle iterations. The iteration error (EPS) which will be tolerated when recycle streams are involved is designated by an easily changeable FORTRAN statement in EXECMAIN. The value for EPS currently used in the program is .10 mg/l. Each stream is referenced by the assigned stream number in the first row of SMATX, the volume flow in mgd in the second row, and the concentration of 17 contaminants in rows 3-19. Row 20 is unassigned at present, although, the number of contaminants contained in the stream vector may increase as new unit process subroutines are added to the program in the future. A list of the information contained in the stream vector is shown in Table 2 along with the FORTRAN variable names that are used.

A decision matrix (DMATX) is provided with 16 rows and 20 columns for storing input design parameters such as settler overflow rates, solids loading rates, detention times, chemical doses, and so on. One decision vector is stored in each column of DMATX corresponding to the user assigned process number on the system diagram. In other words, input parameters for process N are stored in the Nth column of DMATX. Column 20 of DMATX is reserved for cost parameters which apply to all

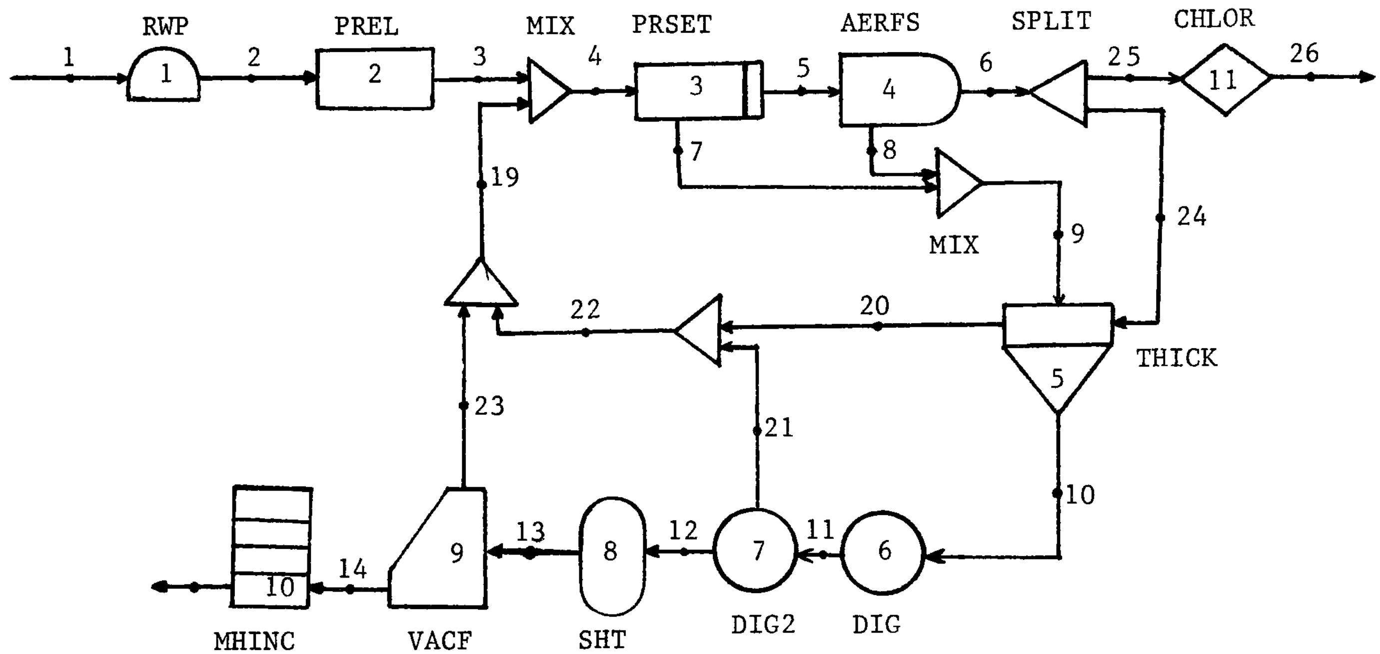

Figure 1 Example system flow diagram

Row Number	FORTRAN Variable Name		Parameter Definition	Nominal Value for Plant Influent
1	SMATX(1,I)	I	stream number	-
2	SMATX(2,I)	Q	volume flow, mgd	10.
3	SMATX(3,I)	SOC	solid organic carbon, mg/1	105.
4	SMATX(4,I)	SNBC	solid nonbiodegradable carbon, mg/1	30.
5	SMATX(5,I)	SON	solid organic nitrogen, mg/1	10.
6	SMATX(6,I)	SOP	solid organic phosphorus, mg/1	2.
7	SMATX(7,I)	SFM	solid fixed matter, mg/1	30.
8	SMATX(8,I)	SBOD	solid 5-day BOD, mg/1	140.
9	SMATX(9,I)	VSS	volatile suspended solids, mg/1	224.
10	SMATX(10,I)	TSS	total suspended solids, mg/1	254.
11	SMATX(11,I)	DOC	dissolved organic carbon, mg/1	43.
12	SMATX(12,I)	DNBC	dissolved nonbiodegradable carbon, mg/1	11.
13	SMATX(13,I)	DN	dissolved nitrogen, mg/1	19.
14	SMATX(14,I)	DP	dissolved phosphorus, mg/1	4.
15	SMATX(15,I)	DFM	dissolved fixed matter, mg/1	500.
16	SMATX(16,I)	ALK	alkalinity, mg/1	250.
17	SMATX(17,I)	DBOD	dissolved 5-day BOD, mg/1	60.
18	SMATX(18,I)	NH3	ammonia nitrogen as N, mg/1	15.
19	SMATX(19,I)	NO3	nitrate as N, mg/1	0.
20	not used			

Table 2 Contents of the stream matrix (SMATX)

processes, such as electrical power cost, construction cost index, hourly labor wage rates, and so on. Row 16 of DMATX (and additional preceding rows if required, such as in the AERFS process) is reserved for the excess capacity factor (ECF), which is a multiplier on the calculated design size of the process, to allow shutdown for cleaning and maintenance work.

For processes having a non-zero process number (N), the contents of the Nth column for DMATX are read into the program from 2 input data cards which follow the process card for the Nth process. For the stream mixer and the stream splitter, where no process number is assigned (the number "0" is given), the 2 cards containing decision parameters are omitted. A listing of the contents of DMATX for each unit process is given in the Subroutine Users Guides, along with definitions of the variables and nominal input values.

An output matrix (OMATX) is provided with 20 rows and 20 columns for storing computed output parameters from the various process subroutines. Output parameters for the Nth process are stored in the Nth column of OMATX. A listing of the contents of OMATX for each unit process is given in the subroutine Users Guides along with definitions of the computer output parameters.

The main program (EXECMAIN) has the function of calling the process subroutines for computing the performance and cost of the individual unit processes in the proper order. When a recycle loop occurs, this involves recomputing all of the processes within the recycle loop in an iterative manner until each element of all stream vectors ceases to vary by more than the prescribed tolerance (EPS).

INPUT REQUIREMENTS

A description of the system configuration (the process locations and interconnecting streams) is communicated to the computer by an input deck of process cards. One card is used for each process with the process number (N) punched in columns 3 and 4 (right-justified). The type of process is specified by an assigned identification number as given in the Subroutine Users Guides. This number is punched in columns 7 and 8 (right-justified) of the process card. If desired, the process subroutine name can be punched in columns 10 to 16 in order to clearly identify the process card and to include this information in the final program printout. The number of the principal input stream to the process (IS1) is punched in columns 20 and 21. If a second input stream exists, the number of the stream (IS2) is punched in columns 30 and 31. The principal output stream from the process (OS1) is punched in columns 40 and 41. If a second output stream exists, the number (OS2) is punched in columns 50 and 51. IS1, IS2, OS1 and OS2 are all punched as right-justified data. Notice that the principal input and output streams must correspond to the designation shown in the Subroutine Users Guides. The two DMATX input cards follow immediately after the process card where required. Also, the user should be careful to arrange the logical order of the process cards so that no streams are used before they are computed.

A listing of the process cards is printed out as part of the output from the program. The process card information for the sample system shown in Figure 1 is listed in Table 3.

The FORTRAN format for the input data can be input in two ways. The first is for both a single design case and multiple design cases, where each design case has a different flow diagram. The second arrangement is used for multiple design cases that all utilize the same flow diagram. The second arrangement simplifies the preparation of input data.

Single Design Case

Table 4 gives Arrangement 1 of the FORTRAN format for reading the input data to the program. Input card 1 tells the program how many data cases (NCASE) are to be run (columns 1 and 2). In addition, REPEAT = "0" in column 4 indicates that each design case will have a different flow diagram. REPEAT = "1" in column 4 indicates that the original flow diagrem is repeated in each design case. Repeat is usually "0" in Arrangement 1. CHECK1 = "1" in column 6 causes the raw sewage composition and process design criteria to be printed out at the beginning of the first iteration. It is used for trouble shooting when one or more of the subroutines produces an overflow calculation error. CHECK1 is usually set equal to zero "0" in column 6 to avoid excess printout.

Input card 2 is the title card for each data case. Any alpha-numeric identifying data may be punched anywhere on this card, and this information will be the title of the program printout.

Input cards 3, 4 and 5 give the composite flow and concentrations of the raw sewage input stream to the treatment plant which is always labeled as Stream 1. Input cards 6 and 7 provide the general cost information. This is stored in column 20 of the decision matrix (DMATX).

The next input cards represent the processes. Each process will have three cards, unless the process number is "0" (SPLIT and/or MIX). The three cards will consist of a process card (card 8 in Table 4) and two decision cards (where necessary, cards 9 and 10 in Table 4). The last card in the data deck has a "9" in column 1. No other data is punched on the termination card. This last card is important because it indicates end-of-file for each data case. Note that the value of K in column 1

EXECUTIVE
DIGITAL COMPUTER PROGRAM
FOR
PRELIMINARY DESIGN OF WASTEWATER TREATMENT SYSTEMS

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DESIGN CASE NO. 1

10 MGD EXECUTIVE PROGRAM STANDARD TEST SYSTEM 1 10-28-1976 JAN 1975 $$$

SYSTEM DIAGRAM
INPUT DATA

K	N	PROCESS		IS1	IS2	OS1	OS2
0	1	15	RWP	1	0	2	0
0	2	1	PREL	2	0	3	0
0	0	4	MIX	3	19	4	0
0	3	2	PRSET	4	0	5	7
0	4	3	AERFS	5	0	6	8
0	0	5	SPLIT	6	0	25	24
0	0	4	MIX	7	8	9	0
0	5	8	THICK	9	24	10	20
0	6	6	DIG	10	0	11	0
0	7	21	DIG2	11	0	12	21
0	8	16	SHT	12	0	13	0
0	9	7	VACF	13	0	14	23
0	0	4	MIX	20	21	22	0
0	0	4	MIX	22	23	19	0
0	10	14	MHINC	14	0	15	0
0	11	12	CHLOR	25	0	26	0
9	0	0		0	0	0	0

Table 3 Sample output of process information

Input Card 1:	NCASE, REPEAT, CHECK1 FORMAT (3I2)
Input Card 2:	LIST FORMAT (40A2)
Input Cards 3, 4, 5:	(SMATX(I,1), I = 2,20) FORMAT (8F10.0)
Input Cards 6, 7:	(DMATX(I,20), I = 1,16) FORMAT (8F10.0)
Input Card 8:	K,N,IPROC,(NAME(I), I = 1,3), IS1,IS2,OS1,OS2 FORMAT (I1,1X,I2,2X,I2,1X,3A2, 4X,I2,8X,I2,8X,I2,8X,I2)
Input Cards 9, 10:	(DMATX(I,N), I = 1,16) FORMAT (8F10.0)
Input Cards 11 and on:	Continue with additional process cards. Process card with a "9" in column 1 indicates end-of-file. Begin next data case with Input Card 2, etc.

Table 4 Arrangement 1 of Fortran format for input data cards

of each process Identification Card, e.g. 8, 11, 14, etc., should be zero "0" except for the termination card.

Multiple Design Cases

Table 5 gives Arrangement 2 of the FORTRAN format for reading multiple input data to the program. On the first input card a value of one for REPEAT (a "1" in column 4) indicates that the multiple design cases will repeat, or utilize the flow diagram used in the original design case. A "0" in column 4 indicates that the original flow diagram is not being repeated, which in essence, is the format of Arrangement 1. CHECK1 can have a value of "0" in column 6. A "1" causes a printout of raw sewage composition and process design criteria to be printed out at the beginning of the first iteration. A value of "0" eliminates this initial printout.

Input cards 2 through M use the same format as in Arrangement 1.

Rather than repunch all M cards for a second (or multiple design case, a simplified, easy to punch format can be followed. Card M+1 indicates whether new raw sewage composition, SMATX (I,1), and/or new cost parameters, DMATX(I,20), and/or new process design criteria, DMATX(I,N) will be used. A value of "1" for NEWRAW in column 2, NEWCOS in column 4 and/or NEWDMX in column 6 indicates that new values are to be added in that category. A value of "0" indicates no new values will be added. Input card M+2 is the title. Beginning with input card M+3 are several possible cards. First, three SMATX(I,1) cards will follow if NEWRAW has a value of "1" rather than "0". Two DMATX(I,20) cards will then follow if NEWCOS has a value of "1" rather than "0". Finally, a series of cards will follow to indicate which processes are to have new design values, and what the new values should be. This of course is for the case where NEWDMX has a value of "1". On the next card NPROC indicates how many of the original processes will have new design criteria added. The value for NPROC is entered in columns 1 and 2 (right-justified). PROC(II) is an array which contains the user assigned number for each of the processes which will be given new design criteria. Finally, there will be two additional design criteria DMATX(I,N) cards for each of the NPROC processes being updated.

In Arrangement 2 a card with a "9" in column 1 is not placed at the end of design case 2, 3, etc. because it is not needed. Also, if three or more design cases are to be evaluated using Arrangement 2, the input cards should repeat the format of input cards M+1 through M+3 etc. for each new design case.

OUTPUT

Sample output from the program is shown in Tables 3 and 6

Input Card 1	NCASE, REPEAT, CHECK1 FORMAT (3I2)
Input Card 2	LIST FORMAT (40A2)
Input Cards 3, 4, 5	(SMATX(I,1), I = 2,20) FORMAT (8F10.0)
Input Cards 6,7	(DMATX(I,20), I = 1,16) FORMAT (8F10.0)
Input Card 8	K,NIPROC,(NAME(I), I = 1,3), IS1, IS2,OS1,OS2 FORMAT (I1,1X,I2,2X,I2,1X,3A2, 4X,I2,8X,I2,8X,I2,8X,I2)
Input Cards 9, 10	(DMATX(I,N), I = 1,16) FORMAT (8F10.0)
Input Cards 11 through M	Continue with additional process cards. Card M will be the design case termination card with a(9) in column(1). The Repeat of the same design flow diagram with different raw sewage stream characteristics, SMATX(I,1), cost parameters DMATX(I,20) and/or process design criteria DMATX(I,N) begins with the next card
Input Card M+1	NEWRAW, NEWCOS, NEWDMX FORMAT (3I2)
Input Card M+2	LIST FORMAT (40A2)

Table 5 Arrangement 2 of Fortran format for input data cards

Input Card M+3	(SMATX(I,1), I = 2,20) FORMAT (8F10.0)	only if new raw sewage characteristics will be added
	and/or	
	(DMATX(I,20) I = 1,16) FORMAT (8F10.0)	will then follow if new cost parameters will be added
	and/or	
	NPROC, (PROCNO(II), II = 1, NPROC) FORMAT (10I2)	will then follow if new process design criteria will be added for one or more of the original processes
	(DMATX(I,N) I = 1,16) FORMAT (8F10.0)	will then follow for each process which will be given new process design criteria

For repeated design cases which use the same flow diagram as the original design case, a termination card is not used. For each additional repeated design case, the sequence of input cards M+1, M+2, M+3 etc. is repeated.

Table 5 (continued)

STREAM CHARACTERISTICS

VOLUME FLOW, MILLIONS OF GALLONS PER DAY
CONCENTRATIONS, MILLIGRAMS PER LITER

S 1.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	10.000	105.000	30.000	10.000	2.000	30.000	140.000	224.000	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	250.000	43.000	11.000	19.000	4.000	500.000	60.000	254.000	.000
S 2.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	10.000	105.000	30.000	10.000	2.000	30.000	140.000	224.000	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	250.000	43.000	11.000	19.000	4.000	500.000	60.000	254.000	.000
S 3.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	10.000	105.000	30.000	10.000	2.000	30.000	140.000	224.000	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	250.000	43.000	11.000	19.000	4.000	500.000	60.000	254.000	.000
S 4.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	12.264	96.539	31.693	9.340	1.787	31.491	121.098	208.103	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	38.117	11.000	23.530	5.079	500.000	50.839	239.594	.000
S 5.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	12.249	48.330	15.866	4.676	.895	15.765	60.625	104.182	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	38.117	11.000	23.530	5.079	500.000	50.839	119.947	.000
S 6.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	11.983	6.044	1.832	.712	.060	1.725	7.986	14.386	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	13.651	11.000	21.697	5.422	500.000	4.958	16.110	.000
S 7.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.015	38615.554	12677.282	3736.050	714.860	12596.289	48439.362	83241.124	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	38.117	11.000	23.530	5.079	500.000	50.839	95837.414	.000

Table 6 Sample output of stream characteristics

S 8.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.265	2276.345	689.802	268.169	22.763	649.528	3007.512	5417.702	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	13.651	11.000	21.697	5.422	500.000	4.958	6067.230	.000
S 9.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.281	4260.209	1344.234	457.491	60.547	1301.736	5487.770	9666.310	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	14.987	11.000	21.798	5.403	500.000	7.463	10968.046	.000
S10.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.059	19414.194	6123.395	2086.842	275.106	5928.239	25014.690	44071.760	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	13.817	11.000	21.710	5.419	500.000	5.268	50000.000	.000
S11.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.059	6468.503	6123.395	708.346	93.380	5928.239	645.353	15395.037	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	3466.444	126.036	11.000	917.732	187.145	500.000	215.118	21323.276	.000
S12.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.020	15167.705	14358.475	1660.970	218.964	13900.863	1513.259	36099.137	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	3466.444	126.036	11.000	917.732	187.145	500.000	215.118	50000.000	.000
S13.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.020	15167.705	14358.475	1660.970	218.964	19725.863	1513.259	36099.137	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	3466.444	126.036	11.000	917.732	187.145	500.000	215.118	55825.000	.000
S14.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.004	78186.274	74014.870	8561.944	1128.710	101682.606	7800.527	186083.332	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	17868.779	649.689	56.703	4730.712	964.690	2577.393	1108.885	287765.941	.000
S15.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.000	.000	.000	.000	.000	.000	.000	.000	.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	.000	.000	.000	.000	.000	.000	.000	.000	.000

Table 6 (continued)

S19.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	2.264	59.171	39.171	6.426	.847	38.074	37.621	137.894	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	345.575	16.551	11.000	43.539	9.846	500.000	10.381	175.969	.000
S20.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	2.209	27.349	8.626	2.940	.388	8.351	35.238	62.084	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	13.817	11.000	21.710	5.419	500.000	5.268	70.435	.000
S21.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.039	1877.612	1777.438	205.612	27.106	1720.790	187.327	4468.718	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	3466.444	126.036	11.000	917.732	187.145	500.000	215.118	6189.508	.000
S22.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	2.248	59.206	39.081	6.429	.848	37.836	37.857	137.957	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	322.722	15.749	11.000	37.137	8.548	500.000	8.882	175.793	.000
S23.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	.016	54.340	51.441	5.951	.784	70.670	5.421	129.330	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	3466.444	126.036	11.000	917.732	187.145	500.000	215.118	200.000	.000
S24.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	1.987	6.044	1.832	.712	.060	1.725	7.986	14.386	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	13.651	11.000	21.697	5.422	500.000	4.958	16.110	.000
S25.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	9.996	6.044	1.832	.712	.060	1.725	7.986	14.386	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	13.651	11.000	21.697	5.422	500.000	4.958	16.110	.000
S26.	Q	SOC	SNBC	SON	SOP	SFM	SBOD	VSS	NH3
	9.996	6.044	1.832	.712	.060	1.725	7.986	14.386	15.000
	ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	NO3
	267.645	13.651	11.000	21.697	5.422	500.000	4.958	16.110	.000

Table 6 (continued)

PROCESS CHARACTERISTICS

CCOST = CAPITAL COST, DOLLARS
COSTO = OPERATING + MAINTENANCE COST, CENTS/1000 GAL.
ACOST = AMORTIZATION COST, CENTS/1000 GAL.
TCOST = TOTAL TREATMENT COST, CENTS/1000 GAL.

P 1 RAW WASTEWATER PUMPING

HEAD	QP	CCOST	COSTO	ACOST	TCOST	ECF
30.00	14.81	710223.	.520	1.522	2.042	1.00

P 2 PRELIMINARY TREATMENT

IPREL	CCOST	COSTO	ACOST	TCOST	ECF
1.0	216086.	.569	.463	1.032	1.00

P 3 PRIMARY SEDIMENTATION

FRPS	URPS	HPWK	GPS	APS	PGPM
.50	400.0	14.0	1375.2	10.701	128.

	CCOST	COSTO	ACOST	TCOST	ECF
SETTLER	312019.	.276	.669	.945	1.20
SLUDGE PUMPS	95348.	.308	.204	.512	1.00

P 4 ACTIVATED SLUDGE-FINAL SETTLER

BOD	MLSS	DEGC	CAER20	DO	AEFF20	URSS	GSS	HEAD	ALMD
13.0	2000.	20.00	1.00	1.00	.05	3.00	700.00	30.00	.00
BOD2	**DOSAT**	**XRSS**	**AFS**	**CAER**	**CEDR**	**VAER**	**VNIT**	**MLASS**	**MLBSS**
111.5	10.8	.0080	20.54	1.00	.125	2.319	3.648	248.	1041.
MLNBSS	**MLDSS**	**MLISS**	**FOOD**	**RTURN**	**CNIT**	**ARCFD**	**BSIZE**	**CFPGL**	**QR**
464.	30.	217.	45.9	.464	.321	4153202.	2884.	.34	5.679

	CCOST	COSTO	ACOST	TCOST	ECF
AERATOR	600279.	.000	1.287	1.287	1.20
BLOWER	254571.	.951	.546	1.497	1.00
SLUDGE PUMPS	160196.	.349	.343	.693	1.00
FINAL SETTLER	506368.	.422	1.085	1.507	1.20

Table 7 Sample output of process characteristics

P 5	GRAVITY THICKENING	TRR	TSS	GTH	GSTH	ATHM	WRT				
		.95	50000.	700.0	8.0	4860.5	7.08				
							CCOST	COSTO	ACOST	TCOST	ECF
							185807.	.153	.398	.551	1.50
P 6	SINGLE STAGE ANAEROBIC DIGESTION	TD	TDIG	C1DIG	C2DIG	VDIG	CH4	CO2			
		15.0	30.0	.234	1154.	154.143	124331.	65296.			
							CCOST	COSTO	ACOST	TCOST	ECF
							624828.	.410	1.339	1.749	1.30
P 7	SECOND STAGE ANAEROBIC DIGESTION	TRR	TSS	TD	VDIG		CCOST	COSTO	ACOST	TCOST	ECF
		.81	50000.	15.0	118.571		521959.	.410	1.119	1.529	1.00
P 8	SLUDGE HOLDING TANKS	TD	VSHT				CCOST	COSTO	ACOST	TCOST	ECF
		15.0	41.0				188161.	.272	.403	.675	1.00
P 9	VACUUM FILTRATION	VFL	HPWK	TSS	IVACF	FECL3	CAO	CFECL	CCAO	DPOLY	CPOLY
		4.90	35.	200.	1.0	42.00	176.00	.0640	.0125	15.00	.3300
		WP	AVF	PSDD			CCOST	COSTO	ACOST	TCOST	ECF
		71.2	671.1	9498.			960780.	1.384	2.059	3.443	1.00
P10	MULTIPLE HEARTH INCINERATION	ML	NINC	HPWK	SPER	WV	HV	TYPE	FC	CNG	
		2.0	1.0	35.0	5.0	.0	10000.0	1.0	.300	.970	
		FHA	WFYR	PSDD	ECOST	FCOST					
		988.	290968.	9505.	1637.	11668.					
							CCOST	COSTO	ACOST	TCOST	ECF
							773168.	.935	1.657	2.592	1.00
P11	CHLORINATION-DECHLORINATION	DCL2	TCL2	CCL2	DS02	CS02	BVOL	CUSE	SUSE		
		8.00	30.0	220.00	2.50	180.00	41762.	121.57	37.99		
							CCOST	COSTO	ACOST	TCOST	ECF
						CONTACT BASIN	129678.	.000	.278	.278	1.50

Table 7 (continued)

		CL2 FEED SYSTEM	106436.	.983	.228	1.211	1.20
		SO2 FEED SYSTEM	33261.	.266	.071	.337	1.20
			CCOST	COSTO	ACOST	TCOST	
ADMINISTRATIVE AND LABORATORY			221023.	.572	.474	1.045	
			CCOST	COSTO	ACOST	TCOST	
GARAGE AND SHOP			65407.	.000	.140	.140	
	XLAB		CCOST	COSTO	ACOST	TCOST	
LABORATORY OPERATION	1.0		0.	.646	.000	.646	
			CCOST	COSTO	ACOST	TCOST	
YARDWORK OPERATION			0.	.354	.000	.354	

Table 7 (continued)

TOTAL PLANT COST

TOTAL CAPITAL COST =	6665598.	DOLLARS	TOT
TOTAL AMORTIZATION COST =	14.286	CENTS/1000 GALLONS	TAMM
TOTAL O + M COST =	9.778	CENTS/1000 GALLONS	TOPER
TOTAL TREATMENT COST =	24.064	CENTS/1000 GALLONS	TOTAL

CCI	WPI	RI	YRS	DHR	PCT	DA	CCINT	XLAB	CKWH
2.257	1.675	.060	25.0	4.73	.150	1000.	.06	1.00	.020

RATIO	TCAP	YARD	TCC	XLAND	ENG	SUBT1	FISC	SUBT2	XINT
1.331	5008960.	701254.	5710214.	19977.	470179.	6200370.	39740.	6240110.	425488.

ACRE	AF
19.98	.07823

Table 8 Output showing total plant cost

ENERGY CONSUMPTION AND COST

10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00	10.00
10.00											
15.00	1.00	2.00	3.00	8.00	6.00	21.00	16.00	7.00	14.00	12.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
25.00											
1450.31	66.37	107.30	5875.37	20.42	453.30	453.30	.00	352.17	245.25	.72	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
210.23											
9234.74											

Table 9 Output showing energy consumption and cost

through 9 for the example wastewater treatment system. For a particular design case, the first group of output shows the title of system and the process cards which describe the simulated wastewater treatment system (see Table 3). The second group of output data (Table 6) shows the volume flow and concentrations of the 17 contaminants in each numbered stream. The stream is identified by the letter S followed by the number in the left-hand column of the printout. For example, stream number 3 is identified by S3. The third part of the output (Table 7) lists the unit processes according to process number and gives the name of the process with all pertinent input and output parameters and cost data relating to the process. The process is identified by the letter P followed by the process number in the left hand column of the printout. For example, process number 3 identified by P3. The fourth set of printout (Table 8) gives the total costs for the entire plant and general items relating to the cost calculations. The fifth and final part of the printout (Table 9) gives the energy requirements of the unit processes used. The electrical power, natural gas, fuel oil, gasoline, etc., required for operation of the plant are converted to British Thermal Units (BTU). This conversion provides an easy means to compare total energy use for alternate treatment systems.

A flow chart of EXECMAIN is shown in Figure 2. The chart shows the major branches and loops in the program.

Discussion of individual process subroutines used in conjunction with EXECMAIN is found in the following sections.

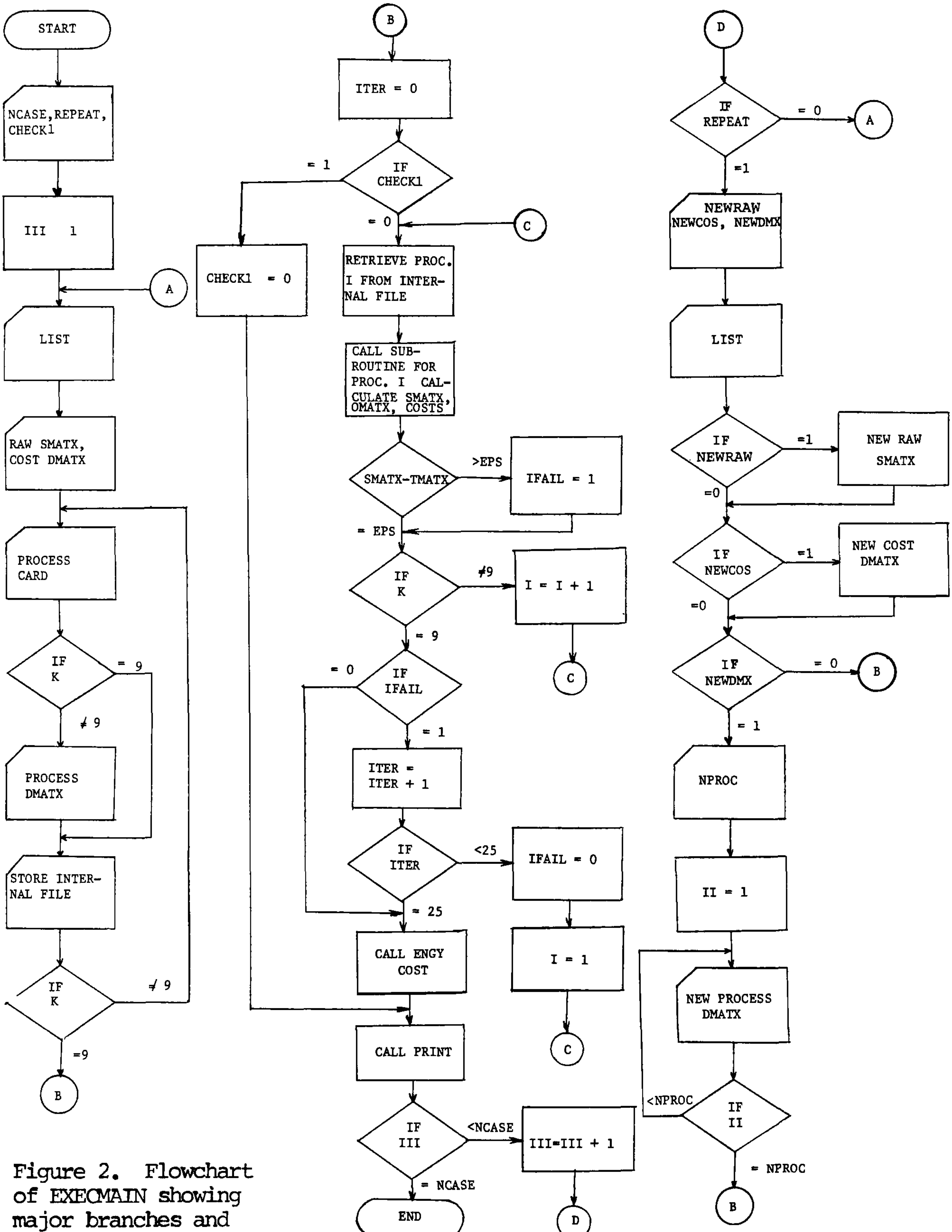


Figure 2. Flowchart of EXECMAIN showing major branches and iterations.

```
C           EXECMAIN
C           EXECUTIVE PROGRAM FOR DESIGN OF WASTEWATER TREATMENT PLANT
C           RICHARD G. EILERS, ROBERT SMITH AND ILLINOIS INSTITUTE
C           OF TECHNOLOGY, ENVIRONMENTAL ENGINEERING DEPARTMENT
C           AUG. 1977
C
C
C           COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2,REPEAT,CHECK1,PROCNO
      DIMENSION NAME(3),LIST(40)
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,PROCNO(10),FLOW(25),POW(25),T
     3KWHD(25)
C
C
C           DEFINE AN INTERNAL FILE FOR TEMPORARY STORAGE OF PROCESS
C           DATA USED LATER IN THE EXECMAIN
C
      DEFINE FILE 2(50,15,U,NNNNN)
C
C
C           ASSIGNMENT OF NUMBERS REPRESENTATIVE OF THE USERS INPUT,
C           INP, AND OUTPUT, IO, DEVICES
C
      INP=5
      IO=6
C
C
C           INPUT   FIRST DATA CARD
C
      READ (INP,10) NCASE,REPEAT,CHECK1
   10 FORMAT (3I2)
C
C
C           MAJOR LOOP FOR EACH DESIGN CASE
C
      DO 770 III=1,NCASE
      IF (III.EQ.1) GO TO 20
      IF (REPEAT.EQ.0) GO TO 20
C
C
C           INPUT   REPEATED DESIGN CASES ONLY - REPEATED FLOW
C           DIAGRAM WITH NEW VALUES FOR RAW SEWAGE STREAM, COST
C           PARAMETERS AND/OR DESIGN MATRIX VALUES
C
      READ (INP,10) NEWRAW,NEWCOS,NEWDMX
      GO TO 50
   20 CONTINUE
C
C
C           INITIAL ZEROING OF ARRAYS - NOT NECESSARY IN SUBSEQUENT
C           DESIGN CASES WHICH USE SAME FLOW DIAGRAM
C
      DO 30 I=1,20
      DO 30 J=1,30
      SMATX(I,J)=0.
```

```
   30 CONTINUE
      DO 40 I=1,20
      IP(I)=0
      DO 40 J=1,20
      DMATX(I,J)=0.
   40 CONTINUE
C
C
C             INITIAL ZEROING OF ARRAYS
C
   50 CONTINUE
      DO 60 I=1,25
      FLOW(I)=0.
      POW(I)=0.
      TKWHD(I)=0.
   60 CONTINUE
      DO 70 I=1,20
      DO 70 J=1,30
      TMATX(I,J)=0.
   70 CONTINUE
      DO 80 I=1,20
      DO 80 J=1,20
      OMATX(I,J)=0.
   80 CONTINUE
      DO 90 I=1,20
      DO 90 J=1,5
      CCOST(I,J)=0.
      COSTO(I,J)=0.
      ACOST(I,J)=0.
      TCOST(I,J)=0.
   90 CONTINUE
      IAERF=0
      CLAND=0.
      DLAND=0.
      EPS=.1
C
C
C             INPUT   NEW AND REPEATED DESIGN CASES
C
      READ (INP,100) LIST
  100 FORMAT (40A2)
      WRITE (IO,110)
  110 FORMAT (1H1,//,55X,'EXECUTIVE',/,47X,'DIGITAL COMPUTER PROGRAM',/,
     158X,'FOR',/,34X,'PRELIMINARY DESIGN OF WASTEWATER TREATMENT SYSTEM
     2S',//,58X,'BY',/,53X,'ROBERT SMITH',/,51X,'RICHARD G. EILERS',/)
      WRITE (IO,120)
  120 FORMAT (41X,'U.S. ENVIRONMENTAL PROTECTION AGENCY',/,39X,'MUNICIPA
     1L ENVIRONMENTAL RESEARCH CENTER',/,45X,'WASTEWATER RESEARCH DIVISI
     2ON',/,40X,'TECHNOLOGY DEVELOPMENT SUPPORT BRANCH',/,40X,'SYSTEMS A
     3ND ECONOMIC ANALYSIS SECTION',/,47X,'CINCINNATI, OHIO   45268',//,
     452X,'(513) 684-7618',/////)
      WRITE (IO,130) III
  130 FORMAT (/,20X,'DESIGN CASE NO.',I2,//)
      WRITE (IO,140) LIST
  140 FORMAT (20X,40A2,//,52X,'SYSTEM DIAGRAM',/,54X,'INPUT DATA',//,28X
     1,'K',5X,'N',5X,'PROCESS',9X,'IS1',7X,'IS2',7X,'OS1',7X,'OS2',/)
      IF (III.EQ.1) GO TO 150
      IF (REPEAT.EQ.1.AND.NEWRAW.EQ.0) GO TO 160
  150 CONTINUE
C
C
C             INPUT   NEW AND SOME REPEATED DESIGN CASES
C
      READ (INP,180) (SMATX(I,1),I=2,20)
  160 CONTINUE
      IF (III.EQ.1) GO TO 170
```

```
      IF (REPEAT.EQ.1.AND.NEWCOS.EQ.0) GO TO 190
  170 CONTINUE
C
C
C               INPUT   NEW AND SOME REPEATED DESIGN CASES
C
      READ (INP,180) (DMATX(I,20),I=1,16)
  180 FORMAT (8F10.0)
  190 CONTINUE
      WPI=DMATX(2,20)/1.122
      DHR=DMATX(5,20)
      PCT=DMATX(6,20)
      IF (III.EQ.1) GO TO 230
      IF (REPEAT.EQ.0) GO TO 230
      WRITE (IO,200)
  200 FORMAT (/////,40X,'PROCESS AND STREAM NUMBERING SAME AS DESIGN CAS
     1E NO. 1')
      IF (NEWDMX.EQ.0) GO TO 340
C
C
C               INPUT   SOME REPEATED DESIGN CASES ONLY - NOT FOR NEW
C               CASES
C
      READ (INP,210) NPROC,(PROCNO(II),II=1,NPROC)
  210 FORMAT (10I2)
      DO 220 II=1,NPROC
      N=PROCNO(II)
C
C
C               INPUT   SOME REPEATED DESIGN CASES ONLY - NOT FOR NEW
C               CASES
C
      READ (INP,180) (DMATX(I,N),I=1,16)
  220 CONTINUE
      GO TO 340
  230 CONTINUE
C
C
C               BEGINNING OF LOOP DOWN TO STATEMENT 340 WHICH WILL
C               ASSIGN VALUES TO EACH PROCESS, INFLUENT STREAM AND
C               EFFLUENT STREAM IN THE FLOW DIAGRAM - IF SAME FLOW
C               DIAGRAM IS USED, THIS SECTION IS SKIPPED
C
      KKK=1
  240 READ (INP,250) K,N,IPROC,(NAME(I),I=1,3),IS1,IS2,OS1,OS2
  250 FORMAT (I1,1X,I2,2X,I2,1X,3A2,4X,I2,8X,I2,8X,I2,8X,I2)
      WRITE (IO,260) K,N,IPROC,(NAME(I),I=1,3),IS1,IS2,OS1,OS2
  260 FORMAT (28X,I1,4X,I2,4X,I2,2X,3A2,7X,I2,8X,I2,8X,I2,8X,I2)
      IF (K-9) 270,330,330
  270 SMATX(1,IS1)=IS1
      SMATX(1,OS1)=OS1
      IF (IS2) 290,290,280
  280 SMATX(1,IS2)=IS2
  290 IF (OS2) 310,310,300
  300 SMATX(1,OS2)=OS2
  310 IF (N) 330,330,320
  320 IP(N)=IPROC
      READ (INP,180) (DMATX(I,N),I=1,16)
C
C
C               WRITING PROCESS AND STREAM NUMBERS ONTO THE INTERNAL
C               FILE WHICH WAS DEFINED ABOVE
C
  330 WRITE (2'KKK) K,N,IPROC,IS1,IS2,OS1,OS2
      KKK=KKK+1
      IF (K-9) 240,350,350
```

```
  340 CONTINUE
  350 ITER=0
C
C
C           BEGINNING OF ITERATIVE LOOP IN WHICH THE STREAM
C           PARAMETERS ARE REEVALUATED TO REFLECT THE EFFECT OF
C           POSSIBLE RECYCLE STREAMS BACK TO THE BEGINNING SECTIONS
C           OF THE PLANT
C
  360 ITER=ITER+1
      IF (ITER.NE.1) GO TO 370
C
C
C           INITIAL VALUES OF ALL PROCESSES AND STREAMS WILL BE
C           PRINTED IF CHECK1 IS EQUAL TO 1 - TROUBLESHOOTING AID
C           IF PROGRAM EXECUTION IS INTERRUPTED
C
      IF (CHECK1.EQ.0) GO TO 370
      CHECK1=0
      CALL PRINT
  370 CONTINUE
      KKK=1
      IFAIL=0
      IF (ITER-25) 400,400,380
  380 WRITE (10,390)
  390 FORMAT (/////,10X,'EXECUTIVE ITERATION DOES NOT CONVERGE',/,10X,'P
     1RINTOUT IS FOR THE LAST ITERATION')
      GO TO 760
C
C
C           READING THE PROCESS AND STREAM NUMBERS STORED IN THE
C           TEMPORARY INTERNAL FILE
C
  400 READ (2'KKK) K,N,IPROC,IS1,IS2,OS1,OS2
      KKK=KKK+1
C
C
C           AFTER ALL PROCESSES HAVE BEEN CALCULATED FOR THE FIRST
C           ITERATION AND THE NEXT PROCESS DATA TO BE READ FROM
C           THE INTERNAL FILE IS THE ONE WITH THE LONE VALUE OF
C           K=9 IN COL. 1., IFAIL WILL BE EQUAL TO 1 AND STATEMENT
C           410 WILL BE EXECUTED
C
      IF (K-9) 420,410,410
C
C
C           WHEN IFAIL=1, CONTROL WILL SHIFT TO STATEMENT 360 WHICH
C           LEADS TO THE INCREMENTATION OF ITER AND RESETTING
C           IFAIL=0 - A SECOND, THIRD, FOURTH,...NTH... ITERATION
C           WHERE ALL THE PROCESSES WILL BE CALCULATED WILL FOLLOW
C           - EVENTUALLY TWO COMPLETE ITERATIONS WOULD BE CALCULATED
C           WITHOUT IFAIL BEING SET EQUAL TO 1 BY STATEMENT 710 -
C           CONTROL WILL THEN SHIFT TO STATEMENT 760 FOR THE
C           BEGINNING OF A NORMAL TERMINATION OF THE DESIGN CASE
C
  410 IF (IFAIL) 760,760,360
  420 GO TO (430,440,450,460,470,480,490,500,510,520,530,540,550,560,570
     1,580,590,600,610,620,630,640,650,660), IPROC
  430 CALL PREL
      GO TO 670
  440 CALL PRSET
      GO TO 670
  450 CALL AERFS
C
C
C           IF THE REQUIRED MLASS, BOD5 OR MLSS CAN NOT BE ATTAINED
```

```
C               IN THE AERFS SUBROUTINE, IAERF WILL BE RETURNED FROM
C               AERFS WITH A VALUE OF 1 (ONE) - THIS TRANSFER CONTROL
C               TO STATEMENT 760 WHICH WILL TERMINATE THE DESIGN CASE
C
      IF (IAERF) 670,670,760
  460 CALL MIX
      GO TO 670
  470 CALL SPLIT
      GO TO 670
  480 CALL DIG
      GO TO 670
  490 CALL VACF
      GO TO 670
  500 CALL THICK
      GO TO 670
  510 CALL ELUT
      GO TO 670
  520 CALL SBEDS
      GO TO 670
  530 CALL TRFS
      GO TO 670
  540 CALL CHLOR
      GO TO 670
  550 CALL TFLOT
      GO TO 670
  560 CALL MHINC
      GO TO 670
  570 CALL RWP
      GO TO 670
  580 CALL SHT
      GO TO 670
  590 CALL CENT
      GO TO 670
  600 CALL AEROB
      GO TO 670
  610 CALL POSTA
      GO TO 670
  620 CALL EQUAL
      GO TO 670
  630 CALL DIG2
      GO TO 670
  640 CALL LANDD
      GO TO 670
  650 CALL LIME
      GO TO 670
  660 CALL RBC
C
C
C               CHECK IF DIFFERENCE BETWEEN LATEST STREAM VALUES,
C               SMATX(I,OS1), AND PREVIOUS STREAM VALUES, TMATX(I,OS1),
C               IS LESS THAN THE ALLOABLE ERROR, EPS, IN MG/L - IF NOT,
C               SET THE ITERATION ERROR TEST PARAMETER IFAIL=1 AND
C               CONTINUE THE ITERATIVE EFFORT TO REFINE THE STREAM
C               PARAMETER VALUES - IF LESS THAN OR EQUAL TO ALLOWABLE
C               ERROR, CHECK THE STREAM PARAMETERS FOR OS2
C
  670 DO 680 I=2,20
      IF (ABS(SMATX(I,OS1)-TMATX(I,OS1))-EPS) 680,680,710
  680 CONTINUE
      IF (OS2) 720,720,690
C
C
C               CHECK PARAMETERS FOR OS2 - IF GREATER THAN ALLOWABLE
C               ERROR, SET THE ITERATION ERROR TEST PARAMETER IFAIL=1
C               AND CONTINUE THE ITERATIVE EFFORT TO REFINE THE STREAM
C               PARAMETER VALUES - IF LESS THAN OR EQUAL TO ALLOWABLE
```

```
C             ERROR, REPLACE THE PREVIOUS STREAM VALUES, TMATX, WITH    EXE32300
C             THE LATEST STREAM VALUES, SMATX                           EXE32400
C                                                                       EXE32500
  690 DO 700 I=2,20                                                     EXE32600
      IF (ABS(SMATX(I,OS2)-TMATX(I,OS2))-EPS) 700,700,710               EXE32700
  700 CONTINUE                                                          EXE32800
      GO TO 720                                                         EXE32900
  710 IFAIL=1                                                           EXE33000
  720 DO 730 I=1,20                                                     EXE33100
      TMATX(I,OS1)=SMATX(I,OS1)                                         EXE33200
  730 CONTINUE                                                          EXE33300
      IF (OS2) 400,400,740                                              EXE33400
  740 DO 750 I=1,20                                                     EXE33500
      TMATX(I,OS2)=SMATX(I,OS2)                                         EXE33600
  750 CONTINUE                                                          EXE33700
      GO TO 400                                                         EXE33800
  760 CALL ENGY                                                         EXE33900
      CALL COST                                                         EXE34000
      CALL PRINT                                                        EXE34100
  770 CONTINUE                                                          EXE34200
      END                                                               EXE34300
```

SECTION 2

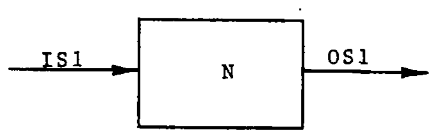
PRELIMINARY TREATMENT, PREL

Subroutine Identification Number 1

Preliminary Treatment, PREL

Rev. Date 8/1/77

1. Process symbol.



IS1: Liquid input stream

OS1: Liquid output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = IPREL	Program control number: 0 = grit removal and flow measurement; 1 = grit removal and flow measurement and screening. [1.]
DMATX(16,N) = ECF	Excess capacity factor for the process.

3. Output parameters which are printed on computer output sheets.

IPREL = DMATX(1,N)

CCOST = Capital cost,(dollars).

COSTO = Operating and maintenance cost,(cents/1000 gal).

ACOST = Amortization cost,(cents/1000 gal).

TCOST = Total treatment cost ,(cents/1000 gal) .

ECF = Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

SMATX(I,OS1) = SMATX(I,IS1) PRE02400

SMATX(I,OS1) = SMATX(I,IS1) [mg/l]

I = 2,20 Q,SOC,SNBC,SON,SOP,SFM,SBOD,VSS,TSS,DOC,DNBC,DN,DP,DFM,ALK,DBOD,NH3,NO3

IPREL = DMATX(1,N) PRE01800

IPREL = DMATX(1,N)

References: Smith, 1969

Patterson and Banker, 1971

5. Cost functions.

a. Capital cost

Function of Q_{IS1}*ECF

X = ALOG(SMATX(2,IS1)*DMATX(16,N)) PRE03000

$X = \ln(Q_{IS1}*ECF)$

(1) For preliminary treatment consisting of grit removal and flow measurement

CCOST(N,1) = EXP(2.566569+.619151*X)*1000. PRE03700

$CCOST = 1000e^{2.566569+0.619151X}$ [dollars]

(2) For preliminary treatment consisting of grit removal, flow measurement and screening

CCOST(N,1) EXP(3.259716 +.619151*X)*1000. PRE04500

$CCOST = 1000e^{3.259716+.619151*X}$ [dollars]

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of Q_{IS1}

X = ALOG(SMATX(2,IS1)) PRE05100

$X = \ln(Q_{IS1})$

(1) Operating manhours

OHRS = EXP(6.398716+.230956*X+.164959*X**2.-.014601*X**3.) PRE05700

$OHRS = e^{6.398716+.230956*X+.164959*X^2-.014601*X^3}$ [hrs/yr]

(2) Maintenance manhours

XMHRS = EXP(5.846098+.206513*X+.068842*X**2+.023824*X**3.-.004410*X**4.) PRE05800

$XMHRS = e^{5.846098+.206513*X+.068842*X^2+.023824*X^3-.004410*X^4}$ [hrs/yr]

(3) Total materials and supplies

```
TMSU = EXP(7.235657+.399935*X-.224979*X**2.+.110099*X**3.-.011026*X**4.) PRE06000
```

$$TMSU = e^{7.235657+.399935*X-.224979*X^2+.110099*X^3-.011026*X^4} \quad [\$/yr]$$

c. Total operating and maintenance costs

```
COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.          PRE06600
```

$$COSTO = \frac{(OHRS+XMHRS)*DHR*(1+PCT)+TMSU*WPI}{Q_{Plant\ Inf.}*3650} \quad [cents/1000\ gal]$$

Cost curves, Patterson and Banker pages 35,36,85,86

```
C
C          PRELIMINARY TREATMENT
C          PROCESS IDENTIFICATION NUMBER   1
C
      SUBROUTINE PREL
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C          ASSIGNMENT OF DESIGN VALUES TO PROCESS PARAMETERS
C
      IPREL=DMATX(1,N)
C
C
C          EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=2,20
   10 SMATX(I,OS1)=SMATX(I,IS1)
C
C
C          CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C          CAPACITY
C
      X=ALOG(SMATX(2,IS1)*DMATX(16,N))
      IF (IPREL) 30,20,30
C
C
C                CALC. OF CAPITAL COSTS FOR PRELIMINARY FACILITY
C                CONSISTING OF GRIT REMOVAL AND FLOW MEASUREMENT
C
   20 CCOST(N,1)=EXP(2.566569+.619151*X)*1000.
      GO TO 40
C
C
C                CALC. OF CAPITAL COSTS FOR PRELIMINARY FACILITY
C                CONSISTING OF GRIT REMOVAL AND FLOW MEASUREMENT AND
C                SCREENING
C
   30 CCOST(N,1)=EXP(3.259716+.619151*X)*1000.
C
C
C          CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C          DOES NOT INCLUDE EXCESS CAPACITY
C
   40 X=ALOG(SMATX(2,IS1))
C
C
C                CALC.OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(6.398716+.230956*X+.164959*X**2.-.014601*X**3.)
      XMHRS=EXP(5.846098+.206513*X+.068842*X**2.+.023824*X**3.-.004410*X
```

```
     1**4.)                                                            PRE05900
      TMSU=EXP(7.235657+.399935*X-.224979*X**2.+.110099*X**3.-.011026*X*PRE06000
     1*4.)                                                             PRE06100
C                                                                      PRE06200
C                                                                      PRE06300
C                   OPERATING COST EQUATION                            PRE06400
C                                                                      PRE06500
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650. PRE06600
C                                                                      PRE06700
C                                                                      PRE06800
C              PROCESS ENERGY INDICES                                  PRE06900
C                                                                      PRE07000
      FLOW(N)=SMATX(2,IS1)                                             PRE07100
      POW(N)=1.                                                        PRE07200
      RETURN                                                           PRE07300
      END                                                              PRE07400
```

SECTION 3

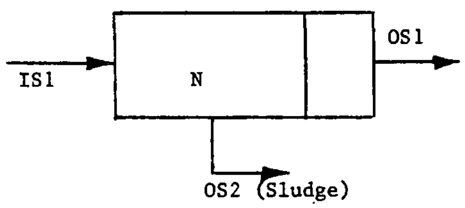
PRIMARY SEDIMENTATION, PRSET

Subroutine Identification Number 2

Primary Sedimentation, PRSET

Rev. Date 8/1/77

1. Process symbol.



IS1: Liquid input stream

OS1: Liquid output stream

OS2: Sludge output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = FRPS	Fraction of solids entering the primary settler which is removed from the main stream and sent on to the sludge handling process, fraction. [.5]
DMATX(2,N) = URPS	Ratio of solids concentration in OS2 from the primary settler to the solids concentration in IS1 to the primary settler. [400.]
DMATX(3,N) = HPWK	Hours per week that the primary sludge pumps are operated, hr/wk. [14.]
DMATX(15,N) = ECF	Excess capacity factor for primary sludge pumps. [1.]
DMATX(16,N) = ECF	Excess capacity factor for primary settler basin. [1.2]

3. Output Parameters which are printed on computer output sheets.

FRPS = DMATX(1,N)	
URPS = DMATX(2,N)	
HPWK = DMATX(3,N)	
GPS = OMATX(1,N)	Overflow rate for the primary settler, [gpd/sq/ft].
APS = OMATX(2,N)	Surface area of the primary settler, [sq ft/1000].
PGPM = OMATX(3,N)	Firm pumping capacity of the primary sludge pumps, [gpm].
CCOST	Capital cost, [dollars] .
COSTO	Operating and maintenance costs, [cents/1000 gal].
ACOST	Amortization cost, [cents/1000 gal].
TCOST	Total treatment cost, [cents/1000 gal].
ECF	Excess capacity factor.

4. Theory and function - FORTRAN statement followed by equivalent algebraic equation.

HPWK = DMATX(3,N) PRS01800

HPWK = DMATX(3,N) [hr/wk]

SMATX(2,OS2) = DMATX(1,N)*SMATX(2,IS1)/DMATX(2,N) PRS02400

$$Q_{OS2} = \frac{FRPS*Q_{IS1}}{URPS} \quad [MGD]$$

SMATX(2,OS1) = SMATX(2,IS1)-SMATX(2,OS2) PRS02500

$$Q_{OS1} = Q_{IS1} - Q_{OS2} \quad [MGD]$$

TEMP1 = (1.-DMATX(1,N))*SMATX(2,IS1)/SMATX(2,OS1) PRS02600

$$TEMP1 = \frac{(1.0-FRPS)*Q_{IS1}}{Q_{OS1}} \quad [no\ units]$$

TEMP2 = DMATX(1,N)*SMATX(2,IS1)/SMATX(2,OS2) PRS02700

$$TEMP2 = \frac{FRPS*Q_{IS1}}{Q_{OS2}} \quad [no\ units]$$

SMATX(I,OS1) = TEMP1*SMATX(I,IS1) PRS03300

SMATX(I,OS1) = TEMP1*SMATX(I,IS1) [mg/l]

where I = 3,10 i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS,TSS

SMATX(I,OS2) = TEMP2*SMATX(I,IS1) PRS03400

SMATX(I,OS2) = TEMP2*SMATX(I,IS1) [mg/l]

where I = 3,10

SMATX(I,OS2) = SMATX(I,IS1) PRS03600

SMATX(I,OS2) = SMATX(I,IS1) [mg/l]

where I = 11,20 i.e. DOC,DNBC,DN,DP,DFM,ALK,DBOD,NH3,NO3

SMATX(I,OS1) = SMATX(I,OS2) PRS03700

SMATX(I,OS1) = SMATX(I,OS2) [mg/l]

where I = 11,20

```
GPS = -2780.*ALOG(DMATX(1,N))-551.7                                  PRS04300
```

$$GPS = -(2780*\ln FRPS)-551.7 \quad [gpd/ft^2]$$

```
APS = SMATX(2,IS1) *1000./GPS*DMATX(16,N)                            PRS04400
```

$$APS = \frac{Q_{IS1}*1000ECF}{GPS} \quad [1000ft^2]$$

```
PGPM = SMATX(2,OS2)*116666.7/HPWK*DMATX(15,N)                        PRS04200
```

$$PGPM = \frac{Q_{OS2}*116666.7*ECF}{HPWK} \quad [gpm]$$

Reference: Smith, 1969

Smith and Eilers, 1975

Patterson and Banker, 1971

5. Cost Functions.

a. Settler

(1) Capital cost for the settler

Function of APS

```
X = ALOG(APS)                                                        PRS05000
```

$$X = \ln APS$$

```
CCOST(N,1) = EXP(3.716354+.389861*X+.084560*X**2.-.004718*X**3.)*1000. PRS05100
```

$$CCOST = 1000e^{3.716354+0.389861X+0.084560X^2-0.004718X^3} \quad [dollars]$$

(2) Operating manhours, maintenance manhours and materials/supplies costs

Function of APS/ECF

```
X = ALOG(APS/DMATX(16,N))                                            PRS05900
```

$$X = \ln \frac{APS}{ECF}$$

(a) Operating manhours

```
OHRS = EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)           PRS06500
```

$$OHRS = e^{5.846565+0.254813X+0.113703X^2-0.010942X^3} \quad [hrs/yr]$$

(b) Maintenance manhours

```
XMHRS = EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)    PRS06600
```

$$XMHRS = e^{5.273419+0.228329X+0.122646X^2-0.011672X^3} \quad [hrs/yr]$$

(c) Total materials and supplies

```
TMSU = EXP(5.669881+.750799*X)    PRS06700
```

$$TMSU = e^{5.669881+0.750799X} \quad [\$/yr]$$

(3) Total operating and maintenance costs

```
COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.  PRS07200
```

$$COSTO = \frac{[(OHRS+XMHRS)DHR(1+PCT)]+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650} \quad [cents/1000\ gal]$$

b. Sludge pumps

(1) Capital cost for sludge pumps

Function of PGPM

```
X = ALOG(PGPM)    PRS07800
```

$$X = \ln(PGPM)$$

```
CCOST(N,2) = EXP(2.237330+.207628*X+.026479*X**2.)*1000.    PRS07900
```

$$CCOST = 1000e^{2.237330+0.207628X+0.026479X^2} \quad [dollars]$$

(2) Operating manhours, maintenance manhours and materials/supplies costs

Function of PGPM/ECF

```
X = ALOG(PGPM/DMATX(15,N))    PRS08500
```

$$X = \ln\frac{PGPM}{ECF}$$

(a) Operating manhours

```
OHRS = EXP(4.945155+.419391*X)    PRS09100
```

$$OHRS = e^{4.945155+0.419391X} \quad [hrs/yr]$$

(b) Maintenance manhours

```
XMHRS = EXP(3.993365+.444966*X)    PRS09200
```

$$XMHRS = e^{3.993365+0.444966X} \quad [hrs/yr]$$

(c) Total materials and supplies

TMSU = EXP(4.433129+.642272*X) PRS09300

$$TMSU = e^{4.433129+0.642272X} \quad [\$/yr]$$

(3) Total operating and maintenance costs

COSTO(N,2) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650. PRS09800

$$COSTO = \frac{[(OHRS+XMHRS)DHR(1+PCT)](TMSU*WPI)}{Q_{Plant\ Inf.}*3650} \quad [cents/1000gal]$$

```
C
C          PRIMARY SEDIMENTATION
C          PROCESS IDENTIFICATION NUMBER   2
C
      SUBROUTINE PRSET
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C          ASSIGNMENT OF DESIGN VALUES TO PROCESS PARAMETERS
C
      HPWK=DMATX(3,N)
C
C
C          PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C          CHARACTERISTICS
C
      SMATX(2,OS2)=DMATX(1,N)*SMATX(2,IS1)/DMATX(2,N)
      SMATX(2,OS1)=SMATX(2,IS1)-SMATX(2,OS2)
      TEMP1=(1.-DMATX(1,N))*SMATX(2,IS1)/SMATX(2,OS1)
      TEMP2=DMATX(1,N)*SMATX(2,IS1)/SMATX(2,OS2)
C
C
C          EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=3,10
      SMATX(I,OS1)=TEMP1*SMATX(I,IS1)
   10 SMATX(I,OS2)=TEMP2*SMATX(I,IS1)
      DO 20 I=11,20
      SMATX(I,OS2)=SMATX(I,IS1)
   20 SMATX(I,OS1)=SMATX(I,OS2)
C
C
C          CALC. OF OUTPUT SIZES AND QUANTITIES
C
      PGPM=SMATX(2,OS2)*116666.7/HPWK*DMATX(15,N)
      GPS=-2780.*ALOG(DMATX(1,N))-551.7
      APS=SMATX(2,IS1)*1000./GPS*DMATX(16,N)
C
C
C          CALC. OF CAPITAL COSTS FOR PRIMARY SETTLER BASIN BASED
C          ON DESIGN PLUS EXCESS CAPACITY
C
      X=ALOG(APS)
      CCOST(N,1)=EXP(3.716354+.389861*X+.084560*X**2.-.004718*X**3.)*100
     10.
C
C
C          CALC. OF OPERATING COSTS FOR PRIMARY SETTLER BASIN BASED
C          ON DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS
C          CAPACITY
C
```

```
      X=ALOG(APS/DMATX(16,N))
C
C
C                 CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                 AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)
      XMHRS=EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)
      TMSU=EXP(5.669881+.750799*X)
C
C
C                 OPERATING COST EQUATION
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C             CALC. OF CAPITAL COSTS FOR SLUDGE PUMPS BASED ON DESIGN
C             PLUS EXCESS CAPACITY
C
      X=ALOG(PGPM)
      CCOST(N,2)=EXP(2.237330+.207628*X+.026479*X**2.)*1000.
C
C
C             CALC. OF OPERATING COSTS FOR SLUDGE PUMPS BASED ON
C             DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(PGPM/DMATX(15,N))
C
C
C                 CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                 AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(4.945155+.419391*X)
      XMHRS=EXP(3.993365+.444966*X)
      TMSU=EXP(4.433129+.642272*X)
C
C
C                 OPERATING COST EQUATION
C
      COSTO(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C             ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=GPS
      OMATX(2,N)=APS
      OMATX(3,N)=PGPM
C
C
C             PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=2.
      RETURN
      END
```

SECTION 4

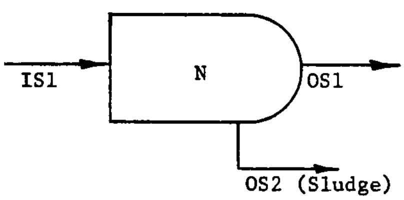
ACTIVATED SLUDGE - FINAL SETTLER, AERFS

Subroutine Identification Number 3

Rev. Date 8/1/77

Activated Sludge - Final Settler, AERFS

1. Process Symbol.



IS1: Liquid input stream

OS1: Liquid output stream

OS2: Sludge output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = BOD	Demand concentration of 5-day BOD in the final effluent from the aeration process, mg/l.[13.]
DMATX(2,N) = MLSS	Total concentration of suspended solids in the aerator, mg/l mass.[2000.]
DMATX(3,N) - DEGC	Water temperature, degrees Centigrade.[20.]
DMATX(4,N) = CAER20	Rate constant used for sizing the aerator when the water temperature is 20° C. 1/(hr gm/L)[1.]
DMATX(5,N) = DO	Concentration of dissolved oxygen in the aerator, mg/l oxygen.[1.]
DMATX(6,N) = AEFF20	Efficiency of the air diffusers in the aerator at zero dissolved oxygen and 20°C.[.05]
DMATX(7,N) = URSS	Ratio of solids concentration in OS2 (underflow stream) from the final settler to the total solids concentration in the aerator.[3.]
DMATX(8,N) = GSS	Design overflow rate for the final settler, gpd/sq ft.[700.]
DMATX(9,N) = HEAD	Pumping head for the sludge return pumps, ft.[30.]
DMATX(10,N) = ALMD	Dose of aluminum added to the aerator, mg/l aluminum.[0.]
DMATX(13,N) = ECF	Excess capacity factor for the final settler.[1.2]
DMATX(14,N) = ECF	Excess capacity factor for the sludge return pumps.[1.]
DMATX(15,N) = ECF	Excess capacity factor for the air blowers.[1.]
DMATX(16,N) = ECF	Excess capacity factor for the aeration tanks.[1.2]

3. Output parameters which are printed on computer output sheets.

BOD = DMATX(1,N)

MLSS = DMATX(2,N)

DEGC = DMATX(3,N)

CAER20 = DMATX(4,N)

DO = DMATX(5,N)

AEFF20 = DMATX(6,N)

URSS = DMATX(7,N)

GSS = DMATX(8,N)

HEAD = DMATX(9,N)

ALMD = DMATX(10,N)

BOD2 = OMATX(1,N)	Influent concentration of 5-day BOD to the aeration process, mg/l.
DOSAT = OMATX(2,N)	Saturation value for dissolved oxygen in the aerator at one-half the water depth, mg/l oxygen.
XRSS = OMATX(3.N)	Ratio of solids concentration of OS1 from the final settler to the total solids concentration in the aerator.
AFS = OMATX(4,N)	Surface area of the final settler, sq ft/1000.

CAER = OMATX(5,N)	Rate constant for sizing the aerator corrected for water temperature, (1/(hr gm/L)).
CEDR = OMATX(6,N)	Rate at which active solids are destroyed by natural causes in the aerator, fraction of mass per day.
VAER = OMATX(7,N)	Volume of the aerator, million gallons.
VNIT = OMATX(8,N)	Volume of the aerator required to achieve nitrification, million gallons.
MLASS = OMATX(9,N)	XMLAS, concentration of active solids held in the aerator, mg/l mass.
MLBSS = OMATX(10,N)	XMLBS, concentration of unmetabolized biodegradable solids held in the aerator, mg/l mass.
MLNBSS = OMATX(11,N)	XMLNB, concentration of non-biodegradable organic solids held in the aerator, mg/l mass.
MLDSS = OMATX(12,N)	XMLDS, concentration of non-biodegradable solids in the aerator caused by the destruction of active solids through natural causes, mg/l mass.
MLISS = OMATX(13,N)	XMLIS, concentration of inert inorganic solids in the aerator caused by inorganic solids in the influent stream, mg/l mass.
FOOD = OMATX(14,N)	Synthesis rate of 5-day BOD to active solids in the aerator each day, mg/l oxygen.
RTURN = OMATX(15,N)	Sludge return ratio for the aerator.
CNIT = OMATX(16,N)	Rate constant for nitrification. (1/day)
ARCFD = OMATX(17,N)	Diffused air requirement for the aerator, scf/day.

BSIZE = OMATX(18,N)	Required size of the blower for supplying to the aerator, cfm.
CFPGL = OMATX(19,N)	Diffused air requirements for the aerator, scf/gallon of sewage entering the system.
QR = OMATX(20,N)	Volume of the return sludge stream, mgd.
CCOST	Capital cost,[dollars].
COSTO	Operating and maintenance costs,[cents/1000gal].
ACOST	Amortization cost,[cents/1000gal].
TCOST	Total treatment cost,[cents/1000gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
BOD2 = SMATX(8,IS1)+SMATX(17,IS1)                                AEF02000
```

$$BOD2 = SBOD_{IS1}+DBOD_{IS1}$$ [mg/l]

```
DBOD2 = SMATX(17,IS1)                                            AEF02100
```

$$DBOD2 = DBOD_{IS1}$$ [mg/l]

```
CEDR = .18*1.047**(DMATX(3,N)-28.)                               AEF02200
```

$$CEDR = 0.18(1.047)^{DEGC-28}$$ $\left[\frac{1}{Day}\right]$

```
CAER = DMATX(4,N)*1.047**(DMATX(3,N)-20.)                        AEF02300
```

$$CAER = CAER20[1.047]^{DEGC-20}$$ $\left[\frac{1}{hr\ \frac{gm}{l}}\right]$

```
SA = DMATX(2,N)/1000.                                            AEF02400
```

$$SA \quad \frac{MLSS}{1000}$$ [gm/l]

```
TA = (BOD2-DMATX(1,N))/(DMATX(1,N)*CAER*SA*24.)                  AEF02500
```

$$TA = \frac{BOD2-BOD}{BOD*CAER*24*SA}$$ [days]

```
VAER = SMATX(2,IS1)*TA                                           AEF02600
```

$$VAER = Q_{IS1}*TA$$ [MG]

```
XRSS = 556.1*DMATX(8,N)**.4942/DMATX(2,N)**1.8165/(TA*24.)**.4386        AEF02700
```

$$XRSS = \frac{556.1*[GSS]^{0.4942}}{[MLSS]^{1.8165}*[24TA]^{0.4386}}$$ [no units]

```
ALD = DMATX(10,N)*.87*SMATX(14,IS1)                                       AEF02800
```

$ALD = 0.87ALMD*DP_{IS1}$ [mg/l]

```
PALS = 1.305*SMATX(14,IS1)+3.*ALD                                         AEF03000
```

$PALS = 1.305DP_{IS1}+3ALD$ [mg/l]

```
ASMAX = DMATX(1,N)/XRSS/.685                                              AEF03300
```

$$ASMAX = \frac{BOD}{0.685XRSS}$$ [mg/l]

```
XMLAS = (ASMAX+ASMIN)/2.                                                  AEF03800
```

$$XMLAS = \frac{ASMAX+ASMIN}{2}$$ [mg/l]

```
FOOD = SMATX(8,IS1)+DBOD2                                                 AEF03900
```

$FOOD = SBOD_{IS1}+DBOD2$ [mg/l]

```
FMAX = FOOD                                                               AEF04000
```

$FMAX = SBOD_{IS1}+DBOD2$ [mg/l]

```
ERROR = FMAX-FMIN                                                         AEF04300
```

ERROR = FMAX-FMIN [mg/l]

```
FOOD = (FMAX+FMIN)/2.                                                     AEF04500
```

$$FOOD = \frac{FMAX+FMIN}{2}$$ [mg/l]

```
DBOD4 = SMATX(17,IS1)-FOOD                                                AEF04700
```

$DBOD4 = DBOD_{IS1}-FOOD$ [mg/l]

SBOD4 = SMATX(8,IS1) AEF04800

$$SBOD4 = SBOD_{IS1}$$ [mg/1]

SBOD4 = (SMATX(8,IS1)+SMATX(17,IS1)-FOOD)*.7 AEF05000

$$SBOD4 \quad 0.7(SBOD_{IS1}+DBOD_{IS1}-FOOD)$$ [mg/1]

DBOD4 = .233*SBOD4 AEF05100

$$DBOD4 = 0.233*0.7(SBOD_{IS1}+DBOD_{IS1}-FOOD)$$ [mg/1]

TEMP1 = .50*FOOD/XMLAS-XRSS AEF05200

$$TEMP1 = \frac{0.50FOOD}{XMLAS} - XRSS$$ [no units]

SMATX(2,OS2) = (SMATX(2,IS1)*TEMP1-CEDR*VAER)/(DMATX(7,N)-XRSS) AEF05300

$$Q_{OS2} = \frac{(Q_{IS1}*TEMP1)-(CEDR*VAER)}{URSS-XRSS}$$ [MGD]

SMATX(2,OS1) = SMATX(2,IS1)-SMATX(2,OS2) AEF05400

$$Q_{OS1} = Q_{IS1}-Q_{OS2}$$ [MGD]

TEMP2 = XRSS*SMATX(2,OS1)+DMATX(7,N)*SMATX(2,OS2) AEF05700

$$TEMP2 = (XRSS*Q_{OS1})+(URSS*Q_{OS2})$$ [MGD]

XMLBS = SMATX(2,IS1)*SBOD4/TEMP2/.8 AEF05800

$$XMLBS = \frac{Q_{IS1}*SBOD4}{0.8TEMP2}$$ [mg/1]

SMATX(8,OS1) = (XMLAS*.685+XMLBS*.8)*XRSS AEF05900

$$SBOD_{OS1} = (0.685XMLAS+0.8XMLBS)XRSS$$ [mg/1]

SMATX(17,OS1) = DBOD4 AEF06000

$$DBOD_{OS1} = DBOD4$$ [mg/1]

TBOD5 = SMATX(8,OS1)+SMATX(17,OS1) AEF06100

$$TBOD5 = SBOD_{OS1}+DBOD_{OS1}$$ [mg/1]

TBOD5 = XMLAS*XRSS*.685 AEF06300

$$TBOD5 = 0.685XMLAS*XRSS$$ [mg/1]

FMIN = (CEDR*VAER/SMATX(2,IS1)+XRSS)*XMLAS/.50 AEF06600

$$FMIN = \left[\frac{CEDR*VAER}{Q_{IS1}} + XRSS\right] * \frac{XMLAS}{0.50}$$ [mg/1]

FOOD = FMIN AEF06700

$$FOOD = \frac{XMLAS}{0.50}\left[\frac{CEDR*VAER}{Q_{IS1}} + XRSS\right]$$ [mg/1]

FMAX = FOOD AEF07300

$$FMAX = FOOD$$ [mg/1]

FMIN = FOOD AEF08000

$$FMIN = FOOD$$ [mg/1]

XMLNB = SMATX(4,IS1)*SMATX(2,IS1)*2.13/TEMP2 AEF08200

$$XMLNB = \frac{SNBC_{IS1}*Q_{IS1}*2.13}{TEMP2}$$ [mg/1]

XMLIS = SMATX(2,IS1)*(SMATX(7,IS1)+PALS)/TEMP2 AEF08300

$$XMLIS = \frac{Q_{IS1}(SFM_{IS1}+PALS)}{TEMP2}$$ [mg/1]

XMLDS = .12*SMATX(2,IS1)*FOOD/TEMP2-.185*XMLAS AEF08400

$$XMLDS = \frac{0.12Q_{IS1}*FOOD}{TEMP2} - 0.185XMLAS$$ [mg/1]

TEMP3 = XMLAS+XMLBS+XMLNB+XMLDS+XMLIS AEF08500

$$TEMP3 = XMLAS+XMLBS+XMLNB+XMLDS+XMLIS$$ [mg/1]

TEMP4 = TEMP3-DMATX(2,N) AEF08600

$$TEMP4 = TEMP3-MLSS \quad [mg/l]$$

ASMIN = XMLAS AEF09500

$$ASMIN = XMLAS \quad [mg/l]$$

ASMAX = XMLAS AEF09700

$$ASMAX = XMLAS \quad [mg/l]$$

SMATX(3,OS1) = (XMLDS+XMLAS)*XRSS/2.46+(XMLBS+XMLNB)*XRSS/2.33 AEF10300

$$SOC_{OS1} = \frac{(XMLDS+XMLAS)XRSS}{2.46} + \frac{(XMLBS+XMLNB)XRSS}{2.33} \quad [mg/l]$$

SMATX(4,OS1) = XMLNB*XRSS/2.33+(XMLDS+.185*XMLAS)*XRSS/2.46 AEF10400

$$SNBC_{OS1} = \frac{XMLNB*XRSS}{2.33} + \frac{(XMLDS+0.185XMLAS)XRSS}{2.46} \quad [mg/l]$$

TEMP5 = XRSS*XMLAS/2.46 AEF10500

$$TEMP5 = \frac{XRSS*XMLAS}{2.46} \quad [mg/l]$$

SMATX(5,OS1) = .234*TEMP5+(SMATX(3,OS1)-TEMP5)/10. AEF10600

$$SON_{OS1} = 0.234TEMP5+ \frac{SOC_{OS1}-TEMP5}{10} \quad [mg/l]$$

SMATX(6,OS1) = SMATX(3,OS1)*.01 AEF10700

$$SOP_{OS1} = 0.01SOC_{OS1} \quad [mg/l]$$

SMATX(7,OS1) = XMLIS*XRSS AEF10800

$$SFM_{OS1} = XMLIS*XRSS \quad [mg/l]$$

```
SMATX(9,OS1) = SMATX(3,OS1)*2.38
```
AEF10900

$$VSS_{OS1} = 2.38SOC_{OS1}$$ [mg/l]

```
SMATX(10,OS1) = SMATX(7,OS1)+SMATX(9,OS1)
```
AEF11000

$$TSS_{OS1} = SFM_{OS1}+VSS_{OS1}$$ [mg/l]

```
SMATX(I,OS2) = SMATX(I,OS1)*DMATX(7,N)/XRSS
```
AEF11200

$$SMATX(I,OS2) = \frac{SMATX(I,OS1)*URSS}{XRSS}$$ [mg/l]

where I = 3,10 i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS,TSS

```
SMATX(11,OS1) = SMATX(12,IS1)+DBOD4/1.87
```
AEF11300

$$DOC_{OS1} = DNBC+ \frac{DBOD4}{1.87}$$ [mg/l]

```
SMATX(12,OS1) = SMATX(12,IS1)
```
AEF11400

$$DNBC_{OS1} = DNBC_{IS1}$$ [mg/l]

```
SMATX(13,OS1) = (SMATX(2,IS1)*(SMATX(5,IS1)+SMATX(13,IS1))-(SMATX(5,OS1)*SMATX(2,OS1)
                +SMATX(5,OS2)*SMATX(2,OS2)))/(SMATX(2,OS1)+SMATX(2,OS2))
```
AEF11500

$$DN_{OS1} = \frac{Q_{IS1}(SON_{IS1}+DN_{IS1})-(SON_{IS1}*Q_{OS1}+SON_{OS2}*Q_{OS2})}{Q_{OS1}+Q_{OS2}}$$ [mg/l]

```
SMATX(14,OS1) = (SMATX(2,IS1)*(SMATX(6,IS1)+SMATX(14,IS1))-(SMATX(6,OS1)*SMATX(2,OS1)
                +SMATX(6,OS2)*SMATX(2,OS2)))/(SMATX(2,OS1)+SMATX(2,OS2))
```
AEF11800

$$DP_{OS1} = \frac{Q_{IS1}(SOP_{IS1}+DP_{IS1})-(SOP_{OS1}*Q_{OS1}+SOP_{OS2}*Q_{OS2})}{Q_{OS1}+Q_{OS2}}$$ [mg/l]

```
SMATX(15,OS1) = SMATX(15,IS1)
```
AEF12100

$$DFM_{OS1} = DFM_{IS1}$$ [mg/l]

SMATX(I,OS2) = SMATX(I,OS1) AEF12300

SMATX(I,OS2) = SMATX(I,OS1) [mg/1]

where I = 11, 15 i.e. DOC,DNBC,DN,DP,DFM

QR = (SMATX(2,IS1)*(1.-.50*FOOD/XMLAS)+CEDR*VAER)/(SMATX(7,N)-1.) AEF12400

$$QR = \frac{Q_{IS1}\left[1-\frac{0.50FOOD}{XMLAS}\right]+(CEDR*VAER)}{URSS-1}$$ [mg/1]

RTURN = QR/SMATX(2,IS1) AEF12500

$$RTURN = \frac{QR}{Q_{IS1}}$$ [no units]

X4X3 = (1.+RTURN)/RTURN/SMATX(7,N) AEF12600

$$X4X3 = \frac{1+RTURN}{RTURN*URSS}$$ [no units]

DN3 = SMATX(13,IS1)/(1.+RTURN) AEF12700

$$DN3 = \frac{DN_{IS1}}{1+RTURN}$$ [mg/1]

X3Y = DN3*.99/(X4X3-1.) AEF12800

$$X3Y = \frac{0.99DN3}{X4X3-1}$$ [mg/1]

CNIT = .18*EXP(.116*(DMATX(3,N)-15.)) AEF12900

$$CNIT \quad 0.18e^{0.116(DEGC-15)}$$ [1/days]

TTAN = (1.+RTURN)*ALOG(X4X3)+4.605/(DN3+X3Y))/CNIT AEF13300

$$TTAN = (1+RTURN)*\ln X4X3+\frac{4.605}{(DN3+X3Y)CNIT}$$ [days]

```
VNIT = SMATX(2,IS1)*TTAN                                         AEF13400
```

$VNIT = Q_{IS1}*TTAN$ [MG]

```
SMATX(16,OS1) = SMATX(16,IS1)+3.57*(SMATX(13,OS1)-SMATX(13,IS1))  AEF13600
```

$ALK_{OS1} = ALK_{IS1}+3.57(DN_{OS1}-DN_{IS1})$ [mg/1]

```
SMATX(16,OS1) = SMATX(16,IS1)                                    AEF13800
```

$ALK_{OS1} = ALK_{IS1}$ [mg/1]

```
SMATX(16,OS2) = SMATX(16,OS1)                                    AEF13900
```

$ALK_{OS2} = ALK_{OS1}$ [mg/1]

```
SMATX(17,OS2) = SMATX(17,OS1)                                    AEF14000
```

$DBOD_{OS2} = DBOD_{OS1}$ [mg/1]

```
SMATX(18,OS1) = SMATX(18,IS1)                                    AEF14100
```

$NH3_{OS1} = NH3_{IS1}$ [mg/1]

```
SMATX(18,OS2) = SMATX(18,IS1)                                    AEF14200
```

$NH3_{OS2} = NH3_{IS1}$ [mg/1]

```
SMATX(19,OS1) = SMATX(19,IS1)                                    AEF14300
```

$NO3_{OS1} = NO3_{IS1}$ [mg/1]

```
SMATX(19,OS2) = SMATX(19,IS1)                                    AEF14400
```

$NO3_{OS2} = NO3_{IS1}$ [mg/1]

SMATX(20,OS1) = SMATX(20,IS1) AEF14500

For future parameter [mg/l]

SMATX(20,OS2) = SMATX(20,IS1) AEF14600

For future parameter [mg/l]

DOSAT = (14.16-.3943*DMATX(3,N)+.007714*DMATX(3,N)**2.-.0000646*DMATX(3,N)**3)*1.221

$DOSAT = 1.221(14.16-0.3943DEGC+0.007714DEGC^2-0.0000646DEGC^3)$ [mg/l] AEF15100

AEFF = DMATX(6,N)*(DOSAT-DMATX(5,N))*1.02**(DMATX(3,N)-20.)/DOSAT AEF15300

$AEFF = \frac{AEFF20*(DOSAT-DO)*[1.02]^{DEGC-20}}{DOSAT}$ [no units]

WFOOD = SMATX(2,IS1)*FOOD*8.33 AEF15400

$WFOOD = 8.33Q_{IS1}*FOOD$ [lb/day]

WAS = XMLAS*VAER*8.33 AEF15500

WAS = 8.33XMLAS*VAER [lb/day]

ARCFD = (.577*WFOOD+1.16*CEDR*WAS)/AEFF/.232/.075 AEF15600

$ARCFD = \frac{0.577WFOOD+(1.16\,DECR*WAS)}{0.232AEFF*0.075}$ $[\frac{ft^3}{day}]$

WDN = (SMATX(2,OS1)*SMATX(13,OS1)+SMATX(2,OS2)*SMATX(13,OS2))*8.33 AEF15700

$WDN = 8.33((Q_{OS1}*DN_{OS1})+(Q_{OS2}*DN_{OS2}))$ [lb/day]

ARCFD = ARCFD+4.6*WDN/AEFF/.232/.075 AEF15900

$ARCFD = ARCFD+\frac{4.6WDN}{0.232AEFF*0.75}$ $[ft^3/day]$

BSIZE = DMATX(15,N)*ARCFD/1440. AEF16000

$$BSIZE = \frac{ECF_b * ARCFD}{1440} \quad [cfm]$$

CFPGL = ARCFD/1000000./SMATX(2,IS1) AEF16100

$$CFPGL = \frac{ARCFD}{1000000Q_{IS1}} \quad \left[\frac{ft^3 air}{gal\ sewage}\right]$$

VAER = VAER*DMATX(16,N) AEF16200

$$VAER = VAER*ECF_a \quad [gal]$$

QR = QR*DMATX(14,N) AEF16300

$$QR = QR*ECF_p \quad [MGD]$$

AFS = SMATX(2,OS1)*1000./DMATX(8,N)*DMATX(13,N) AEF16400

$$AFS = \frac{1000\ Q_{OS1} * ECF_s}{GSS} \quad \left[\frac{ft^2}{1000}\right]$$

Pump efficiency - Current values used in program; each can be changed by the replacement on punched card.

PEFF = 0.70 For QR<1.44MGD AEF23800

PEFF = 0.74 For QR<10.08MGD AEF24100

PEFF = 0.83 For $QR \geq 10.08$MGD AEF24300

References:

Smith, 1969

Patterson and Banker, 1971

5. Cost Functions.

Aerator

a. Capital cost

Function of VAER

X = ALOG(VAER*1000./7.48) AEF17000

$$X = \ln \frac{1000VAER}{7.48}$$

```
CCOST(N,1) = EXP(2.414380+.175682*X+.084742*X**2.-.002670*X**3.)*1000.        AEF17100
```

$CCOST = 1000e^{2.414380+0.175682X+0.084742X^2-0.002670X^3}$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

(1) Operating manhours AEF17800

OHRS = 0 [hrs/yr]

(2) Maintenance manhours AEF17900

XMHRS = 0 [hrs/yr]

(3) Total materials and supplies AEF18000

TMSU = 0 [dollars/yr]

c. Total operating and maintenance costs AEF18100

COSTO(N,1) = 0 [cents/1000gal]

Blower

a. Capital cost

Function of BSIZE

```
X = ALOG(BSIZE/1000.)                                                         AEF18700
```

$X \quad \ln \frac{BSIZE}{1000}$

```
CCOST(N,2) = EXP(4.145454+.633339*X+.031939*X**2.-.002419*X**3.)*1000.        AEF18800
```

$CCOST = 1000e^{4.145454+0.633339X+0.031939X^2-0.002419X^3}$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of $BSIZE/ECF_b$

```
X = ALOG(BSIZE/1000./DMATX(15,N))                                             AEF19500
```

$X = \ln \frac{BSIZE}{1000ECF_b}$

(1) Operating manhours

```
OHRS = EXP(6.900586+.323725*X+.059093*X**2.-.004926*X**3.)                AEF20100
```

$$OHRS = e^{6.900586+0.323725X+0.059093X^2-0.004926X^3}$$ [hrs/yr]

(2) Maintenance manhours

```
                                                                          AEF20200
XMHRS = EXP(6.169937+.294853*X+.175999X**2.-.040947*X**3.+.003300*X**4.)
```

$$XMHRS = e^{6.169937+0.294853X+0.175999X^2-0.040947X^3+0.003300X^4}$$ [hrs/yr]

(3) Blower horsepower

```
HP = BSIZE/DMATX(15,N)*8.1*144./(33000.*.8)                               AEF20400
```

$$HP = \frac{BSIZE*8.1*144}{ECF_b*33000*0.8}$$ [horsepower]

(4) Blower kilowatts

```
XKW = .8*HP                                                               AEF20500
```

$$XKW = \frac{BSIZE*8.1*144}{33000ECF_b}$$ [kilowatts]

(5) Blower kilowatt years

```
XKWPY = XKW*24.*365.                                                      AEF20600
```

$$XKWPY = 24XKW*365$$ [kw hr/yr]

(6) Energy cost

```
ECOST = XKWPY*DMATX(10,20)                                                AEF20700
```

$$ECOST = XKWPY*CKWH$$ [dollars/yr]

(7) Service cost

```
SCOST = EXP(.621382+.482047*X)*1000.                                      AEF20800
```

$$SCOST = 1000e^{0.621382+0.482047X}$$ [dollars/yr]

c. Total operating and maintenance costs AEF21300

COSTO(N,2) = ((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/3650.

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+(SCOST*WPI)+ECOST}{Q_{Plant\ Inf.}*3650} \quad [cents/1000gal]$$

Sludge pumps

a. Capital cost

Function QR

X = ALOG(QR) AEF22000

$$X = \ln QR$$

CCOST(N,3) = EXP(3.481553+.377485*X+.093349*X**2.-.006222*X**3.)*1000. AEF22100

$$CCOST = 1000e^{3.481553+0.377485X+0.093349X^2-0.006222X^3} \quad [dollars]$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of QR/ECF_p

X = ALOG(QR/DMATX(14,N)) AEF22800

$$X = \ln \frac{QR}{ECF_p}$$

(1) Operating manhours

OHRS = EXP(6.097269+.253066*X-.193659*X**2.+.078201*X**3.-.006680*X**4.) AEF23400

$$OHRS = e^{6.097269+0.253066X-0.193659X^2+0.078201X^3-0.006680X^4} \quad [hrs/yr]$$

(2) Maintenance manhours

XMHRS EXP(5.911541-.013158*X+.076643*X**2.) AEF23600

$$XMHRS = e^{5.911541-0.013158X+0.076643X^2} \quad [hrs/yr]$$

(3) Kilowatt hrs per year

```
YRKW = QR*1000000.*HEAD/1440./3960./PEFF/.9*.7457*24.*365.          AEF24400
```

$$YRKW = \frac{1000000QR*HEAD*0.7457*24*365}{1440*3960PEFF*0.9}$$ [kw hr/yr]

(4) Energy cost

```
ECOST = YRKW*DMATX(10,20)                                           AEF24500
```

ECOST = YRKW*CKWH [dollars/yr]

(5) Service cost

```
SCOST = EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)         AEF24600
```

$$SCOST = e^{5.851743+0.301610X+0.197183X^2-0.017962X^3}$$ [dollars/yr]

(6) Total materials and supplies

```
TMSU = ECOST+SCOST*WPI                                              AEF24700
```

TMSU = ECOST+(SCOST*WPI) [dollars/yr]

c. Total operating and maintenance costs

```
COSTO(N,3) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.      AEF25200
```

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+TMSU}{Q_{Plant\ Inf.}*3650}$$ [cents/1000gal]

Final settling tank

a. Capital cost

Function of AFS

```
X = ALOG(AFS)                                                       AEF25800
```

X = ln AFS

```
CCOST(N,4) = EXP(3.716354+.389861*X+.084560*X**2.-.004718*X**3.)*1000.   AEF25900
```

$$CCOST = 1000e^{3.716354+0.389861X+0.084560X^2-0.004718X^3}$$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of AFS/ECF_s

```
X = ALOG(AFS/DMATX(13,N))                                            AEF26600
```

$$X = \ln \frac{AFS}{ECF_s}$$

(1) Operating manhours

```
OHRS = EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)           AEF27200
```

$$OHRS = e^{5.846565+0.254813X+0.113703X^2-0.010942X^3} \quad [hrs/yr]$$

(2) Maintenance manhours

```
XMHRS = EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)          AEF27300
```

$$XMHRS = e^{5.273419+0.228329X+0.122646X^2-0.011672X^3} \quad [hrs/yr]$$

(3) Total materials and supplies

```
TMSU = EXP(5.669881+.750799*X)                                       AEF27400
```

$$TMSU = e^{5.669881+0.750799X} \quad [dollars/yr]$$

c. Total operating and maintenance costs

```
COSTO(N,4) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.   AEF27900
```

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650} \quad [cents/1000gal]$$

```
C                                                                       AEF00100
C           ACTIVATED SLUDGE - FINAL SETTLER                            AEF00200
C           PROCESS IDENTIFICATION NUMBER   3                           AEF00300
C                                                                       AEF00400
      SUBROUTINE AERFS                                                  AEF00500
C                                                                       AEF00600
C                                                                       AEF00700
C           COMMON INITIAL STATEMENTS                                   AEF00800
C                                                                       AEF00900
      INTEGER OS1,OS2                                                   AEF01000
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),AEF01100
     1INP,JO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)AEF01200
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)   AEF01300
C                                                                       AEF01400
C                                                                       AEF01500
C           PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM        AEF01600
C           CHARACTERISTICS                                             AEF01700
C                                                                       AEF01800
      HEAD=DMATX(9,N)                                                   AEF01900
      BOD2=SMATX(8,IS1)+SMATX(17,IS1)                                   AEF02000
      DBOD2=SMATX(17,IS1)                                               AEF02100
      CEDR=.18*1.047**(DMATX(3,N)-28.)                                  AEF02200
      CAER=DMATX(4,N)*1.047**(DMATX(3,N)-20.)                           AEF02300
      SA=DMATX(2,N)/1000.                                               AEF02400
      TA=(BOD2-DMATX(1,N))/(DMATX(1,N)*CAER*SA*24.)                     AEF02500
      VAER=SMATX(2,IS1)*TA                                              AEF02600
      XRSS=556.1*DMATX(8,N)**.4942/DMATX(2,N)**1.8165/(TA*24.)**.4386   AEF02700
      ALD=DMATX(10,N)*.87*SMATX(14,IS1)                                 AEF02800
      IF (ALD) 10,20,10                                                 AEF02900
   10 PALS=1.305*SMATX(14,IS1)+3.*ALD                                   AEF03000
      GO TO 30                                                          AEF03100
   20 PALS=0.                                                           AEF03200
   30 ASMAX=DMATX(1,N)/XRSS/.685                                        AEF03300
      ASMIN=0.                                                          AEF03400
      NAER=0                                                            AEF03500
      IF (ASMAX-DMATX(2,N)) 50,50,40                                    AEF03600
   40 ASMAX=DMATX(2,N)                                                  AEF03700
   50 XMLAS=(ASMAX+ASMIN)/2.                                            AEF03800
      FOOD=SMATX(8,IS1)+DBOD2                                           AEF03900
      FMAX=FOOD                                                         AEF04000
      N1=1                                                              AEF04100
      GO TO 110                                                         AEF04200
   60 ERROR=FMAX-FMIN                                                   AEF04300
      IF (ERROR-.1) 240,240,70                                          AEF04400
   70 FOOD=(FMAX+FMIN)/2.                                               AEF04500
   80 IF (FOOD-SMATX(17,IS1)) 90,90,100                                 AEF04600
   90 DBOD4=SMATX(17,IS1)-FOOD                                          AEF04700
      SBOD4=SMATX(8,IS1)                                                AEF04800
      GO TO 110                                                         AEF04900
  100 SBOD4=(SMATX(8,IS1)+SMATX(17,IS1)-FOOD)*.7                        AEF05000
      DBOD4=.233*SBOD4                                                  AEF05100
  110 TEMP1=.50*FOOD/XMLAS-XRSS                                         AEF05200
      SMATX(2,OS2)=(SMATX(2,IS1)*TEMP1-CEDR*VAER)/(DMATX(7,N)-XRSS)     AEF05300
      SMATX(2,OS1)=SMATX(2,IS1)-SMATX(2,OS2)                            AEF05400
      N1=N1+1                                                           AEF05500
      IF (N1-2) 130,130,120                                             AEF05600
  120 TEMP2=XRSS*SMATX(2,OS1)+DMATX(7,N)*SMATX(2,OS2)                   AEF05700
      XMLBS=SMATX(2,IS1)*SBOD4/TEMP2/.8                                 AEF05800
```

```
      SMATX(8,OS1)=(XMLAS*.685+XMLBS*.8)*XRSS                           AEF05900
      SMATX(17,OS1)=DBOD4                                               AEF06000
      TBOD5=SMATX(8,OS1)+SMATX(17,OS1)                                  AEF06100
      GO TO 140                                                         AEF06200
  130 TBOD5=XMLAS*XRSS*.685                                             AEF06300
  140 IF (TBOD5-DMATX(1,N)) 150,150,200                                 AEF06400
  150 IF (N1-3) 160,170,190                                             AEF06500
  160 FMIN=(CEDR*VAER/SMATX(2,IS1)+XRSS)*XMLAS/.50                      AEF06600
      FOOD=FMIN                                                         AEF06700
      GO TO 80                                                          AEF06800
  170 WRITE (IO,180)                                                    AEF06900
  180 FORMAT (///,10X,'MLASS DEMAND CANNOT BE ACHIEVED')                AEF07000
      IAERF=1                                                           AEF07100
      GO TO 470                                                         AEF07200
  190 FMAX=FOOD                                                         AEF07300
      GO TO 60                                                          AEF07400
  200 IF (N1-3) 210,60,230                                              AEF07500
  210 WRITE (IO,220)                                                    AEF07600
  220 FORMAT (///,10X,'BOD5 DEMAND CANNOT BE ACHIEVED')                 AEF07700
      IAERF=1                                                           AEF07800
      GO TO 470                                                         AEF07900
  230 FMIN=FOOD                                                         AEF08000
      GO TO 60                                                          AEF08100
  240 XMLNB=SMATX(4,IS1)*SMATX(2,IS1)*2.13/TEMP2                        AEF08200
      XMLIS=SMATX(2,IS1)*(SMATX(7,IS1)+PALS)/TEMP2                      AEF08300
      XMLDS=.12*SMATX(2,IS1)*FOOD/TEMP2-.185*XMLAS                      AEF08400
      TEMP3=XMLAS+XMLBS+XMLNB+XMLDS+XMLIS                               AEF08500
      TEMP4=TEMP3-DMATX(2,N)                                            AEF08600
      NAER=NAER+1                                                       AEF08700
      IF (ABS(TEMP4)-5.) 310,310,250                                    AEF08800
  250 IF (25-NAER) 260,280,280                                          AEF08900
  260 WRITE (IO,270)                                                    AEF09000
  270 FORMAT (///,10X,'MLSS DEMAND CANNOT BE ACHIEVED')                 AEF09100
      IAERF=1                                                           AEF09200
      GO TO 470                                                         AEF09300
  280 IF (TEMP4) 290,290,300                                            AEF09400
  290 ASMIN=XMLAS                                                       AEF09500
      GO TO 50                                                          AEF09600
  300 ASMAX=XMLAS                                                       AEF09700
      GO TO 50                                                          AEF09800
C                                                                       AEF09900
C                                                                       AEF10000
C               EFFLUENT STREAM CALCULATIONS                            AEF10100
C                                                                       AEF10200
  310 SMATX(3,OS1)=(XMLDS+XMLAS)*XRSS/2.46+(XMLBS+XMLNB)*XRSS/2.33      AEF10300
      SMATX(4,OS1)=XMLNB*XRSS/2.33+(XMLDS+.185*XMLAS)*XRSS/2.46         AEF10400
      TEMP5=XRSS*XMLAS/2.46                                             AEF10500
      SMATX(5,OS1)=.234*TEMP5+(SMATX(3,OS1)-TEMP5)/10.                  AEF10600
      SMATX(6,OS1)=SMATX(3,OS1)*.01                                     AEF10700
      SMATX(7,OS1)=XMLIS*XRSS                                           AEF10800
      SMATX(9,OS1)=SMATX(3,OS1)*2.38                                    AEF10900
      SMATX(10,OS1)=SMATX(7,OS1)+SMATX(9,OS1)                           AEF11000
      DO 320 I=3,10                                                     AEF11100
  320 SMATX(I,OS2)=SMATX(I,OS1)*DMATX(7,N)/XRSS                         AEF11200
      SMATX(11,OS1)=SMATX(12,IS1)+DBOD4/1.87                            AEF11300
      SMATX(12,OS1)=SMATX(12,IS1)                                       AEF11400
      SMATX(13,OS1)=(SMATX(2,IS1)*(SMATX(5,IS1)+SMATX(13,IS1))-(SMATX(5,AEF11500
     1OS1)*SMATX(2,OS1)+SMATX(5,OS2)*SMATX(2,OS2)))/(SMATX(2,OS1)+SMATX(AEF11600
     22,OS2))                                                           AEF11700
      SMATX(14,OS1)=(SMATX(2,IS1)*(SMATX(6,IS1)+SMATX(14,IS1))-(SMATX(6,AEF11800
     1OS1)*SMATX(2,OS1)+SMATX(6,OS2)*SMATX(2,OS2)))/(SMATX(2,OS1)+SMATX(AEF11900
     22,OS2))                                                           AEF12000
      SMATX(15,OS1)=SMATX(15,IS1)                                       AEF12100
```

```
      DO 330 I=11,15
  330 SMATX(I,OS2)=SMATX(I,OS1)
      QR=(SMATX(2,IS1)*(1.-.50*FOOD/XMLAS)+CEDR*VAER)/(DMATX(7,N)-1.)
      RTURN=QR/SMATX(2,IS1)
      X4X3=(1.+RTURN)/RTURN/DMATX(7,N)
      DN3=SMATX(13,IS1)/(1.+RTURN)
      X3Y=DN3*.99/(X4X3-1.)
      CNIT=.18*EXP(.116*(DMATX(3,N)-15.))
      IF (X4X3) 340,340,350
  340 TTAN=0.
      GO TO 360
  350 TTAN=(1.+RTURN)*(ALOG(X4X3)+4.605/(DN3+X3Y))/CNIT
  360 VNIT=SMATX(2,IS1)*TTAN
      IF (VNIT-VAER) 370,370,380
  370 SMATX(16,OS1)=SMATX(16,IS1)+3.57*(SMATX(13,OS1)-SMATX(13,IS1))
      GO TO 390
  380 SMATX(16,OS1)=SMATX(16,IS1)
  390 SMATX(16,OS2)=SMATX(16,OS1)
      SMATX(17,OS2)=SMATX(17,OS1)
      SMATX(18,OS1)=SMATX(18,IS1)
      SMATX(18,OS2)=SMATX(18,IS1)
      SMATX(19,OS1)=SMATX(19,IS1)
      SMATX(19,OS2)=SMATX(19,IS1)
      SMATX(20,OS1)=SMATX(20,IS1)
      SMATX(20,OS2)=SMATX(20,IS1)
C
C
C              CALC. OF OUTPUT SIZES AND QUANTITIES
C
      DOSAT=(14.16-.3943*DMATX(3,N)+.007714*DMATX(3,N)**2-.0000646*DMATX
     1(3,N)**3)*1.221
      AEFF=DMATX(6,N)*(DOSAT-DMATX(5,N))*1.02**(DMATX(3,N)-20.)/DOSAT
      WFOOD=SMATX(2,IS1)*FOOD*8.33
      WAS=XMLAS*VAER*8.33
      ARCFD=(.577*WFOOD+1.16*CEDR*WAS)/AEFF/.232/.075
      WDN=(SMATX(2,OS1)*SMATX(13,OS1)+SMATX(2,OS2)*SMATX(13,OS2))*8.33
      IF (VNIT-VAER) 400,400,410
  400 ARCFD=ARCFD+4.6*WDN/AEFF/.232/.075
  410 BSIZE=DMATX(15,N)*ARCFD/1440.
      CFPGL=ARCFD/1000000./SMATX(2,IS1)
      VAER=VAER*DMATX(16,N)
      QR=QR*DMATX(14,N)
      AFS=SMATX(2,OS1)*1000./DMATX(8,N)*DMATX(13,N)
C
C
C              CALC. OF CAPITAL COSTS FOR AERATOR BASED ON DESIGN PLUS
C              EXCESS CAPACITY
C
      X=ALOG(VAER*1000./7.48)
      CCOST(N,1)=EXP(2.414380+.175682*X+.084742*X**2.-.002670*X**3.)*100
     10.
C
C
C              CALC. OF OPERATING COSTS FOR AERATOR BASED ON DESIGN
C              CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
      OHRS=0.
      XMHRS=0.
      TMSU=0.
      COSTO(N,1)=0.
C
C
C              CALC. OF CAPITAL COSTS FOR BLOWER BASED ON DESIGN PLUS
C              EXCESS CAPACITY
C
```

```
      X=ALOG(BSIZE/1000.)                                                 AEF18700
      CCOST(N,2)=EXP(4.145454+.633339*X+.031939*X**2.-.002419*X**3.)*100AEF18800
     10.                                                                  AEF18900
C                                                                         AEF19000
C                                                                         AEF19100
C            CALC. OF OPERATING COSTS FOR BLOWER BASED ON DESIGN          AEF19200
C            CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY             AEF19300
C                                                                         AEF19400
      X=ALOG(BSIZE/1000./DMATX(15,N))                                     AEF19500
C                                                                         AEF19600
C                                                                         AEF19700
C                  CALC. OF OPERATING MANHOURS MAINTENANCE MANHOURS       AEF19800
C                  ELECTRICAL POWER AND SUPPLY COSTS                      AEF19900
C                                                                         AEF20000
      OHRS=EXP(6.900586+.323725*X+.059093*X**2.-.004926*X**3.)            AEF20100
      XMHRS=EXP(6.169937+.294853*X+.175999*X**2.-.040947*X**3.+.003300*XAEF20200
     1**4.)                                                               AEF20300
      HP=BSIZE/DMATX(15,N)*8.1*144./(33000.*.8)                           AEF20400
      XKW=.8*HP                                                           AEF20500
      XKWPY=XKW*24.*365.                                                  AEF20600
      ECOST=XKWPY*DMATX(10,20)                                            AEF20700
      SCOST=EXP(.621382+.482047*X)*1000.                                  AEF20800
C                                                                         AEF20900
C                                                                         AEF21000
C                  OPERATING COST EQUATION                                AEF21100
C                                                                         AEF21200
      COSTO(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/AEF21300
     13650.                                                               AEF21400
C                                                                         AEF21500
C                                                                         AEF21600
C            CALC. OF CAPITAL COSTS FOR SLUDGE PUMPS BASED ON DESIGN      AEF21700
C            PLUS EXCESS CAPACITY                                         AEF21800
C                                                                         AEF21900
      X=ALOG(QR)                                                          AEF22000
      CCOST(N,3)=EXP(3.481553+.377485*X+.093349*X**2.-.006222*X**3.)*100AEF22100
     10.                                                                  AEF22200
C                                                                         AEF22300
C                                                                         AEF22400
C            CALC. OF OPERATING COSTS FOR SLUDGE PUMPS BASED ON           AEF22500
C            DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY      AEF22600
C                                                                         AEF22700
      X=ALOG(QR/DMATX(14,N))                                              AEF22800
C                                                                         AEF22900
C                                                                         AEF23000
C                  CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS      AEF23100
C                  AND MATERIALS AND SUPPLIES                             AEF23200
C                                                                         AEF23300
      OHRS=EXP(6.097269+.253066*X-.193659*X**2.+.078201*X**3.-.006680*X*AEF23400
     1*4.)                                                                AEF23500
      XMHRS=EXP(5.911541-.013158*X+.076643*X**2.)                         AEF23600
      IF (QR-1.44) 420,430,430                                            AEF23700
  420 PEFF=.70                                                            AEF23800
      GO TO 460                                                           AEF23900
  430 IF (QR-10.08) 440,450,450                                           AEF24000
  440 PEFF=.74                                                            AEF24100
      GO TO 460                                                           AEF24200
  450 PEFF=.83                                                            AEF24300
  460 YRKW=QR*1000000.*HEAD/1440./3960./PEFF/.9*.7457*24.*365.            AEF24400
      ECOST=YRKW*DMATX(10,20)                                             AEF24500
      SCOST=EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)           AEF24600
      TMSU=ECOST+SCOST*WPI                                                AEF24700
C                                                                         AEF24800
C                                                                         AEF24900
C                  OPERATING COST EQUATION                                AEF25000
C                                                                         AEF25100
```

```
      COSTO(N,3)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.       AEF25200
C                                                                         AEF25300
C                                                                         AEF25400
C             CALC. OF CAPITAL COSTS FOR FINAL SETTLER BASED ON DESIGN    AEF25500
C             PLUS EXCESS CAPACITY                                        AEF25600
C                                                                         AEF25700
      X=ALOG(AFS)                                                         AEF25800
      CCOST(N,4)=EXP(3.716354+.389861*X+.084560*X**2.-.004718*X**3.)*100AEF25900
     10.                                                                  AEF26000
C                                                                         AEF26100
C                                                                         AEF26200
C             CALC. OF OPERATING COSTS FOR FINAL SETTLER BASED ON         AEF26300
C             DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY     AEF26400
C                                                                         AEF26500
      X=ALOG(AFS/DMATX(13,N))                                             AEF26600
C                                                                         AEF26700
C                                                                         AEF26800
C                  CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS      AEF26900
C                  AND MATERIALS AND SUPPLIES                             AEF27000
C                                                                         AEF27100
      OHRS=EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)            AEF27200
      XMHRS=EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)           AEF27300
      TMSU=EXP(5.669881+.750799*X)                                        AEF27400
C                                                                         AEF27500
C                                                                         AEF27600
C                  OPERATING COST EQUATION                                AEF27700
C                                                                         AEF27800
      COSTO(N,4)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.   AEF27900
C                                                                         AEF28000
C                                                                         AEF28100
C             ASSIGNMENT OF VALUES TO OMATX                               AEF28200
C                                                                         AEF28300
      OMATX(1,N)=BOD2                                                     AEF28400
      OMATX(2,N)=DOSAT                                                    AEF28500
      OMATX(3,N)=XRSS                                                     AEF28600
      OMATX(4,N)=AFS                                                      AEF28700
      OMATX(5,N)=CAER                                                     AEF28800
      OMATX(6,N)=CEDR                                                     AEF28900
      OMATX(7,N)=VAER                                                     AEF29000
      OMATX(8,N)=VNIT                                                     AEF29100
      OMATX(9,N)=XMLAS                                                    AEF29200
      OMATX(10,N)=XMLBS                                                   AEF29300
      OMATX(11,N)=XMLNB                                                   AEF29400
      OMATX(12,N)=XMLDS                                                   AEF29500
      OMATX(13,N)=XMLIS                                                   AEF29600
      OMATX(14,N)=FOOD                                                    AEF29700
      OMATX(15,N)=RTURN                                                   AEF29800
      OMATX(16,N)=CNIT                                                    AEF29900
      OMATX(17,N)=ARCFD                                                   AEF30000
      OMATX(18,N)=BSIZE                                                   AEF30100
      OMATX(19,N)=CFPGL                                                   AEF30200
      OMATX(20,N)=QR                                                      AEF30300
C                                                                         AEF30400
C                                                                         AEF30500
C             PROCESS ENERGY INDICES                                      AEF30600
C                                                                         AEF30700
      FLOW(N)=SMATX(2,IS1)                                                AEF30800
      POW(N)=3.                                                           AEF30900
  470 RETURN                                                              AEF31000
      END                                                                 AEF31100
```

SECTION 5

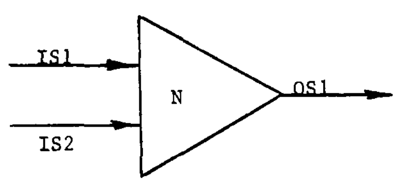
STREAM MIXER, MIX

Subroutine Identification Number 4

Rev. Date 8/1/77

Stream Mixer, MIX

1. Process symbol.



IS1: Primary input stream

IS2: Secondary input stream

OS1: Primary output stream

N: User assigned number to the process, must be zero for mixer

2. Input parameters and nominal values.

No input data.

3. Output parameters which are printed on computer output sheets.

No output data.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
SMATX(2,OS1) = SMATX(2,IS1)+SMATX(2,IS2)                        MIX01900
```

$$Q_{OS1} = Q_{IS1}+Q_{IS2} \quad [MGD]$$

```
TEMP1 = SMATX(2,IS1)/(SMATX(2,IS1)+SMATX(2,IS2))                MIX02100
```

$$TEMP1 = \frac{Q_{IS1}}{Q_{IS1}+Q_{IS2}}$$

```
TEMP2 = SMATX(2,IS2)/(SMATX(2,IS1)+SMATX(2,IS2))                MIX02200
```

$$TEMP2 = \frac{Q_{IS2}}{Q_{IS1}+Q_{IS2}}$$

SMATX(I,OS1) = TEMP1*SMATX(I,IS1)+TEMP2*SMATX(I,IS2) MIX02800

$$SMATX(I,OS1) = \frac{Q_{IS1}}{Q_{IS1}+Q_{IS2}} * SMATX(I,IS1) + \frac{Q_{IS2}}{Q_{IS1}+Q_{IS2}} * SMATX(I,IS2) \quad [mg/l]$$

where I = 3,20 i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS,TSS,DOC,DNBC,DN,
DP,DFM,ALK,DBOD,NH3,NO3

5. Cost functions.

No cost functions.

```
C
C           STREAM MIXER
C           PROCESS IDENTIFICATION NUMBER    4
C
      SUBROUTINE MIX
C
C
C           COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C           PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C           CHARACTERISTICS
C
      SMATX(2,OS1)=SMATX(2,IS1)+SMATX(2,IS2)
      IF (SMATX(2,OS1)) 10,30,10
   10 TEMP1=SMATX(2,IS1)/(SMATX(2,IS1)+SMATX(2,IS2))
      TEMP2=SMATX(2,IS2)/(SMATX(2,IS1)+SMATX(2,IS2))
C
C
C           EFFLUENT STREAM CALCULATIONS
C
      DO 20 I=3,20
   20 SMATX(I,OS1)=TEMP1*SMATX(I,IS1)+TEMP2*SMATX(I,IS2)
   30 RETURN
      END
```

SECTION 6

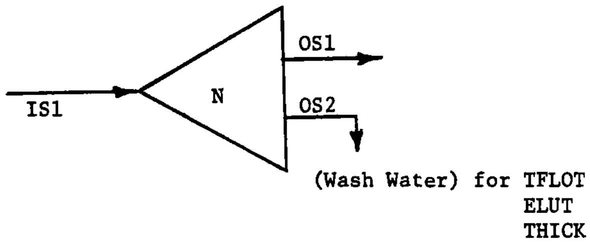
STREAM SPLITTER, SPLIT

Subroutine Identification Number 5

Stream Splitter, SPLIT

Rev. Date 8/1/77

1. Process symbol.



IS1: Primary input stream

OS1: Primary output stream

OS2: Secondary output stream

N: User assigned number to the process, must be zero for splitter

2. Input parameters and nominal values.

No input data.

3. Output parameters which are printed on computer output sheets.

No output data.

4. Theory and functions- FORTRAN statement followed by equivalent algebraic equation.

SMATX(2,OS1) = SMATX(2,IS1)-SMATX(2,OS2) SPL01900

$Q_{OS1} = Q_{IS1} - Q_{OS2}$ [MGD]

SMATX(I,OS1) = SMATX(I,IS1) SPL02500

SMATX(I,OS1) = SMATX(I,IS1) [mg/l]

where I = 3 ,20 i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS,TSS,DOC, DNBC,DN,DP,DFM,ALK,DBOD,NH3,NO3

SMATX(I,OS2) = SMATX(I,IS1) SPL02600

SMATX(I,OS2) = SMATX(I,IS1) [mg/l]

5. Cost functions.

No cost function.

```
C
C          STREAM SPLITTER
C          PROCESS IDENTIFICATION NUMBER   5
C
      SUBROUTINE SPLIT
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C          PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C          CHARACTERISTICS
C
      SMATX(2,OS1)=SMATX(2,IS1)-SMATX(2,OS2)
C
C
C          EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=3,20
      SMATX(I,OS1)=SMATX(I,IS1)
   10 SMATX(I,OS2)=SMATX(I,IS1)
      RETURN
      END
```

SECTION 7

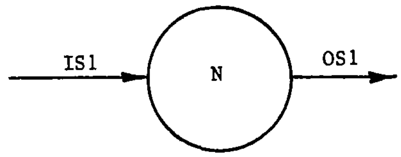
ANAEROBIC DIGESTER, DIG

Subroutine Identification Number 6

Rev. Date 8/1/77

Anaerobic Digester, DIG

1. Process symbol.



IS1: Sludge input stream

OS1: Sludge output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = TD	Digester dentention time, days. [15.]
DMATX(2,N) = TDIG	Sludge temperature in digester, degrees Centigrade. [33.]
DMATX(16,N) = ECF	Excess capacity factor. [1.3]

3. Output parameters which are printed on computer output sheets.

TD = DMATX(1,N)	
TDIG = DMATX(2,N)	
C1DIG = OMATX(1,N)	Rate constant for digester, [1/day].
C2DIG = OMATX(2,N)	Rate constant for biodegradable carbon, [1/day].
VDIG = OMATX(3,N)	Volume of digester facilities, [cu.ft./1000].
CH4 = OMATX(4,N)	Standard cubic feet of methane produced in the digester each day, [scf/day methane].
CO2 = OMATX(5,N)	Standard cubic feet of carbon dioxide produced in the digester each day, [scf/day carbon dioxide] .
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000 gal].
ACOST	Amortization cost, [cents/1000 gal].
TCOST	Total treatment cost, [cents/1000 gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
C1DIG = .28/EXP(.036*(35.-DMATX(2,N)))                                      DIG02500
```

$$C1DIG = \frac{0.28}{e^{0.036(35-TDIG)}} \qquad \left[\frac{1}{days}\right]$$

```
C2DIG = 700.*EXP(.10*(35.-DMATX(2,N)))                                      DIG02600
```

$$C2DIG = 700e^{0.10(35-TDIG)} \qquad \left[\frac{mg/l}{day}\right]$$

```
DIG13 = C2DIG/(C1DIG*DMATX(1,N)-1.)                                         DIG02700
```

$$DIG13 = \frac{C2DIG}{C1DIG(TD) - 1} \qquad [mg/l]$$

```
DIG12 = SMATX(3,IS1)-SMATX(4,IS1)+SMATX(11,IS1)-SMATX(12,IS1)               DIG02800
```

$$DIG12 = SOC_{IS1} - SNBC_{IS1} + DOC_{IS1} - DNBC_{IS1}$$

= total biodegradable carbon [mg/l]

```
TEMP1 = (DIG12-DIG13)/(SMATX(3,IS1)+SMATX(11,IS1))                          DIG02900
```

$$TEMP1 = \frac{DIG12 - DIG13}{SOC_{IS1} + DOC_{IS1}}$$

= fraction of biodegradable carbon remaining relative to total organic carbon entering digester

```
SMATX(2,OS1) = SMATX(2,IS1)                                                 DIG03400
```

$$Q_{OS1} = Q_{IS1} \qquad [MGD]$$

```
SMATX(3,OS1) = SMATX(4,IS1)+.75*DIG13                                       DIG03500
```

$$SOC_{OS1} = SNBC_{IS1} + 0.75(DIG13) \qquad [mg/l]$$

```
SMATX(4,OS1) = SMATX(4,IS1)                                                 DIG03600
```

$$SNBC_{OS1} = SNBC_{IS1} \qquad [mg/l]$$

```
SMATX(5,OS1) = (1.-TEMP1)*SMATX(5,IS1)                                      DIG03700
```

$$SON_{OS1} = (1-TEMP1)\ SON_{IS1} \qquad [mg/l]$$

```
SMATX(6,OS1) = (1.-TEMP1)*SMATX(6,OS1)                                      DIG03800
```

$$SOP_{OS1} = (1-TEMP1)\ SOP_{IS1} \qquad [mg/l]$$

SMATX(7,OS1) = SMATX(7,IS1) DIG03900

$SFM_{OS1} = SFM_{IS1}$ [mg/l]

SMATX(8,OS1) = (SMATX(3,OS1)-SMATX(4,OS1))*1.87 DIG04000

$SBOD_{OS1} = (SOC_{OS1} - SNBC_{OS1})1.87$ [mg/l]

SMATX(9,OS1) = SMATX(3,OS1)*2.38 DIG04100

$VSS_{OS1} = (SOC_{OS1})2.38$ [mg/l]

SMATX(10,OS1) = SMATX(9,OS1)+SMATX(7,OS1) DIG04200

$TSS_{OS1} = VSS_{OS1} + SFM_{OS1}$ [mg/l]

SMATX(11,OS1) = SMATX(12,IS1)+.25*DIG13 DIG04300

$DOC_{OS1} = DNBC_{IS1} + 0.25DIG13$ [mg/l]

SMATX(12,OS1) = SMATX(12,IS1) DIG04400

$DNBC_{OS1} = DNBC_{IS1}$ [mg/l]

SMATX(13,OS1) = SMATX(13,IS1)+SMATX(5,IS1)*.65*TEMP1 DIG04500

$DN_{OS1} = DN_{IS1} + (SON_{IS1})0.65TEMP1$ [mg/l]

SMATX(14,OS1) = SMATX(14,IS1) + TEMP1*SMATX(6,IS1) DIG04600

$DP_{OS1} = DP_{OS1} + TEMP1(SOP_{IS1})$ [mg/l]

SMATX(15,OS1) = SMATX(15,IS1) DIG04700

$DFM_{OS1} = DFM_{IS1}$ [mg/l]

SMATX(16,OS1) = SMATX(16,IS1)+(SMATX(13,OS1) - SMATX(13,IS1))*3.57 DIG04800

$ALK_{OS1} = ALK_{IS1} + 3.57(DN_{OS1} - DN_{IS1})$ [mg/l]

SMATX(17,OS1) = (SMATX(11,OS1)-SMATX(12,OS1))*1.87 DIG04900

$DBOD_{OS1} = (DOC_{OS1} - DNBC_{OS1})\ 1.87$ [mg/l]

CH4 = 163.85*(DIG12-DIG13)*SMATX(2,IS1) DIG05700

$CH4 = 163.85(DIG12-DIG13)\ Q_{IS1}$ [scfd]

CO_2 = 249.9*(DIG12-DIG13)*SMATX(2,IS1) - CH_4 DIG05800

$CO_2 = 249.9(DIG12-DIG13)\ Q_{IS1} - CH4$ [scfd]

```
VDIG = SMATX(2,IS1)*DMATX(1,N)*1000/7.48*DMATX(16,N)                DIG05900
```

$$VIDG = Q_{IS1} * TD * \frac{1000\ ECF}{7.48} \qquad [\frac{ft^3}{1000}]$$

References:

Patterson and Banker, 1971

Lawrence and McCarty, 1969

O'Rourke, 1968

Smith, 1969

5. Cost functions.

a. Capital cost

Function of VDIG

```
X = ln VDIG                                                         DIG06500
```

(1) Digester facilities less than 20000 ft^3

```
CCOST(N,1) = EXP(4.594215+.127244X-.004001*X**2.)*1000.             DIG07200
```

$$CCOST = 1000e^{4.594215+0.127244X-0.004001X^2} \qquad [dollars]$$

(2) Digester facilities equal or greater than 20000 ft^3 DIG07900

```
CCOST(N,1) = EXP(7.679634-1.949689*X+.402610*X**2.-.018211*X**3.)*1000.
```

$$CCOST = 1000e^{7.679634-1.949689X+0.402610X^2-0.018211X^3} \qquad [dollars]$$

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of VDIG/ECF

```
X = ln (VDIG/ECF)                                                   DIG08600
```

(1) Digester facilities less than 20000 ft^3

(a) Operating manhours

```
OHRS = EXP(6.163803+0.166305*X-.012470*X**2.)                       DIG09400
```

$$OHRS = e^{6.163803+0.166305X-0.012470X^2} \qquad [hrs/yr]$$

(b) Maintenance manhours

```
XMHRS = EXP(5.726981+.113674*X)                                     DIG09500
```

$$XMHRS = e^{5.726981+0.113674X} \qquad [hrs/yr]$$

(c) Total materials and supplies

TMSU = EXP(6.531623+.198417*X+.021660*X**2.) DIG09600

$$TMSU = e^{6.531623+0.198417X+0.021660X^2} \quad \text{[dollars/yr]}$$

2. Digester facilities equal or greater than 20000 ft^3

(a) Operating manhours DIG10400

OHRS = EXP(9.129250-1.816736*X+.373282*X**2.-.017290*X**3.)

$$OHRS = e^{9.129250-1.816736X+0.373282X^2-0.017290X^3} \quad \text{[hrs/yr]}$$

(b) Maintenance manhours DIG10500

XMHRS = EXP(8.566752-1.768137*X+.363173*X**2.-.016620*X**3.)

$$XMHRS = e^{8.566752-1.768137X+0.363173X^2-0.016620X^3} \quad \text{[hrs/yr]}$$

(c) Total materials and supplies DIG10600

TMSU = EXP(8.702803-1.182711*X+.282691*X**2.-.013672*X**3.)

$$TMSU = e^{8.702803-1.182711X+0.282691X^2-0.013672X^3} \quad \text{[dollars/yr]}$$

c. Total operating and maintenance costs

COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1+PCT)+TMSU*WPI)/SMATX(2,1)/3650. DIG11100

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+TMSU(WPI)}{Q_{Plant\ Inf.} * 3650} \quad \text{[cents/1000 gal]}$$

```
C
C          SINGLE STAGE ANAEROBIC DIGESTION
C          PROCESS IDENTIFICATION NUMBER   6
C
      SUBROUTINE DIG
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C          FORCING DIGESTER TO HAVE AT LEAST 10 DAYS DETENTION TIME
C
      IF (DMATX(1,N)-10.) 10,10,20
   10 DMATX(1,N)=10.
C
C
C          PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C          CHARACTERISTICS
C
   20 C1DIG=.28/EXP(.036*(35.-DMATX(2,N)))
      C2DIG=700.*EXP(.10*(35.-DMATX(2,N)))
      DIG13=C2DIG/(C1DIG*DMATX(1,N)-1.)
      DIG12=SMATX(3,IS1)-SMATX(4,IS1)+SMATX(11,IS1)-SMATX(12,IS1)
      TEMP1=(DIG12-DIG13)/(SMATX(3,IS1)+SMATX(11,IS1))
C
C
C          EFFLUENT STREAM CALCULATIONS
C
      SMATX(2,OS1)=SMATX(2,IS1)
      SMATX(3,OS1)=SMATX(4,IS1)+.75*DIG13
      SMATX(4,OS1)=SMATX(4,IS1)
      SMATX(5,OS1)=(1.-TEMP1)*SMATX(5,IS1)
      SMATX(6,OS1)=(1.-TEMP1)*SMATX(6,IS1)
      SMATX(7,OS1)=SMATX(7,IS1)
      SMATX(8,OS1)=(SMATX(3,OS1)-SMATX(4,OS1))*1.87
      SMATX(9,OS1)=SMATX(3,OS1)*2.38
      SMATX(10,OS1)=SMATX(9,OS1)+SMATX(7,OS1)
      SMATX(11,OS1)=SMATX(12,IS1)+.25*DIG13
      SMATX(12,OS1)=SMATX(12,IS1)
      SMATX(13,OS1)=SMATX(13,IS1)+SMATX(5,IS1)*.65*TEMP1
      SMATX(14,OS1)=SMATX(14,IS1)+TEMP1*SMATX(6,IS1)
      SMATX(15,OS1)=SMATX(15,IS1)
      SMATX(16,OS1)=SMATX(16,IS1)+(SMATX(13,OS1)-SMATX(13,IS1))*3.57
      SMATX(17,OS1)=(SMATX(11,OS1)-SMATX(12,OS1))*1.87
      SMATX(18,OS1)=SMATX(18,IS1)
      SMATX(19,OS1)=SMATX(19,IS1)
      SMATX(20,OS1)=SMATX(20,IS1)
C
C
C          CALC. OF OUTPUT SIZES AND QUANTITIES
C
      CH4=163.85*(DIG12-DIG13)*SMATX(2,IS1)
      CO2=249.9*(DIG12-DIG13)*SMATX(2,IS1)-CH4
```

```
      VDIG=SMATX(2,IS1)*DMATX(1,N)*1000./7.48*DMATX(16,N)
C
C
C             CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C             CAPACITY
C
      X=ALOG(VDIG)
      IF (VDIG-20.) 30,40,40
C
C
C                     CALC. OF CAPITAL COSTS FOR SMALL DIG FACILITY, LESS
C                     THAN 20000 CU. FT.
C
   30 CCOST(N,1)=EXP(4.594215+.127244*X-.004001*X**2.)*1000.
      GO TO 50
C
C
C                     CALC. OF CAPITAL COSTS FOR LARGE DIG FACILITY, EQUAL
C                     OR GREATER THAN 20000 CU. FT.
C
   40 CCOST(N,1)=EXP(7.679634-1.949689*X+.402610*X**2.-.018211*X**3.)*10
     100.
C
C
C             CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C             DOES NOT INCLUDE EXCESS CAPACITY
C
   50 X=ALOG(VDIG/DMATX(16,N))
      IF (VDIG-20.) 60,70,70
C
C
C                     CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                     AND MATERIALS AND SUPPLIES FOR DIG FACILITY, LESS
C                     THAN 20000 CU. FT.
C
   60 OHRS=EXP(6.163803+.166305*X-.012470*X**2.)
      XMHRS=EXP(5.726981+.113674*X)
      TMSU=EXP(6.531623+.198417*X+.021660*X**2.)
      GO TO 80
C
C
C                     CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                     AND MATERIALS AND SUPPLIES FOR DIG FACILITY, EQUAL
C                     OR GREATER THAN 20000 CU. FT.
C
   70 OHRS=EXP(9.129250-1.816736*X+.373282*X**2.-.017290*X**3.)
      XMHRS=EXP(8.566752-1.768137*X+.363173*X**2.-.016620*X**3.)
      TMSU=EXP(8.702803-1.182711*X+.282691*X**2.-.013672*X**3.)
C
C
C                     OPERATING COST EQUATION
C
   80 COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C             ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=C1DIG
      OMATX(2,N)=C2DIG
      OMATX(3,N)=VDIG
      OMATX(4,N)=CH4
      OMATX(5,N)=CO2
C
C
C             PROCESS ENERGY INDICES
C
```

```
      FLOW(N)=SMATX(2,IS1)                                              DIG12500
      POW(N)=6.                                                         DIG12600
      RETURN                                                            DIG12700
      END                                                               DIG12800
```

SECTION 8

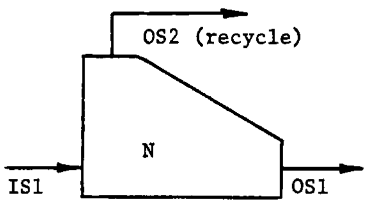
VACUUM FILTRATION, VACF

Subroutine Identification Number 7

Vacuum Filtration, VACF

Rev. Date 8/1/77

1. Process symbol.



IS1: Sludge input stream

OS1: Sludge cake output stream

OS2: Liquid recycle output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX (1,N) = VFL	Vacuum filter loading rate, gph/sq ft. [4.9]
DMATX (2,N) = HPWK	Hours per week that the vacuum filter is operated, hr/wk. [35.]
DMATX (3,N) = TSS	Total suspended solids concentration of OS2, mg/l. [200.]
DMATX (4,N) = IVACF	Program control: 0 = landfill disposal of sludge, 1 = incineration disposal of sludge. [1.]
DMATX (5,N) = FECL3	Dose of ferric chloride added to condition the sludge, lb/ton. [42.]
DMATX (6,N) = CAO	Dose of lime added to condition the sludge, lb/ton. [176.]
DMATX (7,N) = CFECL	Cost of ferric chloride, $/lb. [.064]
DMATX (8,N) = CCAO	Cost of lime, $/lb. [.0125]
DMATX (9,N) = DPOLY	Dose of polymer added to condition the sludge, lb/ton. [15.]
DMATX (10,N) = CPOLY	Cost of polymer, $/lb. [.33]
DMATX (16,N) = ECF	Excess capacity factor for the process. [1.]

3. Output parameters which are printed on computer output sheets.

IVACF = DMATX (4,N)

FECL3 = DMATX (5,N)

CAO = DMATX (6,N)

CFECL = DMATX (7,N)

CCAO = DMATX (8,N)

DPOLY = DMATX (9,N)

CPOLY = DMATX(10,N)

WP = OMATX(1,N) — Percentage of moisture in the filtered sludge.

AVF = OMATX(2,N) — Surface area of the vacuum filter, sq.ft.

PSDD = OMATX(3,N) — Amount of dry solids produced by the vacuum filter, lb/day.

CCOST — Capital cost, [dollars].

COSTO — Operating and maintenance costs,[cents/1000 gal].

ACOST — Amortization cost, [cents/1000 gal].

TCOST — Total treatment cost,[cents/1000 gal].

ECF — Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
SMATX(7,IS1) = SMATX(7,IS1)+(FECL3+CAO+DPOLY)*SMATX(10,IS1)/2000.     VAC02900
```

$$SFM_{IS1} = SFM_{IS1} + \frac{(FECL3+CAO+DPOLY)TSS_{IS1}}{2000} \quad [mg/l]$$

```
SMATX(10,IS1) = SMATX(10,IS1)+(FECL3+CAO+DPOLY)*SMATX(10,IS1)/2000.   VAC03000
```

$$TSS_{IS1} = TSS_{IS1} + \frac{(FECL3+CAO+DPOLY)TSS_{IS1}}{2000} \quad [mg/l]$$

```
SMATX(10,OS2) = DMATX(3,N)                                            VAC03100
```

$$TSS_{OS2} = TSS \quad [mg/l]$$

```
WP = 88./(SMATX(10,IS1)/10000.)**.123                                 VAC03200
```

$$WP = \frac{88}{\left[\frac{TSS_{IS1}}{10000}\right]^{0.123}} \quad [mg/l]$$

```
SMATX(10,OS1) = (100.-WP)*10000.                                      VAC03300
```

$$TSS_{OS1} = 10000(100-WP) \quad [mg/l]$$

```
SMATX(2,OS1) =(SMATX(2,IS1)*SMATX(10,IS1))/(SMATX(10,OS1)-SMATX(10,OS2))
```

$$Q_{OS1} = \frac{Q_{IS1} * TSS_{IS1}}{TSS_{OS1} - TSS_{OS2}} \quad [mg/l] \quad VAC03400$$

SMATX(2,OS2) = SMATX(2,IS1)-SMATX(2,OS1) VAC03600

$Q_{OS2} = Q_{IS1} - Q_{OS1}$ [mg/1]

TEMP2 = SMATX(10,OS1)/SMATX(10,IS1) VAC03700

$TEMP2 = \frac{TSS_{OS1}}{TSS_{IS1}}$ [no units]

TEMP3 = SMATX(10,OS2)/SMATX(10,IS1) VAC03800

$TEMP3 = \frac{TSS_{OS2}}{TSS_{IS1}}$ [no units]

SMATX(I,OS1) = TEMP2*SMATX(I,IS1) ·VAC04400

SMATX(I,OS1) = TEMP2*SMATX(I,IS1) [mg/1]

where I = 3,9 i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS

SMATX(I,OS2) = TEMP3*SMATX(I,IS1) VAC04500

SMATX(I,OS2) = TEMP3*SMATX(I,IS1) [mg/1]

where I = 3,9

SMATX(I,OS1) = TEMP2*SMATX(I,IS1) VAC04700

SMATX(I,OS1) = TEMP2*SMATX(I,IS1) [mg/1]

where I = 11,17 i.e. DOC,DNBC,DN,DP,DFM,ALK,DBOD

SMATX(I,OS2) = SMATX(I,IS1) VAC04800

SMATX(I,OS2) = SMATX(I,IS1) [mg/1]

where I = 11,17

SMATX(18,OS1) = SMATX(18,IS1) VAC04900

$NH3_{OS1} = NH3_{IS1}$ [mg/1]

SMATX(18,OS2) = SMATX(18,IS1) VAC05000

$NH3_{OS2} = NH3_{IS1}$ [mg/1]

SMATX(19,OS1) = SMATX(19,IS1) VAC05100

$NO3_{OS1} = NO3_{IS1}$ [mg/1]

SMATX(19,OS2) = SMATX(19,IS1) VAC05200

$NO3_{OS2} = NO3_{IS1}$ [mg/1]

SMATX(20,OS1) = SMATX(20,IS1) VAC05300

SMATX(20,OS1) = SMATX(20,IS1) Future parameter

SMATX(20,OS2) = SMATX(20,IS1) VAC05400

SMATX(20,OS2) = SMATX(20,IS1) Future parameter

SF = SMATX(10,IS1)/10000. VAC05900

$$SF = \frac{TSS_{IS1}}{10000}$$ [%]

SC = 100.-WP VAC06000

SC = 100-WP [%]

FVF = DMATX(1,N)/11.99/(1./SF-1./SC) VAC06100

$$FVF = \frac{VFL}{11.99\left[\frac{1}{SF} - \frac{1}{SC}\right]}$$ $[lb/hr/ft^2]$

AVF = SMATX(10,IS1)*SMATX(2,IS1)*58.31/FVF/DMATX(2,N)*DMATX(16,N) VAC06200

$$AVF = \frac{TSS_{IS1}*Q_{IS1}*58.31*ECF}{FVF*HPWK}$$ $[ft^2]$

PSDD = SMATX(10,IS1)*SMATX(2,IS1)*8.33 VAC06400

$PSDD = TSS_{IS1} * Q_{IS1} * 8.33$ [lb/day]

References:

Smith and Eilers, 1975

Patterson and Banker, 1971

5. Cost functions.

a. Capital cost

Function of AVF

X = ALOG(AVF) VAC07000

X = ln AVF

```
CCOST(N,1) = EXP(3.288028+.194537*X+.038313*X**2.)*1000.                VAC07100
```

$$CCOST = 1000e^{3.288028+0.194537X+0.038313X^2} \quad [dollars]$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of PSDD

```
X = ALOG(PSDD*365./2000.)                                              VAC07700
```

$$X = \ln \frac{365\ PSDD}{2000}$$

(1) Operating manhours

(a) For IVACF = 0 Landfill operation

```
OHRS = EXP(6.069419-.009894*X+.042699*X **2.)                          VAC08400
```

$$OHRS = e^{6.069419-0.009894X+0.042699X^2} \quad [hrs/yr]$$

(b) For IVACF = 1 Incineration operation

```
OHRS = EXP(3.714368+.850848*X-.074615*X**2.+.005085*X**3.)             VAC09100
```

$$OHRS = e^{3.714368+0.850848X-0.074615X^2+0.005085X^3} \quad [hrs/yr]$$

(2) Maintenance manhours

```
XMHRS = EXP(4.306110-.093695*X+.047738*X**2.)                          VAC09700
```

$$XMHRS = e^{4.306110-0.093695X+0.047738X^2} \quad [hrs/yr]$$

(3) Supplies

```
SUPP = EXP(-3.113515+.718466*X)*1000.                                  VAC09800
```

$$SUPP = 1000e^{-3.113515+0.718466X} \quad [dollars/yr]$$

(4) Chemicals

```
CHEM = PSDD*365./2000.*(FECL3*CFECL+CAO*CCAO+DPOLY*CPOLY)              VAC09900
```

$$CHEM = \frac{PSDD*365*[(FECL3*CFECL)+(CAO*CCAO)+(DPOLY*CPOLY)]}{2000} \quad [dollars/yr]$$

c. Total operating and maintenance costs VAC10400

```
COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+SUPP*WPI+CHEM)/SMATX(2,1)/3650.
```

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+(SUPP*WPI)+CHEM}{Q_{Plant\ Inf.}*3650} \quad [\text{cents/1000 gal}]$$

Cost curves, Banker and Patterson page 50.

```
C                                                                       VAC00100
C           VACUUM FILTRATION                                           VAC00200
C           PROCESS IDENTIFICATION NUMBER   7                           VAC00300
C                                                                       VAC00400
      SUBROUTINE VACF                                                   VAC00500
C                                                                       VAC00600
C                                                                       VAC00700
C           COMMON INITIAL STATEMENTS                                   VAC00800
C                                                                       VAC00900
      INTEGER OS1,OS2                                                   VAC01000
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),VAC01100
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)VAC01200
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)   VAC01300
C                                                                       VAC01400
C                                                                       VAC01500
C           ASSIGNMENT OF DESIGN VALUES TO CHEMICAL PARAMETERS          VAC01600
C                                                                       VAC01700
      FECL3=DMATX(5,N)                                                  VAC01800
      CAO=DMATX(6,N)                                                    VAC01900
      CFECL=DMATX(7,N)                                                  VAC02000
      CCAO=DMATX(8,N)                                                   VAC02100
      DPOLY=DMATX(9,N)                                                  VAC02200
      CPOLY=DMATX(10,N)                                                 VAC02300
C                                                                       VAC02400
C                                                                       VAC02500
C           PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM        VAC02600
C           CHARACTERISTICS                                             VAC02700
C                                                                       VAC02800
      SMATX(7,IS1)=SMATX(7,IS1)+(FECL3+CAO+DPOLY)*SMATX(10,IS1)/2000.   VAC02900
      SMATX(10,IS1)=SMATX(10,IS1)+(FECL3+CAO+DPOLY)*SMATX(10,IS1)/2000. VAC03000
      SMATX(10,OS2)=DMATX(3,N)                                          VAC03100
      WP=88./(SMATX(10,IS1)/10000.)**.123                               VAC03200
      SMATX(10,OS1)=(100.-WP)*10000.                                    VAC03300
      SMATX(2,OS1)=(SMATX(2,IS1)*SMATX(10,IS1))/(SMATX(10,OS1)-SMATX(10,VAC03400
     1OS2))                                                             VAC03500
      SMATX(2,OS2)=SMATX(2,IS1)-SMATX(2,OS1)                            VAC03600
      TEMP2=SMATX(10,OS1)/SMATX(10,IS1)                                 VAC03700
      TEMP3=SMATX(10,OS2)/SMATX(10,IS1)                                 VAC03800
C                                                                       VAC03900
C                                                                       VAC04000
C           EFFLUENT STREAM CALCULATIONS                                VAC04100
C                                                                       VAC04200
      DO 10 I=3,9                                                       VAC04300
      SMATX(I,OS1)=TEMP2*SMATX(I,IS1)                                   VAC04400
   10 SMATX(I,OS2)=TEMP3*SMATX(I,IS1)                                   VAC04500
      DO 20 I=11,17                                                     VAC04600
      SMATX(I,OS1)=TEMP2*SMATX(I,IS1)                                   VAC04700
   20 SMATX(I,OS2)=SMATX(I,IS1)                                         VAC04800
      SMATX(18,OS1)=SMATX(18,IS1)                                       VAC04900
      SMATX(18,OS2)=SMATX(18,IS1)                                       VAC05000
      SMATX(19,OS1)=SMATX(19,IS1)                                       VAC05100
      SMATX(19,OS2)=SMATX(19,IS1)                                       VAC05200
      SMATX(20,OS1)=SMATX(20,IS1)                                       VAC05300
      SMATX(20,OS2)=SMATX(20,IS1)                                       VAC05400
C                                                                       VAC05500
C                                                                       VAC05600
C           CALC. OF OUTPUT SIZES AND QUANTITIES                        VAC05700
C                                                                       VAC05800
```

```
      SF=SMATX(10,IS1)/10000.
      SC=100.-WP
      FVF=DMATX(1,N)/11.99/(1./SF-1./SC)
      AVF=SMATX(10,IS1)*SMATX(2,IS1)*58.31/FVF/DMATX(2,N)*DMATX(16,N)
      IVACF=DMATX(4,N)
      PSDD=SMATX(10,IS1)*SMATX(2,IS1)*8.33
C
C
C              CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C              CAPACITY
C
      X=ALOG(AVF)
      CCOST(N,1)=EXP(3.288028+.194537*X+.038313*X**2.)*1000.
C
C
C              CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C              DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(PSDD*365./2000.)
      IF (IVACF) 40,30,40
C
C
C                     CALC. OF OPERATING MANHOURS IF LANDFILL DISPOSAL IS
C                     USED
C
   30 OHRS=EXP(6.069419-.009894*X+.042699*X**2.)
      GO TO 50
C
C
C                     CALC. OF OPERATING MANHOURS IF INCINERATION DISPOSAL
C                     IS USED
C
   40 OHRS=EXP(3.714368+.850848*X-.074615*X**2.+.005085*X**3.)
C
C
C                     CALC. OF MAINTENANCE MANHOURS AND SUPPLIES AND
C                     CHEMICAL COSTS FOR VACF FACILITY
C
   50 XMHRS=EXP(4.306110-.093695*X+.047738*X**2.)
      SUPP=EXP(-3.113515+.718466*X)*1000.
      CHEM=PSDD*365./2000.*(FECL3*CFECL+CAO*CCAO+DPOLY*CPOLY)
C
C
C                     OPERATING COST EQUATION
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+SUPP*WPI+CHEM)/SMATX(2,1)/36
     150.
C
C
C              ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=WP
      OMATX(2,N)=AVF
      OMATX(3,N)=PSDD
C
C
C              PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=7.
      RETURN
      END
```

SECTION 9

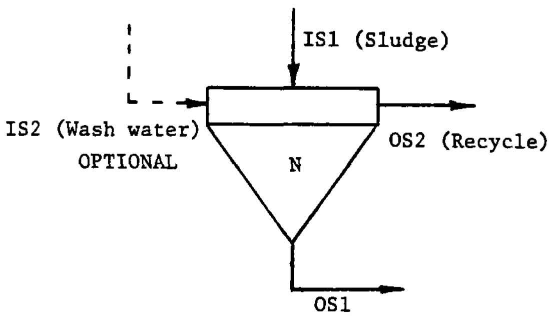
GRAVITY THICKENING, THICK

Subroutine Identification Number 8

Gravity Thickening, THICK

Rev. Date 8/1/77

1. Process symbol.



IS1: Sludge input stream

IS2: Wash water input stream

OS1: Liquid output stream

OS2: Recycle output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = TRR	Solids recovery ratio for thickening. [.95]
DMATX(2,N) = TSS	Total suspended solids concentration of OS1, mg/l. [50,000.]
DMATX(3,N) = GTH	Design overflow rate for the thickener, gpd/sq ft. [700.]
DMATX(4,N) = GSTH	Design solids loading rate for the thickener, lb/day/sq ft. [8.]
DMATX(16,N) = ECF	Excess capacity factor for the process. [1.5]

3. Output parameters which are printed on computer output sheets.

TSS_{OS1} = DMATX(2,N)

ATHM = OMATX(1,N)	Surface area of the gravity thickener, [sq. ft.]
WRT = OMATX(2,N)	Ratio of dilution stream flow in mgd/influent sludge stream flow in mgd.
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000 gal].
ACOST	Amortization cost, [cents/1000 gal].

TCOST Total treatment cost,[cents/1000 gal].

ECF Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

SMAT(I) = 0 THI02100

where I = 1,20

SMAT(I) = SMATX(I,IS2) THI02400

SMAT(I)=SMATX(I,IS2) [MGD and mg/l]

where I = 1,20

i.e. I, Q, SOC, SNBC, SON, SOP, SFM, SBOD, VSS, TSS, DOC, DNBC, DN, DP, DFM, ALK, DBOD, NH3,NO3

SMATX(2,OS1) = DMATX(1,N)*(SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10))/SMATX(10,OS1)

$$Q_{OS1} = \frac{TRR*[(Q_{IS1}*TSS_{IS1})+(Q_{IS2}*TSS_{IS2})]}{TSS_{OS1}} \quad [MGD] \qquad THI02600$$

TEMP = DMATX(4,N)/DMATX(3,N)*1000000./8.33 THI02800

$$TEMP = \frac{1000000\ GSTH}{8.33\ GTH} \quad [mg/l]$$

WRT = (SMATX(10,IS1)-TEMP)/(TEMP-SMAT(10)) THI03200

$$WRT = \frac{TSS_{IS1}-TEMP}{TEMP-TSS_{IS2}} \quad [mg/l]$$

SMATX(2,IS2) = WRT*SMATX(2,IS1) THI03300

$$Q_{IS2} = WRT*Q_{IS1} \quad [MGD]$$

SMAT(2) SMATX(2,IS2) THI03400

$$SMAT(2) \quad Q_{IS2} \quad [MGD]$$

SMATX(2,OS2) = SMATX(2,IS1)+SMAT(2)-SMATX(2,OS1) THI03500

$$Q_{OS2} = Q_{IS1}+Q_{IS2}-Q_{OS1} \quad [MGD]$$

TEMP = SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10) THI03600

$$TEMP = Q_{IS1}*TSS_{IS1}+Q_{IS2}*TSS_{IS2} \quad [MGD-mg/l]$$

SMATX(10,OS2) = (TEMP-SMATX(2,OS1)*SMATX(10,OS1))/SMATX(2,OS2) THI03700

$$TSS_{OS2} = \frac{TEMP-(Q_{OS1}*TSS_{OS1})}{Q_{OS2}} \quad [mg/l]$$

TEMP = TEMP/(SMATX(2,IS1)+SMAT(2)) THI03800

$$TEMP = \frac{TEMP}{Q_{IS1}+Q_{IS2}} \quad [mg/l]$$

TEMP1 = SMATX(10,OS1)/TEMP THI03900

$$TEMP1 = \frac{TSS_{OS1}}{TEMP} \quad [no\ units]$$

TEMP2 = SMATX(10,OS2)/TEMP THI04000

$$TEMP2 = \frac{TSS_{OS2}}{TEMP} \quad [no\ units]$$

TEMP3 = (SMATX(2,IS1)*SMATX(I,IS1)+SMAT(2)*SMAT(I))/(SMATX(2,IS1)+SMAT(2))

$$TEMP3 = \frac{(Q_{IS1}*SMATX(I,IS1))+(Q_{IS2}*SMAT(I))}{Q_{IS1}+Q_{IS2}} \quad [mg/l]$$ THI04600

where I = 3,9

i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS

SMATX(I,OS1) = TEMP1*TEMP3 THI04800

SMATX(I,OS1) = TEMP1 * TEMP3 [mg/l]

where I = 3,9

SMATX(I,OS2) = TEMP2 * TEMP3 THI04900

SMATX(I,OS2) = TEMP2*TEMP3 [mg/l]

where I = 3,9

SMATX(I,OS1) = (SMATX(I,IS1)*SMATX(2,IS1)+SMAT(I)*SMAT(2))/(SMATX(2,IS1)+SMAT(2))

$$SMATX(I,OS1) = \frac{(SMATX(I,IS1)*Q_{IS1})+(SMAT(I)*Q_{IS2})}{Q_{IS1}+Q_{IS2}} \quad [mg/l]$$ THI05100

where I = 11,20

i.e. DOC,DNBC,DN,DP.DFM,ALK,DBOD,NH3,NO3

SMATX(I,OS2) = SMATX(I,OS1) THI05300

SMATX(I,OS2) = SMATX(I,OS1) [mg/l]

where I = 11,20

ATH1 = (SMATX(2,OS2)+SMATX(2,OS1))*1000000./DMATX(3,N)*DMATX(16,N)

$$ATH1 = \frac{(Q_{OS2}+Q_{OS1})*1000000*ECF}{GTH} \quad [ft^2]$$ THI05800

```
ATH2 = SMATX(2,IS1)*SMATX(10,IS1)*8.33/DMATX(4,N)*DMATX(16,N)         THI06000
```

$$ATH2 = \frac{Q_{IS1}*TSS_{IS1}*8.33*ECF}{GSTH} \quad [ft^2]$$

ATHM = ATH2 [For ATH1 - ATH2 <0] THI06200

ATHM = ATH1 [For ATH1 - ATH2 $\geq$0] THI06400

References:

Smith and Eilers, 1975

Patterson and Banker, 1971

5. Cost functions.

a. Capital cost

Function of ATHM

```
X = ALOG(ATHM/1000.)                                                  THI07000
```

$$X = \ln \frac{ATHM}{1000}$$

```
CCOST(N,1) = EXP(3.725902+.397690*X+.075742*X**2.-.001977*X**3.-.000296*X**4.)*1000.
                                                                        THI07100
```

$$CCOST = 1000e^{3.725902+0.397690X+0.075742X^2-0.001977X^3-0.000296X^4} \quad [dollars]$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of ATHM/ECF

```
X = ALOG(ATHM/1000./DMATX(16,N))                                      THI07800
```

$$X = \ln \frac{ATHM}{1000ECF}$$

(1) For (EXP(X)-1<0)

(a) Operating manhours

OHRS = 350 [hrs/yr] THI08600

(b) Maintenance manhours

XMHRS 190 [hrs/yr] THI08700

(c) Total materials and supplies

TMSU 250 [dollars/yr] THI08800

(2) For (EXP(X)-1$\geq$0)

(a) Operating manhours

```
OHRS = EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)            THI09600
```

$$OHRS \quad e^{5.846565+0.254813X+0.113703X^2-0.010942X^3} \quad [hrs/yr]$$

(b) Maintenance manhours

```
XMHRS = EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)          THI09700
```

$$XMHRS = e^{5.273419+0.228329X+0.122646X^2-0.011672X^3} \quad [hrs/yr]$$

(c) Total materials and supplies

```
TMSU = EXP(5.669881+.750799*X)                                        THI09800
```

$$TMSU = e^{5.669881+0.750799X} \quad [dollars/yr]$$

c. Total operating and maintenance costs

```
COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.   THI10300
```

$$COSTO = \frac{(OHRS+XMHRS)*DHR*(1+PCT)+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650} \quad [cents/1000\ gal]$$

```
C
C          GRAVITY THICKENING
C          PROCESS IDENTIFICATION NUMBER   8
C
      SUBROUTINE THICK
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      DIMENSION SMAT(20)
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C          PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C          CHARACTERISTICS
C
      DO 10 I=1,20
   10 SMAT(I)=0.
      IF (IS2) 40,40,20
   20 DO 30 I=1,20
   30 SMAT(I)=SMATX(I,IS2)
   40 SMATX(10,OS1)=DMATX(2,N)
      SMATX(2,OS1)=DMATX(1,N)*(SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(1
     10))/SMATX(10,OS1)
      TEMP=DMATX(4,N)/DMATX(3,N)*1000000./8.33
      IF (IS2) 60,50,60
   50 WRT=0.
      GO TO 70
   60 WRT=(SMATX(10,IS1)-TEMP)/(TEMP-SMAT(10))
      SMATX(2,IS2)=WRT*SMATX(2,IS1)
      SMAT(2)=SMATX(2,IS2)
   70 SMATX(2,OS2)=SMATX(2,IS1)+SMAT(2)-SMATX(2,OS1)
      TEMP=SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10)
      SMATX(10,OS2)=(TEMP-SMATX(2,OS1)*SMATX(10,OS1))/SMATX(2,OS2)
      TEMP=TEMP/(SMATX(2,IS1)+SMAT(2))
      TEMP1=SMATX(10,OS1)/TEMP
      TEMP2=SMATX(10,OS2)/TEMP
C
C
C          EFFLUENT STREAM CALCULATIONS
C
      DO 80 I=3,9
      TEMP3=(SMATX(2,IS1)*SMATX(I,IS1)+SMAT(2)*SMAT(I))/(SMATX(2,IS1)+SM
     1AT(2))
      SMATX(I,OS1)=TEMP1*TEMP3
   80 SMATX(I,OS2)=TEMP2*TEMP3
      DO 90 I=11,20
      SMATX(I,OS1)=(SMATX(I,IS1)*SMATX(2,IS1)+SMAT(I)*SMAT(2))/(SMATX(2,
     1IS1)+SMAT(2))
   90 SMATX(I,OS2)=SMATX(I,OS1)
C
C
C          CALC. OF OUTPUT SIZES AND QUANTITIES
C
      ATH1=(SMATX(2,OS2)+SMATX(2,OS1))*1000000./DMATX(3,N)*DMATX(16,N)
```

```
      IF (IS2) 120,100,120
  100 ATH2=SMATX(2,IS1)*SMATX(10,IS1)*8.33/DMATX(4,N)*DMATX(16,N)
      IF (ATH1-ATH2) 110,120,120
  110 ATHM=ATH2
      GO TO 130
  120 ATHM=ATH1
C
C
C             CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C             CAPACITY
C
  130 X=ALOG(ATHM/1000.)
      CCOST(N,1)=EXP(3.725902+.397690*X+.075742*X**2.-.001977*X**3.-.000
     1296*X**4.)*1000.
C
C
C             CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C             DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(ATHM/1000./DMATX(16,N))
      IF (EXP(X)-1.) 140,150,150
C
C
C                   CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                   AND MATERIALS AND SUPPLIES FOR THICK FACILITY,
C                   LESS THAN 1000 SQ. FT.
C
  140 OHRS=350.
      XMHRS=190.
      TMSU=250.
      GO TO 160
C
C
C                   CALC.OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                   AND MATERIALS AND SUPPLIES FOR THICK FACILITY,
C                   EQUAL OR GREATER THAN 1000 SQ. FT.
C
  150 OHRS=EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)
      XMHRS=EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)
      TMSU=EXP(5.669881+.750799*X)
C
C
C                   OPERATING COST EQUATION
C
  160 COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C             ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=ATHM
      OMATX(2,N)=WRT
C
C
C             PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=8.
      RETURN
      END
```

SECTION 10

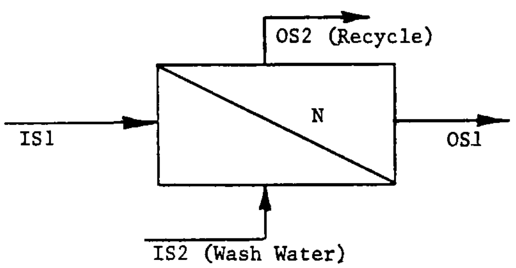
ELUTRIATION, ELUT

Subroutine Identification Number 9

Rev. Date 8/1/77

Elutriation, ELUT

1. Process symbol.



IS1: Sludge input stream

IS2: Wash water input stream

OS1: Sludge output stream

OS2: Recycle output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) - ERR	Solids recovery ratio for elutriation. [.76]
DMATX(2,N) = TSS	Total suspended solids concentration of OS1, mg/l. [60,000.]
DMATX(3,N) = WRE	Wash water ratio for elutriation. [3.]
DMATX(4,N) = GE	Design overflow rate for elutriation, gpd/sq ft. [800.]
DMATX(5,N) = GES	Design solids loading rate for elutriation, lb/day/sq ft. [9.]
DMATX(16,N) = ECF	Excess capacity factor for the process. [1.5]

3. Output parameters which are printed on computer output sheets.

ERR = DMATX(1,N)	
TSS = DMATX(2,N)	
WRE = DMATX(3,N)	
GE = DMATX(4,N)	
GES = DMATX(5,N)	
AE = OMATX(1,N)	Surface area of the elutriation tank, sq. ft.
CCOST	Capital cost, [dollars]
COSTO	Operating and maintenance cost, [cents/1000 gal]
ACOST	Amortization cost, [cents/1000 gal]
TCOST	Total treatment cost, [cents/1000 gal]
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
SMATX(10,OS1) = DMATX(2,N)                    ELU01900
```

$$TSS_{OS1} = TSS \quad [mg/l]$$

```
SMATX(2,IS2) = DMATX(3,N)*SMATX(2,IS1)        ELU02000
```

$$Q_{IS2} = WRE * Q_{IS1} \quad [MGD]$$

```
AE1 = SMATX(2,IS1)*1000000./DMATX(4,N)        ELU04500
```

$$AE1 = \frac{Q_{IS1} * 1000000}{GE} \quad [ft^2]$$

AE2 = SMATX(2,IS1)*SMATX(10,IS1)*8.33/DMATX(5,N) ELU04600

$$AE2 = \frac{Q_{IS1} * TSS_{IS1} * 8.33}{GES} \quad [ft^2]$$

AE = AE1*DMATX(16,N) If (AE1-AE2)>0 ELU04800

$$AE = AE1 * ECF \quad [ft^2]$$

AE = AE2*DMATX(16,N) If (AE1-AE2)≤0 ELU05000

$$AE \quad AE2 * ECF \quad [ft^2]$$

SMATX(2,OS1)=DMATX(1,N)*SMATX(2,IS1)*SMATX(10,IS1)/SMATX(10,OS1) ELU02100

$$Q_{OS1} = \frac{ERR * Q_{IS1} * TSS_{IS1}}{TSS_{OS1}} \quad [MGD]$$

SMATX(2,OS2)=SMATX(2,IS1)+SMATX(2,IS2)-SMATX(2,OS1) ELU02200

$$Q_{OS2} = Q_{IS1} + Q_{IS2} - Q_{OS1} \quad [MGD]$$

TEMP - SMATX(2,IS1)*SMATX(10,IS1)+SMATX(2,IS2)*SMATX(10,IS2) ELU02300

$$TEMP = [Q_{IS1}*TSS_{IS1}] + [Q_{IS2}*TSS_{IS2}] \quad [MGD \cdot mg/l]$$

SMATX(10,OS2)=(TEMP-SMATX(2,OS1)*SMATX(10,OS1))/SMATX(2,OS2) ELU02400

$$TSS_{OS2} = \frac{TEMP - [Q_{OS1}*TSS_{OS1}]}{Q_{OS2}} \quad [mg/l]$$

TEMP = TEMP/(SMATX(2,IS1)+SMATX(2,IS2)) ELU02500

$$TEMP \quad \frac{TEMP}{Q_{IS1}+Q_{IS2}} \quad [mg/l]$$

TEMP1 = SMATX(10,OS1)/TEMP ELU02600

$$TEMP1 = \frac{TSS_{OS1}}{TEMP} \quad [no\ units]$$

TEMP2 = SMATX(10,OS2)/TEMP ELU02700

$$TEMP2 = \frac{TSS_{OS2}}{TEMP} \quad \text{[no units]}$$

TEMP3 = (SMATX(2,IS1)*SMATX(I,IS1)+SMATX(2,IS2)*SMATX(I,IS2))/(SMATX(2,IS1)+SMATX(2,IS2)) ELU03300

$$TEMP3 = \frac{[Q_{IS1}*SMATX(I,IS1)] + [Q_{IS2}*SMATX(I,IS2)]}{Q_{IS1} + Q_{IS2}} \quad \text{[mg/l]}$$

where I = 3,9 i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS

SMATX(I,OS1) = TEMP1 * TEMP3 ELU03500

SMATX(I,OS1) = TEMP1 * TEMP3 [mg/l]

where I = 3,9

i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS

SMATX(I,OS2) = TEMP2 * TEMP3 ELU03600

SMATX(I,OS2) = TEMP2 * TEMP3 [mg/l]

where I = 3,9

SMATX(I,OS1) = (SMATX(I,IS1)*SMATX(2,IS1)+SMATX(I,IS2)*SMATX(2,IS2))/(SMATX(2,IS1)+SMATX(2,IS2)) ELU03800

$$SMATX(I,OS1) = \frac{(SMATX(I,IS1)*Q_{IS1})+(SMATX(I,IS2)*Q_{IS2})}{Q_{IS1} + Q_{IS2}} \quad \text{[mg/l]}$$

where I = 11,20 i.e. DOC,DNBC,DN,DP,DFM,ALK,DBOD,NH3,NO3

SMATX(I,OS2) = SMATX(I,OS1) ELU04000

SMATX(I,OS2) = SMATX(I,OS1) [mg/l]

where I = 11,20.

References:

Smith and Eilers, 1975

Patterson and Banker, 1971

5. Cost functions.

a. Capital cost

Function of AE

X = ALOG(AE/1000.) ELU05600

$$X = \ln \frac{AE}{1000}$$

CCOST(N,1) EXP(3.725902+.397690*X+.075742*X**2.-.001977*X**3.-.000296*X**4.)*1000.

$$CCOST = 1000e^{3.725902+0.397690X+0.075742X^2-0.001977X^3-0.000296X^4} \quad \text{[dollars]}$$

ELU05700

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of AE/ECF

X = ALOG(AE/1000./DMATX(16,N)) ELU06400

$$X \quad \ln \frac{AE}{1000*ECF}$$

(1) Operating manhours

(a) EXP(X)<1 ELU06500

OHRS 350. [hrs/yr] ELU07200

(b) EXP(X)$\geq$1 ELU06500

OHRS = EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.) ELU08200

$$OHRS = e^{5.846565+0.254813X+0.113703X^2-0.010942X^3} \quad \text{[hrs/yr]}$$

(2) Maintenance manhours

(a) EXP(X)<1 ELU06500

XMHRS = 190. [hrs/yr] ELU07300

(b) EXP(X)$\geq$1 ELU06500

XMHRS = EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.) ELU08300

$$XMHRS = e^{5.273419+0.228329X+0.122646X^2-0.011672X^3} \quad \text{[hrs/yr]}$$

(3) Total materials and supplies

(a) EXP(X)<1 ELU06500

TMSU = 250 [dollars/yr] ELU07400

(b) EXP(X)≥1 ELU06500

TMSU = EXP(5.669881+.750799*X) ELU08400

$$TMSU = e^{5.669881+0.750799X} \quad [dollars/yr]$$

c. Total operating and maintenance costs

COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1+PCT)+TMSU*WPI)/SMATX(2,1)/3650. ELU08900

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+(TMSU*WPI)}{Q_{Plant\ Inf.} * 3650} \quad [cents/1000\ gal]$$

```
C
C          ELUTRIATION
C          PROCESS IDENTIFICATION NUMBER   9
C
      SUBROUTINE ELUT
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C          PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C          CHARACTERISTICS
C
      SMATX(10,OS1)=DMATX(2,N)
      SMATX(2,IS2)=DMATX(3,N)*SMATX(2,IS1)
      SMATX(2,OS1)=DMATX(1,N)*SMATX(2,IS1)*SMATX(10,IS1)/SMATX(10,OS1)
      SMATX(2,OS2)=SMATX(2,IS1)+SMATX(2,IS2)-SMATX(2,OS1)
      TEMP=SMATX(2,IS1)*SMATX(10,IS1)+SMATX(2,IS2)*SMATX(10,IS2)
      SMATX(10,OS2)=(TEMP-SMATX(2,OS1)*SMATX(10,OS1))/SMATX(2,OS2)
      TEMP=TEMP/(SMATX(2,IS1)+SMATX(2,IS2))
      TEMP1=SMATX(10,OS1)/TEMP
      TEMP2=SMATX(10,OS2)/TEMP
C
C
C          EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=3,9
      TEMP3=(SMATX(2,IS1)*SMATX(I,IS1)+SMATX(2,IS2)*SMATX(I,IS2))/(SMATX
     1(2,IS1)+SMATX(2,IS2))
      SMATX(I,OS1)=TEMP1*TEMP3
   10 SMATX(I,OS2)=TEMP2*TEMP3
      DO 20 I=11,20
      SMATX(I,OS1)=(SMATX(I,IS1)*SMATX(2,IS1)+SMATX(I,IS2)*SMATX(2,IS2))
     1/(SMATX(2,IS1)+SMATX(2,IS2))
   20 SMATX(I,OS2)=SMATX(I,OS1)
C
C
C          CALC. OF OUTPUT SIZES AND QUANTITIES
C
      AE1=SMATX(2,IS1)*1000000./DMATX(4,N)
      AE2=SMATX(2,IS1)*SMATX(10,IS1)*8.33/DMATX(5,N)
      IF (AE1-AE2) 40,40,30
   30 AE=AE1*DMATX(16,N)
      GO TO 50
   40 AE=AE2*DMATX(16,N)
C
C
C          CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C          CAPACITY
C
   50 X=ALOG(AE/1000.)
      CCOST(N,1)=EXP(3.725902+.397690*X+.075742*X**2.-.001977*X**3.-.000
     1296*X**4.)*1000.
```

```
C                                                                       ELU05900
C                                                                       ELU06000
C          CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,     ELU06100
C          DOES NOT INCLUDE EXCESS CAPACITY                             ELU06200
C                                                                       ELU06300
      X=ALOG(AE/1000./DMATX(16,N))                                      ELU06400
      IF (EXP(X)-1.) 60,70,70                                           ELU06500
C                                                                       ELU06600
C                                                                       ELU06700
C                CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS      ELU06800
C                AND MATERIALS AND SUPPLIES FOR ELUT FACILITY, LESS     ELU06900
C                THAN 1000 SQ. FT.                                      ELU07000
C                                                                       ELU07100
   60 OHRS=350.                                                         ELU07200
      XMHRS=190.                                                        ELU07300
      TMSU=250.                                                         ELU07400
      GO TO 80                                                          ELU07500
C                                                                       ELU07600
C                                                                       ELU07700
C                CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS      ELU07800
C                AND MATERIALS AND SUPPLIES FOR ELUT FACILITY, EQUAL    ELU07900
C                OR GREATER THAN 1000 SQ. FT.                           ELU08000
C                                                                       ELU08100
   70 OHRS=EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)          ELU08200
      XMHRS=EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)         ELU08300
      TMSU=EXP(5.669881+.750799*X)                                      ELU08400
C                                                                       ELU08500
C                                                                       ELU08600
C                OPERATING COST EQUATION                                ELU08700
C                                                                       ELU08800
   80 COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.  ELU08900
C                                                                       ELU09000
C                                                                       ELU09100
C          ASSIGNMENT OF VALUES TO OMATX                                ELU09200
C                                                                       ELU09300
      OMATX(1,N)=AE                                                     ELU09400
C                                                                       ELU09500
C                                                                       ELU09600
C          PROCESS ENERGY INDICES                                       ELU09700
C                                                                       ELU09800
      FLOW(N)=SMATX(2,IS1)                                              ELU09900
      POW(N)=9.                                                         ELU10000
      RETURN                                                            ELU10100
      END                                                               ELU10200
```

SECTION 11

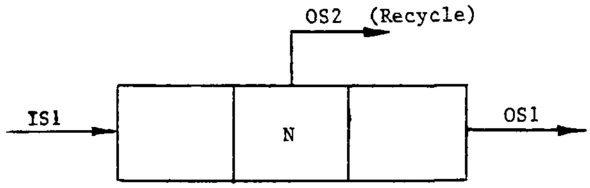
SAND DRYING BEDS, SBEDS

Subroutine Identification Number 10

Sand Drying Beds, SBEDS

Rev. Date 8/1/77

1. Process symbol.



IS1: Sludge input stream

OS1: Sludge cake stream

OS2: Recycle output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = SOUT	Percent solids of OS1, fraction, [.35].
DMATX(2,N) = TSS	Total suspended solids concentration of OS2, mg/l, [50.].
DMATX(16,N) = ECF	Excess capacity factor for the process, [1.5].

3. Output parameters which are printed on computer output sheets.

SOUT = DMATX(1,N)	
TSS = DMATX(2,N)	
ASB = OMATX(1,N)	Area of the sludge drying beds, [sq. ft.].
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000 gal].
ACOST	Amortization cost , [cents/1000 gal].
TCOST	Total treatment cost , [cents/1000 gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

SMATX(2,OS2) = SMATX(2,IS1) SBE01800

$$Q_{OS2} = Q_{IS1} \quad [MGD]$$

SMATX(10,OS2) = DMATX(2,N) SBE01900

$$TSS_{OS2} = TSS \quad [mg/l]$$

TEMP = SMATX(10,OS2)/SMATX(10,IS1) SBE02000

$$TEMP = \frac{TSS_{OS2}}{TSS_{IS1}} \quad [\text{no units}]$$

SMATX(I,OS2) = TEMP*SMATX(I,IS1) SBE02200

SMATX(I,OS2) = TEMP*SMATX(I,IS1) [mg/l]

where I = 3,9 i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS

SMATX(I,OS2) = SMATX(I,IS1) SBE02400

SMATX(I,OS2) = SMATX(I,IS1) [mg/l]

where I = 11,20 i.e. DOC,DNBC,DN,DP,DFM,ALK,DBOD,NH3,NO3

SF = SMATX(10,IS1)/10000. SBE02900

$$SF = \frac{TSS_{IS1}}{10000} \quad [\%]$$

SC = DMATX(1,N)*100. SBE03000

SC = SOUT*100 [%]

FSB = (29.84*SF-33.3)/SC SBE03100

$$FSB = \frac{29.84SF-33.3}{SC} \quad [\text{lb dry solids applied/ft}^2\text{/30 days}]$$

TEMP = SMATX(2,IS1)*SMATX(10,IS1)*249.9 SBE03200

$$TEMP = Q_{IS1}*TSS_{IS1}*249.9 \quad [\text{lb dry solids/30 days}]$$

ASB = TEMP/FSB*DMATX(16,N) SBE03300

$$ASB = \frac{TEMP*ECF}{FSB} \quad [ft^2]$$

PSDD = SMATX(10,IS1)*SMATX(2,IS1)*8.33 SBE03400

$$PSDD = TSS_{IS1}*Q_{IS1}*8.33 \quad [\text{lb dry solids applied/day}]$$

Reference: Smith and Eilers, 1975
Patterson and Banker, 1971

5. Cost functions. (Cost curves, Patterson and Banker pages 48,102,103)

a. Capital cost

Function of ASB

```
X = ALOG(ASB/1000.)                                            SBE04000
```

$$X = \ln\left(\frac{ASB}{1000}\right)$$

```
CCOST(N,1) = EXP(1.971125+.083841*X+.146751*X**2.-.007718*X**3.)*1000.    SBE04100
```

$$CCOST = 1000e^{1.971125+0.083841X+0.146751X^2-0.007718X^3} \quad \text{[dollars]}$$

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of PSDD

```
X = ALOG(PSDD*365./2000.)                                      SBE04800
```

$$X = \ln\left(\frac{365PSDD}{2000}\right) \quad \text{[ln(tons applied/year)]}$$

(1) Operating manhours

```
OHRS = EXP(6.345052-.476780*X+.101319*X**2.)                   SBE05400
```

$$OHRS = e^{6.345052-0.476780X+0.101319X^2} \quad \text{[hrs/yr]}$$

(2) Maintenance manhours

```
XMHRS = EXP(4.290089-.098293*X+.075453*X**2.)                  SBE05500
```

$$XMHRS = e^{4.290089-0.098293X+0.075453X^2} \quad \text{[hrs/yr]}$$

(3) Total materials and supplies

```
TMSU = EXP(.693148+1.000000*X)                                 SBE05600
```

$$TMSU = e^{0.693148+X} \quad \text{[dollars/yr]}$$

c. Total operating and maintenance costs

```
COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
                                                               SBE06100
```

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+[TMSU*WPI]}{Q_{Plant\ Inf.}*3650} \quad \text{[cents/1000 gal]}$$

```
C
C              SAND DRYING BEDS
C              PROCESS IDENTIFICATION NUMBER  10
C
      SUBROUTINE SBEDS
C
C
C              COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C              EFFLUENT STREAM CALCULATIONS
C
      SMATX(2,OS2)=SMATX(2,IS1)
      SMATX(10,OS2)=DMATX(2,N)
      TEMP=SMATX(10,OS2)/SMATX(10,IS1)
      DO 10 I=3,9
   10 SMATX(I,OS2)=TEMP*SMATX(I,IS1)
      DO 20 I=11,20
   20 SMATX(I,OS2)=SMATX(I,IS1)
C
C
C              CALC. OF OUTPUT SIZES AND QUANTITIES
C
      SF=SMATX(10,IS1)/10000.
      SC=DMATX(1,N)*100.
      FSB=(29.84*SF-33.3)/SC
      TEMP=SMATX(2,IS1)*SMATX(10,IS1)*249.9
      ASB=TEMP/FSB*DMATX(16,N)
      PSDD=SMATX(10,IS1)*SMATX(2,IS1)*8.33
C
C
C              CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C              CAPACITY
C
      X=ALOG(ASB/1000.)
      CCOST(N,1)=EXP(1.971125+.083841*X+.146751*X**2.-.007718*X**3.)*100
     10.
C
C
C              CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C              DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(PSDD*365./2000.)
C
C
C                   CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                   AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(6.345052-.476780*X+.101319*X**2.)
      XMHRS=EXP(4.290089-.098293*X+.075453*X**2.)
      TMSU=EXP(.693148+1.000000*X)
C
C
```

```
C                   OPERATING COST EQUATION                                  SBE05900
C                                                                            SBE06000
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.       SBE06100
C                                                                            SBE06200
C                                                                            SBE06300
C             ASSIGNMENT OF VALUES TO OMATX                                  SBE06400
C                                                                            SBE06500
      OMATX(1,N)=ASB                                                         SBE06600
C                                                                            SBE06700
C                                                                            SBE06800
C             PROCESS ENERGY INDICES                                         SBE06900
C                                                                            SBE07000
      FLOW(N)=SMATX(2,IS1)                                                   SBE07100
      POW(N)=10.                                                             SBE07200
      RETURN                                                                 SBE07300
      END                                                                    SBE07400
```

SECTION 12

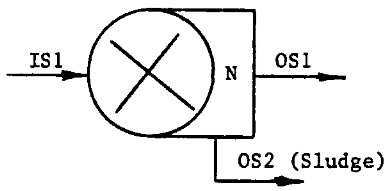
TRICKLING FILTER - FINAL SETTLER, TRFS

Subroutine Identification Number 11

Rev. Date 8/1/77

Trickling Filter - Final Settler, TRFS

1. Process symbol.



IS1: Liquid input stream
OS1: Liquid output stream
OS2: Sludge output stream
N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = BOD	Demand concentration of 5-day BOD in the final effluent from the trickling filter process. [26.]
DMATX(2,N) = DEGC	Water temperature, degrees Centigrade.[20.]
DMATX(3,N) = HQ	Hydraulic loading on the filter, based on sewage flow and not recycly, mgd/acre,[10.]
DMATX(4,N) = SAREA	Specific surface area of the filter, sq ft/cu ft. [10.]
DMATX(5,N) = URSS	Ratio of solids concentration in OS2 (underflow stream) from the final settler to the total solids concentration in the filter effluent.[2.]
DMATX(6,N) = XRSS	Ratio of solids concentration in the final settler effluent to the solids concentration in the filter effluent.[.6]
DMATX(7,N) = RECYCL	Trickling filter recycle ratio.[1.]
DMATX(8,N) = GSS	Design overflow rate for the final settler, gpd/sq ft.[2000.]
DMATX(9,N) = HEAD	Pumping head of the sludge return pumps, ft.[30.]
DMATX(14,N) = ECF	Excess capacity factor fot the sludge return pumps.[1.5]
DMATX(15,N) = ECF	Excess capacity factor for the final settler.[1.2]
DMATX(16,N) = ECF	Excess capacity factor for the filter [1.2]

3. Output parameters which are printed on computer output sheets.

BOD = DMATX(1,N)

DEGC = DMATX(2,N)

HQ = DMATX(3,N)

SAREA = DMATX(4,N)

URSS = DMATX(5,N)

XRSS = DMATX(6,N)

RECYCL = DMATX(7,N)

GSS = DMATX(8,N)

HEAD = DMATX(9,N)

AFS = OMATX(1,N)	Surface area of the final settler, sq ft/1000.
VOL = OMATX(2,N)	Trickling filter total volume, cu ft.
FAREA = OMATX(3,N)	Area of the face of the filter, sq ft.
DEPTH = OMATX(4,N)	Depth of the trickling filter, ft.
CCOST	Capital cost,[dollars]
COSTO	Operating and maintenance cost,[cents/1000gal]
ACOST	Amortization cost,[cents/1000gal]
TCOST	Total treatment cost,[cents/1000gal]
ECF	Excess capacity factor

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

BODIN = SMATX(8,IS1)+SMATX(17,IS1) TRF02000

$BODIN = SBOD_{IS1}+DBOD_{IS1}$ [mg/l]

BETA = .0245*1.035**(DMATX(2,N)-20.) TRF02100

$BETA = 0.0245*[1.035]^{DEGC-20}$ [constant]

XN = .91-6.45/DMATX(4,N) TRF02200

$XN = 0.91- \frac{6.45}{SAREA}$ [constant]

FAREA = SMATX(2,IS1)/DMATX(3,N)*43560. TRF08500

$FAREA = \frac{Q_{IS1}*43560}{HQ}$ [ft^2]

Q6 = DMATX(7,N)*SMATX(2,IS1) TRF02300

$Q6 = RECYCL*Q_{IS1}$ [MGD]

```
RHQ = ((DMATX(7,N)+1.)*DMATX(3,N))**XN                                   TRF02400
```

$$RHQ = [(RECYCL+1)*HQ]^{XN} \qquad [MGAD^{xn}]$$

```
BOD = (SMATX(17,IS1)+DMATX(6,N)*SMATX(8,IS1))/DMATX(1,N)                 TRF02500
```

$$BOD = \frac{DBOD_{IS1}+(XRSS*SBOD_{IS1})}{BOD_{OS1}} \qquad [\text{no units}]$$

```
DEPTH = RHQ*ALOG((BOD+DMATX(7,N))/(DMATX(7,N)+1.))/(BETA*DMATX(4,N))     TRF02600
```

$$DEPTH = \frac{RHQ}{BETA*SAREA}*\ln \frac{BOD+RECYCL}{1+RECYCL} \qquad [ft]$$

```
XPO = EXP(BETA*DMATX(4,N)*DEPTH/RHQ)                                     TRF02700
```

$$XPO = e^{\frac{BETA*SAREA*DEPTH}{RHQ}}$$

```
BODO = BODIN/(XPO*(DMATX(7,N)*(1.-1./XPO)+1.))                           TRF02800
```

$$BODO = \frac{BODIN}{XPO*[RECYCL*(1-\frac{1}{XPO})+1]} \qquad [mg/l]$$

```
DBODO = SMATX(17,IS1)/(XPO*(DMATX(7,N)*(1.-1./XPO)+1.))                  TRF02900
```

$$DBODO = \frac{DBOD_{IS1}}{XPO*[RECYCL*(1-\frac{1}{XPO})+1]} \qquad [mg/l]$$

```
SBOD4 = BODO-DBODO                                                       TRF03000
```

$$SBOD4 = \frac{BODIN-DBOD_{IS1}}{XPO*[RECYCL*(1-\frac{1}{XPO})+1]} \qquad [mg/l]$$

```
SBOD5 = SBOD4*DMATX(6,N)                                                 TRF03100
```

$$SBOD5 = SBOD4*XRSS \qquad [mg/l]$$

```
BETAN = .00307*1.141**(DMATX(2,N)-20.)                                   TRF03200
```

$$BETAN = 0.00307*[1.141]^{DEGC-20} \qquad [\text{empirical parameter}]$$

XPON = EXP(BETAN*DMATX(4,N)*DEPTH/RHQ) TRF03300

$$XPON = e^{\frac{BETAN*SAREA*DEPTH}{RHQ}}$$ [empirical parameter]

SON4 = SMATX(5,IS1)*SBOD4/SMATX(8,IS1) TRF03400

$$SON4 = \frac{SON_{IS1}*SBOD4}{SBOD_{IS1}}$$ [mg/l]

DN4 = (SMATX(13,IS1)+SMATX(5,IS1)-SON4)/(XPON+(XPON-1.)*DMATX(7,N)) TRF03500

$$DN4 = \frac{DN_{IS1}+SON_{IS1}-SON4}{XPON+(XPON-1)*RECYCL}$$ [mg/l]

DN5 DN4 TRF03600

$$DN5 = \frac{DN_{IS1}+SON_{IS1}-SON4}{XPON+(XPON-1)*RECYCL}$$ [mg/l]

SON5 = SON4*DMATX(6,N) TRF03700

SON5 = SON4*XRSS [mg/l]

SMATX(2,OS1) = SMATX(2,IS1)*(1.-DMATX(5,N))/(DMATX(6,N)-DMATX(5,N)) TRF04200

$$Q_{OS1} = \frac{Q_{IS1}*(1-URSS)}{XRSS-URSS}$$ [MGD]

SMATX(2,OS2) = SMATX(2,IS1)*(1.-DMATX(6,N))/(DMATX(5,N)-DMATX(6,N)) TRF04300

$$Q_{OS2} = \frac{Q_{IS1}*(1-XRSS)}{URSS-XRSS}$$ [MGD]

SMATX(4,OS1) = SMATX(4,IS1)*DMATX(6,N) TRF04400

$SNBC_{OS1} = SNBC_{IS1}*XRSS$ [mg/l]

SMATX(4,OS2) = SMATX(4,IS1)*DMATX(5,N) TRF04500

$SNBC_{OS2} = SNBC_{IS1}*URSS$ [mg/l]

SMATX(5,OS1) = SON5 TRF04600

$SON_{OS1} = SON5$ [mg/l]

SMATX(5,OS2) = SON4*DMATX(5,N) TRF04700

$$SON_{OS2} = SON4*URSS$$

SMATX(6,OS1) = SMATX(6,IS1)*DMATX(6,N)*SBOD4/SMATX(8,IS1) TRF04800

$$SOP_{OS1} = \frac{SOP_{IS1}*XRSS*SBOD4}{SBOD_{IS1}} \qquad [mg/1]$$

SMATX(6,OS2) = SMATX(6,IS1)*DMATX(5,N)*SBOD4/SMATX(8,IS1) TRF04900

$$SOP_{OS2} = \frac{SOP_{IS1}*URSS*SBOD4}{SBOD_{IS1}} \qquad [mg/1]$$

SMATX(7,OS1) = SMATX(7,IS1)*DMATX(6,N) TRF05000

$$SFM_{OS1} = SFM_{IS1}*XRSS \qquad [mg/1]$$

SMATX(7,OS2) = SMATX(7,IS1)*DMATX(5,N) TRF05100

$$SFM_{OS2} = SFM_{IS1}*URSS \qquad [mg/1]$$

SMATX(8,OS1) = SBOD4*DMATX(6,N) TRF05200

$$SBOD_{OS1} = SBOD4*XRSS \qquad [mg/1]$$

SMATX(8,OS2) SBOD4*DMATX(5,N) TRF05300

$$SBOD_{OS2} = SBOD4*URSS \qquad [mg/1]$$

SMATX(9,OS1) = SBOD4*DMATX(6,N)+SON5+SMATX(4,IS1)*DMATX(6,N) TRF05400

$$VSS_{OS1} = (SBOD4*XRSS)+SON5+(SNBC_{IS1}*XRSS) \qquad [mg/1]$$

SMATX(9,OS2) = SBOD4*DMATX(5,N)+SON4*DMATX(5,N)+SMATX(4,IS1)*DMATX(5,N) TRF05500

$$VSS_{OS2} = URSS*(SBOD4+SON4+SNBC_{IS1}) \qquad [mg/1]$$

SMATX(10,OS1) = SMATX(9,OS1)+SMATX(7,OS1)+SMATX(6,OS1) TRF05700

$TSS_{OS1} = VSS_{OS1}+SFM_{OS1}+SOP_{OS1}$ [mg/1]

SMATX(10,OS2) = SMATX(9,OS2)+SMATX(7,OS2)+SMATX(6,OS2) TRF05800

$TSS_{OS2} = VSS_{OS2}+SFM_{OS2}+SOP_{OS2}$ [mg/1]

SMATX(12,OS1) SMATX(12,IS1) TRF05900

$DNBC_{OS1} = DNBC_{IS1}$ [mg/1]

SMATX(12,OS2) = SMATX(12,IS1) TRF06000

$DNBC_{OS2} = DNBC_{IS1}$ [mg/1]

SMATX(13,OS1) = DN5 TRF06100

$DN_{OS1} = DN5$ [mg/1]

SMATX(13,OS2) DN5 TRF06200

$DN_{OS2} = DN5$ [mg/1]

SMATX(14,OS1) SMATX(14,IS1)+SMATX(6,IS1)*(1.-SBOD4/SMATX(8,IS1)) TRF06300

$DP_{OS1} \quad DP_{IS1}+SOP_{IS1}*(1-\frac{SBOD4}{SBOD_{IS1}})$ [mg/1]

SMATX(14,OS2) = SMATX(14,OS1) TRF06400

$DP_{OS2} = DP_{OS1}$ [mg/1]

SMATX(15,OS1) = SMATX(15,IS1) TRF06500

$DFM_{OS1} = DFM_{IS1}$ [mg/1]

SMATX(15,OS2) = SMATX(15,IS1) TRF06600

$DFM_{OS2} = DFM_{IS1}$ [mg/1]

SMATX(16,OS1) = SMATX(16,IS1) TRF06700

$ALK_{OS1} = ALK_{IS1}$ [mg/1]

SMATX(16,OS2) = SMATX(16,IS1) TRF06800

$ALK_{OS2} = ALK_{IS1}$ [mg/1]

SMATX(17,OS1) = DBODO TRF06900

$DBOD_{OS1} = DBODO$ [mg/1]

SMATX(17,OS2) = SMATX(17,OS1) TRF07000

$DBOD_{OS2} = DBODO$ [mg/1]

SMATX(3,OS1) = (SBOD5+1.87*SMATX(4,OS1))/1.87 TRF07100

$$SOC_{OS1} = \frac{SBOD5+(1.87*SNBC_{OS1})}{1.87}$$ [mg/1]

SMATX(3,OS2) = (SMATX(8,OS2)+1.87*SMATX(4,OS2))/1.87 TRF07200

$$SOC_{OS2} = \frac{SBOD_{OS2}+(1.87*SNBC_{OS2})}{1.87}$$ [mg/1]

SMATX(11,OS1) = (DBODO+1.87*SMATX(12,OS1))/1.87 TRF07300

$$DOC_{OS2} = \frac{DBODO+(1.87*DNBC_{OS1})}{1.87}$$ [mg/1]

SMATX(11,OS2) = SMATX(11,OS1) TRF07400

$DOC_{OS2} = DOC_{OS1}$ [mg/1]

SMATX(18,OS1) = SMATX(18,IS1) TRF07500

$NH3_{OS1} = NH3_{IS1}$ [mg/1]

SMATX(18,OS2) = SMATX(18,IS1) TRF07600

$NH3_{OS2} = NH3_{IS1}$ [mg/1]

SMATX(19,OS1) = SMATX(19,IS1) TRF07700

$NO3_{OS1} = NO3_{IS1}$ [mg/l]

SMATX(19,OS2) = SMATX(19,IS1) TRF07800

$NO3_{OS2} = NO3_{IS1}$ [mg/l]

SMATX(20,OS1) = SMATX(20,IS1) TRF07900

Future parameter [mg/l]

SMATX(20,OS2) = SMATX(20,IS1) TRF08000

Future parameter [mg/l]

PCR = (BODIN-DMATX(1,N))*100./BODIN TRF08600

$PCR = \frac{(BODIN-BOD)*100}{BODIN}$ [%]

AFS SMATX(2,IS1)*1000./DMATX(8,N)*DMATX(15,N) TRF08700

$AFS = \frac{Q_{IS1}*1000*ECF}{GSS}$ [ft^2/1000]

VOL = FAREA*DEPTH*DMATX(16,N) TRF08800

VOL FAREA*DEPTH*ECF [ft^3]

References

Roesler and Smith, 1969

5. Cost functions.

Trickling filter

a. Capital cost

Function of VOL

X = ALOG(VOL/1000.) TRF09400

$X = \ln \frac{VOL}{1000}$

```
CCOST(N,1) = EXP(2.924951+.036285*X+.114673*X**2.-.004587*X**3.)*1000.    TRF09500
```

$$CCOST = 1000e^{2.924951+0.036285X+0.114673X^2-0.004587X^3} \quad [\text{dollars}]$$

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of Q_{IS1}/HQ

```
X = ALOG(SMATX(2,IS1)/DMATX(3,N)*43560./1000.)    TRF10200
```

$$X = \ln \frac{Q_{IS1}*43560}{HQ*1000} \quad [\ln \frac{ft^2}{1000}]$$

(1) Operating manhours

```
OHRS = EXP(4.536510-.095731*X+.173718*X**2.-.010114*X**3.)    TRF10800
```

$$OHRS = e^{4.536510-0.095731X+0.173718X^2-0.010114X^3} \quad [\text{hrs/yr}]$$

(2) Maintenance manhours

```
XMHRS = EXP(4.312739-.052122*X+.157473*X**2.-.010245*X**3.)    TRF10900
```

$$XMHRS = e^{4.312739-0.052122X+0.157473X^2-0.010245X^3} \quad [\text{hrs/yr}]$$

(3) Total materials and supplies

```
TMSU = EXP(5.105946+.465100*X)    TRF11000
```

$$TMSU = e^{5.105946+0.465100X} \quad [\text{dollars/yr}]$$

c. Total operating and maintenance costs

```
COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.    TRF11500
```

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650} \quad [\text{cents/1000gal}]$$

Final settler

a. Capital cost

Function of AFS

```
X = ALOG(AFS)    TRF12100
```

$$X = \ln AFS$$

```
CCOST(N,2) = EXP(3.716354+.389861*X+.084560*X**2.-.004718*X**3.)*1000.  TRF12200
```

$$CCOST = 1000e^{3.716354+0.389861X+0.084560X^2-0.004718X^3}$$ [dollars]

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of AFS/ECF

```
X = ALOG(AFS/DMATX(15,N))                                                 TRF12900
```

$$X = \ln \frac{AFS}{ECF}$$

(1) Operating manhours

```
OHRS = EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)               TRF13500
```

$$OHRS = e^{5.846565+0.254813X+0.113703X^2-0.010942X^3}$$ [hrs/yr]

(2) Maintenance manhours

```
XMHRS = EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)              TRF13600
```

$$XMHRS = e^{5.273419+0.228329X+0.122646X^2-0.011672X^3}$$ [hrs/yr]

(3) Total materials and supplies

```
TMSU = EXP(5.669881+.750799*X)                                            TRF13700
```

$$TMSU \quad e^{5.669881+0.750799X}$$ [dollars/yr]

c. Total operating and maintenance costs

```
COSTO(N,2) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.        TRF14200
```

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650}$$ [cents/1000gal]

Waste sludge pumps

a. Capital cost

Function of Q_{IS1}*ECF

```
X = ALOG(SMATX(2,IS1)*1.5*DMATX(14,N))                                    TRF14800
```

$$X = \ln Q_{IS1}*1.5*ECF$$

```
CCOST(N,3) = EXP(3.481553+.377485*X+.093349*X**2.-.006222*X**3.)*1000.    TRF14900
```

$$CCOST = 1000e^{3.481553+0.377485X+0.093349X^2-0.006222X^3}$$ [dollars]

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of Q_{IS1}

```
X = ALOG(SMATX(2,IS1)*1.5)                                                  TRF15700
```

$$X = \ln (Q_{IS1}*1.5)$$

(1) Operating manhours TRF16300

```
OHRS = EXP(6.097269+.253066*X-.193659*X**2.+.078201*X**3.-.006680*X**4.)
```

$$OHRS = e^{6.097269+0.253066X-0.193659X^2+0.078201X^3-0.006680X^4}$$ [hrs/yr]

(2) Maintenance manhours

```
XMHRS = EXP(5.911541-.013158*X+.076643*X**2.)                               TRF16500
```

$$XMHRS = e^{5.911541-0.013158X+0.076643X^2}$$ [hrs/yr]

(3) Kilowatt hrs per year

Pump efficiency - current values used in program; each can be changed by the replacement on punched card.

PEFF = 0.70 for Q_{IS1}<1.44MGD TRF16800

PEFF = 0.74 for Q_{IS1}<10.08MGD TRF17100

PEFF = 0.84 for Q_{IS1}≥10.08MGD TRF17300

```
YRKW = SMATX(2,IS1)*1000000.*HEAD/1440./3960./PEFF/.9*.7457*24 *365.   TRF17400
```

$$YRKW = \frac{Q_{IS1}*1000000*HEAD*0.7457*24*365}{1440*3960*PEFF*0.9}$$ [kilowatt/yrs]

(4) Energy cost

```
ECOST = YRKW*DMATX(10,20)                                                   TRF17500
```

ECOST = YRKW*CKWH [dollars/yr]

(5) Supplies

```
SCOST = EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)          TRF17600
```

$$SCOST = e^{5.851743+0.301610X+0.197183X^2-0.017962X^3} \quad [\$/yr]$$

(6) Total materials and supplies

```
TMSU = ECOST+SCOST*WPI                                                TRF17700
```

TMSU = ECOST+(SCOST*WPI) [dollars/yr]

c. Total operating and maintenance costs

```
COSTO(N,3) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.       TRF18200
```

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+TMSU}{Q_{Plant\ Inf.}*3650} \quad [cents/1000gal]$$

```
C                                                                        TRF00100
C          TRICKLING FILTER - FINAL SETTLER                              TRF00200
C          PROCESS IDENTIFICATION NUMBER  11                             TRF00300
C                                                                        TRF00400
      SUBROUTINE TRFS                                                    TRF00500
C                                                                        TRF00600
C                                                                        TRF00700
C          COMMON INITIAL STATEMENTS                                     TRF00800
C                                                                        TRF00900
      INTEGER OS1,OS2                                                    TRF01000
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),TRF01100
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)TRF01200
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)    TRF01300
C                                                                        TRF01400
C                                                                        TRF01500
C          PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM          TRF01600
C          CHARACTERISTICS                                               TRF01700
C                                                                        TRF01800
      HEAD=DMATX(9,N)                                                    TRF01900
      BODIN=SMATX(8,IS1)+SMATX(17,IS1)                                   TRF02000
      BETA=.0245*1.035**(DMATX(2,N)-20.)                                 TRF02100
      XN=.91-6.45/DMATX(4,N)                                             TRF02200
      QB=DMATX(7,N)*SMATX(2,IS1)                                         TRF02300
      RHQ=((DMATX(7,N)+1.)*DMATX(3,N))**XN                               TRF02400
      BOD=(SMATX(17,IS1)+DMATX(6,N)*SMATX(8,IS1))/DMATX(1,N)             TRF02500
      DEPTH=RHQ*ALOG((BOD+DMATX(7,N))/(DMATX(7,N)+1.))/(BETA*DMATX(4,N))TRF02600
      XPO=EXP(BETA*DMATX(4,N)*DEPTH/RHQ)                                 TRF02700
      BODO=BODIN/(XPO*(DMATX(7,N)*(1.-1./XPO)+1.))                       TRF02800
      DBODO=SMATX(17,IS1)/(XPO*(DMATX(7,N)*(1.-1./XPO)+1.))              TRF02900
      SBOD4=BODO-DBODO                                                   TRF03000
      SBOD5=SBOD4*DMATX(6,N)                                             TRF03100
      BETAN=.00307*1.141**(DMATX(2,N)-20.)                               TRF03200
      XPON=EXP(BETAN*DMATX(4,N)*DEPTH/RHQ)                               TRF03300
      SON4=SMATX(5,IS1)*SBOD4/SMATX(8,IS1)                               TRF03400
      DN4=(SMATX(13,IS1)+SMATX(5,IS1)-SON4)/(XPON+(XPON-1.)*DMATX(7,N))  TRF03500
      DN5=DN4                                                            TRF03600
      SON5=SON4*DMATX(6,N)                                               TRF03700
C                                                                        TRF03800
C                                                                        TRF03900
C          EFFLUENT STREAM CALCULATIONS                                  TRF04000
C                                                                        TRF04100
      SMATX(2,OS1)=SMATX(2,IS1)*(1.-DMATX(5,N))/(DMATX(6,N)-DMATX(5,N))  TRF04200
      SMATX(2,OS2)=SMATX(2,IS1)*(1.-DMATX(6,N))/(DMATX(5,N)-DMATX(6,N))  TRF04300
      SMATX(4,OS1)=SMATX(4,IS1)*DMATX(6,N)                               TRF04400
      SMATX(4,OS2)=SMATX(4,IS1)*DMATX(5,N)                               TRF04500
      SMATX(5,OS1)=SON5                                                  TRF04600
      SMATX(5,OS2)=SON4*DMATX(5,N)                                       TRF04700
      SMATX(6,OS1)=SMATX(6,IS1)*DMATX(6,N)*SBOD4/SMATX(8,IS1)            TRF04800
      SMATX(6,OS2)=SMATX(6,IS1)*DMATX(5,N)*SBOD4/SMATX(8,IS1)            TRF04900
      SMATX(7,OS1)=SMATX(7,IS1)*DMATX(6,N)                               TRF05000
      SMATX(7,OS2)=SMATX(7,IS1)*DMATX(5,N)                               TRF05100
      SMATX(8,OS1)=SBOD4*DMATX(6,N)                                      TRF05200
      SMATX(8,OS2)=SBOD4*DMATX(5,N)                                      TRF05300
      SMATX(9,OS1)=SBOD4*DMATX(6,N)+SON5+SMATX(4,IS1)*DMATX(6,N)         TRF05400
      SMATX(9,OS2)=SBOD4*DMATX(5,N)+SON4*DMATX(5,N)+SMATX(4,IS1)*DMATX(5TRF05500
     1,N)                                                                TRF05600
      SMATX(10,OS1)=SMATX(9,OS1)+SMATX(7,OS1)+SMATX(6,OS1)               TRF05700
      SMATX(10,OS2)=SMATX(9,OS2)+SMATX(7,OS2)+SMATX(6,OS2)               TRF05800
```

```
      SMATX(12,OS1)=SMATX(12,IS1)
      SMATX(12,OS2)=SMATX(12,IS1)
      SMATX(13,OS1)=DN5
      SMATX(13,OS2)=DN5
      SMATX(14,OS1)=SMATX(14,IS1)+SMATX(6,IS1)*(1.-SBOD4/SMATX(8,IS1))
      SMATX(14,OS2)=SMATX(14,OS1)
      SMATX(15,OS1)=SMATX(15,IS1)
      SMATX(15,OS2)=SMATX(15,IS1)
      SMATX(16,OS1)=SMATX(16,IS1)
      SMATX(16,OS2)=SMATX(16,IS1)
      SMATX(17,OS1)=DBODO
      SMATX(17,OS2)=SMATX(17,OS1)
      SMATX(3,OS1)=(SBOD5+1.87*SMATX(4,OS1))/1.87
      SMATX(3,OS2)=(SMATX(8,OS2)+1.87*SMATX(4,OS2))/1.87
      SMATX(11,OS1)=(DBODO+1.87*SMATX(12,OS1))/1.87
      SMATX(11,OS2)=SMATX(11,OS1)
      SMATX(18,OS1)=SMATX(18,IS1)
      SMATX(18,OS2)=SMATX(18,IS1)
      SMATX(19,OS1)=SMATX(19,IS1)
      SMATX(19,OS2)=SMATX(19,IS1)
      SMATX(20,OS1)=SMATX(20,IS1)
      SMATX(20,OS2)=SMATX(20,IS1)
C
C
C          CALC. OF OUTPUT SIZES AND QUANTITIES
C
      FAREA=SMATX(2,IS1)/DMATX(3,N)*43560.
      PCR=(BODIN-DMATX(1,N))*100./BODIN
      AFS=SMATX(2,IS1)*1000./DMATX(8,N)*DMATX(15,N)
      VOL=FAREA*DEPTH*DMATX(16,N)
C
C
C          CALC. OF CAPITAL COSTS FOR TRICKLING FILTER BASED ON
C          DESIGN PLUS EXCESS CAPACITY
C
      X=ALOG(VOL/1000.)
      CCOST(N,1)=EXP(2.924951+.036285*X+.114673*X**2.-.004587*X**3.)*100
     10.
C
C
C          CALC. OF OPERATING COSTS FOR TRICKLING FILTER BASED ON
C          DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(SMATX(2,IS1)/DMATX(3,N)*43560./1000.)
C
C
C                CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(4.536510-.095731*X+.173718*X**2.-.010114*X**3.)
      XMHRS=EXP(4.312739-.052122*X+.157473*X**2.-.010245*X**3.)
      TMSU=EXP(5.105946+.465100*X)
C
C
C                OPERATING COST EQUATION
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C          CALC. OF CAPITAL COSTS FOR FINAL SETTLER BASED ON DESIGN
C          PLUS EXCESS CAPACITY
C
      X=ALOG(AFS)
      CCOST(N,2)=EXP(3.716354+.389861*X+.084560*X**2.-.004718*X**3.)*100
     10.
C
```

```
C
C          CALC. OF OPERATING COSTS FOR FINAL SETTLER BASED ON
C          DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(AFS/DMATX(15,N))
C
C
C                CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)
      XMHRS=EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)
      TMSU=EXP(5.669881+.750799*X)
C
C
C                OPERATING COST EQUATION
C
      COSTO(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C          CALC. OF CAPITAL COSTS FOR SLUDGE RETURN PUMPS BASED
C          ON DESIGN PLUS EXCESS CAPACITY
C
      X=ALOG(SMATX(2,IS1)*1.5*DMATX(14,N))
      CCOST(N,3)=EXP(3.481553+.377485*X+.093349*X**2.-.006222*X**3.)*100
     10.
C
C
C          CALC. OF OPERATING COSTS FOR SLUDGE RETURN PUMPS BASED
C          ON DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS
C          CAPACITY
C
      X=ALOG(SMATX(2,IS1)*1.5)
C
C
C                CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(6.097269+.253066*X-.193659*X**2.+.078201*X**3.-.006680*X*
     1*4.)
      XMHRS=EXP(5.911541-.013158*X+.076643*X**2.)
      X=ALOG(SMATX(2,IS1))
      IF (SMATX(2,IS1)-1.44) 10,20,20
   10 PEFF=.70
      GO TO 50
   20 IF (SMATX(2,IS1)-10.08) 30,40,40
   30 PEFF=.74
      GO TO 50
   40 PEFF=.83
   50 YRKW=SMATX(2,IS1)*1000000.*HEAD/1440./3960./PEFF/.9*.7457*24.*365.
      ECOST=YRKW*DMATX(10,20)
      SCOST=EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)
      TMSU=ECOST+SCOST*WPI
C
C
C                OPERATING COST EQUATION
C
      COSTO(N,3)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.
C
C
C          ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=AFS
      OMATX(2,N)=VOL
      OMATX(3,N)=FAREA
      OMATX(4,N)=DEPTH
```

```
C                                                                       TRF19100
C                                                                       TRF19200
C               PROCESS ENERGY INDICES                                  TRF19300
C                                                                       TRF19400
      FLOW(N)=SMATX(2,IS1)                                              TRF19500
      POW(N)=11.                                                        TRF19600
      RETURN                                                            TRF19700
      END                                                               TRF19800
```

SECTION 13

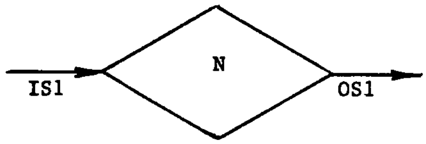
CHLORINATION - DECHLORINATION, CHLOR

Subroutine Identification Number 12

Chlorination - Dechlorination, CHLOR

Rev. Date 8/1/77

1. Process symbol.



IS1: Liquid input stream

OS1: Liquid output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = DCL2	Dose of chlorine, mg/l. [8.]
DMATX(2,N) = TCL2	Chlorine contact time, minutes. [30.]
DMATX(3,N) = CCL2	Cost of chlorine, $/ton. [220.]
DMATX(4,N) = DSO2	Dose of sulfur dioxide, mg/l. [2.5]
DMATX(5,N) = CSO2	Cost of sulfur dioxide, $/ton. [180.]
DMATX(14,N) = ECF	Excess capacity factor for the sulfur dioxide feed system. [1.2]
DMATX(15,N) = ECF	Excess capacity factor for the chlorine feed system. [1.2]
DMATX(16,N) = ECF	Excess capacity factor for the contact basin. [1.5]

3. Output parameters which are printed on computer output sheets.

DCL2 = DMATX(1,N)	
TCL2 = DMATX(2,N)	
CCL2 = DMATX(3,N)	
DSO2 = DMATX(4,N)	
CSO2 = DMATX(5,N)	
BVOL = OMATX(1,N)	Volume of the chlorine contact basin, [cu. ft.].

CUSE = OMATX(2,N)	Amount of chlorine used, [tons/yr].
SUSE = OMATX(3,N)	Amount of sulfur dioxide used, [tons/yr].
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000 gal].
ACOST	Amortization cost, [cents/1000 gal].
TCOST	Total treatment cost, [cents/1000 gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

BVOL = SMATX(2,IS1)*TCL2/1.44/7.48*1000.*DMATX(16,N) CHL03300

$$BVOL = \frac{Q_{IS1}*TCL2*1000*ECF}{1.44*7.48} \quad [ft^3]$$

CUSE = SMATX(2,IS1)*DCL2*8.33*365./2000. CHL03400

$$CUSE = \frac{Q_{IS1}*DCL2*8.33*365}{2000} \quad [tons/yr]$$

SUSE = SMATX(2,IS1)*DSO2*8.33*365./2000. CHL03500

$$SUSE = \frac{Q_{IS1}*DSO2*8.33*365}{2000} \quad [tons/yr]$$

FACTR = CUSE/(CUSE+SUSE) CHL03600

$$FACTR = \frac{CUSE}{CUSE+SUSE} \quad [no\ units]$$

OC = FACTR*OHRS CHL07800

OC = FACTR*OHRS

XC = FACTR*XMHRS CHL07900

XC = FACTR*XMHRS

References:

Smith, 1969

Patterson and Banker, 1971

5. **Cost functions.**

a. **Capital cost**

Contact basin:

Function of BVOL

```
X = ALOG(BVOL/1000.)                                                    CHL04200
```

$$X = \ln \frac{BVOL}{1000}$$

```
CCOST(N,1) = EXP(2.048061+.521909*X-.002674*X**2.+.004159*X**3.)*1000.
                                                                        CHL04300
```

$$CCOST = 1000e^{2.048061+0.521909X-0.002674X^2+0.004159X^3} \quad \text{[dollars]}$$

Cl_2 feed system:

```
CUSE = SMATX(2,IS1)*DCL2*8.33*365./2000.                                CHL03400
```

$$CUSE = \frac{Q_{IS1}*DCL2*8.33*365}{2000} \quad \text{[tons/yr]}$$

```
SUSE = SMATX(2,IS1)*DSO2*8.33*365./2000.                                CHL03500
```

$$SUSE = \frac{Q_{IS1}*DSO2*8.33*365}{2000} \quad \text{[tons/yr]}$$

```
FACTR = CUSE/(CUSE+SUSE)                                                CHL03600
```

$$FACTR = \frac{CUSE}{CUSE+SUSE} \quad \text{[no units]}$$

Function of CUSE

```
X = ALOG(CUSE*2000./365.*DMATX(15,N)+SUSE*2000./365.*DMATX(14,N))
```

$$X = \ln((CUSE*ECF_c+SUSE*ECF_s)*\frac{2000}{365}) \quad \text{CHL05500}$$

```
XCOST = EXP(2.264294-.044271*X+.065029*X**2.-.002536*X**3.)*1000.
                                                                        CHL05600
```

$$XCOST = 1000e^{2.264294-0.044271X+0.065029X^2-0.002536X^3} \quad \text{[dollars]}$$

```
CCOST(N,2) = FACTR*XCOST                                                CHL06100
```

$$CCOST = \frac{CUSE}{CUSE+SUSE}*XCOST \quad \text{[dollars]}$$

SO_2 Feed system (If used)

Function of SUSE

```
CCOST(N,3) = XCOST-CCOST(N,2)          [dollars]                        CHL10500
```

$$CCOST_s = XCOST-CCOST_c$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of (CUSE+SUSE)

X = ALOG(CUSE+SUSE) CHL06900

$$X = \ln(CUSE+SUSE)$$

(1) Operating manhours (Cl_2+SO_2 Feed Systems)

OHRS = EXP(4.538517+.543669*X) CHL07000

$$OHRS = e^{4.538517+0.543669X} \quad \text{[hrs/yr]}$$

(2) Maintenance manhours (Cl_2+SO_2 Feed Systems)

XMHRS = EXP(3.752071-.224812*X+.158849*X**2.-.006064*X**3.) CHL07100

$$XMHRS = e^{3.752071-0.224812X+0.158849X^2-0.006064X^3} \quad \text{[hrs/yr]}$$

(3) Total materials and supplies (Cl_2+SO_2 Feed Systems)

TMSU = EXP(6.126105+.287016*X) CHL07200

$$TMSU = e^{6.126105+0.287016X} \quad \text{[dollars/yr]}$$

c. Total operating and maintenance costs

Contact Basin:

Operating cost assumed zero

COSTO(N,1) = 0 CHL04900

COSTO = 0 [cents/1000 gal]

Cl_2 Feed System

(1) Operating manhours

OC = FACTR*OHRS CHL07800

(2) Maintenance manhours

XC = FACTR*XMHRS CHL07900

(3) Total materials and supplies

TMSUC = CUSE*CCL2+FACTR*TMSU CHL08000

TMSUC = (CUSE*CCL2)+(FACTR*TMSU) [dollars/yr]

COSTO(N,2) = ((OC+XC)*DHR*(1.+PCT)+TMSUC)/SMATX(2,1)/3650. CHL08500

$$COSTO = \frac{[(OC+XC)*DHR*(1+PCT)]+TMSUC}{Q_{Plant\ Inf.}*3650} \quad [cents/1000\ gal]$$

SO_2 Feed System (If Used)

(1) Operating manhours

OS = OHRS-OC CHL11200

(2) Maintenance manhours

XS = XMHRS-XC CHL11300

(3) Total materials and supplies

TMSUS = SUSE*CSO2+(1.-FACTR)*TMSU CHL11400

$$TMSUS = (SUSE*CSO2)+[(1-FACTR)*TMSU] \quad [dollars/yr]$$

COSTO(N,3) = ((OS+XS)*DHR*(1.+PCT)+TMSUS)/SMATX(2,1)/3650. CHL12000

$$COSTO = \frac{[(OS+XS)*DHR*(1+PCT)]+TMSUS}{Q_{Plant\ Inf.}*3650} \quad [cents/1000\ gal]$$

```
C
C           CHLORINATION - DECHLORINATION
C           PROCESS IDENTIFICATION NUMBER  12
C
      SUBROUTINE CHLOR
C
C
C           COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C           ASSIGNMENT OF DESIGN VALUES TO PROCESS PARAMETERS
C
      DCL2=DMATX(1,N)
      TCL2=DMATX(2,N)
      CCL2=DMATX(3,N)
      DSO2=DMATX(4,N)
      CSO2=DMATX(5,N)
C
C
C           EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=2,20
   10 SMATX(I,OS1)=SMATX(I,IS1)
C
C
C           CALC. OF OUTPUT SIZES AND QUANTITIES
C
      BVOL=SMATX(2,IS1)*TCL2/1.44/7.48*1000.*DMATX(16,N)
      CUSE=SMATX(2,IS1)*DCL2*8.33*365./2000.
      SUSE=SMATX(2,IS1)*DSO2*8.33*365./2000.
      FACTR=CUSE/(CUSE+SUSE)
C
C
C           CALC. OF CAPITAL COSTS FOR CONTACT BASIN BASED ON DESIGN
C           PLUS EXCESS CAPACITY
C
      X=ALOG(BVOL/1000.)
      CCOST(N,1)=EXP(2.048061+.521909*X-.002674*X**2.+.004159*X**3.)*100
     10.
C
C
C           CALC. OF OPERATING COSTS FOR CONTACT BASIN
C
      COSTO(N,1)=0.
C
C
C           CALC. OF CAPITAL COSTS FOR CHLORINE AND SULFUR DIOXIDE
C           FEED SYSTEMS BASED ON DESIGN PLUS EXCESS CAPACITY
C
      X=ALOG(CUSE*2000./365.*DMATX(15,N)+SUSE*2000./365.*DMATX(14,N))
      XCOST=EXP(2.264294-.044271*X+.065029*X**2.-.002536*X**3.)*1000.
C
C
```

```
C                 CALC. OF CAPITAL COSTS FOR CHLORINE FEED SYSTEM
C
      CCOST(N,2)=FACTR*XCOST
C
C
C             CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS AND
C             MATERIALS AND SUPPLIES FOR CHLORINE AND SULFUR DIOXIDE
C             FEED SYSTEMS BASED ON DESIGN CAPACITY ALONE, DOES NOT
C             INCLUDE EXCESS CAPACITY
C
      X=ALOG(CUSE+SUSE)
      OHRS=EXP(4.538517+.543669*X)
      XMHRS=EXP(3.752071-.224812*X+.158849*X**2.-.006064*X**3.)
      TMSU=EXP(6.126105+.287016*X)
C
C
C                 CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                 AND MATERIALS AND SUPPLIES FOR CHLORINE FEED SYSTEM
C
      OC=FACTR*OHRS
      XC=FACTR*XMHRS
      TMSUC=CUSE*CCL2+FACTR*TMSU
C
C
C                 OPEARTING COST EQUATION FOR CHLORINE FEED SYSTEM
C
      COSTO(N,2)=((OC+XC)*DHR*(1.+PCT)+TMSUC)/SMATX(2,1)/3650.
C
C
C             CALC. OF CAPITAL AND OPERATING COSTS FOR SULFUR DIOXIDE
C             FEED SYSTEM
C
      IF (DSO2) 20,20,30
C
C
C                 CALC. OF CAPITAL AND OPERATING COSTS FOR SULFUR
C                 DIOXIDE FEED SYSTEM IF NO SO2 IS USED
C
   20 CCOST(N,3)=0.
      COSTO(N,3)=0.
      GO TO 40
C
C
C                 CALC. OF CAPITAL COSTS FOR SULFUR DIOXIDE FEED
C                 SYSTEM IF ANY SO2 IS USED
C
   30 CCOST(N,3)=XCOST-CCOST(N,2)
C
C
C                 CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                 AND MATERIALS AND SUPPLIES FOR SULFUR DIOXIDE FEED
C                 SYSTEM
C
      OS=OHRS-OC
      XS=XMHRS-XC
      TMSUS=SUSE*CSO2+(1.-FACTR)*TMSU
C
C
C                 OPERATING COST EQUATION FOR SULFUR DIOXIDE FEED
C                 SYSTEM
C
      COSTO(N,3)=((OS+XS)*DHR*(1.+PCT)+TMSUS)/SMATX(2,1)/3650.
C
C
C             ASSIGNMENT OF VALUES TO OMATX
```

```
C
   40 OMATX(1,N)=BVOL
      OMATX(2,N)=CUSE
      OMATX(3,N)=SUSE
C
C
C              PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=12.
      RETURN
      END
```

SECTION 14

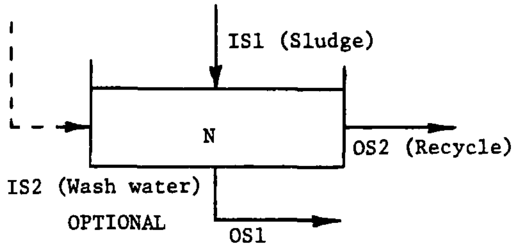
FLOTATION THICKENING, TFLOT

Subroutine Identification Number 13

Flotation Thickening, TFLOT

Rev. Date 8/1/77

1. Process symbol.



IS1: Sludge input stream

IS2: Wash water input stream

OS1: Sludge output stream

OS2: Recycle output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = TRR	Solids recovery ratio for thickening. [.95]
DMATX(2,N) = TSS	Total suspended solid concentration of OS1, mg/l. [40,000.]
DMATX(3,N) = GTH	Design overflow rate for the thickener, gpd/sq ft. [1150.]
DMATX(4,N) = GSTH	Design solids loading rate for the thickener, lb/day/sq ft. [48.]
DMATX(5,N) = HPWK	Hours per week that the thickener is operated, hr/wk. [100.]
DMATX(6,N) = DPOLY	Dose of polymer, lb/ton [10.]
DMATX(7,N) = CPOLY	Cost of polymer, $/ton. [.45]
DMATX(15,N) = ECF	Excess capacity factor for the process. [2.]

3. Output parameters which are printed on computer output sheets.

TRR = DMATX(1,N)

TSS = DMATX(2,N)

GTH = DMATX(3,N)

GSTH = DMATX(4,N)

HPWK = DMATX(5,N)

DPOLY = DMATX(6,N)

CPOLY = DMATX(7,N)

ATHM = OMATX(1,N) — Surface area of each flotation thickener used, [sq ft.]

XN = OMATX(2,N) — Number of flotation thickeners used.

ATHM1 = OMATX(3,N) — Total required surface area for flotation thickening, [sq ft].

CCOST — Capital cost,[dollars].

COSTO — Operating and maintenance cost,[cents/ 1000gal].

ACOST — Amortization cost, [cents/1000 gal].

TCOST — Total treatment cost, [cents/1000 gal].

ECF — Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

SMAT(I) = SMATX(I, IS2) TFL02500

SMAT(I) = SMATX(I,IS2) [mg/1]

where I = 1,20 i.e. I,Q,SOC,SNBC,SON,SOP,SFM,SBOD,VSS,TSS,DOC,DNBC,DN,DP,DFM, ALK,DBOD,NH3,NO3

SMATX(10,OS1) = DMATX(2,N) TFL02600

$$TSS_{OS1} = TSS \quad [mg/1]$$

SMATX(2,OS1) = DMATX(1,N)*(SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10))/SMATX(10,OS1)

$$Q_{OS1} \quad \frac{TRR*\ [[Q_{IS1}*TSS_{IS1}]+[Q_{IS2}*TSS_{IS2}]]}{TSS_{OS1}} \quad [MGD] \quad TFL02700$$

ATH1 = (SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10))*8.33/DMATX(4,N)*168./DMATX(5,N)

$$ATH1 = \frac{[Q_{IS1}*TSS_{IS1}+Q_{IS2}*TSS_{IS2}]*8.33*168}{GSTH*HPWK} \quad [ft^2] \quad TFL02900$$

ARCY = .00288*ATH1 TFL03400

ARCY 0.00288ATH1 [MGD]

SMATX(2,IS2) ARCY TFL03500

$$Q_{IS2} = ARCY \quad [MGD]$$

SMATX(2,OS2) = SMATX(2,IS1)+SMAT(2)-SMATX(2,OS1) TFL03700

$Q_{OS2} = Q_{IS1}+Q_{IS2}-Q_{OS1}$ [MGD]

ATH2 = SMATX(2,OS2)*1000000./DMATX(3,N)*168./DMATX(5,N) TFL03800

$ATH2 = \frac{Q_{OS2}*1000000*168}{GTH*HPWK}$ [ft^2]

ATHM = ATH2*DMATX(16,N) TFL04000

ATHM = ATH2*ECF [ft^2]

ATHM = ATH1*DMATX(16,N) TFL04200

ATHM = ATH1*ECF [ft^2]

TEMP = SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10) TFL04300

$TEMP = [Q_{IS1}*TSS_{IS1}]+[Q_{IS2}*TSS_{IS2}]$ [MGD (mg/1)]

SMATX(10,OS2) = (TEMP-SMATX(2,OS1)*SMATX(10,OS1))/SMATX(2,OS2) TFL04400

$TSS_{OS2} = \frac{TEMP-(Q_{OS1}*TSS_{OS1})}{Q_{OS2}}$ [MGD (mg/1)]

TEMP = TEMP/(SMATX(2,IS1)+SMAT(2)) TFL04500

$TEMP = \frac{TEMP}{Q_{IS1}+Q_{IS2}}$ [mg/1]

TEMP1 = SMATX(10,OS1)/TEMP TFL04600

$TEMP1 = \frac{TSS_{OS1}}{TEMP}$ [no units]

TEMP2 = SMATX(10,OS2)/TEMP TFL04700

$TEMP2 \quad \frac{TSS_{OS2}}{TEMP}$ [no units]

TEMP3 = (SMATX(2,IS1)*SMATX(I,IS1)+SMAT(2)*SMAT(I))/(SMATX(2,IS1)+SMAT(2))

$$TEMP3 \quad \frac{Q_{IS1}*SMATX(I,IS1)+Q_{IS2}*SMAT(I)}{Q_{IS1}+Q_{IS2}} \qquad [mg/l] \qquad TFL05300$$

where I = 3,9 i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS

SMATX(I,OS1) = TEMP1*TEMP3 TFL05500

SMATX(I,OS1) = TEMP1*TEMP3 [mg/1]

where I = 3,9

SMATX(I,OS2) = TEMP2*TEMP3 TFL05600

SMATX(I,OS2) TEMP2*TEMP3 [mg/1]

where I = 3,9

SMATX(I,OS1) = (SMATX(I,IS1)*SMATX(2,IS1)+SMAT(I)*SMAT(2))/(SMATX(2,IS1)+SMAT(2))

$$SMATX(I,OS1) \quad \frac{[SMATX(I,IS1)*Q_{IS1}]+[SMAT(I)*Q_{IS2}]}{Q_{IS1}+Q_{IS2}} \quad [mg/l] \qquad TFL05800$$

where I = 11,20 i.e. DOC,DNBC,DN,DP,DFM,ALK,DBOD,NH3,NO3

SMATX(I,OS2) = SMATX(I,OS1) TFL06000

SMATX(I,OS2) SMATX(I,OS1) [mg/1]

where I 11,20

References:

Smith and Eilers, 1975
McMichael, 1973
Patterson and Banker, 1971

5. Cost Functions.

a. Capital cost

Function of ATHM

X = ALOG(ATHM) TFL09600

X ln ATHM

```
CCOST(N,1) = EXP(1.717538+.453735*X)*1000.*XN                    TFL09700
```

$$CCOST = 1000XN*e^{1.717538+0.453735X} \quad [dollars]$$

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of ATHM*XN/ECF

```
X = ALOG(ATHM/DMATX(16,N)*XN)                                    TFL10300
```

$$X = \ln \frac{ATHM*XN}{ECF}$$

(1) Operating manhours

```
OHRS = EXP(4.992517-.325053*X+.084026*X**2.)                     TFL10900
```

$$OHRS = e^{4.992517-0.325053X+0.084026X^2} \quad [hrs/yr]$$

(2) Maintenance manhours

```
XMHRS = EXP(4.832373-.336504*X+.083020*X**2.)                    TFL11000
```

$$XMHRS = e^{4.832373-0.336504X+0.083020X^2} \quad [hrs/yr]$$

(3) Materials and supplies

```
HPD = EXP(-1.254959+.852347*X)                                   TFL11100
```

$$HPD = e^{-1.254959+0.852347X}$$

```
ELEC = HPD*4.54*(DMATX(5,N)/7.)                                  TFL11200
```

$$ELEC = \frac{HPD*4.54*HPWK}{7} \quad [dollars/yr]$$

```
PWAS = (SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10))*8.33        TFL11300
```

$$PWAS = [(Q_{IS1}*TSS_{IS1})+(Q_{IS2}*TSS_{IS2})]*8.33 \quad [lb/day]$$

```
POLC = PWAS*365./2000.*DMATX(6,N)*DMATX(7,N)                          TFL11400
```

$$POLC = \frac{PWAS*365*DPOLY*CPOLY}{2000} \quad [dollars/yr]$$

c. Total operating and maintenance costs

```
COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+ELEC+POLC)/SMATX(2,1)/3650.
                                                                       TFL11900
```

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+ELEC+POLC}{Q_{Plant\ inf.}*3650} \quad [cents/1000gal]$$

```
C
C           FLOTATION THICKENING
C           PROCESS IDENTIFICATION NUMBER  13
C
      SUBROUTINE TFLOT
C
C
C           COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      DIMENSION Y(12),SMAT(20)
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
      DATA Y/25.,50.,100.,150.,200.,250.,300.,400.,500.,600.,800.,1000./
C
C
C           PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C           CHARACTERISTICS
C
      DO 10 I=1,20
   10 SMAT(I)=0.
      IF (IS2) 40,40,20
   20 DO 30 I=1,20
   30 SMAT(I)=SMATX(I,IS2)
   40 SMATX(10,OS1)=DMATX(2,N)
      SMATX(2,OS1)=DMATX(1,N)*(SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(1
     10))/SMATX(10,OS1)
      ATH1=(SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10))*8.33/DMATX(4,N)
     1*168./DMATX(5,N)
      IF (IS2) 60,50,60
   50 ARCY=0.
      GO TO 70
   60 ARCY=.00268*ATH1
      SMATX(2,IS2)=ARCY
   70 SMAT(2)=ARCY
      SMATX(2,OS2)=SMATX(2,IS1)+SMAT(2)-SMATX(2,OS1)
      ATH2=SMATX(2,OS2)*1000000./DMATX(3,N)*168./DMATX(5,N)
      IF (ATH1-ATH2) 80,90,90
   80 ATHM=ATH2*DMATX(16,N)
      GO TO 100
   90 ATHM=ATH1*DMATX(16,N)
  100 TEMP=SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10)
      SMATX(10,OS2)=(TEMP-SMATX(2,OS1)*SMATX(10,OS1))/SMATX(2,OS2)
      TEMP=TEMP/(SMATX(2,IS1)+SMAT(2))
      TEMP1=SMATX(10,OS1)/TEMP
      TEMP2=SMATX(10,OS2)/TEMP
C
C
C           EFFLUENT STREAM CALCULATIONS
C
      DO 110 I=3,9
      TEMP3=(SMATX(2,IS1)*SMATX(I,IS1)+SMAT(2)*SMAT(I))/(SMATX(2,IS1)+SM
     1AT(2))
      SMATX(I,OS1)=TEMP1*TEMP3
  110 SMATX(I,OS2)=TEMP2*TEMP3
      DO 120 I=11,20
      SMATX(I,OS1)=(SMATX(I,IS1)*SMATX(2,IS1)+SMAT(I)*SMAT(2))/(SMATX(2,
```

```
     1IS1)+SMAT(2))
  120 SMATX(I,OS2)=SMATX(I,OS1)
C
C
C             CALC. OF OUTPUT SIZES AND QUANTITIES
C
      ATHM1=ATHM
      XN=0.
      XX=0.
      K=0
      DO 160 I=1,12
      IF (ATHM-Y(I)) 130,130,140
  130 ATHM=Y(I)
      GO TO 170
  140 IF (I-12) 160,150,160
  150 ATHM=Y(12)
  160 CONTINUE
  170 IF (ATHM-25.) 180,180,190
  180 ATHM=25.
      XN=1.
      GO TO 240
  190 IF (ATHM1-1000.) 230,230,200
  200 XN=ATHM1/1000.
      K=XN
      XX=K
      IF ((XN-XX)*1000.-500.) 210,210,220
  210 XN=XX+.5
      GO TO 240
  220 XN=XX+1.
      GO TO 240
  230 ATHM=ATHM/2.
      XN=2.
C
C
C             CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C             CAPACITY
C
  240 X=ALOG(ATHM)
      CCOST(N,1)=EXP(1.717538+.453735*X)*1000.*XN
C
C
C             CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C             DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(ATHM/DMATX(16,N)*XN)
C
C
C                   CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                   ELECTRIC POWER AND POLYMER COSTS
C
      OHRS=EXP(4.992517-.325053*X+.084026*X**2.)
      XMHRS=EXP(4.832373-.336504*X+.083020*X**2.)
      HPD=EXP(-1.254959+.852347*X)
      ELEC=HPD*4.54*(DMATX(5,N)/7.)
      PWAS=(SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10))*8.33
      POLC=PWAS*365./2000.*DMATX(6,N)*DMATX(7,N)
C
C
C                   OPERATING COST EQUATION
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+ELEC+POLC)/SMATX(2,1)/3650.
C
C
C             ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=ATHM
```

```
      OMATX(2,N)=XN
      OMATX(3,N)=ATHM1
C
C
C              PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=13.
      RETURN
      END
```

SECTION 15

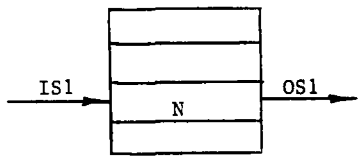
MULTIPLE HEARTH INCINERATION, MHINC

Subroutine Identification Number 14

Multiple Hearth Incineration, MHINC

Rev. Date 8/1/77

1. Process symbol.



IS1: Liquid input stream

OS1: Liquid output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = ML	Mass loading, lb/hr/sq ft of hearth area. [2.]
DMATX(2,N) = NINC	Number of multiple hearth incinerators. [1.]
DMATX(3,N) = HPWK	Hours per week that the incinerators are operated hr/wk. [35.]
DMATX(4,N) = SPER	Number of startup periods per week. [5.]
DMATX(5,N) = WV	Wind velocity, mph. [0.]
DMATX(6,N) = HV	Higher heat value for volatiles, Btu/lb. [10,000.]
DMATX(7,N) = TYPE	Program control: type of fuel used; 1 = fuel oil, 2 = natural gas, 3 = digester gas. [1.]
DMATX(8,N) = FC	Cost of fuel oil, $/gallon. [.30]
DMATX(9,N) = CNG	Cost of natural gas, $/1000 cu ft. [.97]
DMATX(16,N) = ECF	Excess capacity factor for the process. [1.]

3. Output parameters which are printed on computer output sheets.

OMATX(1,N) = FHA	Total hearth area, [sq ft].
OMATX(2,N) = WFYR	Total fuel usage, [lb/yr].
OMATX(3,N) = PSDD	Amount of dry solids to be incinerated, [lb/day].
OMATX(4,N) = ECOST	Cost of electrical power to operate the incinerator, [$/yr].
OMATX(5,N) = FCOST	Cost of fuel to operate the incinerator, [$/yr].

CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000 gal].
ACOST	Amortization cost, [cents/1000 gal].
TCOST	Total treatment cost, [cents/1000 gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
PSDD = SMATX(10,IS1)*SMATX(2,IS1)*8.33                                MHI02500
```

$$PSDD = 8.33TSS_{IS1}*Q_{IS1} \quad [lb/day]$$

```
FHAT = 58.31*SMATX(2,IS1)*SMATX(10,IS1)/DMATX(3,N)/DMATX(1,N)*DMATX(16,N)
```

$$FHAT = \frac{58.31\ Q_{IS1}*TSS_{IS1}*ECF}{HPWK*ML} \quad \text{MHI02600} \quad [ft^2]$$

```
XX = FHAT/DMATX(2,N)                                                  MHI02800
```

$$XX = \frac{FHAT}{NINC} \quad [ft^2]$$

```
FHA = SFHA(I)                                                         MHI03100
```

$$FHA = SFHA(I) \quad [ft^2]$$

where I = 1,59

```
FHA = 3120                                              MHI03400      [ft^2]
```

```
CYT = 13.+.024*FHA        (For FHA <= 1700)                           MHI03900
```

$$CYT = 13+0.024FHA \quad [hrs]$$

```
CYT = .09*(FHA-1100.)     (For FHA <= 2300)                           MHI04200
```

$$CYT = 0.09(FHA-1100) \quad [hrs]$$

```
PASH = (SMATX(10,IS1)-SMATX(9,IS1))/SMATX(9,IS1)                      MHI04500
```

$$PASH = \frac{TSS_{IS1}-VSS_{IS1}}{VSS_{IS1}} \quad [no\ units]$$

```
HASH = 68.*PASH                                                       MHI04600
```

$$HASH = 68PASH \quad [BTU/lb\ dry\ VS]$$

```
PWAT = (1000000.-SMATX(10,IS1))/SMATX(9,IS1)                                MHI04700
```

$$PWAT = \frac{1000000 - TSS_{IS1}}{VSS_{IS1}}$$ [no units]

```
HWSL = 1404.3*PWAT                                                          MHI04800
```

$$HWSL = 1404.3PWAT$$ [BTU/lb dry VS]

```
SAREA = 64.03*FHA**.51                                                      MHI04900
```

$$SAREA = 64.03[FHA]^{0.51}$$ [ft^2]

```
VSPH = SMATX(9,IS1)*SMATX(2,IS1)*58.31/DMATX(3,N)                           MHI05000
```

$$VSPH = \frac{VSS_{IS1}*Q_{IS1}*58.31}{HPWK}$$ [lb dry VS/hr]

```
HC = 1.735*(1.+.374*DMATX(5,N))                                             MHI05100
```

$$HC = 1.735(1+0.374WV)$$ [BTU/hr/ft^2]

```
QTRAN = (1.279+HC)*100.*SAREA*DMATX(2,N)/VSPH                               MHI05200
```

$$QTRAN = \frac{100(1.279+HC)*SAREA*NINC}{VSPH}$$ [BTU/lb dry VS]

```
QCOOL = 267.*FHA*DMATX(2,N)/VSPH                                            MHI05300
```

$$QCOOL = \frac{267FHA*NINC}{VSPH}$$ [BTU/lb dry VS]

```
QNET = 2725.+HASH+HWSL+QCOOL+QTRAN-DMATX(6,N)+246.                          MHI05400
```

$$QNET = 2725+HASH+HWSL+QCOOL+QTRAN-HV+246$$ [BTU/lb dry VS]

```
TEMP = SMATX(9,IS1)*SMATX(2,IS1)*8.33*365.                                  MHI05700
```

$$TEMP = VSS_{IS1}*Q_{IS1}*8.33*365$$ [lb dry VS/yr]

```
QNET = QNET*TEMP                                                            MHI05800
```

$$QNET = QNET*VSS_{IS1}*Q_{IS1}8.33*365$$ [BTU/yr]

```
YSBH = 8.*CYT/9.+8736.-52.*DMATX(3,N)*7./9.                                 MHI05900
```

$$YSBH = \frac{8CYT}{9} + 8736 - \frac{52HPWK*7}{9}$$ [hr/yr]

```
YHUH = 10.*CYT/9.+52.*CYT*DMATX(4,N)/9.                                     MHI06000
```

$$YHUH = \frac{10CYT+(52CYT*SPER)}{9}$$ [hr/yr]

QHUP = YHUH*1913.*FHA*DMATX(2,N) MHI06100

$$QHUP = YHUH*1913FHA*NINC$$ [BTU/yr]

QSB = YSBH*315*FHA*DMATX(2,N) MHI06200

$$QSB = 315YSBH*FHA*NINC$$ [BTU/yr]

QTOT = QHUP+QSB+QNET MHI06300

$$QTOT = QHUP+QSB+QNET$$ [BTU/yr]

WFYR = QTOT/15019. (For oil) MHI06900

$$WFYR = \frac{QHUP+QSB+QNET}{15019}$$ [lb/yr]

FCOST = WFYR/7.481*DMATX(8,N) MHI07000

$$FCOST = \frac{WFYR*FC}{7.481}$$ [dollars/yr]

WFYR QTOT/15581. (For nat. gas) MHI07700

$$WFYR = \frac{QTOT}{15581}$$ [lb/yr]

FCOST = WFYR/45.8*DMATX(9,N) MHI07800

$$FCOST = \frac{QTOT*CNG}{15581*45.8}$$ [dollars/yr]

CFDG = QTOT/8967./.0695 (For dig gas) MHI08500

$$CFDG = \frac{QTOT}{8967*0.0695}$$ [ft^3/yr]

TYR = SMATX(10,IS1)*SMATX(2,IS1)*1.52 MHI09100

$$TYR = TSS_{IS1}*Q_{IS1}*1.52$$

WTON = 554.24/FHA**.3572 MHI09200

$$WTON = \frac{554.24}{[FHA]^{0.3572}}$$

ECOST = WTON*TYR*DMATX(10,20) MHI09300

$$ECOST = WTON*TYR*CKWH$$ [dollars/yr]

DPTON = FCOST/(PSDD*365./2000.) MHI09900

$$DPTON = \frac{FCOST}{\frac{365PSDD}{2000}}$$ [dollars/ton]

References:

Patterson and Banker, 1971

Smith and Eilers, 1975

5. Cost functions.

a. Capital cost

Function of PSDD*ECF

X = ALOG(PSDD/24.*DMATX(16,N)) MHI10500

$$X = \ln \frac{PSDD*ECF}{24}$$

CCOST(N,1) = EXP(2.377364+.598986*X)*1000. MHI10600

$$CCOST = 1000e^{2.377364+0.598986X}$$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of $PSDD*\frac{VSS_{IS1}}{TSS_{IS1}}$

X = ALOG(PSDD*365./2000.*(SMATX(9,IS1)/SMATX(10,IS1))) MHI11200

$$X = \ln \frac{365PSDD*VSS_{IS1}}{2000TSS_{IS1}}$$

(1) Operating manhours

OHRS = EXP(3.402537+1.215130*X-.157203*X**2.+.009771*X**3.) MHI11800

$$OHRS = e^{3.402537+1.215130X-0.157203X^2+0.009771X^3}$$ [hrs/yr]

(2) Maintenance manhours

XMHRS = EXP(3.906553+.702471*X-.088337*X**2.+.006827*X**3.) MHI11900

$$XMHRS = e^{3.906553+0.702471X-0.088337X^2+0.006827X^3}$$ [hrs/yr]

(3) Total materials and supplies

TMSU = EXP(7.864729-.338816*X+.054026*X**2.) MHI12000

$$TMSU = e^{7.864729-0.338816X+0.054026X^2}$$ [dollars/yr]

c. **Total operating and maintenance costs** MHI12500

```
COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI+ECOST+FCOST)/SMATX(2,1)/3650.
```

$$COSTO = \frac{(OHRS+XMHRS)*DHR*(1+PCT)+(TMSU*WPI)+ECOST+FCOST}{Q_{Plant\ Inf.} * 3650} \quad [cents/1000\ gal]$$

```
C
C          MULTIPLE HEARTH INCINERATION
C          PROCESS IDENTIFICATION NUMBER  14
C
      SUBROUTINE MHINC
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      DIMENSION SFHA(59)
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
      DATA SFHA/85.,98.,112.,125.,126.,140.,145.,166.,187.,193.,208.,225
     1.,256.,276.,288.,319.,323.,351.,364.,383.,411.,452.,510.,560.,575.
     2,672.,760.,845.,857.,944.,988.,1041.,1068.,1117.,1128.,1249.,1260.
     3,1268.,1400.,1410.,1483.,1540.,1580.,1591.,1660.,1675.,1752.,1849.
     4,1875.,1933.,2060.,2084.,2090.,2275.,2350.,2464.,2600.,2860.,3120.
     5/
C
C
C          CALC. OF OUTPUT SIZES AND QUANTITIES
C
      PSDD=SMATX(10,IS1)*SMATX(2,IS1)*8.33
      FHAT=58.31*SMATX(2,IS1)*SMATX(10,IS1)/DMATX(3,N)/DMATX(1,N)*DMATX(
     116,N)
      XX=FHAT/DMATX(2,N)
      DO 20 I=1,59
      IF (XX-SFHA(I)) 10,10,20
   10 FHA=SFHA(I)
      GO TO 30
   20 CONTINUE
      FHA=3120.
   30 IF (FHA-200.) 40,40,50
   40 CYT=18.
      GO TO 100
   50 IF (FHA-1700.) 60,60,70
   60 CYT=13.+.024*FHA
      GO TO 100
   70 IF (FHA-2300.) 80,80,90
   80 CYT=.09*(FHA-1100.)
      GO TO 100
   90 CYT=108.
  100 PASH=(SMATX(10,IS1)-SMATX(9,IS1))/SMATX(9,IS1)
      HASH=68.*PASH
      PWAT=(1000000.-SMATX(10,IS1))/SMATX(9,IS1)
      HWSL=1404.3*PWAT
      SAERA=64.03*FHA**.51
      VSPH=SMATX(9,IS1)*SMATX(2,IS1)*58.31/DMATX(3,N)
      HC=1.735*(1.+.374*DMATX(5,N))
      QTRAN=(1.279+HC)*100.*SAERA*DMATX(2,N)/VSPH
      QCOOL=267.*FHA*DMATX(2,N)/VSPH
      QNET=2725.+HASH+HWSL+QCOOL+QTRAN-DMATX(6,N)+246.
      IF (QNET) 110,110,120
  110 QNET=0.
  120 TEMP=SMATX(9,IS1)*SMATX(2,IS1)*8.33*365.
      QNET=QNET*TEMP
```

```
      YSBH=8.*CYT/9.+8736.-52.*DMATX(3,N)*7./9.
      YHUH=10.*CYT/9.+52.*CYT*DMATX(4,N)/9.
      QHUP=YHUH*1913.*FHA*DMATX(2,N)
      QSB=YSBH*315.*FHA*DMATX(2,N)
      QTOT=QHUP+QSB+QNET
C
C
C                 CALC. OF FUEL COSTS IF FUEL OIL IS USED
C
      IF (DMATX(7,N)-1.) 130,130,140
  130 WFYR=QTOT/15019.
      FCOST=WFYR/7.481*DMATX(8,N)
      GO TO 180
C
C
C                 CALC. OF FUEL COSTS IF NATURAL GAS IS USED
C
  140 IF (DMATX(7,N)-2.) 150,150,160
  150 WFYR=QTOT/15561.
      FCOST=WFYR/45.8*DMATX(9,N)
      GO TO 180
C
C
C                 CALC. OF FUEL COSTS IF DIGESTER GAS IS USED
C
  160 IF (DMATX(7,N)-3.) 170,170,180
  170 CFDG=QTOT/8967./.0695
      FCOST=0.
C
C
C                 CALC. OF ELECTRICAL POWER COSTS
C
  180 TYR=SMATX(10,IS1)*SMATX(2,IS1)*1.52
      WTON=554.24/FHA**.3572
      ECOST=WTON*TYR*DMATX(10,20)
C
C
C                 RATIO OF FUEL COST TO AMOUNT OF DRY SOLIDS TO BE
C                 INCINERATED
C
      DPTON=FCOST/(PSDD*365./2000.)
C
C
C             CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C             CAPACITY
C
      X=ALOG(PSDD/24.*DMATX(16,N))
      CCOST(N,1)=EXP(2.377364+.598986*X)*1000.
C
C
C             CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C             DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(PSDD*365./2000.*(SMATX(9,IS1)/SMATX(10,IS1)))
C
C
C                 CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                 AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(3.402537+1.215130*X-.157203*X**2.+.009771*X**3.)
      XMHRS=EXP(3.906553+.702471*X-.088337*X**2.+.006827*X**3.)
      TMSU=EXP(7.864729-.338816*X+.054026*X**2.)
C
C
C                 OPERATING COST EQUATION
C
```

```
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI+ECOST+FCOST)/SMATX(
     12,1)/3650.
C
C
C             ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=FHA
      OMATX(2,N)=WFYR
      OMATX(3,N)=PSDD
      OMATX(4,N)=ECOST
      OMATX(5,N)=FCOST
      OMATX(6,N)=CFDG
C
C
C             PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=14.
      RETURN
      END
```

SECTION 16

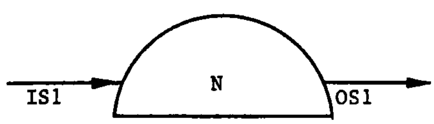
RAW WASTEWATER PUMPING, RWP

Subroutine Identification Number 15

Raw Wastewater Pumping, RWP

Rev. Date 8/1/77

1. Process symbol.



IS1: Liquid input stream

OS1: Liquid output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = HEAD	Pumping head of the influent pumps, ft. [30.]
DMATX(16,N) = ECF	Excess capacity factor for the pumps. [1.]

3. Output parameters which are printed on computer output sheets.

HEAD = DMATX(1,N)	
QP = OMATX(1,N)	Peak flow capacity of the raw wastewater pumping system, [MGD].
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost,[cents/1000gal].
ACOST	Amortization cost,[cents/1000gal].
TCOST	Total treatment cost,[cents/1000gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
SMATX(I,OS1) = SMATX(I,IS1)                                    RWP01900
```

SMATX(I,OS1) = SMATX (I,IS1)   [mg/l]

```
HEAD = DMATX(1,N)                                              RWP02400
```

HEAD = DMATX (1,N)   [ft.]

```
QP = 1.78*SMATX(2,IS1)**.92
```

$QP = 1.78[Q_{IS1}]^{0.92}$ [MGD]   RWP02500

Pump Efficiency - Current values used in program; each can be changed by the replacement on punched card.

PEFF = 0.70 for $Q_{IS1}<1.44$ MGD   RWP04900

PEFF = 0.74 for $Q_{IS1}<10.08$ MGD   RWP05200

PEFF = 0.83 for $Q_{IS1} \geq 10.08$ MGD   RWP05400

References:

Patterson and Banker, 1971

5. Cost functions.

a. Capital cost

Function of QP * ECF

```
X    ALOG(QP*DMATX(16,N))                                      RWP03100
```

X = ln (QP * ECF)

```
CCOST(N,1)   EXP(4.004828+.519499*X+.082262*X**2.-.006492*X**3.)*1000.
                                                               RWP03200
```

$CCOST = 1000*e^{4.004828+.519499X+.082262X^2-.006492X^3}$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of Q_{IS1}

```
X = ALOG(SMATX(2,IS1))                                         RWP03900
```

X   ln (Q_{IS1})

(1) Operating manhours

```
OHRS = EXP(6.097269+.253066*X-.193659*X**2.+.078201*X**3.-.006680*X**4.)
```
RWP04500

$$OHRS = e^{6.097269+0.253066X-0.193659X^2+0.078201X^3-0.006680X^4} \quad [hrs/yr]$$

(2) Maintenance manhours

```
XMHRS = EXP(5.911541-.013158*X+.076643*X**2.)
```
RWP04700

$$XMHRS = e^{5.911541-0.013158X+0.076643X^2} \quad [hrs/yr]$$

(3) Kilowatt hrs per year

```
YRKW = SMATX(2,IS1)*1000000.*HEAD/1440./3960./PEFF/.9*.7457*24.*365.
```
RWP05500

$$YRKW = \frac{Q_{IS1}*1000000HEAD*.7457*24*365}{1440*3960*PEFF*0.9} \quad [KwHr/yr]$$

(4) Energy cost

```
ECOST = YRKW*DMATX(10,20)
```
RWP05600

ECOST = YRKW*CKWH [dollars/yr]

(5) Supplies cost

```
SCOST = EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)
```
RWP05700

$$SCOST = e^{5.851743+0.301610X+0.197183X^2-0.017962X^3} \quad [dollars/yr]$$

(6) Total materials and supplies

```
TMSU = ECOST + SCOST * WPI
```
RWP05800

TMSU = ECOST + (SCOST * WPI) [$/yr]

c. Total operating and maintenance costs

```
COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.
```
RWP06300

$$COSTO = \frac{(OHRS+XMHRS)*DHR*(1\ +PCT)+TMSU}{Q_{Plant\ Inf.}*3650} \quad [cents/1000gal]$$

Cost curves, Patterson and Banker pages 34, 83, 84

```
C
C           RAW WASTEWATER PUMPING
C           PROCESS IDENTIFICATION NUMBER  15
C
      SUBROUTINE RWP
C
C
C           COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C           EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=2,20
   10 SMATX(I,OS1)=SMATX(I,IS1)
C
C
C           CALC. OF OUTPUT SIZES AND QUANTITIES
C
      HEAD=DMATX(1,N)
      QP=1.78*SMATX(2,IS1)**.92
C
C
C           CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C           CAPACITY
C
      X=ALOG(QP*DMATX(16,N))
      CCOST(N,1)=EXP(4.004828+.519499*X+.082262*X**2.-.006492*X**3.)*100
     10.
C
C
C           CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C           DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(SMATX(2,IS1))
C
C
C                 CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                 AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(6.097269+.255066*X-.193659*X**2.+.078201*X**3.-.006680*X*
     1*4.)
      XMHRS=EXP(5.911541-.013158*X+.076643*X**2.)
      IF (SMATX(2,IS1)-1.44) 20,30,30
   20 PEFF=.70
      GO TO 60
   30 IF (SMATX(2,IS1)-10.08) 40,50,50
   40 PEFF=.74
      GO TO 60
   50 PEFF=.83
   60 YRKW=SMATX(2,IS1)*1000000.*HEAD/1440./3960./PEFF/.9*.7457*24.*365.
      ECOST=YRKW*DMATX(10,20)
      SCOST=EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)
      TMSU=ECOST+SCOST*WPI
```

```
C
C
C                 OPERATING COST EQUATION
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.
C
C
C           ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=QP
C
C
C           PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=15.
      RETURN
      END
```

SECTION 17

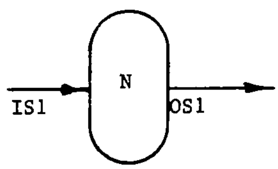
SLUDGE HOLDING TANKS, SHT

Subroutine Identification Number 16

Sludge Holding Tanks, SHT

Rev. Date 8/1/77

1. Process symbol.



IS1: Sludge input stream

OS1: Sludge output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = TD	Sludge holding tank detention time, days. [15.]
DMATX(16,N) = ECF	Excess capacity factor for the process. [1.]

3. Output parameters which are printed on computer output sheets.

TD = DMATX(1,N)	
VSHT = OMATX(1,N)	Volume of the sludge holding tanks, cu ft/ 1000.
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000 gal].
ACOST	Amortization cost, [cents/1000 gal].
TCOST	Total treatment cost, [cents/1000 gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
SMATX(I,OS1) = SMATX(I,IS1)                                  SHT01900
```

SMATX(I,OS1) = SMATX(I,IS1) [mg/l]

where I = 2,20

i.e. Q, SOC, SNBC, SON, SOP, SFM, SBOD, VSS, TSS, DOC, DNBC, DN, DP, DFM, ALK, DBOD, NH3, NO3

```
VSHT = SMATX(2,IS1)*DMATX(1,N)*1000./7.48*DMATX(16,N)                SHT02400
```

$$VSHT = \frac{Q_{IS1}*TD*ECF*1000}{7.48} \qquad [ft^3/1000]$$

```
V1 = SMATX(2,IS1)*DMATX(1,N)*1000./7.48                               SHT03800
```

$$V1 = \frac{Q_{IS1}*TD*1000}{7.48} \qquad [ft^3/1000]$$

References:

Smith and Eilers, 1975

Patterson and Banker, 1971

5. Cost functions.

a. Capital cost

Function of VSHT

```
X = ALOG(VSHT)                                                         SHT03000
```

$$X = \ln VSHT$$

```
CCOST(N,1) = EXP(2.625751+.484180*X+.000613*X**2.+.002252*X**3.)*1000.
                                                                      SHT03100
```

$$CCOST = 1000e^{2.625751+0.484180X+0.000613X^2+0.002252X^3} \qquad [dollars]$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of V1

```
X = ALOG(V1)                                                           SHT03900
```

$$X = \ln (V1)$$

(1) Operating manhours

```
OHRS = EXP(5.727345+.000762*X+.098701*X**2.-.006786*X**3.)            SHT04500
```

$$OHRS = e^{5.727345+0.000762X+0.098701X^2-0.006786X^3} \qquad [hrs/yr]$$

(2) Maintenance manhours

```
XMHRS = EXP(4.506628+.214662*X+.071402*X**2.-.004681*X**3.)           SHT04600
```

$$XMHRS = e^{4.506628+0.214662X+0.071402X^2-0.004681X^3} \qquad [hrs/yr]$$

(3) Total materials and supplies

```
TMSU = EXP(5.479939+.299282*X+.106008*X**2.-.008658*X**3.)            SHT04700
```

$$TMSU = e^{5.479939+0.299282X+0.106008X^2-0.008658X^3} \qquad [dollars/yr]$$

c. Total operating and maintenance costs SHT05200

COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650} \quad [cents/1000\ gal]$$

Cost curves, Patterson and Banker pages 46,98,99

```
C
C           SLUDGE HOLDING TANKS
C           PROCESS IDENTIFICATION NUMBER  16
C
      SUBROUTINE SHT
C
C
C           COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C           EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=2,20
   10 SMATX(I,OS1)=SMATX(I,IS1)
C
C
C           CALC. OF OUTPUT SIZES AND QUANTITIES
C
      VSHT=SMATX(2,IS1)*DMATX(1,N)*1000./7.48*DMATX(16,N)
C
C
C           CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C           CAPACITY
C
      X=ALOG(VSHT)
      CCOST(N,1)=EXP(2.625751+.484180*X+.000613*X**2.+.002252*X**3.)*100
     10.
C
C
C           CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C           DOES NOT INCLUDE EXCESS CAPACITY
C
      V1=SMATX(2,IS1)*DMATX(1,N)*1000./7.48
      X=ALOG(V1)
C
C
C                 CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                 AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(5.727345+.000762*X+.098701*X**2.-.006786*X**3.)
      XMHRS=EXP(4.506628+.214662*X+.071402*X**2.-.004681*X**3.)
      TMSU=EXP(5.479939+.299282*X+.106008*X**2.-.006658*X**3.)
C
C
C                 OPERATING COST EQUATION
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C           ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=VSHT
C
```

```
C                                                                       SHT05900
C             PROCESS ENERGY INDICES                                    SHT06000
C                                                                       SHT06100
      FLOW(N)=SMATX(2,IS1)                                              SHT06200
      POW(N)=16.                                                        SHT06300
      RETURN                                                            SHT06400
      END                                                               SHT06500
```

SECTION 18

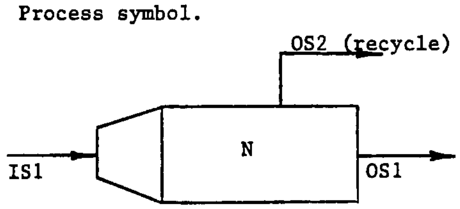
CENTRIFUGATION, CENT

Subroutine Identification Number 17

Centrifugation, CENT

Rev. Date 8/1/77

1. Process symbol.



IS1: Sludge input stream

OS1: Sludge cake output stream

OS2: Centrate output stream

N: User assigned number to the process.

2. Input parameters and nominal values.

DMATX(1,N) = CRR	Solids recovery ratio for centrifugation. [.95]
DMATX(2,N) = TSS	Total suspended solids concentration of OS1, mg/l. [200,000.]
DMATX(3,N) = HPWK	Hours per week that the centrifuges are operated, hr/wk. [35.]
DMATX(4,N) = XCEN	Program control: 0 = landfill sludge disposal, 1 = incineration sludge disposal. [0.]
DMATX(5,N) = POLY	Dose of polymer added to condition sludge, lb/ton. [2.]
DMATX(6,N) = CPOLY	Cost of polymer, $/lb. [2.]
DMATX(7,N) = GPMN	Capacity of each centrifuge that is used (4 sizes of centrifuges are possible depending on the type of sludge), gpm. [100.]
DMATX(8,N) = CNMIN	Minimum number of centrifuges to be used. [2.]
DMATX(16,N) = ECF	Excess capacity factor for the process. [1.]

3. Output parameters which are printed on computer output sheets.

HPWK = DMATX(3,N)

XCEN = DMATX(4,N)

POLY = DMATX(5,N)

CPOLY = DMATX(6,N)

GPMN = DMATX(7,N)

CNMIN = DMATX(8,N)	
CGPM = OMATX(1,N)	Design capacity of the centrifuges, [gpm.]
DSOL = OMATX(2,N)	Dry solids incl. chem fed to centrifuges, [tons/yr.]
AFC = OMATX(3,N)	Amortization factor for centrifuges based on a 10 year lifetime.
CSIZE = OMATX(4,N)	Size of each centrifuge used, [gpm.]
CN = OMATX(5,N)	Number of centrifuges used.
CCOST	Capital cost, [dollars]
COSTO	Operating and maintenance cost, [cents/1000 gal.]
ACOST	Amortization cost, [cents/1000 gal.]
TCOST	Total treatment cost, [cents/1000 gal.]
ECF	Excess capacity factor.

References:

Patterson and Banker, 1971

Smith and Eilers, 1975

4. Theory and functions - FORTRAN statement followed by an equivalent algebraic equation.

```
SMATX(7,IS1) = SMATX(7,IS1)+POLY*SMATX(10,IS1)/2000.          CEN02900
```

$$SFM_{IS1} = SFM_{IS1} + \frac{POLY*TSS_{IS1}}{2000} \qquad [mg/1]$$

```
SMATX(10,IS1) = SMATX(10,IS1)+POLY*SMATX(10,IS1)/2000.        CEN03000
```

$$TSS_{IS1} = TSS_{IS1} + \frac{POLY*TSS_{IS1}}{2000} \qquad [mg/1]$$

```
DSOL = SMATX(10,IS1)*SMATX(2,IS1)*8.33*365./2000.             CEN03100
```

$$DSOL \quad \frac{TSS_{IS1}*Q_{IS1}*8.33*365}{2000} \qquad [ton/yr]$$

SMATX(10,OS2) = ((1.-DMATX(1,N))/(1.-DMATX(1,N)*SMATX(10,IS1)/DMATX(2,N)))*SMATX(10,IS1)

$$TSS_{OS2} = \frac{(1-CRR)*TSS_{IS1}}{1-\frac{CRR*TSS_{IS1}}{TSS_{OS1}}}$$ [mg/1] CEN03200

TEMP1 = DMATX(2,N)/SMATX(10,IS1) CEN03400

$$TEMP1 = \frac{TSS_{OS1}}{TSS_{IS1}}$$

TEMP2 = SMATX(10,OS2)/SMATX(10,IS1) CEN03500

$$TEMP2 = \frac{TSS_{OS2}}{TSS_{IS1}}$$

SMATX(10,OS1) = DMATX(2,N) CEN03600

$$TSS_{OS1} = TSS_{OS1}$$ [mg/1]

SMATX(2,OS1) = (SMATX(10,IS1)-SMATX(10,OS2))*SMATX(2,IS1)/(SAMTX(10,OS1)-SMATX(10,OS2))

$$Q_{OS1} = \frac{(TSS_{IS1}-TSS_{OS2})*Q_{IS1}}{(TSS_{OS1}-TSS_{OS2})}$$ [MGD] CEN03700

SMATX(2,OS2) = SMATX(2,IS1)-SMATX(2,OS1) CEN03900

$$Q_{OS2} = Q_{IS1}-Q_{OS1}$$ [MGD]

SMATX(I,OS1) = TEMP1*SMATX(I,IS1) CEN04500

SMATX(I,OS1) = TEMP1*SMATX(I,IS1) [mg/1]

where I = 3,9

i.e. SOC, SNBC,SON,SOP,SFM,SBOD,VSS

SMATX(I,OS2) = TEMP2*SMATX(I,IS1) CEN04600

SMATX(I,OS2) = TEMP2*SMATX(I,IS1) [mg/1]

where I = 3,9

SMATX(I,OS1) = SMATX(I,IS1) CEN04800

SMATX(I,OS1) = SMATX(I,IS1) [mg/1]

where I = 11,20

i.e. DOC,DNBC,DN,DP,DFM,ALK,DBOD,NH3,NO3

SMATX(I,OS2) = SMATX(I,IS1) CEN04900

SMATX(I,OS2) = SMATX(I,IS1) [mg/1]

where I = 11,20

CN = CNMIN CEN05400

CN = CNMIN

CGPM = SMATX(2, IS1)*116666.7/HPWK*DMATX(16,N)/CN CEN05500

$$CGPM = \frac{116666.7*Q_{IS1}*ECF}{HPWK*CN} \quad [gpm/centrifuge]$$

CSIZE = .275*GPMN CEN05700

CSIZE = 0.275 GPMN

CSIZE = .350*GPMN [For (CGPM-CSIZE)>0] CEN06400

CSIZE = 0.350 GPMN

CSIZE = .590*GPMN [For (CGPM-CSIZE)>0] CEN06600

CSIZE = 0.590 GPMN

CSIZE = GPMN [For (CGPM-CSIZE)>0] CEN06800

CSIZE = GPMN

NCN = CGPM/CSIZE CEN06900

$$NCN = \frac{CGPM}{CSIZE}$$

5. Cost functions. (Cost curves, Banker and Patterson page 109)

a. Capital cost

Function of GPMM, CSIZE and CN

CCOST(N,1) = 78500.*(1.-.044*(CN-2.))*CN CEN09000

CCOST = 78500CN*(1-0.044(CN-2)) [dollars]

CCOST(N,1) = 98000.*(1.-.044*(CN-2.))*CN CEN09800

CCOST = 98000CN*(1-0.044(CN-2)) [dollars]

CCOST(N,1) = 140000.*(1.-.044*(CN-2.))*CN CEN10600

CCOST = 140000CN*(1-0.044(CN-2)) [dollars]

CCOST(N,1) = 160000.*(1.-.044*(CN-2.))*CN CEN11400

CCOST = 160000CN*(1-0.044(CN-2)) [dollars]

Amortization factor for centrifuges

AFC = DMATX(3,20)*(1.+DMATX(3,20))**10./((1.+DMATX(3,20))**10.-1.)

$$AFC = \frac{RI[1+RI]^{10}}{[1+RI]^{10}-1}$$ CEN11900

Amortization cost

ACOST(N,1) = CCOST(N,1)*AFC/SMATX(2,1)/3650. CEN12000

$$ACOST = \frac{CCOST * AFC}{Q_{Plant\ Inf.} * 3650}$$ [cents/1000 gal]

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of DSOL.

X = ALOG (DSOL) CEN12600

$X = \ln DSOL$

(1) Operating manhours

(For XCEN = 0)

OHRS = EXP(7.621517-.476977*X+.071516*X**2.) CEN13300

$$OHRS = e^{7.621517-0.476977X+0.071516X^2}$$ [hrs/yr]

(For XCEN ≠ 0)

OHRS = EXP(7.264153-.466246*X+.069552*X**2.) CEN14000

$$OHRS = e^{7.264153-0.466246X+0.069552X^2}$$ [hrs/yr]

(2) Maintenance manhours

XMHRS = EXP(5.997115-.493809*X+.070892*X**2.) CEN14600

$$XMHRS = e^{5.997115-0.493809X+0.070892X^2}$$ [hrs/yr]

(3) Total materials and supplies

SUPP = EXP(-2.822519+.700948*X)*1000. CEN14700

$$SUPP = 1000e^{-2.822519+0.700948X}$$ [dollars/yr]

CHEM = DSOL*POLY*CPOLY CEN14800

CHEM = DSOL*POLY*CPOLY [dollars/yr]

c. Total operating and maintenance costs

COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+SUPP*WPI+CHEM)/SMATX(2,1)/3650. CEN15300

$$COSTO = \frac{(OHRS+XMHRS)*DHR*(1+PCT)+(SUPP*WPI)+CHEM}{Q_{Plant\ Inf.} * 3650}$$ [cents/1000 gal]

```
C
C           CENTRIFUGATION
C           PROCESS IDENTIFICATION NUMBER  17
C
      SUBROUTINE CENT
C
C
C           COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C           ASSIGNMENT OF DESIGN VALUES TO PROCESS PARAMETERS
C
      HPWK=DMATX(3,N)
      XCEN=DMATX(4,N)
      POLY=DMATX(5,N)
      CPOLY=DMATX(6,N)
      GPMN=DMATX(7,N)
      CNMIN=DMATX(8,N)
C
C
C           PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C           CHARACTERISTICS
C
      SMATX(7,IS1)=SMATX(7,IS1)+POLY*SMATX(10,IS1)/2000.
      SMATX(10,IS1)=SMATX(10,IS1)+POLY*SMATX(10,IS1)/2000.
      DSOL=SMATX(10,IS1)*SMATX(2,IS1)*8.33*365./2000.
      SMATX(10,OS2)=((1.-DMATX(1,N))/(1.-DMATX(1,N)*SMATX(10,IS1)/DMATX(
     12,N)))*SMATX(10,IS1)
      TEMP1=DMATX(2,N)/SMATX(10,IS1)
      TEMP2=SMATX(10,OS2)/SMATX(10,IS1)
      SMATX(10,OS1)=DMATX(2,N)
      SMATX(2,OS1)=(SMATX(10,IS1)-SMATX(10,OS2))*SMATX(2,IS1)/(SMATX(10,
     1OS1)-SMATX(10,OS2))
      SMATX(2,OS2)=SMATX(2,IS1)-SMATX(2,OS1)
C
C
C           EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=3,9
      SMATX(I,OS1)=TEMP1*SMATX(I,IS1)
   10 SMATX(I,OS2)=TEMP2*SMATX(I,IS1)
      DO 20 I=11,20
      SMATX(I,OS1)=SMATX(I,IS1)
   20 SMATX(I,OS2)=SMATX(I,IS1)
C
C
C           CALC. OF OUTPUT SIZES AND QUANTITIES
C
      CN=CNMIN
      CGPM=SMATX(2,IS1)*116666.7/HPWK*DMATX(16,N)/CN
      GPMM=SMATX(2,IS1)*1000000./1440.
      CSIZE=.275*GPMN
C
```

```
C                                                                       CEN05900
C          CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS           CEN06000
C          CAPACITY                                                     CEN06100
C                                                                       CEN06200
      IF (CGPM-CSIZE) 60,60,30                                          CEN06300
   30 CSIZE=.350*GPMN                                                   CEN06400
      IF (CGPM-CSIZE) 80,80,40                                          CEN06500
   40 CSIZE=.590*GPMN                                                   CEN06600
      IF (CGPM-CSIZE) 100,100,50                                        CEN06700
   50 CSIZE=GPMN                                                        CEN06800
      NCN=CGPM/CSIZE                                                    CEN06900
      CN=NCN+1                                                          CEN07000
      GO TO 120                                                         CEN07100
   60 IF (GPMM-CSIZE*(CN-1.)) 140,140,70                                CEN07200
   70 CN=CN+1.                                                          CEN07300
      GO TO 60                                                          CEN07400
   80 IF (GPMM-CSIZE*(CN-1.)) 150,150,90                                CEN07500
   90 CN=CN+1.                                                          CEN07600
      GO TO 80                                                          CEN07700
  100 IF (GPMM-CSIZE*(CN-1.)) 160,160,110                               CEN07800
  110 CN=CN+1.                                                          CEN07900
      GO TO 100                                                         CEN08000
  120 IF (GPMM-CSIZE*(CN-1.)) 170,170,130                               CEN08100
  130 CN=CN+1.                                                          CEN08200
      GO TO 120                                                         CEN08300
C                                                                       CEN08400
C                                                                       CEN08500
C               CALC. OF CAPITAL COSTS FOR CENT FACILITY WHOSE          CEN08600
C               DESIGN CAPACITY DOES NOT EXCEED 27.5% OF THE CAPACITYCEN08700
C               OF EACH CENTRIFUGE                                      CEN08800
C                                                                       CEN08900
  140 CCOST(N,1)=78500.*(1.-.044*(CN-2.))*CN                            CEN09000
      GO TO 180                                                         CEN09100
C                                                                       CEN09200
C                                                                       CEN09300
C               CALC. OF CAPITAL COSTS FOR CENT FACILITY WHOSE          CEN09400
C               DESIGN CAPACITY DOES NOT EXCEED 35% OF THE CAPACITY     CEN09500
C               OF EACH CENTRIFUGE                                      CEN09600
C                                                                       CEN09700
  150 CCOST(N,1)=98000.*(1.-.044*(CN-2.))*CN                            CEN09800
      GO TO 180                                                         CEN09900
C                                                                       CEN10000
C                                                                       CEN10100
C               CALC. OF CAPITAL COSTS FOR CENT FACILITY WHOSE          CEN10200
C               DESIGN CAPACITY DOES NOT EXCEED 59% OF THE CAPACITY     CEN10300
C               OF EACH CENTRIFUGE                                      CEN10400
C                                                                       CEN10500
  160 CCOST(N,1)=140000.*(1.-.044*(CN-2.))*CN                           CEN10600
      GO TO 180                                                         CEN10700
C                                                                       CEN10800
C                                                                       CEN10900
C               CALC. OF CAPITAL COSTS FOR CENT FACILITY WHOSE          CEN11000
C               DESIGN CAPACITY EQUALS THE CAPACITY OF EACH CENTRI-     CEN11100
C               FUGE.                                                   CEN11200
C                                                                       CEN11300
  170 CCOST(N,1)=160000.*(1.-.044*(CN-2.))*CN                           CEN11400
C                                                                       CEN11500
C                                                                       CEN11600
C          CALC. OF AMORTIZATION COSTS                                  CEN11700
C                                                                       CEN11800
  180 AFC=DMATX(3,20)*(1.+DMATX(3,20))**10./((1.+DMATX(3,20))**10.-1.)  CEN11900
      ACOST(N,1)=CCOST(N,1)*AFC/SMATX(2,1)/3650.                        CEN12000
C                                                                       CEN12100
C                                                                       CEN12200
C          CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,     CEN12300
C          DOES NOT INCLUDE EXCESS CAPACITY                             CEN12400
```

```
C
      X=ALOG(DSOL)
      IF (XCEN) 200,190,200
C
C
C                    CALC. OF OPERATING MANHOURS IF LANDFILL DISPOSAL IS
C                    USED
C
  190 OHRS=EXP(7.621517-.476977*X+.071516*X**2.)
C
C
C                    CALC. OF OPERATING MANHOURS IF INCINERATION DISPOSAL
C                    IS USED
C
      GO TO 210
  200 OHRS=EXP(7.264153-.466246*X+.069552*X**2.)
C
C
C                    CALC. OF MAINTENANCE MANHOURS, SUPPLIES AND CHEMICAL
C                    COSTS
C
  210 XMHRS=EXP(5.997115-.493809*X+.070892*X**2.)
      SUPP=EXP(-2.822519+.700948*X)*1000.
      CHEM=DSOL*POLY*CPOLY
C
C
C                    OPERATING COST EQUATION
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+SUPP*WPI+CHEM)/SMATX(2,1)/36
     150.
C
C
C              ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=CGPM
      OMATX(2,N)=DSOL
      OMATX(3,N)=AFC
      OMATX(4,N)=CSIZE
      OMATX(5,N)=CN
C
C
C              PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=17.
      RETURN
      END
```

SECTION 19

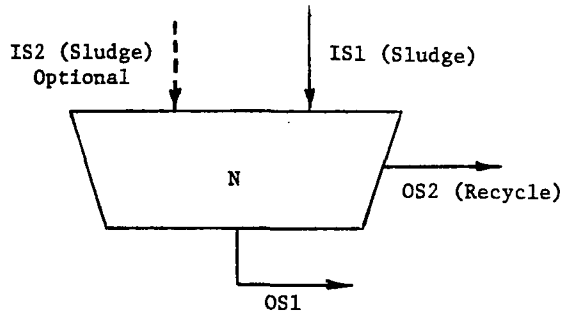
AEROBIC DIGESTION, AEROB

Subroutine Identification Number 18

Rev. Date 8/1/77

Aerobic Digestion, AEROB

1. Process symbol.



IS1: Primary sludge input stream

IS2: Secondary sludge input stream

OS1: Sludge output stream

OS2: Supernatant recycle output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = XL	Program control: this input variable is set equal to the user assigned process number (N) which the user assigned to the aeration (AERFS) process to allow the AEROB subroutine to use output parameters calculated in the aeration process. [varies]
DMATX(2,N) = XAFS	Program control: 0 = no final settler or sludge return pumps are required, 1 = a final settler and sludge return pumps are required with the aerobic digestion process. [1.]
DMATX(3,N) = DTA	Detention time for the aeration, days. [30.]
DMATX(4,N) = TSS1	Total suspended solids in OS1, mg/l. [40,000.]
DMATX(5,N) = TSS2	Total suspended solids in OS2, mg/l. [150.]
DMATX(6,N) = BOD2	Concentration of 5-day BOD in OS2, mg/l. [50.]
DMATX(7,N) = GSS	Overflow rate for the final settlers, gpd/sq ft. [150.]
DMATX(8,N) = HEAD	Pumping head of the sludge return pumps, ft. [30.]
DMATX(13,N) = ECF	Excess capacity factor for the final settlers. [1.2]
DMATX(14,N) = ECF	Excess capacity factor for the sludge return pumps. [1.25]
DMATX(15,N) = ECF	Excess capacity factor for the air blowers. [1.5]
DMATX(16,N) = ECF	Excess capacity factor for the aeration tank. [1.2]

3. Output parameters which are printed on computer output sheets.

XL = DMATX(1,N)

XAFS = DMATX(2,N)

DTA = DMATX(3,N)

TSS1 = DMATX(4,N)

TSS2 = DMATX(5,N)

BOD2 = DMATX(6,N)

GSS = DMATX(7,N)

HEAD = DMATX(8,N)

VAER = OMATX(1,N)	Volume of the aerator, cu ft/1000.
ACFM = OMATX(2,N)	Required size of the blower for supplying air to the aerator, cfm.
QPUMP = OMATX(3,N)	Volume of the return stream flow to the aerator, mgd.
AFS = OMATX(4,N)	Surface area of the final settler, sq ft/1000.
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000 gal].
ACOST	Amortization cost, [cents/1000 gal].
TCOST	Total treatment cost, [cents/1000 gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
SMAT(I) = SMATX(I,IS2)                                              AE002400
```

SMAT(I) = SMATX(I,IS2) [mg/l]

where I = 1,20 i.e. I,Q,SOC,SNBC,SON,SOP,SFM,SBOD,VSS,TSS,DOC,DNBC, DN,DP,DFM,ALK,DBOD,NH3,NO3

```
TEMP1 = (SMAT(4)*2.13+(SMAT(8)+SMAT(17))*.65*.18)*SMAT(2)           AE002600
```

$$TEMP1 = (2.13SNBC_{IS2}+0.65(SBOD_{IS2}+DBOD_{IS2})0.18)Q_{IS2} \quad [mg/l\ MGD]$$

```
TEMP2   (OMATX(9,L)*.18+OMATX(10,L)*.0938+OMATX(11,L)+OMATX(12,L))*DMATX(7,L)*SMATX(2,IS1)
                                                                    AE002700
```

$$TEMP2 = (0.18OMATX(9,L)+0.0938OMATX(10,L)+OMATX(11,L)+OMATX(12,L))*DMATX(7,L)*Q_{IS1}$$

[mg/l MGD]

```
TEMP3 = SMAT(7)*SMAT(2)                                              AE002900
```

$TEMP3 = SFM_{IS2} * Q_{IS2}$ [mg/1 MGD]

```
TEMP4 = OMATX(13,L)*DMATX(7,L)*SMATX(2,IS1)                          AE003000
```

$TEMP4 = OMATX(13,L) * DMATX(7,L) * Q_{IS1}$ [mg/1 MGD]

```
SMATX(2,OS1) = ((TEMP1+TEMP2+TEMP3+TEMP4)-(SMATX(2,IS1)+SMAT(2))*    AE003500
  DMATX(5,N))/(DMATX(4,N)-DMATX(5,N))
```

$$Q_{OS1} = \frac{TEMP1+TEMP2+TEMP3+TEMP4-(Q_{IS1}+Q_{IS2})TSS2}{TSS1 - TSS2}$$ [MGD]

```
SMATX(2,OS2) = SMATX(2,IS1)+SMAT(2)-SMATX(2,OS1)                     AE003700
```

$Q_{OS2} = Q_{IS1}+Q_{IS2}-Q_{OS1}$ [MGD]

```
VOLPC = (TEMP1+TEMP2)/(TEMP1+TEMP2+TEMP3+TEMP4)                      AE003800
```

$$VOLPC = \frac{TEMP1+TEMP2}{TEMP1+TEMP2+TEMP3+TEMP4}$$ [no units]

```
SMATX(9,OS1) = DMATX(4,N)*VOLPC                                      AE003900
```

$VSS_{OS1} = TSS1 * VOLPC$ [mg/1]

```
SMATX(7,OS1) = DMATX(4,N)-SMATX(9,OS1)                               AE004000
```

$SFM_{OS1} = TSS1 - VSS_{OS1}$ [mg/1]

```
SMATX(3,OS1) = SMATX(9,OS1)/2.13                                     AE004100
```

$$SOC_{OS1} = \frac{VSS_{OS1}}{2.13}$$ [mg/1]

```
SMATX(4,OS1) = SMATX(3,OS1)                                          AE004200
```

$SNBC_{OS1} = SOC_{OS1}$ [mg/1]

```
SMATX(5,OS1) = SMATX(3,OS1)/10.                                      AE004300
```

$$SON_{OS1} = \frac{SOC_{OS1}}{10}$$ [mg/1]

```
SMATX(6,OS1) = SMATX(3,OS1)/100.                                     AE004400
```

$$SOP_{OS1} = \frac{SOC_{OS1}}{100}$$ [mg/1]

SMATX(10,OS1) = DMATX(4,N) AE004600

TSS_{OS1} TSS1 [mg/l]

SMATX(10,OS2) = DMATX(5,N) AE004700

$TSS_{OS2} = TSS2$ [mg/l]

SMATX(9,OS2) = SMATX(10,OS2)*VOLPC AE004800

$VSS_{OS2} = TSS2*VOLPC$ [mg/l]

SMATX(3,OS2) = SMATX(9,OS2)/2.13 AE004900

$SOC_{OS2} = \frac{VSS_{OS2}}{2.13}$ [mg/l]

SMATX(4,OS2) = SMATX(3,OS2) AE005000

$SNBC_{OS2} = SOC_{OS2}$ [mg/l]

SMATX(5,OS2) SMATX(3,OS2)/10. AE005100

$SON_{OS2} = \frac{SOC_{OS2}}{10}$ [mg/l]

SMATX(6,OS2) SMATX(3,OS2)/100. AE005200

$SOP_{OS2} \quad \frac{SOC_{OS2}}{100}$ [mg/l]

SMATX(7,OS2) = SMATX(10,OS2)-SMATX(9,OS2) AE005300

$SFM_{OS2} = TSS_{OS2} - VSS_{OS2}$ [mg/l]

SMATX(11,OS1) (500.-SMATX(9,OS2)*1.42)/3.2 AE005500

$DOC_{OS1} = \frac{500-1.42VSS_{OS2}}{3.2}$ [mg/l]

SMATX(11,OS2) = SMATX(11,OS1) AE005600

$DOC_{OS2} = DOC_{OS1}$ [mg/l]

SMATX(12,OS1) = SMATX(11,OS2)/2. AE005700

$$DNBC_{OS1} = \frac{DOC_{OS2}}{2}$$ [mg/l]

SMATX(12,OS2) = SMATX(12,OS1) AE005800

$$DNBC_{OS2} = \frac{DOC_{OS2}}{2}$$ [mg/l]

ENTN = SMATX(2,IS1)*(SMATX(5,IS1)+SMATX(13,IS1))+SMAT(2)*(SMAT(5)+SMAT(13)) AE005900

$$ENTN = Q_{IS1}(SON_{IS1}+DN_{IS1})+Q_{IS2}(SON_{IS2}+DN_{IS2})$$ [MGD mg/l]

EXSN = SMATX(2,OS1)*SMATX(5,OS1)+SMATX(2,OS2)*SMATX(5,OS2) AE006100

$$EXSN = (Q_{OS1}*SON_{OS1})+(Q_{OS2}*SON_{OS2})$$ [MGD mg/l]

SMATX(13,OS1) = (ENTN-EXSN)/(SMATX(2,OS1)+SMATX(2,OS2)) AE006200

$$DN_{OS1} = \frac{ENTN-EXSN}{Q_{OS1}+Q_{OS2}}$$ [mg/l]

SMATX(13,OS2) = SMATX(13,OS1) AE006300

$$DN_{OS2} = DN_{OS1}$$ [mg/l]

ENTP = SMATX(2,IS1)*(SMATX(6,IS1)+SMATX(14,IS1))+SMAT(2)*(SMAT(6)+SMAT(14)) AE006400

$$ENTP = Q_{IS1}(SOP_{IS1}+DP_{IS1})+Q_{IS2}(SOP_{IS2}+DP_{IS2})$$ [MGD mg/l]

EXSP = SMATX(2,OS1)*SMATX(6,OS1)+SMATX(2,OS2)*SMATX(6,OS2) AE006600

$$EXSP = (Q_{OS1}*SOP_{OS1})+(Q_{OS2}*SOP_{OS2})$$ [MGD mg/l]

SMATX(14,OS2) = (ENTP-EXSP)/(SMATX(2,OS1)+SMATX(2,OS2)) AE006700

$$DP_{OS2} = \frac{ENTP-EXSP}{Q_{OS1}+Q_{OS2}}$$ [mg/l]

SMATX(14,OS1) = SMATX(14,OS2) AE006800

$$DP_{OS1} = DP_{OS2}$$ [mg/l]

SMATX(15,OS1) = SMATX(15,IS1) AE006900

$$DFM_{OS1} = DFM_{IS1}$$ [mg/l]

```
SMATX(15,OS2) = SMATX(15,IS1)                                          AE007000
```

$DFM_{OS2} = DFM_{IS1}$ [mg/l]

```
SMATX(17,OS1) = DMATX(6,N)-50.                                         AE007300
```

$DBOD_{OS1} = BOD2-50$ [mg/l]

```
SMATX(17,OS2) = SMATX(17,OS1)                                          AE007400
```

$DBOD_{OS2} = BOD2-50$ [mg/l]

```
SMATX(18,OS1) = SMATX(18,IS1)                                          AE007500
```

$NH3_{OS1} = NH3_{IS1}$ [mg/l]

```
SMATX(18,OS2) = SMATX(18,IS1)                                          AE007600
```

$NH3_{OS2} = NH3_{IS1}$ [mg/l]

```
SMATX(19,OS1) = SMATX(19,IS1)                                          AE007700
```

$NO3_{OS1} = NO3_{IS1}$ [mg/l]

```
SMATX(19,OS2) = SMATX(19,IS1)                                          AE007800
```

$NO3_{OS2} = NO3_{IS1}$ [mg/l]

```
SMATX(20,OS1) = SMATX(20,IS1)                                          AE007900
```

Future parameter [mg/l]

```
SMATX(20,OS2) = SMATX(20,IS1)                                          AE008000
```

Future parameter [mg/l]

```
VAER1 = (SMATX(2,IS1)+SMAT(2))*DMATX(3,N)*1000./7.48*DMATX(16,N)      AE008500
```

$$VAER_1 = \frac{(Q_{IS1}+Q_{IS2})1000DTA*ECF_a}{7.48} \quad \left[\frac{ft^3}{1000}\right]$$

```
VAER2 = (SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10))*8.33/.05/1000.*DMATX(16,N)
                                                                       AE008600
```

$$VAER2 = \frac{[(Q_{IS1}*TSS_{IS1})+(Q_{IS2}*TSS_{IS2})]8.33ECF_a}{0.05*1000} \quad \left[\frac{ft^3}{1000}\right]$$

```
BSIZE = 20.*VAER*DMATX(15,N)                                              AE009200
```

$$BSIZE = 20VAER*ECF_b \qquad [\frac{ft^3}{min}]$$

```
AFS = (SMATX(2,IS1)+SMAT(2))*1000./DMATX(7,N)*DMATX(13,N)                 AE009600
```

$$AFS = \frac{1000(Q_{IS1}+Q_{IS2})ECF_s}{GSS} \qquad [\frac{ft^2}{1000}]$$

```
DEMO = (SMATX(9,IS1)*SMATX(2,IS1)+SMAT(9)*SMAT(2)-TEMP1-TEMP2)*8.33*1.5    AE009700
```

$$DEMO = 8.33[(VSS_{IS1}*Q_{IS1})+(VSS_{IS2}*Q_{IS2})-TEMP1-TEMP2]*1.5$$

```
CFM = DEMO/.075/.232/.05/1440.*DMATX(15,N)                                AE009900
```

$$CFM = \frac{DEMO*ECF_b}{0.075*0.232*0.05*1440} \qquad [\frac{ft^3}{min}]$$

```
QPUMP = (SMATX(2,IS1)+SMAT(2))*DMATX(14,N)*1.5                            AE010400
```

$$QPUMP = (Q_{IS1}+Q_{IS2})*1.5ECF_p \qquad [MGD]$$

Pump efficiency - Current values used in program; each can be changed by the replacement on punched card.

```
PEFF = 0.70 for QPUMP<1.44 MGD                                            AE019000
PEFF = 0.74 for QPUMP<10.08 MGD                                           AE019300
PEFF = 0.83 for QPUMP>=10.08 MGD                                          AE019500
```

References:

Patterson and Banker, 1971

5. Cost functions.

Aerator

a. Capital cost

Function of VAER

```
X = ALOG(VAER)                                                            AE011000
```

$$X = \ln VAER$$

```
CCOST(N,1) = EXP(2.414380+.175682*X+.084742*X**2.-.002670*X**3.) *1000.   AE011100
```

$$CCOST = 1000e^{2.414380+0.175682X+0.084742X^2-0.002670X^3} \qquad [dollars]$$

b. Operating manhours, maintenance manhours and materials/supplies costs

(1) Operating manhours AE011700

OHRS = 0 [hrs/yr]

(2) Maintenance manhours AE011800

XMHRS = 0 [hrs/yr]

(3) Total materials and supplies AE011900

TMSU = 0 [dollars/yr]

c. Total operating and maintenance costs AE012000

COSTO(N,1) = 0 [cents/1000 gal]

Blower

a. Capital cost

Function of ACFM

X = ALOG(ACFM/1000.) AE012600

$$X = \ln \frac{ACFM}{1000}$$

CCOST(N,2) = EXP(4.145454+.633339*X+.031939*X**2.-.002419*X**3.)*1000. AE012700

$$CCOST = 1000e^{4.145454+0.633339X+0.031939X^2-0.002419X^3}$$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of $ACFM/ECF_b$

X = ALOG(ACFM/1000./DMATX(15,N)) AE013400

$$X = \ln \frac{ACFM}{1000ECF_b}$$

(1) For $\frac{ACFM}{1000ECF_b} < 1$

(a) Operating manhours AE014100

OHRS = 850 [hrs/yr]

(b) Maintenance manhours AE014200

XMHRS 350 [hrs/ yr]

(2) For $\frac{ACFM}{1000ECF_b} \geq 1$

(a) Operating manhours

OHRS = EXP(6.900586+.323725*X+.059093*X**2.-.004926*X**3.) AE014400

$$OHRS = e^{6.900586+0.323725X+0.059093X^2-0.004926X^3} \quad [hrs/yr]$$

(b) Maintenance manhours

AE014500

XMHRS = EXP(6.169937+.294853*X+.175999*X**2.-.040947*X**3.+.003300*X**4.)

$$XMHRS = e^{6.169937+0.294853X+0.175999X^2-0.040947X^3+0.003300X^4}$$

[hrs/yr]

(3) Blower horsepower

HP = ACFM/DMATX(15,N)*8.1*144./(33000.*.8) AE014700

$$HP = \frac{8.1ACFM*144}{ECF_b*33000*0.8} \quad [horsepower]$$

(4) Blower kilowatts

XKW = .8*HP AE014800

$$XKW = \frac{8.1ACFM*144}{33000\ ECF_b} \quad [kilowatts]$$

(5) Blower kilowatt years

XKWPY = XKW*24.*365. AE014900

XKWPY = 24XKW*365 [kwhr/yr]

(6) Energy cost

ECOST = XKWPY*DMATX(10,20) AE015000

ECOST = XKWPY*CKWH [dollars/yr]

(7) Service cost

SCOST = EXP(.621382+.482047*X)*1000. AE015100

$$SCOST = 1000e^{0.621382+0.482047X} \quad [dollars/yr]$$

c. Total operating and maintenance costs

AE015600

```
COSTO(N,2) = ((OHRS+XMHRS)*DHR*(1+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/3650.
```

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+(SCOST*WPI)+ECOST}{Q_{Plant\ Inf.} * 3650} \quad [cents/1000\ gal]$$

Sludge pumps

a. Capital cost

Function of QPUMP

```
X = ALOG(QPUMP)
```
AE016700

$$X = \ln QPUMP$$

(1) QPUMP < 5 AE016500

CCOST 20000 [dollars]

(2) QPUMP $\geq$ 5 AE016800

```
CCOST(N,3) = EXP(3.481553+.377485*X+.093349*X**2.-.006222*X**3.)*1000.
```

$$CCOST = 1000e^{3.481553+0.377485X+0.093349X^2-0.006222X^3} \quad [dollars]$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of $QPUMP/ECF_p$

```
X = ALOG(QPUMP/DMATX(14,N))
```
AE018500

$$X = \ln \frac{QPUMP}{ECF_p}$$

(1) Operating manhours

(a) $\frac{QPUMP}{ECF_p} < 7$ AE018100

OHRS 400 [hrs/yr]

(b) $\frac{QPUMP}{ECF_p} \geq 7$ AE018600

```
OHRS EXP(6.097269+.253066*X-.193659*X**2.+.078201*X**3.-.006680*X**4.)
```

$$OHRS = e^{6.097269+0.253066X-0.193659X^2+0.078201X^3-0.006680X^4} \quad [hrs/yr]$$

(2) Maintenance manhours

(a) $\frac{QPUMP}{ECF_p} < 7$ AE018200

XMHRS = 250 [hrs/yr]

(b) $\frac{QPUMP}{ECF_p} \geq 7$ AE018800

```
XMHRS = EXP(5.911541-.013158*X+.076643*X**2.)
```

$$XMHRS = e^{5.911541-0.013158X+0.076643X^2}$$ [hrs/yr]

(3) Total materials and sunplies

(a) $\frac{QPUMP}{ECF_p} < 7$ AE018300

```
TMSU = 200.+(DMATX(8,N)/30.)*400.
```

$$TMSU = 200 + \frac{400HEAD}{30}$$ [dollars/yr]

(b) $\frac{QPUMP}{ECF_p} \geq 7$ AE019900

```
TMSU = ECOST+SCOST*WPI
```

TMSU = ECOST+(SCOST*WPI) [dollars/yr]

(4) Kilowatt hrs per year AE019600

```
YRKW = QPUMP*1000000.*DMATX(8,N)/1440./3960./PEFF/.9*.7457*24.*365.
```

$$YRKW = \frac{1000000QPUMP*0.7457HEAD*24*365}{1440*3960PEFF*0.9}$$ [kwhr/yr]

(5) Energy cost AE019700

```
ECOST = YRKW*DMATX(10,20)
```

ECOST = YRKW*CKWH [dollars/yr]

(6) Service cost AE019800

```
SCOST = EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)
```

$$SCOST = e^{5.851743+0.301610X+0.197183X^2-0.017962X^3}$$ [dollars/yr]

c. Total operating and maintenance costs AE020400

```
COSTO(N,3) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.
```

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+TMSU}{Q_{Plant\ Inf.} * 3650} \quad [cents/1000\ gal]$$

Final settler

a. Capital cost

Function of AFS

```
X = ALOG(AFS)
```
AE021300

$X = \ln AFS$

(1) AFS < 1 acre AE021100

CCOST = 25000 [dollars]

(2) AFS $\geq$ 1 acre AE021400

```
CCOST(N,4) = EXP(3.716354+.389861*X+.084560*X**2.-.004718*X**3.)*1000.
```

$$CCOST = 1000e^{3.716354+0.389861X+0.084560X^2-0.004718X^3} \quad [dollars]$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of AFS/ECF_s

```
X = ALOG(AFS/DMATX(13,N))
```
AE023000

$X = \ln \frac{AFS}{ECF_s}$

(1) Operating manhours

(a) $\frac{AFS}{ECF_s} < 1$ AE022600

OHRS = 300 [hrs/yr]

(b) $\frac{AFS}{ECF_s} \geq 1$ AE023100

```
OHRS = EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)
```

$$OHRS = e^{5.846565+0.254813X+0.113703X^2-0.010942X^3} \quad [hrs/yr]$$

(2) Maintenance manhours

(a) $\frac{AFS}{ECF_s} < 1$ AE022700

XMHRS = 150 [hrs/yr]

(b) $\frac{AFS}{ECF_s} \geq 1$ AE023200

XMHRS = EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)

$$XMHRS = e^{5.273419+0.228329X+0.122646X^2-0.011672X^3} \quad [hrs/yr]$$

(3) Total materials and supplies

(a) $\frac{AFS}{ECF_s} < 1$ AE022800

TMSU = 125 [dollars/yr]

(b) $\frac{AFS}{ECF_s} \geq 1$ AE023300

TMSU = EXP(5.669881+.750799*X)

$$TMSU = e^{5.669881+0.750799X} \quad [dollars/yr]$$

(4) Total operating and maintenance costs AE023800

COSTO(N,4) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+(TMSU*WPI)}{Q_{Plant\ Inf.} * 3650} \quad [cents/1000\ gal]$$

```
C
C          AEROBIC DIGESTION
C          PROCESS IDENTIFICATION NUMBER  18
C
      SUBROUTINE AEROB
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      DIMENSION SMAT(20)
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C          PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C          CHARACTERISTICS
C
      DO 10 I=1,20
   10 SMAT(I)=0.
      IF (IS2) 20,40,20
   20 DO 30 I=1,20
   30 SMAT(I)=SMATX(I,IS2)
   40 L=DMATX(1,N)
      TEMP1=(SMAT(4)*2.13+(SMAT(8)+SMAT(17))*.65*.18)*SMAT(2)
      TEMP2=(OMATX(9,L)*.18+OMATX(10,L)*.0938+OMATX(11,L)+OMATX(12,L))*D
     1MATX(7,L)*SMATX(2,IS1)
      TEMP3=SMAT(7)*SMAT(2)
      TEMP4=OMATX(13,L)*DMATX(7,L)*SMATX(2,IS1)
C
C
C          EFFLUENT STREAM CALCULATIONS
C
      SMATX(2,OS1)=((TEMP1+TEMP2+TEMP3+TEMP4)-(SMATX(2,IS1)+SMAT(2))*DMA
     1TX(5,N))/(DMATX(4,N)-DMATX(5,N))
      SMATX(2,OS2)=SMATX(2,IS1)+SMAT(2)-SMATX(2,OS1)
      VOLPC=(TEMP1+TEMP2)/(TEMP1+TEMP2+TEMP3+TEMP4)
      SMATX(9,OS1)=DMATX(4,N)*VOLPC
      SMATX(7,OS1)=DMATX(4,N)-SMATX(9,OS1)
      SMATX(3,OS1)=SMATX(9,OS1)/2.13
      SMATX(4,OS1)=SMATX(3,OS1)
      SMATX(5,OS1)=SMATX(3,OS1)/10.
      SMATX(6,OS1)=SMATX(3,OS1)/100.
      SMATX(8,OS1)=0.
      SMATX(10,OS1)=DMATX(4,N)
      SMATX(10,OS2)=DMATX(5,N)
      SMATX(9,OS2)=SMATX(10,OS2)*VOLPC
      SMATX(3,OS2)=SMATX(9,OS2)/2.13
      SMATX(4,OS2)=SMATX(3,OS2)
      SMATX(5,OS2)=SMATX(3,OS2)/10.
      SMATX(6,OS2)=SMATX(3,OS2)/100.
      SMATX(7,OS2)=SMATX(10,OS2)-SMATX(9,OS2)
      SMATX(8,OS2)=50.
      SMATX(11,OS1)=(500.-SMATX(9,OS2)*1.42)/3.2
      SMATX(11,OS2)=SMATX(11,OS1)
      SMATX(12,OS1)=SMATX(11,OS2)/2.
      SMATX(12,OS2)=SMATX(12,OS1)
```

```
C
      X=ALOG(ACFM/1000.)
      CCOST(N,2)=EXP(4.145454+.633339*X+.031939*X**2.-.002419*X**3.)*100
     10.
C
C
C             CALC. OF OPERATING COSTS FOR BLOWER BASED ON DESIGN
C             CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(ACFM/1000./DMATX(15,N))
C
C
C                   CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                   AND ELECTRICAL POWER AND SUPPLY COSTS
C
      IF (ACFM/1000./DMATX(15,N)-1.) 140,150,150
  140 OHRS=850.
      XMHRS=350.
      GO TO 160
  150 OHRS=EXP(6.900586+.323725*X+.059093*X**2.-.004926*X**3.)
      XMHRS=EXP(6.169937+.294853*X+.175999*X**2.-.040947*X**3.+.003300*X
     1**4.)
  160 HP=ACFM/DMATX(15,N)*8.1*144./(33000.*.8)
      XKW=.8*HP
      XKWPY=XKW*24.*365.
      ECOST=XKWPY*DMATX(10,20)
      SCOST=EXP(.621382+.482047*X)*1000.
C
C
C                   OPERATING COST EQUATION
C
      COSTO(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/
     13650.
C
C
C             CALC. OF CAPITAL COSTS FOR SLUDGE RETURN PUMPS BASED
C             ON DESIGN PLUS EXCESS CAPACITY
C
      IF (DMATX(2,N)) 170,350,170
  170 IF (QPUMP-.5) 180,190,190
  180 CCOST(N,3)=20000.
      GO TO 200
  190 X=ALOG(QPUMP)
      CCOST(N,3)=EXP(3.481553+.377485*X+.093349*X**2.-.006222*X**3.)*100
     10.
C
C
C             CALC. OF OPERATING COSTS FOR SLUDGE RETURN PUMPS BASED
C             ON DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS
C             CAPACITY
C
C
C                   CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                   AND MATERIALS AND SUPPLIES
C
  200 IF (QPUMP/DMATX(14,N)-.7) 210,220,220
  210 OHRS=400.
      XMHRS=250.
      TMSU=200.+(DMATX(8,N)/30.)*400.
      GO TO 280
  220 X=ALOG(QPUMP/DMATX(14,N))
      OHRS=EXP(6.097269+.253066*X-.193659*X**2.+.078201*X**3.-.006680*X*
     1*4.)
      XMHRS=EXP(5.911541-.013158*X+.076643*X**2.)
```

```
      ENTN=SMATX(2,IS1)*(SMATX(5,IS1)+SMATX(13,IS1))+SMAT(2)*(SMAT(5)+SMA
     1AT(13))
      EXSN=SMATX(2,OS1)*SMATX(5,OS1)+SMATX(2,OS2)*SMATX(5,OS2)
      SMATX(13,OS1)=(ENTN-EXSN)/(SMATX(2,OS1)+SMATX(2,OS2))
      SMATX(13,OS2)=SMATX(13,OS1)
      ENTP=SMATX(2,IS1)*(SMATX(6,IS1)+SMATX(14,IS1))+SMAT(2)*(SMAT(6)+SMA
     1AT(14))
      EXSP=SMATX(2,OS1)*SMATX(6,OS1)+SMATX(2,OS2)*SMATX(6,OS2)
      SMATX(14,OS2)=(ENTP-EXSP)/(SMATX(2,OS1)+SMATX(2,OS2))
      SMATX(14,OS1)=SMATX(14,OS2)
      SMATX(15,OS1)=SMATX(15,IS1)
      SMATX(15,OS2)=SMATX(15,IS1)
      SMATX(16,OS1)=300.
      SMATX(16,OS2)=300.
      SMATX(17,OS1)=DMATX(6,N)-50.
      SMATX(17,OS2)=SMATX(17,OS1)
      SMATX(18,OS1)=SMATX(18,IS1)
      SMATX(18,OS2)=SMATX(18,IS1)
      SMATX(19,OS1)=SMATX(19,IS1)
      SMATX(19,OS2)=SMATX(19,IS1)
      SMATX(20,OS1)=SMATX(20,IS1)
      SMATX(20,OS2)=SMATX(20,IS1)
C
C
C              CALC. OF OUTPUT SIZES AND QUANTITIES
C
      VAER1=(SMATX(2,IS1)+SMAT(2))*DMATX(3,N)*1000./7.48*DMATX(16,N)
      VAER2=(SMATX(2,IS1)*SMATX(10,IS1)+SMAT(2)*SMAT(10))*8.33/.05/1000.
     1*DMATX(16,N)
      IF (VAER1-VAER2) 50,60,60
   50 VAER=VAER2
      GO TO 70
   60 VAER=VAER1
   70 BSIZE=20.*VAER*DMATX(15,N)
      IF (DMATX(2,N)) 90,80,90
   80 AFS=0.
      GO TO 100
   90 AFS=(SMATX(2,IS1)+SMAT(2))*1000./DMATX(7,N)*DMATX(13,N)
  100 DEMO=(SMATX(9,IS1)*SMATX(2,IS1)+SMAT(9)*SMAT(2)-TEMP1-TEMP2)*8.33*
     11.5
      CFM=DEMO/.075/.232/.05/1440.*DMATX(15,N)
      IF (BSIZE-CFM) 110,120,120
  110 ACFM=CFM
      GO TO 130
  120 ACFM=BSIZE
  130 QPUMP=(SMATX(2,IS1)+SMAT(2))*DMATX(14,N)*1.5
C
C
C              CALC. OF CAPITAL COSTS FOR AERATION TANK BASED ON DESIGN
C              PLUS EXCESS CAPACITY
C
      X=ALOG(VAER)
      CCOST(N,1)=EXP(2.414380+.175682*X+.084742*X**2.-.002670*X**3.)*100
     10.
C
C
C              CALC. OF OPERATING COSTS FOR AERATION TANK
C
      OHRS=0.
      XMHRS=0.
      TMSU=0.
      COSTO(N,1)=0.
C
C
C              CALC. OF CAPITAL COSTS FOR BLOWER BASED ON DESIGN PLUS
C              EXCESS CAPACITY
```

```
      IF (QPUMP-1.44) 230,240,240
  230 PEFF=.70
      GO TO 270
  240 IF (PEFF-10.08) 250,260,260
  250 PEFF=.74
      GO TO 270
  260 PEFF=.83
  270 YRKW=QPUMP*1000000.*DMATX(8,N)/1440./3960./PEFF/.9*.7457*24.*365.
      ECOST=YRKW*DMATX(10,20)
      SCOST=EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)
      TMSU=ECOST+SCOST*WPI
C
C
C                   OPERATING COST EQUATION
C
  280 COSTO(N,3)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.
C
C
C             CALC. OF CAPITAL COSTS FOR FINAL SETTLER BASED ON DESIGN
C             PLUS EXCESS CAPACITY
C
      IF (AFS-1.) 290,300,300
  290 CCOST(N,4)=25000.
      GO TO 310
  300 X=ALOG(AFS)
      CCOST(N,4)=EXP(3.716354+.389861*X+.084560*X**2.-.004718*X**3.)*100
     10.
C
C
C             CALC. OF OPERATING COSTS FOR FINAL SETTLER BASED ON
C             DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
C
C                   CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                   AND MATERIALS AND SUPPLIES
C
  310 IF (AFS/DMATX(13,N)-1.) 320,330,330
  320 OHRS=300.
      XMHRS=150.
      TMSU=125.
      GO TO 340
  330 X=ALOG(AFS/DMATX(13,N))
      OHRS=EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)
      XMHRS=EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)
      TMSU=EXP(5.669881+.750799*X)
C
C
C                   OPERATING COST EQUATION
C
  340 COSTO(N,4)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C             ASSIGNMENT OF VALUES TO OMATX
C
  350 OMATX(1,N)=VAER
      OMATX(2,N)=ACFM
      OMATX(3,N)=QPUMP
      OMATX(4,N)=AFS
C
C
C             PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=18.
      RETURN
      END
```

SECTION 20

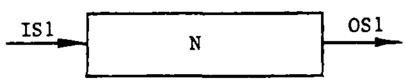
POST AERATION, POSTA

Subroutine Identification Number 19

Rev. Date 8/1/77

Post Aeration, POSTA

1. Process symbol.



IS1: Liquid input stream
OS1: Liquid output stream
N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = ITYPE	Program control: -1 = mechanical aeration system is used, 0 = diffused air aeration system is used (plug flow), +1 = diffused air aeration system is used (complete mix).[-1.]
DMATX(2,N) = L	Program control: set equal to the user assigned process number (N) given to the aeration process (AERFS) to allow the POSTA subroutine to use output parameters calculated in the aeration process.[varies].
DMATX(3,N) = DOIN	Dissolved oxygen concentration in the influent stream to the post aeration process, mg/l.[1.]
DMATX(4,N) = DOUT	Dissolved oxygen concentration in the effluent stream from the post aeration process, mg/l.[4.]
DMATX(5,N) = TL	Water temperature, degrees Centigrade.[20.]
DMATX(6,N) = TD	Tank depth (for diffused air only), ft.[15.]
DMATX(7,N) = TW	Tank width (for diffused air only), ft.[24.]
DMATX(8,N) = AERFO	Aeration efficiency at standard conditions (for diffused air only), fraction.[.08]
DMATX(9,N) = HPHRO	Efficiency measure for the mechanical aerators, lb of oxygen transferred per hp-hr.[3.5]
DMATX(10,N) = ALT	Altitude of the plant site above sea level. ft.[0.]
DMATX(11,N) = CFMDF	Capacity of each air diffuser, scfm.[15.]
DMATX(12,N) = DIFFT	Number of diffusers per foot of tank length.[1.]
DMATX(13,N) = DD	Depth of diffusers below the water surface, ft.[13.]
DMATX(15,N) = ECF	Excess capacity factor for the air supply system.[1.]
DMATX(16,N) = ECF	Excess capacity factor for the aeration basin.[1.]

3. Output parameters which are printed on computer output sheets.

ITYPE = DMATX(1,N)	
L = DMATX(2,N)	
DOIN = DMATX(3,N)	
DOUT = DMATX(4,N)	
TL = DMATX(5,N)	
TD = DMATX(6,N)	
TW = DMATX(7,N)	
AERFO = DMATX(8,N)	
HPHRO = DMATX(9,N)	
ALT = DMATX(10,N)	
CFMDF = DMATX(11,N)	
DIFFT = DMATX(12,N)	
DD = DMATX(13,N)	
VAER = OMATX(1,N)	Volume of the post aeration basin, cu ft/1000.
CFM = OMATX(2,N)	Air requirement for the diffusers, cfm.
HP = OMATX(3,N)	Installed brake horsepower for mechanical aeration, hp.
TMIN = OMATX(4,N)	Detention time in the post aeration basin, minutes.
VMG = OMATX(5,N)	Volume of the post aeration basin, million gallons.
AERFF = OMATX(6,N)	Aeration efficiency corrected to plant conditions.
CLEN OMATX(7,N)	Aeration channel length (plug flow), ft.
HPI = OMATX(8,N)	Installed brake horsepower (HP) rounded off to the next higher available size mechanical aerator, hp.
XN - OMATX(9,N)	Number of mechanical aerators required.
THP = OMATX(10,N)	Total mechanical aeration horsepower required (HP1*XN), hp.
WIDTH = OMATX(11,N)	Mechanical aeration basin width, ft.

DEPTH = OMATX(12,N)	Mechanical aeration basin depth, ft.
TLEN = OMATX(13,N)	Aeration basin length (diffused air, complete mix), ft.
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000gal].
ACOST	Amortization cost, [cents/1000gal].
TCOST	Total treatment cost, [cents/1000gal],
ECF	Excess capacity factor,

References:

Smith, Eilers and Hall, 1973

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
S = SMATX(8,IS1)+SMATX(17,IS1)                                  POS05200
```

$S = SBOD_{IS1}+DBOD_{IS1}$ [mg/l]

```
XA = OMATX(9,L)*OMATX(3,L)                                      POS05300
```

XA = OMATX(9,L)*OMATX(3,L) [mg/l]

```
SMATX(I,OS1) = SMATX(I,IS1)                                     POS03900
```

SMATX(I,OS1) = SMATX(I,IS1) [mg/l]

where I = 2,20 i.e. Q.SOC,SNBC,SON,SOP,SFM,SBOD,VSS,TSS,DOC,DNBC,DN,DP,DFM,ALK,DBOD, NH3,NO3

```
CSS = 14.652-.410220*TL+.007991*TL**2.-.000078*TL**3.           POS07200
```

$CSS = 14.652-0.410220TL+0.007991TL^2-0.000078TL^3$ [mg/l]

```
RP = (760.-.025*ALT)/760.                                       POS07300
```

$RP = \frac{760-0.025ALT}{760}$ [no units]

```
CSW = RP*CSS*BETA                                                    POS07400
```

$CSW = RP*CSS*BETA$ [mg/1]

```
AERK1 = .31942*(CSW-DOUT)*HPHRO*ALPHA*1.025**(TL-20.)                POS07700
```

$AERK1 = 0.31942(CSW-DOUT)*HPHRO*ALPHA*(1.025)^{TL-20}$ [1/day]

```
AERK2 = .58*CAER*XA*S/CY+1.16*CE*XA                                  POS07800
```

$AERK2 = \frac{0.58CAER*XA*S}{CY} + (1.16CE*XA)$ $[\frac{mg/1}{day}]$

```
HP = (SMATX(2,IS1)*(DOUT-DOIN)+AERK2*VMG)/AERK1*DMATX(15,N)          POS08100
```

$HP = \frac{[Q_{IS1}*(DOUT-DOIN)+(AERK2*VMG)]ECF}{AERK1}$ [horsepower]

```
VCF = (17.+.53*HP)**2.*(5.+.07*HP)                                   POS08200
```

$VCF = (17+0.53HP)^2*(5+0.07HP)$ $[ft^3]$

```
VMG = VCF*7.48/1000000.*DMATX(16,N)                                  POS08400
```

$VMG = \frac{7.48VCF*ECF}{1000000}$ [MG]

```
VDEL = ABS(VMG-VMGP)                                                 POS08500
```

$VDEL = |VMG-VMGP|$ [MG]

```
HP1 = SIZE(I)     (For HP≤ size (I))                                 POS09300
```

HP1 = SIZE(I) [horsepower]

where I = 1,14

```
XN =HP /150.                                                         POS09800
```

$XN = \frac{HP}{150}$ [number]

```
THP = HP1*XN                                   POS10100
```

$THP = HP1*XN$ [horsepower]

```
WIDTH = 17.+.53*HP1                            POS10200
```

$WIDTH = 17+0.53HP1$ [ft]

```
DEPTH = 5.+.07*HP1                             POS10300
```

$DEPTH = 5+0.07HP1$ [ft]

```
VCF = DEPTH*WIDTH**2.                          POS10400
```

$VCF = DEPTH*WIDTH^2$ [ft^3]

```
VMG = (VCF*7.48/1000000.)*XN                   POS10500
```

$$VMG = \frac{7.48VCF*XN}{1000000}$$ [MG]

```
HPMG = THP/VMG                                 POS10600
```

$$HPMG = \frac{THP}{VMG}$$ [$\frac{hp}{MG}$]

```
DAYS = VMG/SMATX(2,IS1)                        POS10700
```

$$DAYS = \frac{VMG}{Q_{IS1}}$$ [days]

```
TMIN = DAYS*1440.                              POS10800
```

$TMIN = 1440\ DAYS$ [min]

```
VAER = VMG*1000./7.48                          POS10900
```

$$VAER = \frac{1000VMG}{7.48}$$ [$\frac{ft^3}{1000}$]

CFMMG = CFMDF*DIFFT*1000000./TD/TW/7.48 POS11100

$$CFMMG = \frac{CFMDF*DIFFT*1000000}{7.48TD*TW} \qquad [\frac{cfm}{MG}]$$

AERFF = AERFO*(DD/13.)**.66666*(8./CFMDF)**.2 POS11200

$$AERFF = AERFO*\left(\frac{DD}{13}\right)^{0.66666}*\left(\frac{8}{CFMDF}\right)^{0.2} \qquad [\text{no units}]$$

AERK1 = .33347*CFMMG*AERFF*ALPHA*1.025**(TL-20.) POS11300

$$AERK1 = 0.33347CFMMG*AERFF*ALPHA*(1.025)^{TL-20} \qquad [1/day]$$

AERK2 = .58*CAER*XA*S/CY-1.16*CE*XA POS11400

$$AERK2 = \frac{0.58*CAER*XA*S}{CY} - (1.16CE*XA) \qquad [\frac{mg/l}{day}]$$

TEMP = (AERK1*(CSW-DOUT)-AERK2)/(AERK1*(CSW-DOIN)-AERK2) POS11500

$$TEMP = \frac{AERK1(CSW-DOUT)-AERK2}{AERK1(CSW-DOIN)-AERK2} \qquad [\text{no units}]$$

DAYS = -1.*ALOG(TEMP)/AERK1 POS11600

$$DAYS = -\frac{\ln TEMP}{AERK1} \qquad [days]$$

TMIN = DAYS*1440. POS11700

$$TMIN = 1440\ DAYS \qquad [min]$$

VFM = SMATX(2,IS1)*92.84/TD/TW POS11800

$$VFM = \frac{92.84Q_{IS1}}{TD*TW} \qquad [ft/min]$$

CLEN = VFM*TMIN POS11900

$$CLEN = \frac{92.84Q_{IS1}*TMIN}{TD*TW} \qquad [ft]$$

CFM = CLEN*CFMDF*DIFFT*DMATX(15,N) POS12000

$$CFM = CLEN*CFMDF*DIFFT*ECF_s$$ [cfm]

CFMMG = CFMDF*DIFFT*1000000./TD/TW/7.48 POS12200

$$CFMMG = \frac{CFMDF*1000000DIFFT}{7.48TD*TW}$$ [ft^3/MG]

AERFF = AERFO*(DD/13.)**.66666*(8./CFMDF)**.2 POS12300

$$AERFF = AERFO(\frac{DD}{13})^{0.66666}*(\frac{8}{CFMDF})^{0.2}$$ [no units]

AERK1 = .33347*CFMMG*AERFF*ALPHA*1.025**(TL-20.) POS12400

$$AERK1 = 0.33347CFMMG*AERFF*ALPHA*[1.025]^{TL-20}$$ [1/days]

AERK2 = .58*CAER*XA*S/CY-1.16*CE*XA POS12500

$$AERK2 = \frac{0.58CAER*XA*S}{CY} -(1.16CE*XA)$$ [$\frac{mg/l}{day}$]

VMG = SMATX(2,IS1)*(DOUT-DOIN)/(AERK1*(CSW-DOUT)-AERK2)*DMATX(16,N) POS12600

$$VMG \quad \frac{Q_{IS1}(DOUT-DOIN)ECF_b}{AERK1(CSW-DOUT)-AERK2}$$ [MG]

DAYS = VMG/SMATX(2,IS1) POS12700

$$DAYS = \frac{VMG}{Q_{IS1}}$$ [days]

TMIN = DAYS*1440. POS12800

$$TMIN \quad 1440DAYS$$ [min]

TLEN = VMG*1000000./TD/TW/7.48 POS12900

$$TLEN = \frac{1000000VMG}{7.48TD*TW}$$ [ft]

```
VAER = VMG*1000./7.48
```
POS13000

$$VAER = \frac{1000VMG}{7.48}$$ $[\frac{ft^3}{1000}]$

```
CFM = CFMMG*VMG*DMATX(15,N)
```
POS13100

$CFM = CFMMG*VMG*ECF_s$ [cfm]

5. Cost functions.

Post aeration basin

a. Capital cost

Function of VAER

```
X = ALOG(VAER)
```
POS14300

$X = \ln VAER$

```
CCOST(N,1) = EXP(2.180040+.351346*X+.064188*X**2.-.003403*X**3.)*1000.
```
POS14400

$CCOST = 1000e^{2.180040+0.351346X+0.064188X^2-0.003403X^3}$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

(1) Operating manhours POS15200

OHRS = 0 [hrs/yr]

(2) Maintenance manhours POS15300

XMHRS = 0 [hrs/yr]

(3) Total materials and supplies POS15400

TMSU = 0 [dollars/yr]

c. Total operating and maintenance costs

```
COSTO(N,1) = 0
```
POS15500

COSTO = 0 [cents/1000gal]

Mechanical aeration

a. Capital cost

Function of THP

X = ALOG(THP) POS16600

$X = \ln THP$

For THP < 20

CCOST(N,2) = 20000. POS17300

CCOST = 20000 [dollars]

For THP $\geq$ 20

CCOST(N,2) = EXP(2.848804-.223685*X+.142476*X**2.-.005985*X**3.)*1000. POS18000

$$CCOST = 1000e^{2.848804-0.223685X+0.142476X^2-0.005985X^3}$$ [dollars]

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of THP/ECF_s

X = ALOG(THP/DMATX(15,N)) POS18800

$$X = \ln \frac{THP}{ECF_s}$$

(*) For ($THP/ECF_s < 40$)

(**) For ($THP/ECF_s \geq 40$)

(1) Operating manhours POS19500

(*) OHRS = 600 [hrs/yr]

(**) OHRS = EXP(6.716272-.310684*X+.112744*X**2.-.004877*X**3.) POS20400

$$OHRS = e^{6.716272-0.310684X+0.112744X^2-0.004877X^3}$$ [hrs/yr]

(2) Maintenance manhours POS19600

(*) XMHRS = 300 [hrs/yr]

(**) XMHRS = EXP(4.251092+.467681*X+.008276*X**2.) POS 20500

$$XMHRS = e^{4.251092+0.467681X+0.008276X^2}$$ [hrs/yr]

(3) Blower kilowatts

XKW = .8*THP/DMATX(15,N) POS21000

$$XKW = \frac{0.8THP}{ECF_s}$$ [kilowatts]

(4) Blower kilowatt years

XKWPY = XKW*24.*365. POS21100

$XKWPY = 24XKW*365$ [kwhr/yr]

(5) Energy cost

ECOST = XKWPY*DMATX(10,20) POS21200

$ECOST = 24XKW*365*CKWH$ [$/yr]

(6) Service cost

PCFM = THP/DMATX(15,N)/8.1/144.*(33000.*.8)/1000. POS21300

$$PCFM = \frac{THP*33000*0.8}{8.1ECF_s*144*1000}$$ [cfm]

SCOST = EXP(.621382+.482047*ALOG(PCFM))*1000. POS21400

$$SCOST = 1000e^{0.621382+0.482047(\ln PCFM)}$$ [$/yr]

c. Total operating and maintenance costs POS21900

COSTO(N,2) = ((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/3650.

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+(SCOST*WPI)+ECOST}{Q_{Plant\ Inf.} * 3650}$$ [cents/1000 gal]

Diffused aeration

a. Capital cost

Function of CFM

X = ALOG(CFM/1000.) POS22700

$$X = \ln \frac{CFM}{1000}$$

(*) For $(\frac{CFM}{1000} < 1)$

(**) For $(\frac{CFM}{1000} \geq 1)$

(*) CCOST = 13000 POS23400 [dollars]

(**) CCOST(N,2) = EXP(4.145454+.633339*X+.031939*X**2.-.002419*X**3.)*1000. POS24100

$$CCOST = 1000e^{4.145454+0.633339X+0.031939X^2-0.002419X^3}$$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of CFM/ECF_s

X = ALOG(CFM/1000./DMATX(15,N)) POS24900

$$X = \ln \frac{CFM}{1000ECF_s}$$

(*) For $\left(\frac{CFM}{1000ECF_s} < 1\right)$

(**) For $\left(\frac{CFM}{1000ECF_s} \geq 1\right)$

(1) Operating manhours POS25700

(*) OHRS = 850 [hrs/yr]

(**) OHRS = EXP(6.900586+.323725*X+.059093*X**2.-.004926*X**3.) POS26600

$$OHRS = e^{6.900586+0.323725X+0.059093X^2-0.004926X^3}$$ [hrs/yr]

(2) Maintenance manhours POS25800

(*) XMHRS = 350 [hrs/yr]

(**) XMHRS = EXP(6.169937+.294853*X+.175999*X**2.-.040947*X**3.+.003300*X**4.)

$$XMHRS = e^{6.169937+0.294853X+0.175999X^2-0.040947X^3+0.003300X^4}$$ [hrs/yr]

POS26700

(3) Blower horsepower

CHP CFM/DMATX(15,N)*8.1*144./(33000.*.8) POS27300

$$CHP = \frac{CFM*8.1*144}{ECF_s*33000*0.8}$$ [horsepower]

(4) Blower kilowatts

XKW = .8*CHP POS27400

$$XKW = \frac{CFM*8.1*144}{ECF_s*33000}$$ [kilowatts]

(5) Blower kilowatt years

XKWPY XKW*24.*365. POS27500

XKWPY = 24XKW*365 [kwhr/yr]

(6) Energy cost

ECOST = XKWPY*DMATX(10,20) POS27600

ECOST = 24XKW*365CKWH [$/yr]

(7) Service cost

```
SCOST = EXP(.621382+.482047*X)*1000.                         POS27700
```

$$SCOST = 1000e^{0.621382+0.482047X} \quad [\$/yr]$$

c. Total operating and maintenance costs POS28200

```
COSTO(N,2) = ((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/3650.
```

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+(SCOST*WPI)+ECOST}{Q_{Plant\ Inf.} * 3650} \quad [cents/1000\ gal]$$

```
C
C           POST AERATION
C           PROCESS IDENTIFICATION NUMBER  19
C
      SUBROUTINE POSTA
C
C
C           COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      DIMENSION SIZE(14)
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
      DATA SIZE/5.,7.5,10.,15.,20.,25.,30.,40.,50.,60.,75.,100.,125.,150
     1./
C
C
C           ASSIGNMENT OF DESIGN VALUES TO PROCESS PARAMETERS
C
      ITYPE=DMATX(1,N)
      L=DMATX(2,N)
      DOIN=DMATX(3,N)
      DOUT=DMATX(4,N)
      TL=DMATX(5,N)
      TD=DMATX(6,N)
      TW=DMATX(7,N)
      AERFO=DMATX(8,N)
      HPHRO=DMATX(9,N)
      ALT=DMATX(10,N)
      CFMDF=DMATX(11,N)
      DIFFT=DMATX(12,N)
      DD=DMATX(13,N)
C
C
C           EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=2,20
   10 SMATX(I,OS1)=SMATX(I,IS1)
C
C
C           CALC. OF OUTPUT SIZES AND QUANTITIES
C
      IF (7.5-DOUT) 20,40,40
   20 WRITE (IO,30)
   30 FORMAT (////,10X,'DEMAND DOUT OF POST AERATION IS TOO HIGH',////)
   40 CAER=.024
      CY=.65
      CE=.125
      ALPHA=.9
      BETA=.95
      S=SMATX(8,IS1)+SMATX(17,IS1)
      XA=OMATX(9,L)*OMATX(3,L)
      CFM=0.
      HP=0.
      CFMMG=0.
      HPMG=0.
      DEPTH=0.
```

```
      TMIN=0.                                                           POS05900
      VAER=0.                                                           POS06000
      VMG=0.                                                            POS06100
      VCF=0.                                                            POS06200
      VDEL=0.                                                           POS06300
      WIDTH=0.                                                          POS06400
      AERFF=0.                                                          POS06500
      CLEN=0.                                                           POS06600
      VFM=0.                                                            POS06700
      TLEN=0.                                                           POS06800
      HP1=0.                                                            POS06900
      XN=0.                                                             POS07000
      THP=0.                                                            POS07100
      CSS=14.652-.410220*TL+.007991*TL**2.-.000078*TL**3.               POS07200
      RP=(760.-.025*ALT)/760.                                           POS07300
      CSW=RP*CSS*BETA                                                   POS07400
      IF (ITYPE) 50,140,150                                             POS07500
   50 VMG=0.                                                            POS07600
      AERK1=.31942*(CSW-DOUT)*HPHRO*ALPHA*1.025**(TL-20.)               POS07700
      AERK2=.58*CAER*XA*S/CY+1.16*CE*XA                                 POS07800
      NT=0                                                              POS07900
   60 NT=NT+1                                                           POS08000
      HP=(SMATX(2,IS1)*(DOUT-DOIN)+AERK2*VMG)/AERK1*DMATX(15,N)         POS08100
      VCF=(17.+.53*HP)**2.*(5.+.07*HP)                                  POS08200
      VMGP=VMG                                                          POS08300
      VMG=VCF*7.48/1000000.*DMATX(16,N)                                 POS08400
      VDEL=ABS(VMG-VMGP)                                                POS08500
      IF (NT-25) 90,90,70                                               POS08600
   70 WRITE (IO,80)                                                     POS08700
   80 FORMAT (////,10X,'POST AERATION ITERATION DOES NOT CONVERGE',////)POS08800
      GO TO 100                                                         POS08900
   90 IF (VDEL-.0001) 100,100,60                                        POS09000
  100 DO 120 I=1,14                                                     POS09100
      IF (HP-SIZE(I)) 110,110,120                                       POS09200
  110 HP1=SIZE(I)                                                       POS09300
      XN=1.                                                             POS09400
      GO TO 130                                                         POS09500
  120 CONTINUE                                                          POS09600
      HP1=150.                                                          POS09700
      XN=HP/150.                                                        POS09800
      IXN=XN                                                            POS09900
      XN=IXN+1                                                          POS10000
  130 THP=HP1*XN                                                        POS10100
      WIDTH=17.+.53*HP1                                                 POS10200
      DEPTH=5.+.07*HP1                                                  POS10300
      VCF=DEPTH*WIDTH**2.                                               POS10400
      VMG=(VCF*7.48/1000000.)*XN                                        POS10500
      HPMG=THP/VMG                                                      POS10600
      DAYS=VMG/SMATX(2,IS1)                                             POS10700
      TMIN=DAYS*1440.                                                   POS10800
      VAER=VMG*1000./7.48                                               POS10900
      GO TO 160                                                         POS11000
  140 CFMMG=CFMDF*DIFFT*1000000./TD/TW/7.48                             POS11100
      AERFF=AERFO*(DD/13.)**.66666*(8./CFMDF)**.2                       POS11200
      AERK1=.33347*CFMMG*AERFF*ALPHA*1.025**(TL-20.)                    POS11300
      AERK2=.58*CAER*XA*S/CY-1.16*CE*XA                                 POS11400
      TEMP=(AERK1*(CSW-DOUT)-AERK2)/(AERK1*(CSW-DOIN)-AERK2)            POS11500
      DAYS=-1.*ALOG(TEMP)/AERK1                                         POS11600
      TMIN=DAYS*1440.                                                   POS11700
      VFM=SMATX(2,IS1)*92.84/TD/TW                                      POS11800
      CLEN=VFM*TMIN                                                     POS11900
      CFM=CLEN*CFMDF*DIFFT*DMATX(15,N)                                  POS12000
      GO TO 160                                                         POS12100
  150 CFMMG=CFMDF*DIFFT*1000000./TD/TW/7.48                             POS12200
      AERFF=AERFO*(DD/13.)**.66666*(8./CFMDF)**.2                       POS12300
```

```
      AERK1=.33347*CFMMG*AERFF*ALPHA*1.025**(TL-20.)
      AERK2=.58*CAER*XA*S/CY-1.16*CE*XA
      VMG=SMATX(2,IS1)*(DOUT-DOIN)/(AERK1*(CSW-DOUT)-AERK2)*DMATX(16,N)
      DAYS=VMG/SMATX(2,IS1)
      TMIN=DAYS*1440.
      TLEN=VMG*1000000./TD/TW/7.48
      VAER=VMG*1000./7.48
      CFM=CFMMG*VMG*DMATX(15,N)
C
C
C               CALC. OF CAPITAL AND OPERATING COSTS FOR POSTA BASIN
C
  160 IF (ITYPE) 170,180,170
C
C
C                         CALC. OF CAPITAL COSTS FOR POSTA BASIN BASED ON
C                         DESIGN PLUS EXCESS CAPACITY IF MECHANICAL AERATION
C                         OR DIFFUSED AIR OF COMPLETE MIX IS USED
C
  170 X=ALOG(VAER)
      CCOST(N,1)=EXP(2.180040+.351346*X+.064188*X**2.-.003403*X**3.)*100
     10.
C
C
C                         CALC. OF OPERATING COSTS FOR POSTA BASIN BASED ON
C                         DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS
C                         CAPACITY
C
      OHRS=0.
      XMHRS=0.
      TMSU=0.
      COSTO(N,1)=0.
C
C
C               CALC. OF CAPITAL AND OPERATING COSTS FOR AERATION
C
  180 IF (ITYPE) 190,260,260
C
C
C                         CALC. OF CAPITAL COSTS FOR MECHANICAL AERATION
C                         SYSTEM BASED ON DESIGN PLUS EXCESS CAPACITY
C
  190 X=ALOG(THP)
      IF (THP-20.) 200,210,210
C
C
C                                  CALC. OF CAPITAL COSTS FOR SMALL AERATION
C                                  CAPACITY, LESS THAN 20 HP.
C
  200 CCOST(N,2)=20000.
      GO TO 220
C
C
C                                  CALC. OF CAPITAL COSTS FOR LARGE AERATION
C                                  CAPACITY, EQUAL OR GREATER THAN 20 HP.
C
  210 CCOST(N,2)=EXP(2.848804-.223685*X+.142476*X**2.-.005985*X**3.)*100
     10.
C
C
C                         CALC. OF OPERATING COSTS FOR MECHANICAL AERATION
C                         SYSTEM BASED ON DESIGN CAPACITY ALONE, DOES NOT
C                         INCLUDE EXCESS CAPACITY
C
  220 X=ALOG(THP/DMATX(15,N))
      IF (THP/DMATX(15,N)-40.) 230,240,240
```

```
C                                                                      POS19000
C                                                                      POS19100
C                     CALC. OF OPERATING MANHOURS AND MAINTENANCE      POS19200
C                     MANHOURS FOR AERATION CAPACITY, LESS THAN 40 HP  POS19300
C                                                                      POS19400
  230 OHRS=600.                                                        POS19500
      XMHRS=300.                                                       POS19600
      GO TO 250                                                        POS19700
C                                                                      POS19800
C                                                                      POS19900
C                     CALC. OF OPERATING MANHOURS AND MAINTENANCE      POS20000
C                     MANHOURS FOR AERATION CAPACITY, EQUAL OR         POS20100
C                     GREATER THAN 40 HP.                              POS20200
C                                                                      POS20300
  240 OHRS=EXP(6.716272-.310684*X+.112744*X**2.-.004877*X**3.)         POS20400
      XMHRS=EXP(4.251092+.467681*X+.008276*X**2.)                      POS20500
C                                                                      POS20600
C                                                                      POS20700
C                     CALC. OF SUPPLIES AND ELECTRICAL POWER COSTS     POS20800
C                                                                      POS20900
  250 XKW=.8*THP/DMATX(15,N)                                           POS21000
      XKWPY=XKW*24.*365.                                               POS21100
      ECOST=XKWPY*DMATX(10,20)                                         POS21200
      PCFM=THP/DMATX(15,N)/8.1/144.*(33000.*.8)/1000.                  POS21300
      SCOST=EXP(.621382+.482047*ALOG(PCFM))*1000.                      POS21400
C                                                                      POS21500
C                                                                      POS21600
C                     OPERATING COST EQUATION                          POS21700
C                                                                      POS21800
      COSTO(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/POS21900
     13650.                                                            POS22000
      GO TO 330                                                        POS22100
C                                                                      POS22200
C                                                                      POS22300
C                 CALC. OF CAPITAL COSTS FOR DIFFUSED AIR AERATION     POS22400
C                 SYSTEM BASED ON DESIGN PLUS EXCESS CAPACITY          POS22500
C                                                                      POS22600
  260 X=ALOG(CFM/1000.)                                                POS22700
      IF (CFM/1000.-.1) 270,280,280                                    POS22800
C                                                                      POS22900
C                                                                      POS23000
C                     CALC. OF CAPITAL COSTS FOR SMALL AIR             POS23100
C                     REQUIREMENT, LESS THAN 1000 CFM.                 POS23200
C                                                                      POS23300
  270 CCOST(N,2)=13000.                                                POS23400
      GO TO 290                                                        POS23500
C                                                                      POS23600
C                                                                      POS23700
C                     CALC. OF CAPITAL COSTS FOR LARGE AIR             POS23800
C                     REQUIREMENT, EQUAL OR GREATER THAN 1000 CFM.     POS23900
C                                                                      POS24000
  280 CCOST(N,2)=EXP(4.145454+.633339*X+.031939*X**2.-.002419*X**3.)*100POS24100
     10.                                                               POS24200
C                                                                      POS24300
C                                                                      POS24400
C                 CALC. OF OPERATING COSTS FOR DIFFUSED AIR AERATION   POS24500
C                 SYSTEM BASED ON DESIGN CAPACITY ALONE, DOES NOT      POS24600
C                 INCLUDE EXCESS CAPACITY                              POS24700
C                                                                      POS24800
  290 X=ALOG(CFM/1000./DMATX(15,N))                                    POS24900
      IF (CFM/1000./DMATX(15,N)-1.) 300,310,310                        POS25000
C                                                                      POS25100
C                                                                      POS25200
C                     CALC. OF OPERATING MANHOURS AND MAINTENANCE      POS25300
C                     MANHOURS FOR AIR REQUIREMENT, LESS THAN 1000     POS25400
C                     CFM.                                             POS25500
```

```
C                                                                       POS25600
  300 OHRS=850.                                                         POS25700
      XMHRS=350.                                                        POS25800
      GO TO 320                                                         POS25900
C                                                                       POS26000
C                                                                       POS26100
C                         CALC. OF OPERATING MANHOURS AND MAINTENANCE   POS26200
C                         MANHOURS FOR AIR REQUIREMENT, EQUAL OR GREATER POS26300
C                         THAN 1000 CFM.                                POS26400
C                                                                       POS26500
  310 OHRS=EXP(6.900586+.323725*X+.059093*X**2.-.004926*X**3.)          POS26600
      XMHRS=EXP(6.169937+.294853*X+.175999*X**2.-.040947*X**3.+.003300*XPOS26700
     1**4.)                                                             POS26800
C                                                                       POS26900
C                                                                       POS27000
C                         CALC. OF SUPPLIES AND ELECTRICAL POWER COSTS  POS27100
C                                                                       POS27200
  320 CHP=CFM/DMATX(15,N)*8.1*144./(33000.*.8)                          POS27300
      XKW=.8*CHP                                                        POS27400
      XKWPY=XKW*24.*365.                                                POS27500
      ECOST=XKWPY*DMATX(10,20)                                          POS27600
      SCOST=EXP(.621382+.482047*X)*1000.                                POS27700
C                                                                       POS27800
C                                                                       POS27900
C                         OPERATING COST EQUATION                       POS28000
C                                                                       POS28100
      COSTO(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/POS28200
     13650.                                                             POS28300
C                                                                       POS28400
C                                                                       POS28500
C              ASSIGNMENT OF VALUES TO OMATX                            POS28600
C                                                                       POS28700
  330 OMATX(1,N)=VAER                                                   POS28800
      OMATX(2,N)=CFM                                                    POS28900
      OMATX(3,N)=HP                                                     POS29000
      OMATX(4,N)=TMIN                                                   POS29100
      OMATX(5,N)=VMG                                                    POS29200
      OMATX(6,N)=AERFF                                                  POS29300
      OMATX(8,N)=HP1                                                    POS29500
      OMATX(9,N)=XN                                                     POS29600
      OMATX(10,N)=THP                                                   POS29700
      OMATX(11,N)=WIDTH                                                 POS29800
      OMATX(12,N)=DEPTH                                                 POS29900
      OMATX(13,N)=TLEN                                                  POS30000
C                                                                       POS30100
C                                                                       POS30200
C              PROCESS ENERGY INDICES                                   POS30300
C                                                                       POS30400
      FLOW(N)=SMATX(2,IS1)                                              POS30500
      POW(N)=19.                                                        POS30600
      RETURN                                                            POS30700
      END                                                               POS30800
```

SECTION 21

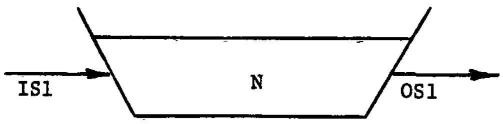
EQUALIZATION, EQUAL

Subroutine Identification Number 20

Equalization, EQUAL

Rev. Date 8/1/77

1. Process symbol.



IS1: Liquid input stream

OS1: Liquid output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = IAER	Program control: 0 = Small impeller mechanical aerators on floating platforms are used, 1 = large impeller mechanical aerators on stationary platforms are used. [1.]
DMATX(2,N) = RLW	Ratio of length to width for the equalization basin. [1.]
DMATX(3,N) = COSTL	Cost of pond lining material, $/sq ft. [.5]
DMATX(4,N) = HEAD	Pumping head of effluent pumps from the equalization basin, ft. [10.]
DMATX(5,N) = IMAT	Program control: 0 = Earthen pond with mechanical aeration is used for the equalization basin, 1 = concrete tank with diffused air is used for the equalization basin. [0.]
DMATX(14,N) = ECF	Excess capacity factor for the pumping system. [1.25]
DMATX(15,) = ECF	Excess capacity factor for the surface aerators. [1.]
DMATX(16,N) = ECF	Excess capacity factor for the equalization basin. [1.]

3. Output parameters which are printed on computer output sheets.

IAER = DMATX(1,N)

RLW = DMATX(2,N)

COSTL = DMATX(3,N)

HEAD = DMATX(4,N)

IMAT = DMATX(5,N)	
WIDTH = OMATX(1,N)	Equalization basin width at the water line, ft.
AREA = OMATX(2,N)	Equalization basin area at the water surface, acres.
VUMG = OMATX(3,N)	Usable liquid volume of the equalization basin, mg.
VOMG = OMATX(4,N)	Minimum liquid volume of the equalization basin, mg.
VT = OMATX(5,N)	Total liquid volume of the equalization basin (VUMG + VOMG), mg.
SAREA = OMATX(6,N)	Area of the lining required for the equalization basin, sq ft.
HP = OMATX(7,N)	Mechanical aerator brake horsepower, hp.
HP1 OMATX(8,N)	Brake horsepower (HP) rounded off to the next higher available size mechanical aerator, hp.
XN = OMATX(9,N)	Number of mechanical aerators required.
THP = OMATX(10,N)	Total mechanical aeration brake horsepower required (HP1*XN),hp.
PLAND = OMATX(11,N)	Amount of land needed for the equalization basin (this land area requirement is included in the total land area requirement, ACRE, for the whole plant), acres.
CLAND = OMATX(12,N)	Cost of land needed for the equalization basin (this cost is included in the total plant cost, XLAND, for land), $.
VAER = OMATX(13,N)	Volume of the concrete tank used for the equalization basin, cu ft/1000.
ECFM = OMATX(14,N)	Required size of the blower for supplying air to the concrete equalization basin, cfm.
CCOST	Capital cost,[dollars].
COSTO	Operating and maintenance cost,[cents/1000gal].
ACOST	Amortization cost,[cents/1000 gal].
TCOST	Total treatment cost,[cents/1000 gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
QP = 1.78*SMATX(2,IS1)**.92                                          EQU04400
```

$$QP = 1.78[Q_{IS1}]^{0.92} \qquad [MGD]$$

```
VU = SMATX(2,IS1)*.12*1000000./7.48*DMATX(16,N)                      EQU04500
```

$$VU = \frac{Q_{IS1}*0.12*1000000*ECF}{7.48} \qquad [ft^3]$$

```
SAREA = (2.*WIDTH*(1.+RLW)-156.)*53.76+(WIDTH-90.)*(RLW*WIDTH-90.)+20.*(24.+
        (1.+RLW)*WIDTH)
                                                                     EQU05200
```

$$SAREA = (2WIDTH(1+RLW)-156)*53.76+(WIDTH-90)(RLW*WIDTH-90)+20(24+(1+RLW)WIDTH) \qquad [ft^2]$$

```
WIDTH = (300.*(1.+RLW)+(90000.*(1.+RLW)**2.-40.*RLW*(12000.-VU))**.5)/20./RLW
```

$$WIDTH = \frac{300(1+RLW)+[90000(1+RLW)^2-40RLW(12000-VU)]^{0.5}}{20RLW} \quad [ft] \qquad \text{EQU05500}$$

```
AREA = RLW*WIDTH**2./43560.                                          EQU05700
```

$$AREA = \frac{RLW(WIDTH)^2}{43560} \qquad [acre]$$

```
VMIN = 5.*RLW*WIDTH**2.-375.*WIDTH*(1.+RLW)+28500.                   EQU05800
```

$$VMIN = 5RLW(WIDTH)^2-375WIDTH(1+RLW)+28500$$

```
SAREA = (2.*WIDTH*(1.+RLW)-156.)*53.76+(WIDTH-90.)*(RLW*WIDTH-90.)+20.*(24.+
        (1.+RLW)*WIDTH)
                                                                     EQU05900
```

$$SAREA = (2WIDTH(1+RLW)-156)53.76+(WIDTH-90)(RLW*WIDTH-90)+20(24+(1+RLW)WIDTH) \qquad [ft^2]$$

```
WIDTH = (300.*(1.+RLW)+(90000.*(1.+RLW)**2.-40.*RLW*(12000.-VU))**.5)/20./RLW
                                                                     EQU06200
```

$$WIDTH = \frac{300(1+RLW)+[90000(1+RLW)^2-40RLW(12000-VU)]^{0.5}}{20RLW} \qquad [ft]$$

AREA = RLW*WIDTH**2./43560. EQU06400

$$AREA = \frac{RLW(WIDTH)^2}{43560} \quad [acre]$$

VMIN = VU*.2857 EQU06500

$$VMIN = 0.2857VU \quad [ft^3]$$

VUMG = VU*7.48/1000000. EQU06700

$$VUMG = \frac{7.48VU}{1000000} \quad [MG]$$

VOMG = VMIN*7.48/1000000. EQU06800

$$VOMG = \frac{7.48VMIN}{1000000} \quad [MG]$$

VT = VUMG+VOMG EQU06900

$$VT = \frac{7.48(VU+VMIN)}{1000000} \quad [MG]$$

HPA = VT*29.88 (For VT>1.4) EQU07200

$$HPA = 29.88VT \quad [horsepower]$$

HPA = VT*35.36/(VT**.5) (For VT≤1.4) EQU07400

$$HPA = \frac{35.36VT}{(VT)^{0.5}} \quad [horsepower]$$

HPB = VT*59./(VT**.4254) EQU07500

$$HPB = \frac{59VT}{(VT)^{0.4254}} \quad [horsepower]$$

HP = HPB*DMATX(15,N) (For HPA<HPB) EQU07700

HP = HPB*ECF [horsepower]

HP = HPA*DMATX(15,N) (For $HPA \geq HPB$) EQU07900

$HP = HPA*ECF$ [horsepower]

HP1 = SIZE(I) EQU08200

$HP1 = SIZE(I)$ [horsepower]

where I = 1,14

Pump efficiency - Current values used in program; each can be changed by the replacement on punched card.

PEFF = 0.70 for Q_{IS1}<1.44MGD EQU11500

PEFF = 0.74 for Q_{IS1}<10.08MGD EQU11800

PEFF = 0.83 for $Q_{IS1} \geq$10.08MGD EQU12000

VAER = VT*1000./7.48 EQU15000

$$VAER = \frac{1000VT}{7.48} \quad [ft^3/1000]$$

ECFM = 20.*VAER*DMATX(15,N) [ft^3/min] EQU17000

$ECFM = 20VAER*ECF$

SMATX(I,OS1) = SMATX(I,IS1)

SMATX(I,OS1) = SMATX(I,IS1) [mg/l]

where I = 2.20 i.e. Q,SOC,SNBC,SON,SOP,SFM,SBOD,VSS,TSS,DOC,DNBC,DN,DP,DFM, ALK,DBOD,NH3,NO3

References:

Patterson and Banker, 1971

Smith Eilers Hall Feb 1973

5. Cost functions.

Equal basin

a. Capital cost

Function of VAER

```
X = ALOG(VAER)
```
EQU15600

$X = \ln VAER$

```
CCOST(N,1) = EXP(2.414380+.175682*X+.084742*X**2.-.002670*X**3.)*1000.
```
EQU15700

$$CCOST = 1000e^{2.414380+0.175682X+0.084742X^2-0.002670X^3}$$ [dollars]

b. Total operating and maintenance costs EQU16400

```
COSTO(N,1) = 0
```
[cents/1000gal]

Blower

a. Capital cost

Function of ECFM

```
X = ALOG(ECFM/1000.)
```
EQU17100

$$X = \ln \frac{ECFM}{1000}$$

```
CCOST(N,2) = EXP(4.145454+.633339*X+.031939*X**2.-.002419*X**3.)*1000.
```
EQU17200

$$CCOST = 1000e^{4.145454+0.633339X+0.031939X^2-0.002419X^3}$$ [dollars]

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of ECFM/ECF

```
X = ALOG(ECFM/1000./DMATX(15,N))
```
EQU17900

$$X = \ln \frac{ECFM}{1000ECF}$$

(1) Operating manhours

```
OHRS = EXP(6.900586+.323725*X+.059093*X**2.-.004926*X**3.)
```
EQU18500

$$OHRS = e^{6.900586+0.323725X+0.059093X^2-0.004926X^3}$$ [hrs/yr]

(2) Maintenance manhours EQU18600

XMHRS = EXP(6.169937+.294853*X+.175999*X**2.-.04097*X** 3.+.003300*X**4.)

$$XHHRS = e^{6.169937+0.294853X+0.175999X^2-0.040947X^3+0.003300X^4} \quad [hrs/yr]$$

(3) Blower horsepower

EHP = ECFM/DMATX(15,N)*8.1*144./(33000.*.8) EQU18800

$$EHP = \frac{8.1ECFM*144}{33000ECF*0.8} \quad [hp]$$

(4) Blower kilowatts

XKW = .8*EHP EQU18900

$$XKW = \frac{8.1ECFM*144}{33000ECF} \quad [kw]$$

(5) Blower kilowatt years

XKWPY = XKW*24.*365. EQU19000

$$XKWPY = 24XKW*365 \quad [kw\text{-}yrs]$$

(6) Energy cost

ECOST = XKWPY*DMATX(10,20) EQU19100

$$ECOST = 24XKW*365*CKWH \quad [dollars/yr]$$

(7) Supplies cost

SCOST = EXP(.621382+.482047*X)*1000. EQU19200

$$SCOST = 1000e^{0.621382+0.482047X} \quad [dollars/yr]$$

c. Total operating and maintenance costs EQU19700

COSTO(N,2) = ((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/3650.

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+(SCOST*WPI)+ECOST}{Q_{Plant\ inf.}*3650} \quad [cents/1000gal]$$

Pumping system of concrete tank

a. Capital cost

Function of Q_{IS1}*ECF

```
X = ALOG(SMATX(2,IS1)*DMATX(14,N))                                  EQU09600
```

$X = \ln(Q_{IS1}*ECF)$

```
CCOST(N,3) = EXP(3.481553+.377485*X+.093349*X**2.-.006222*X**3.)*1000.
                                                                    EQU09700
```

$CCOST = 1000e^{3.481553+0.377485X+0.093349X^2-0.006222X^3}$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of Q_{IS1}

```
X = ALOG(SMATX(2,IS1))                                              EQU10500
```

$X = \ln Q_{IS1}$

(1) Operating manhours EQU11100

```
OHRS = EXP(6.097269+.253066*X-.193659*X**2.+.078201*X**3.-.006680*X**4.)
```

$OHRS = e^{6.097269+0.253066X-0.193659X^2+0.078201X^3-0.006680X^4}$ [hrs/yr]

(2) Maintenance manhours

```
XMHRS = EXP(5.911541-.013158*X+.076643*X**2.)                       EQU11300
```

$XMHRS = e^{5.911541-0.013158X+0.076643X^2}$ [hrs/yr]

(3) Kilowatt hrs per year EQU12100

```
YRKW = SMATX(2,IS1)*1000000.*HEAD/1440./3960./PEFF/.9*.7457*24.*365.
```

$$YRKW = \frac{Q_{IS1}*1000000*HEAD*0.7457*24*365}{1440*3960*PEFF*0.9}$$ [kwhr/yr]

(4) Energy cost

```
ECOST = YRKW*DMATX(10,20)                                           EQU12200
```

$ECOST = YRKW*CKWH$ [dollars/yr]

(5) Supplies cost

```
SCOST = EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)
```
EQU12300

$$SCOST = e^{5.851743+0.301610X+0.197183X^2-0.017962X^3}$$ [dollars/yr]

(6) Total materials and supplies

```
TMSU = ECOST+SCOST*WPI
```
EQU12400

$$TMSU = ECOST+(SCOST*WPI)$$ [dollars/yr]

c. Total operating and maintenance costs

```
COSTO(N,3) = (COHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.
```
EQU12900

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+TMSU}{Q_{Plant\ Inf.}*3650}$$ [cents/1000gal]

Pumping system of earthen pond

a. Capital cost

Function of Q_{IS1}*ECF

```
X = ALOG(SMATX(2,IS1)*DMATX(14,N))
```
EQU13500

$$X = \ln(Q_{IS1}*ECF)$$

```
CCOST(N,4) = EXP(8.109253+.646743*X)
```
EQU13600

$$CCOS_{\text{\i}} = e^{8.109253+0.646743X}$$ [dollars]

b. Total operating and maintenance costs EQU14200

COSTO(N,4) = 0 [cents/1000gal]

Equal basin for earthen pond

a. Capital cost

Function of AREA

X ALOG(AREA) EQU20400

$X = \ln AREA$

(1) For AREA<1 ACRE EQU21100

CCOST(N,1) = 22000 [dollars]

(2) For AREA≥1 ACRE EQU22500

```
CCOST(N,1) = EXP(3.501091+.422086*X+.079097*X**2.-.008338*X**3.)*1000.
```

$$CCOST = 1000e^{3.501091+0.422086X+0.079097X^2-0.008338X^3} \quad \text{[dollars]}$$

b. Operating manhours, maintenance manhours and materials/supplies costs

(1) For AREA<1 ACRE

(a) Operating manhours EQU21700

OHRS = 600 [hrs/yr]

(b) Maintenance manhours EQU21800

XMHRS = 100 [hrs/yr]

(c) Total materials and supplies EQU23900

TMSU = 0 [dollars/yr]

(2) For AREA≥1 ACRE

(a) Operating manhours EQU23200

```
OHRS = EXP(6.547042+.262634*X+.058298*X**2.-.013454*X**3.+.001494*X**4.)
```

$$OHRS = e^{6.547042+0.262634X+0.058298X^2-0.013454X^3+0.001494X^4} \quad \text{[hrs/yr]}$$

(b) Maintenance manhours

XMHRS = EXP(4.844423+.327982*X+.017677*X**2.) EQU23400

$$XMHRS = e^{4.844423+0.327982X+0.017677X^2} \quad \text{[hrs/yr]}$$

(c) Total materials and supplies EQU23900

TMSU = 0 [dollars/yr]

c. Total operating and maintenance costs EQU24400

COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.

$$COSTO = \frac{(OHRS+XMHRS)*DHR*(1+PCT)+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650} \quad \text{[cents/1000gal]}$$

Blower for earthen pond

a. Capital cost

Function of THP

X = ALOG(THP) EQU25000

$$X = \ln THP$$

(1) For IAER = 0 EQU25800

CCOST(N,2) = EXP(.647120+.438812*X+.031192*X**2.)*1000.

$$CCOST = 1000e^{0.647120+0.438812X+0.031192X^2} \quad \text{[dollars]}$$

(2) For IAER<>0 EQU26600

CCOST(N,2) = EXP(3.141014-.218751*X+.136739*X**2.-.006042*X**3.)*1000.

$$CCOST \quad 1000e^{3.141014-0.218751X+0.136739X^2-0.006042X^3} \quad \text{[dollars]}$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of THP/ECF

X = ALOG(THP/DMATX(15,N)) EQU27300

$$X = \ln \frac{THP}{ECF}$$

(1) Operating manhours EQU27900

OHRS = 0 [hrs/yr]

(2) Maintenance manhours EQU28000

XMHRS = 0 [hrs/yr]

(3) Blower kilowatts

XKW = .8*THP/DMATX(15,N) EQU28100

$$XKW = \frac{0.8THP}{ECF} \quad \text{[kw]}$$

(4) Blower kilowatt years

XKWPY = XKW*24.*365. EQU28200

XKWPY = 24XKW*365 [kw/yrs]

(5) Energy cost

ECOST = XKWPY*DMATX(10,20) EQU28300

ECOST = 24XKW*365*CKWH [dollars/yr]

(6) Supplies cost

SCOST = EXP(4.016957+.534211*X) EQU28400

$$SCOST = e^{4.016957+0.534211X} \quad \text{[dollars/yr]}$$

c. Total operating and maintenance costs EQU28900

COSTO(N,2) = ((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/3650.

$$COSTO = \frac{(OHRS+XMHRS)*DHR*(1+PCT)+(SCOST*WPI)+ECOST}{Q_{Plant\ Inf.}*3650} \quad \text{[cents/1000gal]}$$

Pond lining

a. Capital cost EQU29500

CCOST(N,5) = SAREA*COSTL [dollars]

b. Total operating and maintenance costs EQU30000

COSTO(N,5) = 0 [cents/1000gal]

Land requirement

Function of AREA

X = ALOG(AREA) EQU30500

$X = \ln AREA$

PLAND = EXP(1.588306+.529246*X+.038611*X**2.) EQU30600

$PLAND = e^{1.588306+0.529246X+0.038611X^2}$ [acres]

CLAND = PLAND*DMATX(7,20) EQU30700

$CLAND = DA*e^{1.588306+0.529246X+0.038611X^2}$ [dollars]

```
C
C          EQUALIZATION
C          PROCESS IDENTIFICATION NUMBER  20
C
      SUBROUTINE EQUAL
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      DIMENSION SIZE(14)
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
      DATA SIZE/5.,7.5,10.,15.,20.,25.,30.,40.,50.,60.,75.,100.,125.,150
     1./
C
C
C          ASSIGNMENT OF DESIGN VALUES TO PROCESS PARAMETERS
C
      VAER=0.
      ECFM=0.
      PLAND=0.
      CLAND=0.
      HP=0.
      HP1=0.
      XN=0.
      THP=0.
      IAER=DMATX(1,N)
      RLW=DMATX(2,N)
      COSTL=DMATX(3,N)
      HEAD=DMATX(4,N)
      IMAT=DMATX(5,N)
C
C
C          EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=2,20
   10 SMATX(I,OS1)=SMATX(I,IS1)
C
C
C          CALC. OF OUTPUT SIZES AND QUANTITIES
C
      QP=1.78*SMATX(2,IS1)**.92
      VU=SMATX(2,IS1)*.12*1000000./7.48*DMATX(16,N)
      IF (IMAT) 50,20,50
   20 IF (VU-39000.) 30,30,40
   30 VU=39000.
      WIDTH=90.
      AREA=.18595
      VMIN=1500.
      SAREA=(2.*WIDTH*(1.+RLW)-156.)*53.76+(WIDTH-90.)*(RLW*WIDTH-90.)+2
     10.*(24.+(1.+RLW)*WIDTH)
      GO TO 60
   40 WIDTH=(300.*(1.+RLW)+(90000.*(1.+RLW)**2.-40.*RLW*(12000.-VU))**.5
     1)/20./RLW
      AREA=RLW*WIDTH**2./43560.
      VMIN=5.*RLW*WIDTH**2.-375.*WIDTH*(1.+RLW)+28500.
```

```
      SAREA=(2.*WIDTH*(1.+RLW)-156.)*53.76+(WIDTH-90.)*(RLW*WIDTH-90.)+2
     10.*(24.+(1.+RLW)*WIDTH)
      GO TO 60
   50 WIDTH=(300.*(1.+RLW)+(90000.*(1.+RLW)**2.-40.*RLW*(12000.-VU))**.5
     1)/20./RLW
      AREA=RLW*WIDTH**2./43560.
      VMIN=VU*.2857
      SAREA=0.
   60 VUMG=VU*7.48/1000000.
      VOMG=VMIN*7.48/1000000.
      VT=VUMG+VOMG
      IF (IMAT) 170,70,170
   70 IF (VT-1.4) 90,90,80
   80 HPA=VT*29.88
      GO TO 100
   90 HPA=VT*35.36/(VT**.5)
  100 HPB=VT*59./(VT**.4254)
      IF (HPA-HPB) 110,120,120
  110 HP=HPB*DMATX(15,N)
      GO TO 130
  120 HP=HPA*DMATX(15,N)
  130 DO 150 I=1,14
      IF (HP-SIZE(I)) 140,140,150
  140 HP1=SIZE(I)
      XN=1
      GO TO 160
  150 CONTINUE
      HP1=150.
      XN=HP/150.
      IXN=XN
      XN=IXN+1
  160 THP=HP1*XN
C
C
C            CALC. OF CAPITAL COSTS FOR PUMPING SYSTEM OF CONCRETE
C            TANK BASED ON DESIGN PLUS EXCESS CAPACITY
C
  170 X=ALOG(SMATX(2,IS1)*DMATX(14,N))
      CCOST(N,3)=EXP(3.481553+.377485*X+.093349*X**2.-.006222*X**3.)*100
     10.
C
C
C            CALC. OF OPERATING COSTS FOR PUMPING SYSTEM OF CONCRETE
C            TANK BASED ON DESIGN CAPACITY ALONE, DOES NOT INCLUDE
C            EXCESS CAPACITY
C
      X=ALOG(SMATX(2,IS1))
C
C
C                 CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                 AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(6.097269+.253066*X-.193659*X**2.+.078201*X**3.-.006680*X*
     1*4.)
      XMHRS=EXP(5.911541-.013158*X+.076643*X**2.)
      IF (SMATX(2,IS1)-1.44) 180,190,190
  180 PEFF=.70
      GO TO 220
  190 IF (SMATX(2,IS1)-10.08) 200,210,210
  200 PEFF=.74
      GO TO 220
  210 PEFF=.83
  220 YRKW=SMATX(2,IS1)*1000000.*HEAD/1440./3960./PEFF/.9*.7457*24.*365.
      ECOST=YRKW*DMATX(10,20)
      SCOST=EXP(5.851743+.301610*X+.197183*X**2.-.017962*X**3.)
      TMSU=ECOST+SCOST*WPI
```

```
C
C
C                OPERATING COST EQUATION
C
      COSTO(N,3)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.
C
C
C             CALC. OF CAPITAL COSTS FOR PUMPING SYSTEM OF EARTHEN
C             POND BASED ON DESIGN PLUS EXCESS CAPACITY
C
      X=ALOG(SMATX(2,IS1)*DMATX(14,N))
      CCOST(N,4)=EXP(8.109253+.646743*X)
C
C
C             CALC. OF OPERATING COSTS FOR PUMPING SYSTEM OF EARTHEN
C             POND
C
      COSTO(N,4)=0.
C
C
C             CALC. OF CAPITAL AND OPERATING COSTS FOR CONCRETE TANK
C
      IF (IMAT) 230,240,230
  230 VOMG=0.
      VT=VOMG
      VAER=VT*1000./7.48
C
C
C                CALC. OF CAPITAL COSTS FOR EQUAL BASIN BASED ON
C                DESIGN PLUS EXCESS CAPACITY
C
      X=ALOG(VAER)
      CCOST(N,1)=EXP(2.414380+.175682*X+.084742*X**2.-.002670*X**3.)*100
     10.
C
C
C                CALC. OF OPERATING COSTS FOR EQUAL BASIN
C
C
      COSTO(N,1)=0.
C
C
C                CALC. OF CAPITAL COSTS FOR BLOWER BASED ON DESIGN
C                PLUS EXCESS CAPACITY
C
      ECFM=20.*VAER*DMATX(15,N)
      X=ALOG(ECFM/1000.)
      CCOST(N,2)=EXP(4.145454+.633339*X+.031939*X**2.-.002419*X**3.)*100
     10.
C
C
C                CALC. OF OPERATING COSTS FOR BLOWER BASED ON DESIGN
C                CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(ECFM/1000./DMATX(15,N))
C
C
C                   CALC. OF OPERATING MANHOURS, MAINTENANCE
C                   MANHOURS AND ELECTRICAL POWER AND SUPPLY COSTS
C
      OHRS=EXP(6.900586+.323725*X+.059093*X**2.-.004926*X**3.)
      XMHRS=EXP(6.169937+.294853*X+.175999*X**2.-.040947*X**3.+.003300*X
     1**4.)
```

```
      EHP=ECFM/DMATX(15,N)*8.1*144./(33000.*.8)
      XKW=.8*EHP
      XKWPY=XKW*24.*365.
      ECOST=XKWPY*DMATX(10,20)
      SCOST=EXP(.621382+.482047*X)*1000.
C
C
C                      OPERATING COST EQUATION
C
      COSTO(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/
     13650.
      GO TO 310
C
C
C             CALC. OF CAPITAL AND OPERATING COSTS FOR EARTHEN POND
C
  240 X=ALOG(AREA)
      IF (AREA-1.) 250,260,260
C
C
C                  CALC. OF CAPITAL COSTS FOR EQUAL BASIN, LESS THAN
C                  1 ACRE
C
  250 CCOST(N,1)=22000.
C
C
C                  CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                  FOR EQUAL BASIN, LESS THAN 1 ACRE
C
      OHRS=600.
      XMHRS=100.
      GO TO 270
C
C
C                  CALC. OF CAPITAL COSTS FOR EQUAL BASIN, EQUAL OR
C                  GREATER THAN 1 ACRE
C
  260 CCOST(N,1)=EXP(3.501091+.422086*X+.079097*X**2.-.008338*X**3.)*100
     10.
C
C
C                  CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                  FOR EQUAL BASIN, EQUAL OR GREATER THAN 1 ACRE
C
      OHRS=EXP(6.547042+.262634*X+.058298*X**2.-.013454*X**3.+.001494*X*
     1*4.)
      XMHRS=EXP(4.844423+.327982*X+.017677*X**2.)
C
C
C                  CALC. OF SUPPLIES AND MATERIALS FOR EQUAL BASIN
C
  270 TMSU=0.
C
C
C                  OPERATING COST EQUATION FOR EQUAL BASIN
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C                  CALC. OF CAPITAL COSTS FOR BLOWER BASED ON DESIGN
C                  PLUS EXCESS CAPACITY
C
      X=ALOG(THP)
      IF (IAER) 290,280,290
C
C
```

```
C                           CALC. OF CAPITAL COSTS FOR BLOWER IF SMALL
C                           IMPELLER MECHANICAL AERATORS ON FLOATING
C                           PLATFORMS ARE USED
C
  280 CCOST(N,2)=EXP(.647120+.438812*X+.031192*X**2.)*1000.
      GO TO 300
C
C
C                           CALC. OF CAPITAL COSTS FOR BLOWER IF LARGE
C                           IMPELLER MECHANICAL AERATORS ON STATIONARY
C                           PLATFORMS ARE USED
C
  290 CCOST(N,2)=EXP(3.141014-.218751*X+.136739*X**2.-.006042*X**3.)*100
     10.
C
C
C                    CALC. OF OPERATING COSTS FOR BLOWER BASED ON DESIGN
C                    CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
  300 X=ALOG(THP/DMATX(15,N))
C
C
C                           CALC. OF OPERATING MANHOURS, MAINTENANCE
C                           MANHOURS AND ELECTRICAL POWER AND SUPPLY COSTS
C
      OHRS=0.
      XMHRS=0.
      XKW=.8*THP/DMATX(15,N)
      XKWPY=XKW*24.*365.
      ECOST=XKWPY*DMATX(10,20)
      SCOST=EXP(4.016957+.534211*X)
C
C
C                           OPERATING COST EQUATION
C
      COSTO(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+SCOST*WPI+ECOST)/SMATX(2,1)/
     13650.
C
C
C             CALC. OF CAPITAL COSTS FOR POND LINING
C
      CCOST(N,5)=SAREA*COSTL
C
C
C             CALC. OF OPERATING COSTS FOR POND LINING
C
      COSTO(N,5)=0.
C
C
C             CALC. OF COST FOR LAND
C
      X=ALOG(AREA)
      PLAND=EXP(1.588306+.529246*X+.038611*X**2.)
      CLAND=PLAND*DMATX(7,20)
C
C
C             ASSIGNMENT OF VALUES TO OMATX
C
  310 OMATX(1,N)=WIDTH
      OMATX(2,N)=AREA
      OMATX(3,N)=VUMG
      OMATX(4,N)=VOMG
      OMATX(5,N)=VT
      OMATX(6,N)=SAREA
      OMATX(7,N)=HP
```

```
      OMATX(8,N)=HP1
      OMATX(9,N)=XN
      OMATX(10,N)=THP
      OMATX(11,N)=PLAND
      OMATX(12,N)=CLAND
      OMATX(13,N)=VAER
      OMATX(14,N)=ECFM
C
C
C              PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=20.
      RETURN
      END
```

SECTION 22

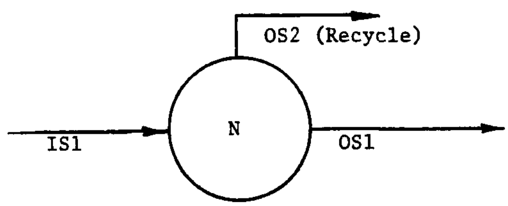
SECOND STAGE ANAEROBIC DIGESTION, DIG2

Subroutine Identification Number 21

Rev. Date 8/1/77

Second Stage Anaerobic Digestion, DIG2

1. Process symbol.



IS1: Sludge input stream

OS1: Sludge output stream

OS2: Supernatant output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) = TRR	Solids recovery ratio for the second stage anaerobic digestion, [.81].
DMATX(2,N) = TSS	Total suspended solids concentration of OS1, mg/1, [50,000.]
DMATX(3,N) = TD	Second stage anaerobic digester detention time, days, [15.].
DMATX(16,N) = ECF	Excess capacity factor for the process, [1.].

3. Output parameters which are printed on computer output sheets.

TRR = DMATX(1,N)	
TSS = DMATX(2,N)	
TD = DMATX(3,N)	
VDIG = OMATX(1,N)	Volume of the second stage anaerobic digester, cu. ft./1000.
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000 gal].
ACOST	Amortization cost, [cents/1000 gal].
TCOST	Total treatment cost, [cents/1000 gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
VDIG = DMATX(3,N)*SMATX(2,IS1)*133.69*DMATX(16,N)                DI204100
```

$$VDIG = TD*Q_{IS1}*133.69*ECF \quad [ft^3/1000]$$

```
SMATX(10,OS2) = ((1.-DMATX(1,N))/(1.-DMATX(1,N)*SMATX(10,IS1)/DMATX(2,N)))*SMATX(10,IS1)
```

$$TSS_{OS2} = \frac{(1-TRR)*TSS_{IS1}}{1-\frac{TRR*TSS_{IS1}}{TSS}} \quad [mg/1]$$ DI201900

```
TEMP1 = DMATX(2;N)/SMATX(10,IS1)                                 DI202100
```

$$TEMP1 = \frac{TSS}{TSS_{IS1}} \quad [no\ units]$$

```
TEMP2 = SMATX(10,OS2)/SMATX(10,IS1)                              DI202200
```

$$TEMP2 = \frac{TSS_{OS2}}{TSS_{IS1}} \quad [no\ units]$$

```
SMATX(10,OS1) = DMATX(2,N)                                       DI202300
```

$$TSS_{OS1} = TSS$$

```
SMATX(2,OS1) = (SMATX(10,IS1)-SMATX(10,OS2))*SMATX(2,IS1)/(SMATX(10,OS1)-SMATX(10,OS2))
```

DI202400

$$Q_{OS1} = \frac{(TSS_{IS1} - TSS_{OS2})*Q_{IS1}}{(TSS_{OS1} - TSS_{OS2})} \quad [MGD]$$

```
SMATX(2,OS2) = SMATX(2,IS1)-SMATX(2,OS1)                         DI202600
```

$$Q_{OS2} = Q_{IS1} - Q_{OS1} \quad [MGD]$$

```
SMATX(I,OS1) = TEMP1*SMATX(I,IS1)                                DI203200
```

SMATX(I,OS1) = TEMP1*SMATX(I,IS1) [mg/1]

I = 3,9, i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS

```
SMATX(I,OS2) = TEMP2*SMATX(I,IS1)                                DI203300
```

SMATX(I,OS2) = TEMP2*SMATX(I,IS1)

I = 3,9

SMATX(I,OS1) = SMATX(I,IS1) DI203500

SMATX(I,OS1) = SMATX(I,IS1)

I = 11,20 i.e. DOC,DNBC,DN,DP,DFM,ALK,DBOD,NH3,NO3

SMATX(I,OS2) = SMATX(I,IS1) DI203600

SMATX(I,OS2) = SMATX(I,IS1)

I = 11,20

References:

Smith, 1969

Patterson and Banker, 1971

5. Cost functions.

a. Capital cost

Function of VDIG

X = ALOG(VDIG) DI204700

$X = \ln VDIG$

(1) Digester facilities less than 20000 ft^3

CCOST(N,1) EXP(4.594215+.127244*X-.004001*X**2.)*1000. DI205400

$CCOST = 1000e^{4.594215+0.127244X-0.004001X^2}$ [dollars]

(2) Digester facilities equal or greater than 20000 ft^3 DI206100

CCOST(N,1) = EXP(7.679634-1.949689*X+.402610*X**2.-.018211*X**3.)*1000.

$CCOST \quad 1000e^{7.679634-1.949689X+0.402610X^2-0.018211X^3}$ [dollars]

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of VDIG/ECF

X = ALOG(VDIG/DMATX(16,N)) DI206800

$X = \ln(VDIG/ECF)$

(1) Digester facilities less than 20000 ft^3

(a) Operating manhours

```
OHRS = EXP(6.163803+.166305*X-.012470*X**2.)
```
DI207600

$$OHRS = e^{6.163803+0.166305X-0.012470X^2} \quad [hrs/yr]$$

(b) Maintenance manhours

```
XMHRS = EXP(5.726981+.113674*X)
```
DI207700

$$XMHRS = e^{5.726981+0.113674X} \quad [hrs/yr]$$

(c) Total materials and supplies

```
TMSU = EXP(6.531623+.198417*X+.021660*X**2.)
```
DI207800

$$TMSU = e^{6.531623+0.198417X+0.021660X^2} \quad [dollars/yr]$$

(2) Digester facilities equal or greater than 20000 ft^3

(a) Operating manhours DI208600

```
OHRS = EXP(9.129250-1.816736*X+.373282*X**2.-.017290*X**3.)
```

$$OHRS = e^{9.129250-1.816736X+0.373282X^2-0.017290X^3} \quad [hrs/yr]$$

(b) Maintenance manhours DI208700

```
XMHRS = EXP(8.566752-1.768137*X+.363173*X**2.-.016620*X**3.)
```

$$XMHRS = e^{8.566752-1.768137X+0.363173X^2-0.016620X^3} \quad [hrs/yr]$$

(c) Total materials and supplies DI208800

```
TMSU = EXP(8.702803-1.182711*X+.282691*X**2.-.013672*X**3.)
```

$$TMSU = e^{8.702803-1.182711X+0.282691X^2-0.013672X^3} \quad [dollars/yr]$$

c. Total operating and maintenance costs DI209300

```
COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
```

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+TMSU(WPI)}{Q_{Plant\ Inf.} * 3650} \quad [cents/1000\ gal]$$

```
C
C          SECOND STAGE ANAEROBIC DIGESTION
C          PROCESS IDENTIFICATION NUMBER  21
C
      SUBROUTINE DIG2
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C          PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C          CHARACTERISTICS
C
      SMATX(10,OS2)=((1.-DMATX(1,N))/(1.-DMATX(1,N)*SMATX(10,IS1)/DMATX(
     12,N)))*SMATX(10,IS1)
      TEMP1=DMATX(2,N)/SMATX(10,IS1)
      TEMP2=SMATX(10,OS2)/SMATX(10,IS1)
      SMATX(10,OS1)=DMATX(2,N)
      SMATX(2,OS1)=(SMATX(10,IS1)-SMATX(10,OS2))*SMATX(2,IS1)/(SMATX(10,
     1OS1)-SMATX(10,OS2))
      SMATX(2,OS2)=SMATX(2,IS1)-SMATX(2,OS1)
C
C
C          EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=3,9
      SMATX(I,OS1)=TEMP1*SMATX(I,IS1)
   10 SMATX(I,OS2)=TEMP2*SMATX(I,IS1)
      DO 20 I=11,20
      SMATX(I,OS1)=SMATX(I,IS1)
   20 SMATX(I,OS2)=SMATX(I,IS1)
C
C
C          CALC. OF OUTPUT SIZES AND QUANTITIES
C
      VDIG=DMATX(3,N)*SMATX(2,IS1)*133.69*DMATX(16,N)
C
C
C          CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C          CAPACITY
C
      X=ALOG(VDIG)
      IF (VDIG-20.) 30,40,40
C
C
C               CALC. OF CAPITAL COSTS FOR SMALL DIG2 FACILITY,
C               LESS THAN 20000 CU. FT.
C
   30 CCOST(N,1)=EXP(4.594215+.127244*X-.004001*X**2.)*1000.
      GO TO 50
C
C
C               CALC. OF CAPITAL COSTS FOR LARGE DIG2 FACILITY,
```

```
C                   EQUAL OR GREATER THAN 20000 CU. FT.
C
   40 CCOST(N,1)=EXP(7.679634-1.949689*X+.402610*X**2.-.018211*X**3.)*10
     100.
C
C
C             CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C             DOES NOT INCLUDE EXCESS CAPACITY
C
   50 X=ALOG(VDIG/DMATX(16,N))
      IF (VDIG-20.) 60,70,70
C
C
C                   CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                   AND MATERIALS AND SUPPLIES FOR DIG2 FACILITY, LESS
C                   THAN 20000 CU. FT.
C
   60 OHRS=EXP(6.163803+.166305*X-.012470*X**2.)
      XMHRS=EXP(5.726981+.113674*X)
      TMSU=EXP(6.531623+.198417*X+.021660*X**2.)
      GO TO 80
C
C
C                   CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                   AND MATERIALS AND SUPPLIES FOR DIG2 FACILITY, EQUAL
C                   OR GREATER THAN 20000 CU. FT.
C
   70 OHRS=EXP(9.129250-1.816736*X+.373282*X**2.-.017290*X**3.)
      XMHRS=EXP(8.566752-1.768137*X+.363173*X**2.-.016620*X**3.)
      TMSU=EXP(8.702803-1.182711*X+.282691*X**2.-.013672*X**3.)
C
C
C                   OPERATING COST EQUATION
C
   80 COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C             ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=VDIG
C
C
C             PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=21.
      RETURN
      END
```

SECTION 23

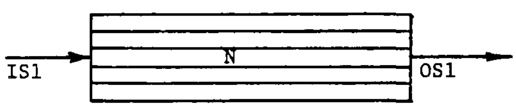
LAND DISPOSAL OF LIQUID SLUDGE, LANDD

Subroutine Identification Number 22

Land Disposal of Liquid Sludge, LANDD

Rev. Date 8/1/77

1. Process symbol.



IS1: Sludge input stream

OS1: Zero output since sludge percolates into soil

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) TAYR	Amount of dry solids disposal, tons/acre/yr. [15.]
DMATX(2,N) = SP	Sludge storage period before disposal, yr. [.25]
DMATX(3,N) DIST	Round trip sludge hauling distance by truck, miles. [10.]
DMATX(4,N) = TS	Sludge leading capacity of trucks used for hauling, gallons. [1200.]
DMATX(5,N) = YRSL	Amortization period for trucks, yr. [6.]
DMATX(15,N) = ECF	Excess capacity factor for trucking capacity. [1.]
DMATX(16,N) = ECF	Excess capacity factor for the sludge holding lagoon. [1.]

3. Output parameters which are printed on computer output sheets.

TAYR = DMATX(1,N)	
SP = DMATX(2,N)	
DIST = DMATX(3,N)	
TS = DMATX(4,N)	
YRSL = DMATX(5,N)	
TYT = OMATX(1,N)	Total number of trips made per year by each truck.
TTYR = OMATX(2,N)	Total number of trips made per year by all the trucks.

TRKN = OMATX(3,N)	Total number of trucks needed to haul the sludge.
SLV = OMATX(4,N)	Volume of sludge in storage, cu ft/1000.
TONS = OMATX(5,N)	Amount of dry solids applied to the land, tons/yr.
ALAND = OMATX(6,N)	Required land area for spreading the sludge (this land area requirement is not included in the total land area requirement, ACRE, for the whole plant), acre.
DLAND = OMATX(7,N)	Interest cost on the capital investment in land for sludge spreading, $/yr.
COL = OMATX(8,N)	Capital cost of land area required for sludge spreading, $.
AFT = OMATX(9,N)	Amortization factor for trucks based on a 6 year lifetime.
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000 gal].
ACOST	Amortization cost, [cents/1000 gal].
TCOST	Total treatment cost, [cents/1000 gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
TYT = 260.*8./(.04*DIST+.5)                          LAN02700
```

$$TYT = \frac{260*8}{0.04DIST+0.5} \qquad [trips/yr/truck]$$

```
TTYR = 365.*SMATX(2,IS1)*1000000./TS                 LAN02800
```

$$TTYR = \frac{365*1000000Q_{IS1}}{TS} \qquad [trips/yr]$$

```
TRKN = TTYR/TYT                                      LAN02900
```

$$TRKN = \frac{TTYR}{TYT} \qquad [number]$$

```
NNN = TRKN*DMATX(15,N)                               LAN03000
```

$$NNN = TRKN*ECF \qquad [number]$$

```
TRKN = NNN+1                                         LAN03100
```

$$TRKN = (TRKN*ECF)+1 \qquad [number]$$

SLV = SP*365.*SMATX(2,IS1)*1000000./7.48/1000.*DMATX(16,N) LAN03200

$$SLV = \frac{365SP*Q_{IS1}*1000000ECF}{7.48*1000} \quad [ft^3/1000]$$

TONS = (SMATX(10,IS1)+SMATX(15,IS1)*SMATX(2,IS1)*8.33*365./2000. LAN03300

$$TONS = \frac{(TSS_{IS1}+DFM_{IS1})*Q_{IS1}*8.33*365}{2000} \quad [tons/yr]$$

ALAND = TONS/TAYR LAN03400

$$ALAND = \frac{TONS}{TAYR} \quad [acres]$$

COL = ALAND*DMATX(7,20) LAN03500

COL = ALAND*DA [dollars]

DLAND = COL*DMATX(3,20) LAN03600

DLAND = COL*RI [dollars]

AF = DMATX(3,20)*(1.+DMATX(3,20))**DMATX(4,20)/((1.+DMATX(3,20))**DMATX(4,20)-1.)

$$AF = \frac{RI*[1+RI]^{YRS}}{[1+RI]^{YRS}-1} \quad [no\ units]$$ LAN03700

AFT = DMATX(3,20)*(1.+DMATX(3,20))**YRSL/((1.+DMATX(3,20))**YRSL-1.) LAN03900

$$AFT = \frac{RI*[1+RI]^{YRSL}}{[1+RI]^{YRSL}-1} \quad [no\ units]$$

References:

Smith and Eilers, 1975

Patterson and Banker, 1971

5. Cost functions.

Sludge storage

a. Capital cost

Function of SLV

X = ALOG(SLV) LAN05000

X = ln SLV

CCOST(N,1) = EXP(.375449+.394996*X+.014726*X**2.)*1000. LAN05100

$$CCOST = 1000e^{0.375449+0.394996X+0.014726X^2} \quad \text{[dollars]}$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of TONS

X = ALOG(TONS) LAN05700

$$X = \ln TONS$$

(1) Operating manhours

OHRS = EXP(6.567594-.971759*X+.095689*X**2.)*SP LAN06300

$$OHRS = SP*e^{6.567594-0.971759X+0.095689X^2} \quad \text{[hrs/yr]}$$

(2) Maintenance manhours

XMHRS = EXP(-2.087393+2.395831*X-.340388*X**2.+.017499*X**3.)*SP LAN06400

$$XMHRS = SP*e^{-2.087393+2.395831X-0.340388X^2+0.017499X^3} \quad \text{[hrs/yr]}$$

(3) Total materials and supplies

TMSU = 0 [dollars/yr] LAN06500

c. Total operating and maintenance costs

COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650. LAN07000

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650} \quad \text{[cents/1000 gal]}$$

Sludge transportation

a. Capital cost

Function of TX

X = ALOG(TS/1000.) LAN07600

$$X = \ln \frac{TS}{1000}$$

CCOST(N,2) = EXP(1.317230+3.959678*X-2.592107*X**2.+.583467*X**3.)*(1.506/1.761)*1000*TRKN

$$CCOST = \frac{1.506}{1.761}*1000TRKN*e^{1.317230+3.959678X-2.592107X^2+0.583467X^3} \quad \text{[dollars]}$$ LAN07700

b. Amortized cost

ACOST(N,2) = CCOST(N,2)*AFT/SMATX(2,1)/3650. LAN08300

$$ACOST = \frac{CCOST*AFT}{Q_{Plant\ Inf.}*3650} \quad [cents/1000\ gal]$$

c. Operating manhours, maintenance manhours and materials/supplies costs

For TS $\geq$ 5500 LAN09400

OM = 0.475*DIST*TTYR [hrs/yr] LAN10000

For TS < 2500 LAN09500

OM = 0.305*DIST*TTYR [hrs/yr] LAN09600

For TS $\geq$ 2500 LAN09500

OM = 0.425*DIST*TTYR [hrs/yr] LAN09800

Maintenance manhours

TMHR = TTYR*(.04*DIST+.5) LAN10100

TMHR = TTYR*(0.04DIST+0.5) [hrs/yr]

d. Total operating and maintenance costs

COSTO(N,2) = (TMHR*DHR*(1.+PCT)+OM*WPI)/SMATX(2,1)/3650. LAN10600

$$COSTO = \frac{[TMHR*DHR*(1+PCT)]+(OM*WPI)}{Q_{Plant\ Inf.}*3650} \quad [cents/1000\ gal]$$

Interest on capital investment

a. Capital cost assumed zero

CCOST(N,3) = 0 [dollars] LAN11200

b. Total operating and maintenance costs

COSTO(N,3) = DLAND/SMATX(2,1)/3650. LAN11300

$$COSTO = \frac{DLAND}{Q_{Plant\ Inf.}*3650} \quad [cents/1000\ gal]$$

```
C
C          LAND DISPOSAL OF LIQUID SLUDGE
C          PROCESS IDENTIFICATION NUMBER  22
C
      SUBROUTINE LANDD
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C          ASSIGNMENT OF DESIGN VALUES TO PROCESS PARAMETERS
C
      TAYR=DMATX(1,N)
      SP=DMATX(2,N)
      DIST=DMATX(3,N)
      TS=DMATX(4,N)
      YRSL=DMATX(5,N)
C
C
C          CALC. OF OUTPUT SIZES AND QUANTITIES
C
      TYT=260.*8./(.04*DIST+.5)
      TTYR=365.*SMATX(2,IS1)*1000000./TS
      TRKN=TTYR/TYT
      NNN=TRKN*DMATX(15,N)
      TRKN=NNN+1
      SLV=SP*365.*SMATX(2,IS1)*1000000./7.48/1000.*DMATX(16,N)
      TONS=(SMATX(10,IS1)+SMATX(15,IS1))*SMATX(2,IS1)*8.33*365./2000.
      ALAND=TONS/TAYR
      COL=ALAND*DMATX(7,20)
      DLAND=COL*DMATX(3,20)
      AF=DMATX(3,20)*(1.+DMATX(3,20))**DMATX(4,20)/((1.+DMATX(3,20))**DM
     1ATX(4,20)-1.)
      AFT=DMATX(3,20)*(1.+DMATX(3,20))**YRSL/((1.+DMATX(3,20))**YRSL-1.)
C
C
C          COST CALCULATIONS
C
      IF (SLV) 10,20,10
C
C
C          CALC. OF CAPITAL COSTS FOR SLUDGE STORAGE BASED ON
C          DESIGN PLUS EXCESS CAPACITY
C
   10 X=ALOG(SLV)
      CCOST(N,1)=EXP(.375449+.394996*X+.014726*X**2.)*1000.
C
C
C          CALC. OF OPERATING COSTS FOR SLUDGE STORAGE BASED ON
C          DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(TONS)
C
```

```
C
C                CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(6.567594-.971759*X+.095689*X**2.)*SP
      XMHRS=EXP(-2.087393+2.395831*X-.340388*X**2.+.017499*X**3.)*SP
      TMSU=0.
C
C
C                OPERATING COST EQUATION
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C           CALC. OF CAPITAL COSTS FOR SLUDGE TRANSPORTATION BASED
C           ON DESIGN PLUS EXCESS CAPACITY
C
   20 X=ALOG(TS/1000.)
      CCOST(N,2)=EXP(1.317230+3.959678*X-2.592107*X**2.+.583467*X**3.)*(
     11.506/1.761)*1000.*TRKN
C
C
C           CALC. OF AMORTIZATION COSTS
C
      ACOST(N,2)=CCOST(N,2)*AFT/SMATX(2,1)/3650.
C
C
C           CALC. OF OPERATING COSTS FOR SLUDGE TRANSPORTATION BASED
C           ON DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS
C           CAPACITY
C
C
C                CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                AND MATERIALS AND SUPPLIES
C
      IF (TS-5500.) 30,60,60
   30 IF (TS-2500.) 40,50,50
   40 OM=.305*DIST*TTYR
      GO TO 70
   50 OM=.425*DIST*TTYR
      GO TO 70
   60 OM=.475*DIST*TTYR
   70 TMHR=TTYR*(.04*DIST+.5)
C
C
C                OPERATING COST EQUATION
C
      COSTO(N,2)=(TMHR*DHR*(1.+PCT)+OM*WPI)/SMATX(2,1)/3650.
C
C
C           CALC. OF CAPITAL AND OPERATING COSTS FOR INTEREST ON
C           THE CAPITAL INVESTMENT
C
      CCOST(N,3)=0.
      COSTO(N,3)=DLAND/SMATX(2,1)/3650.
C
C
C           ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=TYT
      OMATX(2,N)=TTYR
      OMATX(3,N)=TRKN
      OMATX(4,N)=SLV
      OMATX(5,N)=TONS
      OMATX(6,N)=ALAND
      OMATX(7,N)=DLAND
```

```
      OMATX(8,N)=COL
      OMATX(9,N)=AFT
C
C
C             PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=22.
      RETURN
      END
```

SECTION 24

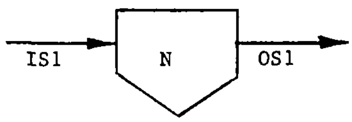
LIME ADDITION TO SLUDGE, LIME

Subroutine Identification Number 23

Rev. Date 8/1/77

Lime Addition to Sludge, LIME

1. Process symbol.



IS1: Sludge input stream

OS1: Sludge output stream

N: User assigned number to the process

2. Input parameters and nominal values.

DMATX(1,N) DLIME	Dose of lime, lb of CaO/ton of dry solids. [200.]
DMATX(2,N) = CLIME	Cost of lime, $/ton. [25.]
DMATX(16,N) = ECF	Excess capacity factor for the process. [1.]

3. Output parameters which are printed on computer output sheets.

DLIME = DMATX(1,N)	
CLIME = DMATX(2,N)	
PPDL = OMATX(1,N)	Lime addition rate, lb of CaO/day.
DTON = OMATX(2,N)	Amount of sludge to be treated with lime, tons/day of dry solids.
CCOST	Capital cost , [dollars].
COSTO	Operating and maintenance cost, [cents/1000gal].
ACOST	Amortization cost, [cents/1000gal].
TCOST	Total treatment cost, [cents/1000gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

DLIME = DMATX(1,N) LIM01800

DLIME = DMATX(1,N) [lb CaO/ton dry solids]

CLIME = DMATX(2,N) LIM01900

CLIME = DMATX(2,N) [$/ton]

DTON = (SMATX(10,IS1)+SMATX(15,IS1))*SMATX(2,IS1)*8.33/2000.

$$DTON = \frac{[TSS_{IS1}+DFM_{IS1}]*Q_{IS1}*8.33}{2000}$$ [tons/day] LIM02400

PPDL = DLIME * DTON * DMATX(16,N) LIM02500

PPDL = DLIME*DTON*ECF [lb/day]

SMATX(I,OS1) = SMATX(I,IS1) LIM03100

SMATX(I,OS1) = SMATX(I,IS1) [mg/l]

where I = 2,6

i.e. Q, SOC, SNBC, SON, SOP

SMATX(7,OS1) = SMATX(7,IS1)+PPDL/8.33/SMATX(2,IS1) LIM03200

$$SFM_{OSI}=SFM_{IS1}+\frac{PPDL}{8.33Q_{IS1}}$$ [mg/l]

SMATX(8,OS1) = SMATX(8,IS1) LIM03300

$$SBOD_{OS1}=SBOD_{IS1}$$

SMATX(9,OS1) = SMATX(9,IS1) LIM03400

$$VSS_{OS1}=VSS_{IS1}$$

SMATX(10,OS1) = SMATX(10,IS1)+PPDL/8.33/SMATX(2,IS1) LIM03500

$$TSS_{OS1}=TSS_{IS1}+\frac{PPDL}{8.33*Q_{IS1}}$$ [mg/l]

SMATX(I,OS1) = SMATX(I,IS1) LIM03700

SMATX(I,OS1) = SMATX(I,IS1)

where I = 11,20

i.e. DOC, DNBC, DN, DP, DFM, ALK, DBOD, NH3, NO3

References:

Smith and Eilers, 1975

Patterson and Banker, 1971

5. Cost functions.

a. Capital cost

Function of PPDL

X = ALOG(PPDL) LIM04300

$$X = \ln PPDL$$

CCOST(N,1) = EXP(-1.800487+.670797*X)*1000. LIM04400

$$CCOST = 1000e^{-1.800487+0.670797X} \quad [\text{dollars}]$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of PPDL/ECF

X = ALOG(PPDL/DMATX(16,N)) LIM05000

$$X = \ln \frac{PPDL}{ECF}$$

(1) Operating manhours

OHRS - 0. LIM05500

$$OHRS \quad 0 \quad [\text{hrs/year}]$$

(2) Maintenance manhours

XMHRS = EXP(6.060054+.197073*X) LIM05600

$$XMHRS = e^{6.060054+0.197073X} \quad [\text{hrs/yr}]$$

(3) Total materials and supplies

CHEM = PPDL*365.*CLIME/2000. LIM06100

$$CHEM = \frac{PPDL*365*CLIME}{2000} \quad [\text{ton CaO/yr}]$$

c. Total operating and maintenance costs

COSTO(N,1) ((OHRS+XMHRS)*DHR*(1.+PCT)+CHEM)/SMATX(2,1)/3650.

LIM06600

$$COSTO = \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+CHEM}{Q_{Plant\ Inf.}*3650} \quad [\text{cents/1000gal}]$$

```
C
C          LIME ADDITION TO SLUDGE
C          PROCESS IDENTIFICATION NUMBER  23
C
      SUBROUTINE LIME
C
C
C          COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C          ASSIGNMENT OF DESIGN VALUES TO CHEMICAL PARAMETERS
C
      DLIME=DMATX(1,N)
      CLIME=DMATX(2,N)
C
C
C          CALC. OF OUTPUT SIZES AND QUANTITIES
C
      DTON=(SMATX(10,IS1)+SMATX(15,IS1))*SMATX(2,IS1)*8.33/2000.
      PPDL=DLIME*DTON*DMATX(16,N)
C
C
C          EFFLUENT STREAM CALCULATIONS
C
      DO 10 I=2,6
   10 SMATX(I,OS1)=SMATX(I,IS1)
      SMATX(7,OS1)=SMATX(7,IS1)+PPDL/8.33/SMATX(2,IS1)
      SMATX(8,OS1)=SMATX(8,IS1)
      SMATX(9,OS1)=SMATX(9,IS1)
      SMATX(10,OS1)=SMATX(10,IS1)+PPDL/8.33/SMATX(2,IS1)
      DO 20 I=11,20
   20 SMATX(I,OS1)=SMATX(I,IS1)
C
C
C          CALC. OF CAPITAL COSTS BASED ON DESIGN PLUS EXCESS
C          CAPACITY
C
      X=ALOG(PPDL)
      CCOST(N,1)=EXP(-1.800487+.670797*X)*1000.
C
C
C          CALC. OF OPERATING COSTS BASED ON DESIGN CAPACITY ALONE,
C          DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(PPDL/DMATX(16,N))
C
C
C                CALC. OF OPERATING MANHOURS AND MAINTENANCE MANHOURS
C
      OHRS=0.
      XMHRS=EXP(6.060054+.197073*X)
C
C
```

```
C                   CALC. OF LIME DOSAGE COSTS
C
      CHEM=PPDL*365.*CLIME/2000.
C
C
C                   OPERATING COST EQUATION
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+CHEM)/SMATX(2,1)/3650.
C
C
C             ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=PPDL
      OMATX(2,N)=DTON
C
C
C             PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=23.
      RETURN
      END
```

SECTION 25

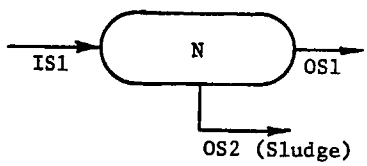
ROTATING BIOLOGICAL CONTACTOR - FINAL SETTLER, RBC

Subroutine Identification Number 24

Rotating Biological Contactor - Final Settler, RBC

Rev. Date 8/1/77

1. Process symbol.



IS1: Liquid input stream
OS1: Liquid output stream
OS2: Sludge output stream
N: User assigned number for the process

2. Input parameters and nominal values.

DMATX(1,N) = BOD	Demand concentration of 5-day BOD in the final effluent stream, mg/l.[13.]
DMATX(2,N) = XNSTG	Number of stages in series for the RBC process.[4.]
DMATX(3,N) = DEGC	Temperature of the water, degrees centrigrade. [20.]
DMATX(4,N) = QPABI	Rate constant for BOD removal at 20°C, gpd/sq ft.[7.]
DMATX(5,N) = QPANI	Rate constant for nitrification at 20°C, gpd/sq ft.[4.45]
DMATX(6,N) = GSS	Design overflow rate (based on average flow) for the final settler, gpd/sq ft.[800.]
DMATX(7,N) = BODN	Concentration of BOD at which nitrification begins, mg/l.[20.]
DMATX(8,N) = TSS	Concentration of waste solids from the final settler underflow, percent.[3.5]
DMATX(9,N) = CPDY	Cost of installed concrete, $/cu.yd.[233.]
DMATX(15,N) = ECF	Excess capacity factor for the final settler.[1.]
DMATX(16,N) = ECF	Excess capacity factor for the rotating biological contactor.[1.]

3. Output parameters which are printed on computer output sheets.

BOD = DMATX(1,N)	
XNSTG = DMATX(2,N)	
DEGC = DMATX(3,N)	
QPABI = DMATX(4,N)	
QPANI = DMATX(5,N)	
GSS = DMATX(6,N)	
BODN = DMATX(7,N)	
TSS DMATX(8,N)	
CPDY = DMATX(9,N)	
QPAB = OMATX(1,N)	Rate constant for BOD removal after correction for water temperature, gpd/sq ft.
QPAN = OMATX(2,N)	Rate constant for nitrification after correction for water temperature, gpd/sq ft.
APSTG = OMATX(3,N)	Area per RBC stage, sq ft/stage.
AREA = OMATX(4,N)	Total RBC active area, sq ft.
FNSTG = OMATX(5,N)	Number of stages required to achieve the BOD concentration (BODN) at which nitrification begins.
RNSTG OMATX(6,N)	Number of remaining stages for nitrification (XNSTG - FNSTG).
RATIO = OMATX(7,N)	Ratio of total BOD in the effluent stream to total BOD in the influent stream.
PREM OMATX(8,N)	Percentage of ammonia nitrogen removal.
QPAT = OMATX(9,N)	Overall hydraulic loading, gpd/sq ft.
AFS OMATX(10,N)	Surface area of the final settler, sq ft.
PDSD = OMATX(11,N)	Solids wasting rate, lb of dry solids/day.
URSS = OMATX(12,N)	Ratio of solid nonbiodegradable carbon concentration in the effluent stream to the concentration in the influent stream.

NTRN = OMATX(13,N)	Number of 100,000 sq ft shafts per stage.
NSHFT = OMATX(14,N)	Number of 100,000 sq ft shafts required.
COSTM = OMATX(15,N)	Materials and supplies cost, $/yr.
COSTE = OMATX(16,N)	Electrical power cost, $/yr.
COSTL = OMATX(17,N)	Operation and maintenance labor cost, $/yr.
CCOST	Capital cost, [dollars].
COSTO	Operating and maintenance cost, [cents/1000gal]
ACOST	Amortization cost,[cents/1000gal].
TCOST	Total treatment cost,[cents/1000gal].
ECF	Excess capacity factor.

4. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
QPAB = DMATX(4,N)*1.04**(DMATX(3,N)-20.)                    RBC03200
```

$$QPAB = QPABI*1.04^{DEGC-20} \qquad [gpd/ft^2]$$

```
QPAN = DMATX(5,N)*1.04**(DMATX(3,N)-20.)                    RBC03300
```

$$QPAN = QPANI*1.04^{DEGC-20} \qquad [gpd/ft^2]$$

```
RATIO = DMATX(1,N)/(SMATX(17,IS1)+SMATX(8,IS1))             RBC03400
```

$$RATIO = \frac{BOD}{DBOD_{IS1}+SBOD_{IS1}} \qquad [no\ units]$$

```
TEMP1 = ALOG(RATIO)/DMATX(2,N)                              RBC03500
```

$$TEMP1 = \frac{\ln RATIO}{XNSTG} \qquad [no\ units]$$

```
TEMP2 = 1./EXP(TEMP1)-1.                                    RBC03600
```

$$TEMP2 = \frac{1}{e^{TEMP1}} - 1 \qquad [no\ units]$$

```
APSTG = SMATX(2,IS1)*1000000.*TEMP2/QPAB                    RBC03700
```

$$APSTG = \frac{Q_{IS1}*1000000*TEMP2}{QPAB} \qquad [ft^2]$$

```
PDSD = .34*(SMATX(8,IS1)+SMATX(17,IS1)+SMATX(10,IS1))*SMATX(2,IS1)*8.33-.3*AREA/1000.
```
RBC03800

$$PDSD = 0.34(SBOD_{IS1}+DBOD_{IS1}+TSS_{IS1})*8.33Q_{IS1}-\frac{0.3AREA}{1000}$$ [lb/day]

```
TEMP3 = 1./(1.+QPAB*APSTG/SMATX(2,IS1)/1000000.)
```
RBC04000

$$TEMP3 = \frac{1}{1+\frac{QPAB*APSTG}{Q_{IS1}*1000000}}$$ [no units]

```
RATIO = DMATX(7,N)/(SMATX(17,IS1)+SMATX(8,IS1))
```
RBC04100

$$RATIO = \frac{BODN}{DBOD_{IS1}+SBOD_{IS1}}$$ [no units]

```
FNSTG = ALOG(RATIO)/ALOG(TEMP3)
```
RBC04200

$$FNSTG = \frac{\ln RATIO}{\ln TEMP3}$$ [no units]

```
RNSTG = XNSTG-FNSTG
```
RBC04300

$$RNSTG = XNSTG-\frac{\ln RATIO}{\ln TEMP3}$$ [no units]

```
RATIO = (1./(1.+QPAN*APSTG/SMATX(2,IS1)/1000000.))**RNSTG
```
RBC04400

$$RATIO = \left[\frac{1}{1+\frac{QPAN*APSTG}{Q_{IS1}*1000000}}\right]^{RNSTG}$$ [no units]

```
SMATX(18,OS1) = SMATX(18,IS1)*RATIO
```
RBC04900

$$NH3_{OS1} = NH3_{IS1}*RATIO$$ [mg/1]

```
SMATX(2,OS2) = PDSD/DMATX(8,N)/10000./8.33
```
RBC05000

$$Q_{OS2} = \frac{PDSD}{TSS*10000*8.33}$$ [MGD]

```
SMATX(2,OS1) = SMATX(2,IS1)-SMATX(2,OS2)
```
RBC05100

$$Q_{OS1} = Q_{IS1}-Q_{OS2}$$ [MGD]

```
SMATX(10,OS1) = 4.5+.51*DMATX(1,N)
```
RBC05200

$$TSS_{OS1} = 4.5+0.51\ BOD$$ [mg/1]

SMATX(10,OS2) = DMATX(8,N)*10000 RBC05300

$TSS_{OS2} = 10000\ TSS$ [mg/l]

SMATX(8,OS1) = (SMATX(10,OS1)-4.5)*.897 RBC05400

$SBOD_{OS1} = (TSS_{OS1}-4.5)*0.897$ [mg/l]

SMATX(17,OS1) = DMATX(1,N)-SMATX(8,OS1) RBC05500

$DBOD_{OS1} = BOD-SBOD_{OS1}$ [mg/l]

SMATX(19,OS1) = SMATX(18,IS1)-SMATX(18,OS1) RBC05600

$NO3_{OS1} = NH3_{IS1}-NH3_{OS1}$ [mg/l]

URSS = SMATX(2,IS1)/(SMATX(2,OS1)+SMATX(2,OS2)*SMATX(10,OS2)/SMATX(10,OS1))

RBC05700

$$URSS = \frac{Q_{IS1}}{Q_{OS1}+\frac{Q_{OS2}*TSS_{OS2}}{TSS_{OS1}}}$$ [no units]

SMATX(4,OS1) = URSS*SMATX(4,IS1) RBC05900

$SNBC_{OS1} = URSS*SNBC_{IS1}$ [mg/l]

SMATX(3,OS1) = DMATX(1,N)*1.6/2.7+SMATX(4,OS1) RBC06000

$SOC_{OS1} = \frac{BOD*1.6}{2.7}+SNBC_{OS1}$ [mg/l]

SMATX(5,OS1) = .1*SMATX(3,OS1) RBC06100

$SON_{OS1} = 0.1SOC_{OS1}$ [mg/l]

SMATX(6,OS1) = .01*SMATX(3,OS1) RBC06200

$SOP_{OS1} = 0.01SOC_{OS1}$ [mg/l]

SMATX(7,OS1) = URSS*SMATX(7,IS1) RBC06300

$SFM_{OS1} = URSS*SFM_{IS1}$ [mg/1]

SMATX(9,OS1) = SMATX(10,OS1)-SMATX(7,OS1) RBC06400

$VSS_{OS1} = TSS_{OS1}-SFM_{OS1}$ [mg/1]

SMATX(11,OS1) = SMATX(12,IS1)+SMATX(17,OS1)*1.6/2.7 RBC06500

$DOC_{OS1} = DNBC_{IS1}+ \frac{1.6DBOD_{OS1}}{2.7}$ [mg/1]

SMATX(12,OS1)   SMATX(12,IS1) RBC06600

$DNBC_{OS1} = DNBC_{IS1}$ [mg/1]

SMATX(13,OS1) = .1*SMATX(11,OS1)+SMATX(18,OS1)+SMATX(19,OS1) RBC06700

$DN_{OS1} = 0.1DOC_{OS1}+NH3_{OS1}+NO3_{OS1}$ [mg/1]

SMATX(14,OS1) = SMATX(14,IS1) RBC06800

$DP_{OS1} = DP_{IS1}$ [mg/1]

SMATX(15,OS1) = SMATX(15,IS1) RBC06900

$DFM_{OS1} = DFM_{IS1}$ [mg/1]

SMATX(16,OS1) = SMATX(16,IS1)-10.*(SMATX(18,IS1)-SMATX(18,OS1)) RBC07000

$ALK_{OS1} = ALK_{IS1}-10(NH3_{IS1}-NH3_{OS1})$ [mg/1]

SMATX(20,OS1) = SMATX(20,IS1) RBC07100

Future parameter [mg/1]

TEMP4 = SMATX(10,OS2)/SMATX(10,OS1) RBC07200

$TEMP4 = \frac{TSS_{OS2}}{TSS_{OS1}}$ [no units]

SMATX(J,OS2) = TEMP4*SMATX(J,OS1) RBC07400

$$SMATX(J,OS2) = TEMP4*SMATX(J,OS1) \quad [mg/l]$$

where J = 3,9 i.e. SOC,SNBC,SON,SOP,SFM,SBOD,VSS

SMATX(J,OS2) = SMATX(J,OS1) RBC07600

$$SMATX(J,OS2) = SMATX(J,OS1) \quad [mg/l]$$

where J = 11,20 i.e. DOC,DNBC,DN,DP,DFM,ALK,DBOD,NH3,NO3

AFS = SMATX(2,OS1)*1000000./DMATX(6,N)*DMATX(15,N) RBC08100

$$AFS = \frac{Q_{OS1}*1000000*ECF}{GSS} \quad [ft^2]$$

PREM = (SMATX(18,IS1)-SMATX(18,OS1))*100./SMATX(18,IS1) RBC08200

$$PREM = \frac{100(NH3_{IS1}-NH3_{OS1})}{NH3_{IS1}} \quad [no\ units]$$

QPAT = SMATX(2,IS1)*1000000./APSTG/XNSTG RBC08300

$$QPAT = \frac{Q_{IS1}*1000000}{APSTG*XNSTG} \quad [gpd/ft^2]$$

NTRN = APSTG*DMATX(16,N)/100000. RBC08400

$$NTRN = \frac{APSTG*ECF}{100000} \quad [no\ units]$$

NSHFT = NTRN*XNSTG RBC08600

$$NSHFT = NTRN*XNSTG \quad [no\ units]$$

AREA = XSHFT*100000. RBC08900

$$AREA = 100000XSHFT \quad [ft^2]$$

5. Cost functions.

Contactor

a. Capital cost

(1) NSHFT-20≤0 RBC09500

CCOST(N,1) = (28500.+45.*DMATX(9,N))*NSHFT*1.506/2.1215 RBC10100

$$CCOST = \frac{(28500+45CPDY)*NSHFT*1.506}{2.1215} \quad [dollars]$$

(2) NSHFT-20>0 RBC09500

CCOST(N,1) = (23000.+45.*DMATX(9,N))*NSHFT*1.506/2.1215 RBC10800

$$CCOST = \frac{(23000+45CPDY)*NSHFT*1.506}{2.1215} \quad [dollars]$$

b. Operating manhours, maintenance manhours and materials/supplies costs

Function of AREA/ECF

X = ALOG(AREA/1000./DMATX(16,N)) RBC11400

$$X = \ln \frac{AREA}{1000ECF}$$

(1) Operating manhours

OHRS = EXP(1.323670+.524215*X+.023076*X**2.) RBC12000

$$OHRS = e^{1.323670+0.524215X+0.023076X^2} \quad [hrs/yr]$$

(2) Maintenance manhours

XMHRS EXP(-.124185+.840104*X+.007757*X**2.) RBC12100

$$XMHRS = e^{-0.124185+0.840104X+0.007757X^2} \quad [hrs/yr]$$

(3) Total materials and supplies

COSTL = (OHRS+XMHRS)*DHR*(1.+PCT) RBC12200

COSTL = (OHRS+XMHRS)*DHR*(1+PCT) [dollars/yr]

COSTM = (CCOST(N,1)-45.*DMATX(9,N)*NSHFT*1.506/2.1215)*.02 RBC12300

$$COSTM = [CCOST- \frac{45*CPDY*NSHFT*1.506}{2.1215}]*0.02 \qquad [dollars/yr]$$

COSTE = NSHFT*5.*.746*24.*365.*DMATX(10,20) RBC12400

COSTE = NSHFT*5*0.746*24*365*CKWH [dollars/yr]

TMSU = COSTM+COSTE RBC12500

TMSU = COSTM+COSTE [dollars/yr]

c. Total operating and maintenance costs

COSTO(N,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650. RBC13000

$$COSTO = \frac{(OHRS+XMHRS)*DHR*(1+PCT)+TMSU}{Q_{Plant\ Inf.}*3650} \qquad [cents/1000gal]$$

Final Settler

a. Capital cost

Function of AFS

X = ALOG(AFS/1000.) RBC13600

$$X = \ln \frac{AFS}{1000}$$

CCOST(N,2) = EXP(3.716354+.389861*X+.084560*X**2.-.004718*X**3.)*1000.

RBC13700

$$CCOST = 1000e^{3.716354+0.389861X+0.084560X^2-0.004718X^3} \qquad [dollars]$$

b. Operating manhours, maintenance manhours, and materials/supplies costs

Function of AFS/ECF

```
X = ALOG(AFS/1000./DMATX(15,N))                                     RBC14400
```

$$X = \ln \frac{AFS}{1000ECF}$$

(1) Operating manhours

```
OHRS = EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)          RBC15000
```

$$OHRS = e^{5.846565+0.254813X+0.113703X^2-0.010942X^3} \quad [\text{hrs/yr}]$$

(2) Maintenance manhours

```
XMHRS = EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)         RBC15100
```

$$XMHRS = e^{5.273419+0.228329X+0.122646X^2-0.011672X^3} \quad [\text{hrs/yr}]$$

(3) Total materials and supplies

```
TMSU = EXP(5.669881+.750799*X)                                      RBC15200
```

$$TMSU \quad e^{5.669881+0.750799X} \quad [\text{dollars/yr}]$$

c. Total operating and maintenance costs

```
COSTO(N,2) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.  RBC15700
```

$$COSTO \quad \frac{[(OHRS+XMHRS)*DHR*(1+PCT)]+(TMSU*WPI)}{Q_{\text{Plant Inf.}} *3650} \quad [\text{cents/1000gal}]$$

```
C
C         ROTATING BIOLOGICAL CONTACTOR - FINAL SETTLER
C         PROCESS IDENTIFICATION NUMBER  24
C
      SUBROUTINE RBC
C
C
C         COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C         ASSIGNMENT OF DESIGN VALUES TO PROCESS PARAMETERS
C
      BOD=DMATX(1,N)
      XNSTG=DMATX(2,N)
      DEGC=DMATX(3,N)
      QPABI=DMATX(4,N)
      QPANI=DMATX(5,N)
      GSS=DMATX(6,N)
      BODN=DMATX(7,N)
      TSS=DMATX(8,N)
      CPDY=DMATX(9,N)
C
C
C         PROCESS RELATIONSHIPS REQD. TO CALC. EFFLUENT STREAM
C         CHARACTERISTICS
C
      QPAB=DMATX(4,N)*1.04**(DMATX(3,N)-20.)
      QPAN=DMATX(5,N)*1.04**(DMATX(3,N)-20.)
      RATIO=DMATX(1,N)/(SMATX(17,IS1)+SMATX(8,IS1))
      TEMP1=ALOG(RATIO)/DMATX(2,N)
      TEMP2=1./EXP(TEMP1)-1.
      APSTG=SMATX(2,IS1)*1000000.*TEMP2/QPAB
      PDSD=.34*(SMATX(8,IS1)+SMATX(17,IS1)+SMATX(10,IS1))*SMATX(2,IS1)*8
     1.33-.3*AREA/1000.
      TEMP3=1./(1.+QPAB*APSTG/SMATX(2,IS1)/1000000.)
      RATIO=DMATX(7,N)/(SMATX(17,IS1)+SMATX(8,IS1))
      FNSTG=ALOG(RATIO)/ALOG(TEMP3)
      RNSTG=XNSTG-FNSTG
      RATIO=(1./(1.+QPAN*APSTG/SMATX(2,IS1)/1000000.))**RNSTG
C
C
C         EFFLUENT STREAM CALCULATIONS
C
      SMATX(18,OS1)=SMATX(18,IS1)*RATIO
      SMATX(2,OS2)=PDSD/DMATX(8,N)/10000./8.33
      SMATX(2,OS1)=SMATX(2,IS1)-SMATX(2,OS2)
      SMATX(10,OS1)=4.5+.51*DMATX(1,N)
      SMATX(10,OS2)=DMATX(8,N)*10000.
      SMATX(8,OS1)=(SMATX(10,OS1)-4.5)*.897
      SMATX(17,OS1)=DMATX(1,N)-SMATX(8,OS1)
      SMATX(19,OS1)=SMATX(18,IS1)-SMATX(18,OS1)
      URSS=SMATX(2,IS1)/(SMATX(2,OS1)+SMATX(2,OS2)*SMATX(10,OS2)/SMATX(1
     10,OS1))
```

```
      SMATX(4,OS1)=URSS*SMATX(4,IS1)
      SMATX(3,OS1)=DMATX(1,N)*1.6/2.7+SMATX(4,OS1)
      SMATX(5,OS1)=.1*SMATX(3,OS1)
      SMATX(6,OS1)=.01*SMATX(3,OS1)
      SMATX(7,OS1)=URSS*SMATX(7,IS1)
      SMATX(9,OS1)=SMATX(10,OS1)-SMATX(7,OS1)
      SMATX(11,OS1)=SMATX(12,IS1)+SMATX(17,OS1)*1.6/2.7
      SMATX(12,OS1)=SMATX(12,IS1)
      SMATX(13,OS1)=.1*SMATX(11,OS1)+SMATX(18,OS1)+SMATX(19,OS1)
      SMATX(14,OS1)=SMATX(14,IS1)
      SMATX(15,OS1)=SMATX(15,IS1)
      SMATX(16,OS1)=SMATX(16,IS1)-10.*(SMATX(18,IS1)-SMATX(18,OS1))
      SMATX(20,OS1)=SMATX(20,IS1)
      TEMP4=SMATX(10,OS2)/SMATX(10,OS1)
      DO 10 J=3,9
   10 SMATX(J,OS2)=TEMP4*SMATX(J,OS1)
      DO 20 J=11,20
   20 SMATX(J,OS2)=SMATX(J,OS1)
C
C
C             CALC. OF OUTPUT SIZES AND QUANTITIES
C
      AFS=SMATX(2,OS1)*1000000./DMATX(6,N)*DMATX(15,N)
      PREM=(SMATX(18,IS1)-SMATX(18,OS1))*100./SMATX(18,IS1)
      QPAT=SMATX(2,IS1)*1000000./APSTG/XNSTG
      NTRN=APSTG*DMATX(16,N)/100000.
      NTRN=NTRN+1
      NSHFT=NTRN*XNSTG
      XNTRN=NTRN
      XSHFT=NSHFT
      AREA=XSHFT*100000.
C
C
C             CALC. OF CAPITAL COSTS FOR ROTATING BIOLOGICAL CONTACTOR
C             BASED ON DESIGN PLUS EXCESS CAPACITY
C
      IF (NSHFT-20) 30,30,40
C
C
C                   CALC. OF CAPITAL COSTS FOR SMALL RBC FACILITY, EQUAL
C                   OR LESS THAN 20 SHAFTS
C
   30 CCOST(N,1)=(28500.+45.*DMATX(9,N))*NSHFT*1.506/2.1215
      GO TO 50
C
C
C                   CALC. OF CAPITAL COSTS FOR LARGE RBC FACILITY,
C                   GREATER THAN 20 SHAFTS
C
   40 CCOST(N,1)=(23000.+45.*DMATX(9,N))*NSHFT*1.506/2.1215
C
C
C             CALC. OF OPERATING COSTS FOR RBC FACILITY BASED ON
C             DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
   50 X=ALOG(AREA/1000./DMATX(16,N))
C
C
C                   CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C                   AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(1.323670+.524215*X+.023076*X**2.)
      XMHRS=EXP(-.124185+.840104*X+.007757*X**2.)
      COSTL=(OHRS+XMHRS)*DHR*(1.+PCT)
      COSTM=(CCOST(N,1)-45.*DMATX(9,N)*NSHFT*1.506/2.1215)*.02
      COSTE=NSHFT*5.*.746*24.*365.*DMATX(10,20)
```

```
      TMSU=COSTM+COSTE
C
C
C              OPERATING COST EQUATION
C
      COSTO(N,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU)/SMATX(2,1)/3650.
C
C
C          CALC. OF CAPITAL COSTS FOR FINAL SETTLER BASED ON DESIGN
C          PLUS EXCESS CAPACITY
C
      X=ALOG(AFS/1000.)
      CCOST(N,2)=EXP(3.716354+.389861*X+.084560*X**2.-.004718*X**3.)*100
     10.
C
C
C          CALC. OF OPERATING COSTS FOR FINAL SETTLER BASED ON
C          DESIGN CAPACITY ALONE, DOES NOT INCLUDE EXCESS CAPACITY
C
      X=ALOG(AFS/1000./DMATX(15,N))
C
C
C              CALC. OF OPERATING MANHOURS, MAINTENANCE MANHOURS
C              AND MATERIALS AND SUPPLIES
C
      OHRS=EXP(5.846565+.254813*X+.113703*X**2.-.010942*X**3.)
      XMHRS=EXP(5.273419+.228329*X+.122646*X**2.-.011672*X**3.)
      TMSU=EXP(5.669881+.750799*X)
C
C
C              OPERATING COST EQUATION
C
      COSTO(N,2)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C          ASSIGNMENT OF VALUES TO OMATX
C
      OMATX(1,N)=QPAB
      OMATX(2,N)=QPAN
      OMATX(3,N)=APSTG
      OMATX(4,N)=AREA
      OMATX(5,N)=FNSTG
      OMATX(6,N)=RNSTG
      OMATX(7,N)=RATIO
      OMATX(8,N)=PREM
      OMATX(9,N)=QPAT
      OMATX(10,N)=AFS
      OMATX(11,N)=PDSD
      OMATX(12,N)=URSS
      OMATX(13,N)=XNTRN
      OMATX(14,N)=XSHFT
      OMATX(15,N)=COSTM
      OMATX(16,N)=COSTE
      OMATX(17,N)=COSTL
C
C
C          PROCESS ENERGY INDICES
C
      FLOW(N)=SMATX(2,IS1)
      POW(N)=24.
      RETURN
      END
```

SECTION 26

ENERGY CONSUMPTION AND COST, ENGY

```
C                                                                       ENG00100
C            ENERGY CONSUMPTION AND COST                                ENG00200
C                                                                       ENG00300
      SUBROUTINE ENGY                                                   ENG00400
C                                                                       ENG00500
C                                                                       ENG00600
C            COMMON INITIAL STATEMENTS                                  ENG00700
C                                                                       ENG00800
      INTEGER OS1,OS2                                                   ENG00900
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),ENG01000
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)ENG01100
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)   ENG01200
C                                                                       ENG01300
C                                                                       ENG01400
C            ASSIGNMENT OF VALUES TO PROCESS PARAMETERS                 ENG01500
C                                                                       ENG01600
      PLANT=DMATX(11,20)                                                ENG01700
      TOTKW=0.                                                          ENG01800
      POW(25)=25.                                                       ENG01900
C                                                                       ENG02000
C                                                                       ENG02100
C            CALC. OF ENERGY COSTS FOR PROCESSES                        ENG02200
C                                                                       ENG02300
      DO 530 I=1,25                                                     ENG02400
      FLOW(I)=SMATX(2,1)                                                ENG02500
      IF (POW(I)) 530,530,10                                            ENG02600
   10 K=POW(I)                                                          ENG02700
      GO TO (20,30,40,50,60,70,110,140,170,180,190,220,270,280,310,370,3ENG02800
     180,410,420,430,440,480,490,500,510), K                            ENG02900
C                                                                       ENG03000
C                                                                       ENG03100
C                  PREL                                                 ENG03200
C                                                                       ENG03300
   20 Q=ALOG(FLOW(I))                                                   ENG03400
      MOT=EXP(Q)/15.001+1.                                              ENG03500
      HP=MOT*.75                                                        ENG03600
      W1=.85*HP*24*.1                                                   ENG03700
      W2=EXP(2.733863+.722304*Q-.070556*Q**2.+.007792*Q**3.)            ENG03800
      MOT=EXP(Q)/5.001+1.                                               ENG03900
      HP=MOT*.5                                                         ENG04000
      W3=.85*HP*24.*.1667                                               ENG04100
      TKWHD(I)=W1+W2+W3                                                 ENG04200
      GO TO 520                                                         ENG04300
C                                                                       ENG04400
C                                                                       ENG04500
C                  PRSET                                                ENG04600
C                                                                       ENG04700
   30 Q=ALOG(FLOW(I))                                                   ENG04800
      HP=EXP(.405835+.248262*Q+.138237*Q**2.-.009162*Q**3.)             ENG04900
      W1=.85*HP*24.                                                     ENG05000
      W2=.64*EXP(Q)                                                     ENG05100
      TKWHD(I)=W1+W2                                                    ENG05200
      GO TO 520                                                         ENG05300
C                                                                       ENG05400
C                                                                       ENG05500
C                  AERFS                                                ENG05600
C                                                                       ENG05700
   40 Q=ALOG(FLOW(I))                                                   ENG05800
```

```
      W1=532.*EXP(Q)
      W2=EXP(3.607707+.925147*Q+.046507*Q**2.-.010295*Q**3.)
      HP=EXP(.405835+.248262*Q+.138237*Q**2.-.009162*Q**3.)
      W3=.85*HP*24.
      W4=2.66*EXP(Q)
      TKWHD(I)=W1+W2+W3+W4
      GO TO 520
C
C
C                    MIX
C
   50 TKWHD(I)=0.
      GO TO 520
C
C
C                    SPLIT
C
   60 TKWHD(I)=0.
      GO TO 520
C
C
C                    DIG
C
   70 Q=ALOG(FLOW(I))
      IF (PLANT) 80,80,90
   80 W1=EXP(4.427327+.301912*Q+.056086*Q**2.-.005112*Q**3.)
      GO TO 100
   90 W1=EXP(4.665033+.392918*Q+.074689*Q**2.-.017843*Q**3.+.001578*Q**4
     1.)
  100 W2=EXP(2.875478+.807735*Q+.033342*Q**2.-.006513*Q**3.)
      TKWHD(I)=W1+W2
      GO TO 520
C
C
C                    VACF
C
  110 Q=ALOG(FLOW(I))
      IF (PLANT) 120,120,130
  120 TKWHD(I)=EXP(2.342858+1.001088*Q+.021774*Q**2.-.006817*Q**3.)
      GO TO 520
  130 TKWHD(I)=EXP(4.042635+.585417*Q+.114499*Q**2.-.010941*Q**3.)
      GO TO 520
C
C
C                    THICK
C
  140 Q=ALOG(FLOW(I))
      IF (PLANT) 150,150,160
  150 TKWHD(I)=EXP(2.321386+.286528*Q+.022247*Q**2.-.007060*Q**3.)
      GO TO 520
  160 TKWHD(I)=EXP(2.321272+.301985*Q)
      GO TO 520
C
C
C                    ELUT
C
  170 TKWHD(I)=0.
      GO TO 520
C
C
C                    SBEDS
C
  180 TKWHD(I)=0.
      GO TO 520
C
C
```

```
C                     TRFS
C
  190 Q=ALOG(FLOW(I))
      W1=EXP(4.110844+.972364*Q-.002399*Q**2.)
      IF (DMATX(7,I)) 210,210,200
  200 W1=(DMATX(7,I)+1.)*W1
  210 HP=EXP(.405835+.248262*Q+.138237*Q**2.-.009162*Q**3.)
      W2=.85*HP*24.
      W3=2.66*EXP(Q)
      TKWHD(I)=W1+W2+W3
      GO TO 520
C
C
C                     CHLOR
C
  220 Q=ALOG(FLOW(I))
      IF (PLANT) 230,230,240
  230 TKWHD(I)=EXP(-.359521+2.273753*Q-.032634*Q**2.-.028066*Q**3.)
      GO TO 520
  240 IF (EXP(Q)-10.) 250,250,260
  250 TKWHD(I)=.72
      GO TO 520
  260 TKWHD(I)=EXP(-6.228734+2.563225*Q)
      GO TO 520
C
C
C                     TFLOT
C
  270 Q=ALOG(FLOW(I))
      TKWHD(I)=EXP(4.255944+.894471*Q+.040044*Q**2.-.007796*Q**3.)
      GO TO 520
C
C
C                     MHINC
C
  280 Q=ALOG(FLOW(I))
      IF (PLANT) 290,290,300
  290 TKWHD(I)=EXP(3.348899+.461306*Q+.149136*Q**2.-.013815*Q**3.)
      GO TO 520
  300 TKWHD(I)=EXP(3.990529+.423371*Q+.126216*Q**2.-.010836*Q**3.)
      GO TO 520
C
C
C                     RWP
C
  310 Q=ALOG(FLOW(I))
      IF (EXP(Q)-1.5) 320,320,330
  320 HE=.70
      GO TO 360
  330 IF (EXP(Q)-10.1) 340,340,350
  340 HE=.74
      GO TO 360
  350 HE=.83
  360 HP=EXP(Q)*1000000.*DMATX(1,I)/1440./3960./HE
      TKWHD(I)=.85*HP*24.
      GO TO 520
C
C
C                     SHT
C
  370 TKWHD(K)=0.
      GO TO 520
C
C
C                     CENT
C
```

```
  380 Q=ALOG(FLOW(I))
      IF (PLANT) 390,390,400
  390 TKWHD(I)=EXP(3.332123+.919832*Q+.045490*Q**2.-.013202*Q**3.)
      GO TO 520
  400 TKWHD(I)=EXP(4.042985+.813216*Q+.006793*Q**2.-.000180*Q**3.)
      GO TO 520
C
C
C                    AEROB
C
  410 TKWHD(I)=0.
      GO TO 520
C
C
C                    POSTA
C
  420 TKWHD(I)=0.
      GO TO 520
C
C
C                    EQUAL
C
  430 TKWHD(I)=0.
      GO TO 520
C
C
C                    DIG2
C
  440 Q=ALOG(FLOW(I))
      IF (PLANT) 450,450,460
  450 W1=EXP(4.427327+.301912*Q+.056086*Q**2.-.005112*Q**3.)
      GO TO 470
  460 W1=EXP(4.665033+.392918*Q+.074689*Q**2.-.017843*Q**3.+.001578*Q**4
     1.)
  470 W2=EXP(2.875478+.807735*Q+.033342*Q**2.-.006513*Q**3.)
      TKWHD(I)=W1+W2
      GO TO 520
C
C
C                    LANDD
C
  480 TKWHD(I)=0.
      GO TO 520
C
C
C                    LIME
C
  490 TKWHD(I)=0.
      GO TO 520
C
C
C                    RBC
C
  500 TKWHD(I)=0.
      GO TO 520
  510 Q=ALOG(SMATX(2,1))
      TKWHD(I)=EXP(4.047318+.198436*Q+.184937*Q**2.-.011184*Q**3.)
C
C
C              SUM OF ENERGY COSTS FOR ENTIRE PLANT
C
  520 TOTKW=TOTKW+TKWHD(I)
  530 CONTINUE
C
C
C              OUTPUT FORMAT OF ENERGY INDICES AND COSTS FOR PROCESSES
```

```
C              AND OF TOTAL ENERGY COST FOR ENTIRE PLANT                 ENG25700
C                                                                        ENG25800
      WRITE (IO,540)                                                     ENG25900
  540 FORMAT (1H1,//,47X,'ENERGY CONSUMPTION AND COST')                  ENG26000
      WRITE (IO,550) (FLOW(I),I=1,25)                                    ENG26100
      WRITE (IO,550) (POW(I),I=1,25)                                     ENG26200
      WRITE (IO,550) (TKWHD(I),I=1,25)                                   ENG26300
  550 FORMAT (//,12F10.2,/,12F10.2,/,F10.2)                              ENG26400
      WRITE (IO,560) TOTKW                                               ENG26500
  560 FORMAT (//,F10.2)                                                  ENG26600
      RETURN                                                             ENG26700
      END                                                                ENG26800
```

SECTION 27

TOTAL PLANT COST CALCULATION, COST

Calculate Total Plant Cost, COST — Rev. Date 8/1/77

1. Input parameters and nominal values.

DMATX(1,20) = CCI	Sewage treatment plant construction cost index to account for the variation of construction cost with time, 1957-59 = 1. [2.257]
DMATX(2,20) = WPI	Wholesale price index for industrial commodities to account for the variation of materials and supplies cost with time, 1957-59 = 1. [1.675]
DMATX(3,20) = RI	Amortization interest rate, fraction. [.06]
DMATX(4,20) = YRS	Amortization period, yr. [25.]
DMATX(5,20) = DHR	Wastewater treatment plant hourly labor rate, $/hr. [4.73]
DMATX(6,20) = PCT	Fraction of direct labor cost that is charged as indirect labor cost, fraction. [.15]
DMATX(7,20) = DA	Cost of land, $/acre. [1000.]
DMATX(8,20) = CCINT	Interest rate for the cost of interest during plant construction, fraction. [.06]
DMATX(9,20) = XLAB	Program control: type of plant laboratory used, 1 = activated sludge, 0 = primary or trickling filter. [1.]
DMATX(10,20) = CKWH	Cost of electrical power, $/kilowatt-hr.[.02]

2. Output parameters which are printed on computer output sheets.

CCI = DMATX(1,20)	
RI = DMATX(3,20)	
YRS = DMATX(4,20)	
DA = DMATX(7,20)	
CCINT = DMATX(8,20)	
XLAB = DMATX(9,20)	
RATIO = OMATX(1,20)	Multiplier used to factor into individual unit process construction costs the cost of yardwork, land, engineering, legal & fiscal, and interest during construction, TOT/TCAP.

TCAP = OMATX(2,20)	Total capital cost of the entire treatment system without yardwork, land, engineering, legal & fiscal, and interest during construction costs factored in, $.
YARD = OMATX(3,20)	Capital cost of yardwork, $.
TCC = OMATX(4,20)	Subtotal of TCAP + YARD, $.
XLAND = OMATX(5,20)	Cost of the required land for plant construction, $.
ENG = OMATX(6,20)	Cost of the engineering services for plant construction, $.
SUBT1 = OMATX(7,20)	Subtotal of TCAP+ YARD + XLAND & ENG, $.
FISC = OMATX(8,20)	Cost of legal, fiscal and administrative services during plant construction, $.
SUBT2 = OMATX(9,20)	Subtotal of TCAP + YARD + XLAND + ENG + FISC, $.
XINT = OMATX(10,20)	Cost of interest during construction, $.
ACRE = OMATX(11,20)	Total land requirement for the entire plant, acres.
AF = OMATX(12,20)	Amortization factor.
TOT = OMATX(17,20)	Total capital cost of the entire plant (SUBT2 + XINT), $.
TAMM = OMATX(18,20)	Total amortization cost of the entire plant, ¢/1000 gallons.
TOPER = OMATX(19,20)	Total operation and maintenance cost of the entire plant, ¢/1000 gallons.
TOTAL = OMATX(20,20)	Total treatment cost of the entire plant (TAMM + TOPER), ¢/1000 gallons.

3. Theory and functions - FORTRAN statement followed by equivalent algebraic equation.

```
CCI = CCI/1.506                                          COS02700
```

$$CCI = \frac{CCI}{1.506} \qquad \text{[no units]}$$

```
AF = RI*(1.+RI)**YRS/((1.+RI)**YRS-1.)                   COS02800
```

$$AF = \frac{RI(1+RI)^{YRS}}{(1+RI)^{YRS}-1} \qquad \text{[no units]}$$

References:

Patterson and Banker, 1971

4. Cost functions.

Administrative and laboratory

a. Capital cost

Function of $Q_{Plant\ Inf.}$

X = ALOG(SMATX(2,1)) COS03400

$X = \ln Q_{Plant\ Inf.}$

CCOST(20,1) = EXP(3.524005+.383129 *X+ .077688*X**2.-.009021*X**3.)*1000. COS03500

$CCOST = 1000e^{3.524005+.383129X+0.077688X^2-0.009021X^3}$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

(1) Operating manhours

OHRS = EXP(5.886104+.778820*X) COS03700

$OHRS = e^{5.886104+0.778820X}$ [hrs/yr]

(2) Maintenance manhours

XMHRS = EXP(4.605170+.661110*X) COS03800

$XMHRS = e^{4.605170+0.661110X}$ [hrs/yr]

(3) Total materials and supplies

TMSU = EXP(7.244226+.500000*X) COS03900

$TMSU = e^{7.244226+0.500000X}$ [dollars/yr]

c. Total operating and maintenance costs

COSTO(20,1) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650. COS04000

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650}$$ [cents/1000 gal]

Garage and shop

a. Capital cost

```
CCOST(20,2) = EXP(2.288450+.446606*X+.032729*X**2.)*1000.        COS04500
```

$$CCOST = 1000e^{2.288450+0.446606X+0.032729X^2}$$ [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

(1) Operating manhours COS04600

OHRS = 0 [hrs/yr]

(2) Maintenance manhours COS04700

XMHRS = 0 [hrs/yr]

(3) Total materials and supplies COS04800

TMSU = 0 [dollars/yr]

c. Total operating and maintenance costs COS04900

COSTO(20,2) = 0 [cents/1000 gal]

Laboratory operations

a. Capital cost COS05500

CCOST(20,3) = 0 [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

(1) Operating manhours

(a) For XLAB = 0 Primary or trickling filter plant COS05600

```
OHRS = EXP(6.551080+.447632*X)        COS05700
```

$$OHRS = e^{6.551080+0.447632X}$$ [hrs/yr]

(b) For XLAB=1 Activated sludge plant COS05600

OHRS = EXP(7.892489+.087261*X+.004753*X**2.+.006532*X**3.) COS05900

$$OHRS = e^{7.892489+0.087261X+0.004753X^2+0.006532X^3}$$ [hrs/yr]

(2) Maintenance manhours

XMHRS = EXP(4.700480+.368379*X) COS06000

$$XMHRS = e^{4.700480+0.368379X}$$ [hrs/yr]

(3) Total materials and supplies

TMSU = EXP(5.972471+.534838*X+.010941*X**2.+.010320*X**3.) COS06100

$$TMSU = e^{5.972471+0.534838X+0.010941X^2+0.010320X^3}$$ [dollars/yr]

c. Total operating and maintenance costs

COSTO(20,3) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650. COS06200

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650}$$ [cents/1000 gal]

Yardwork operations

a. Capital cost COS06800

CCOST(20,4) = 0 [dollars]

b. Operating manhours, maintenance manhours and materials/supplies costs

(1) Operating manhours COS06900

OHRS = 0 [hrs/yr]

(2) Maintenance manhours

XMHRS = EXP(6.542359+.082452*X+.184209*X**2.-.013606*X**3.) COS07000

$$XMHRS = e^{6.542359+0.082452X+0.184209X^2-0.013606X^3}$$ [hrs/yr]

(3) Total materials and supplies

TMSU = EXP(5.991464+.650515*X) COS07100

$$TMSU = e^{5.991464+0.650515X}$$ [dollars/yr]

c. Total operating and maintenance costs

COSTO(20,4) = ((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650. COS07200

$$COSTO = \frac{(OHRS+XMHRS)DHR(1+PCT)+(TMSU*WPI)}{Q_{Plant\ Inf.}*3650}$$ [cents/1000 gal]

Intermediate plant costs

(1) CCOST(J,I) = CCOST(J,I)*CCI/1000. COS08000

$$CCOST = \frac{CCOST*CCI}{1000}$$ $[\frac{dollars}{1000}]$

where J = 1,20 and I = 1,5

(2) TCAP = TCAP+CCOST(J,I) COS08100

TCAP = TCAP+CCOST(J,I) $[\frac{dollars}{1000}]$

where J = 1,20 and I = 1,5

(3) YARD = .14*TCAP COS08200

YARD = 0.14TCAP $[\frac{dollars}{1000}]$

(4) TCC = ALOG(TCAP+YARD) COS08300

TCC = ln (TCAP+YARD) $[\ln(\frac{dollars}{1000})]$

Q = ALOG(SMATX(2,1)) COS08400

$$Q = \ln Q_{Plant\ Inf.}$$

(5) XLAND = EXP(2.405815+.010392*Q+.127563*Q**2.-.009133*Q**3.)*DA/1000.+CLAND/1000.
+DLAND/1000. COS08500

$$XLAND = \frac{DA*e^{2.405815+0.010392Q+0.127563Q^2-0.009133Q^3}+CLAND+DLAND}{1000}$$ $[\frac{dollars}{1000}]$

(6) ENG = EXP(.557449+.462790*TCC+.021284*TCC**2.) COS08700

$$ENG = e^{0.557449+0.462790TCC+0.021284TCC^2}$$ $[\frac{dollars}{1000}]$

(7) SUBT1 = ALOG(TCAP+YARD+XLAND+ENG) COS08800

$$SUBT1 = \ln (TCAP+YARD+XLAND+ENG)$$ $[\ln (\frac{dollars}{1000})]$

(8) FISC = EXP(-2.497954+.916338*SUBT1-.023887*SUBT1**2.) COS08900

$$FISC = e^{-2.497954+0.916338SUBT1-0.023887SUBT1^2}$$ $[\frac{dollars}{1000}]$

(9) SUBT2 = ALOG(TCAP+YARD+XLAND+ENG+FISC) COS09000

$$SUBT2 = \ln (TCAP+YARD+XLAND+ENG+FISC)$$ $[\ln (\frac{dollars}{1000})]$

(10) P =-1.475131+.428894*SUBT2) COS09100

$$P = -1.475131+0.428894SUBT2$$ [no units]

(11) XINT = CCINT*P/2.*EXP(SUBT2) COS09200

$$XINT = \frac{CCINT*P*e^{SUBT2}}{2}$$ $[\frac{dollars}{1000}]$

(12) TOT = TCAP+YARD+XLAND+ENG+FISC+XINT COS09300

$$TOT = TCAP+YARD+XLAND+ENG+FISC+XINT$$ $[\frac{dollars}{1000}]$

(13) TCC = EXP(TCC) COS09400

$$TCC = e^{TCC}$$ $[\frac{dollars}{1000}]$

(14) SUBT1 = EXP(SUBT1) COS09500

$$SUBT1 = e^{SUBT1}$$ $[\frac{dollars}{1000}]$

(15) SUBT2 = EXP(SUBT2) COS09600

$$SUBT2 = e^{SUBT2}$$ $[\frac{dollars}{1000}]$

(16) TCAP = TCAP*1000. COS09700

$$TCAP = 1000TCAP$$ [dollars]

(17) TOT = TOT*1000. COS09800

TOT = 1000TOT [dollars]

(18) YARD = YARD*1000. COS09900

YARD = 1000YARD [dollars]

(19) TCC = TCC*1000. COS10000

TCC = 1000TCC [dollars]

(20) XLAND = XLAND*1000. COS10100

XLAND = 1000XLAND [dollars]

(21) ENG = ENG*1000. COS10200

ENG = 1000ENG [dollars]

(22) SUBT1 = SUBT1*1000. COS10300

SUBT1 = 1000SUBT1 [dollars]

(23) FISC = FISC*1000. COS10400

FISC = 1000FISC [dollars]

(24) SUBT2 = SUBT2*1000. COS10500

SUBT2 = 1000SUBT2 [dollars]

(25) XINT = XINT*1000. COS10600

XINT = 1000XINT [dollars]

(26) RATIO = TOT/TCAP COS10700

$$RATIO = \frac{TOT}{TCAP}$$ [no units]

(27) ACRE = (XLAND-DLAND)/DA COS10800

$$ACRE = \frac{XLAND-DLAND}{DA}$$ [acres]

Total plant cost

a. Capital cost

CCOST(J,I) = CCOST(J,I)*1000.*RATIO COS11900

CCOST = 1000CCOST*RATIO [dollars]

where J = 1,20 and I = 1,5

b. Amortized cost

(1) For ACOST(J,I) = 0 COS12000

ACOST(J,I) = CCOST(J,I)*AF/SMATX(2,1)/3650. COS12300

$$ACOST = \frac{CCOST*AF}{Q_{Plant\ Inf.}*3650}$$ [cents/1000 gal]

where J = 1,20 and I = 1,5

(2) For ACOST(J,I) > 0 Where ACOST calculated in subroutine e.g., LANDD,CENT

ACOST(J,I) = ACOST(J,I)*RATIO*CCI COS12100

ACOST = ACOST*RATIO*CCI [cents/1000 gal]

where J = 1,20 and I = 1,5

c. Treatment cost

TCOST(J,I) = COSTO(J,I)+ACOST(J,I) COS12400

TCOST = COSTO+ACOST [cents/1000 gal]

where J = 1,20 and I = 1,5

d. Total capital cost

TOT = TOT+CCOST(J,I) COS12500

TOT = TOT+CCOST $[\frac{dollars}{1000}]$

where J = 1,20 and I = 1,5

e. Total amortized cost

TAMM = TAMM+ACOST(J,I) COS12600

TAMM = TAMM+ACOST [cents/1000 gal]

where J = 1,20 and I = 1,5

f. Total operating cost

TOPER = TOPER+COSTO(J,I) COS12700

TOPER = TOPER+COSTO [cents/1000 gal]

where J = 1,20 and I = 1,5

g. Total treatment cost

TOTAL = TOTAL+TCOST(J,I) COS12800

TOTAL = TOTAL+TCOST [cents/1000 gal]

where J = 1,20 and I = 1,5

```
C
C           CALCULATE TOTAL PLANT COST
C
      SUBROUTINE COST
C
C
C           COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TRWHD(25)
C
C
C           ASSIGNMENT OF DESIGN VALUES TO ECONOMIC PARAMETERS
C
      CCI=DMATX(1,20)
      RI=DMATX(3,20)
      YRS=DMATX(4,20)
      DA=DMATX(7,20)
      CCINT=DMATX(8,20)
      XLAB=DMATX(9,20)
C
C
C           CALC. OF OUTPUT QUANTITIES
C
      CCI=CCI/1.506
      AF=RI*(1.+RI)**YRS/((1.+RI)**YRS-1.)
C
C
C           CALC. OF CAPITAL AND OPERATING COSTS FOR ADMINISTRATIVE
C           AND LABORATORY
C
      X=ALOG(SMATX(2,1))
      CCOST(20,1)=EXP(3.524005+.383129*X+.077688*X**2.-.009021*X**3.)*10
     100.
      OHRS=EXP(5.886104+.778820*X)
      XMHRS=EXP(4.605170+.661110*X)
      TMSU=EXP(7.244226+.500000*X)
      COSTO(20,1)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.
C
C
C           CALC. OF CAPITAL AND OPERATING COSTS FOR GARAGE AND SHOP
C
      CCOST(20,2)=EXP(2.288450+.446606*X+.032729*X**2.)*1000.
      OHRS=0.
      XMHRS=0.
      TMSU=0.
      COSTO(20,2)=0.
C
C
C           CALC. OF CAPITAL AND OPERATING COSTS FOR LABORATORY
C           OPERATION
C
      CCOST(20,3)=0.
      IF (XLAB) 20,10,20
   10 OHRS=EXP(6.551080+.447632*X)
      GO TO 30
```

```
   20 OHRS=EXP(7.892489+.087261*X+.004753*X**2.+.006532*X**3.)            COS05900
   30 XMHRS=EXP(4.700480+.368379*X)                                       COS06000
      TMSU=EXP(5.972471+.534838*X+.010941*X**2.+.010320*X**3.)            COS06100
      COSTO(20,3)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.  COS06200
C                                                                         COS06300
C                                                                         COS06400
C              CALC. OF CAPITAL AND OPERATING COSTS FOR YARDWORK          COS06500
C              OPERATION                                                  COS06600
C                                                                         COS06700
      CCOST(20,4)=0.                                                      COS06800
      OHRS=0.                                                             COS06900
      XMHRS=EXP(6.542359+.082452*X+.184209*X**2.-.013606*X**3.)           COS07000
      TMSU=EXP(5.991464+.650515*X)                                        COS07100
      COSTO(20,4)=((OHRS+XMHRS)*DHR*(1.+PCT)+TMSU*WPI)/SMATX(2,1)/3650.  COS07200
C                                                                         COS07300
C                                                                         COS07400
C              CALC. OF OUTPUT COSTS AND QUANTITIES                       COS07500
C                                                                         COS07600
      TCAP=0.                                                             COS07700
      DO 40 J=1,20                                                        COS07800
      DO 40 I=1,5                                                         COS07900
      CCOST(J,I)=CCOST(J,I)*CCI/1000.                                     COS08000
   40 TCAP=TCAP+CCOST(J,I)                                                COS08100
      YARD=.14*TCAP                                                       COS08200
      TCC=ALOG(TCAP+YARD)                                                 COS08300
      Q=ALOG(SMATX(2,1))                                                  COS08400
      XLAND=EXP(2.405815+.010392*Q+.127563*Q**2.-.009133*Q**3.)*DA/1000.COS08500
     1+CLAND/1000.+DLAND/1000.                                            COS08600
      ENG=EXP(.557449+.462790*TCC+.021284*TCC**2.)                        COS08700
      SUBT1=ALOG(TCAP+YARD+XLAND+ENG)                                     COS08800
      FISC=EXP(-2.497954+.916338*SUBT1-.023887*SUBT1**2.)                 COS08900
      SUBT2=ALOG(TCAP+YARD+XLAND+ENG+FISC)                                COS09000
      P=-1.475131+.428894*SUBT2                                           COS09100
      XINT=CCINT*P/2.*EXP(SUBT2)                                          COS09200
      TOT=TCAP+YARD+XLAND+ENG+FISC+XINT                                   COS09300
      TCC=EXP(TCC)                                                        COS09400
      SUBT1=EXP(SUBT1)                                                    COS09500
      SUBT2=EXP(SUBT2)                                                    COS09600
      TCAP=TCAP*1000.                                                     COS09700
      TOT=TOT*1000.                                                       COS09800
      YARD=YARD*1000.                                                     COS09900
      TCC=TCC*1000.                                                       COS10000
      XLAND=XLAND*1000.                                                   COS10100
      ENG=ENG*1000.                                                       COS10200
      SUBT1=SUBT1*1000.                                                   COS10300
      FISC=FISC*1000.                                                     COS10400
      SUBT2=SUBT2*1000.                                                   COS10500
      XINT=XINT*1000.                                                     COS10600
      RATIO=TOT/TCAP                                                      COS10700
      ACRE=(XLAND-DLAND)/DA                                               COS10800
C                                                                         COS10900
C                                                                         COS11000
C              CALC. OF TOTAL COSTS OF ENTIRE PLANT                       COS11100
C                                                                         COS11200
      TOT=0.                                                              COS11300
      TAMM=0.                                                             COS11400
      TOPER=0.                                                            COS11500
      TOTAL=0.                                                            COS11600
      DO 80 J=1,20                                                        COS11700
      DO 80 I=1,5                                                         COS11800
      CCOST(J,I)=CCOST(J,I)*1000.*RATIO                                   COS11900
      IF (ACOST(J,I)) 50,60,50                                            COS12000
   50 ACOST(J,I)=ACOST(J,I)*RATIO*CCI                                     COS12100
      GO TO 70                                                            COS12200
   60 ACOST(J,I)=CCOST(J,I)*AF/SMATX(2,1)/3650.                           COS12300
   70 TCOST(J,I)=COSTO(J,I)+ACOST(J,I)                                    COS12400
```

```
      TOT=TOT+CCOST(J,I)                                                COS12500
      TAMM=TAMM+ACOST(J,I)                                              COS12600
      TOPER=TOPER+COSTO(J,I)                                            COS12700
   60 TOTAL=TOTAL+TCOST(J,I)                                            COS12800
C                                                                       COS12900
C                                                                       COS13000
C              ASSIGNMENT OF VALUES TO OUTPUT DMATX                     COS13100
C                                                                       COS13200
      DMATX(1,20)=CCI*1.506                                             COS13300
      DMATX(2,20)=WPI*1.122                                             COS13400
C                                                                       COS13500
C                                                                       COS13600
C              ASSIGNMENT OF VALUES TO OMATX                            COS13700
C                                                                       COS13800
      OMATX(1,20)=RATIO                                                 COS13900
      OMATX(2,20)=TCAP                                                  COS14000
      OMATX(3,20)=YARD                                                  COS14100
      OMATX(4,20)=TCC                                                   COS14200
      OMATX(5,20)=XLAND                                                 COS14300
      OMATX(6,20)=ENG                                                   COS14400
      OMATX(7,20)=SUBT1                                                 COS14500
      OMATX(8,20)=FISC                                                  COS14600
      OMATX(9,20)=SUBT2                                                 COS14700
      OMATX(10,20)=XINT                                                 COS14800
      OMATX(11,20)=ACRE                                                 COS14900
      OMATX(12,20)=AF                                                   COS15000
      OMATX(17,20)=TOT                                                  COS15100
      OMATX(18,20)=TAMM                                                 COS15200
      OMATX(19,20)=TOPER                                                COS15300
      OMATX(20,20)=TOTAL                                                COS15400
      RETURN                                                            COS15500
      END                                                               COS15600
```

SECTION 28

OUTPUT SUBROUTINE, PRINT

```
C
C           PRINT OUTPUT
C
      SUBROUTINE PRINT
C
C
C           COMMON INITIAL STATEMENTS
C
      INTEGER OS1,OS2
      COMMON SMATX(20,30),TMATX(20,30),DMATX(20,20),OMATX(20,20),IP(20),
     1INP,IO,IS1,IS2,OS1,OS2,N,IAERF,CCOST(20,5),COSTO(20,5),ACOST(20,5)
     2,TCOST(20,5),DHR,PCT,WPI,CLAND,DLAND,FLOW(25),POW(25),TKWHD(25)
C
C
C           OUTPUT FORMAT FOR STREAM CHARACTERISTICS
C
      WRITE (IO,10)
   10 FORMAT (1H1,////,44X,'STREAM CHARACTERISTICS',//,66X,'VOLUME FLOW,
     1 MILLIONS OF GALLONS PER DAY',/,66X,'CONCENTRATIONS, MILLIGRAMS PE
     2R LITER',/)
      DO 40 I=1,30
      IF (SMATX(1,I)) 20,40,20
   20 WRITE (IO,30) (SMATX(J,I),J=1,9),SMATX(18,I),SMATX(16,I),(SMATX(J,
     1I),J=11,15),SMATX(17,I),SMATX(10,I),SMATX(19,I)
   30 FORMAT (2X,'S',F3.0,9X,'Q',8X,'SOC',7X,'SNBC',8X,'SON',8X,'SOP',8X
     1,'SFM',7X,'SBOD',8X,'VSS',8X,'NH3',/,7X,9F11.3,/,13X,'ALK',8X,'DOC
     2',7X,'DNBC',9X,'DN',9X,'DP',8X,'DFM',7X,'DBOD',8X,'TSS',8X,'NO3',/
     3,7X,9F11.3,//)
   40 CONTINUE
C
C
C           OUTPUT FORMAT FOR PROCESS CHARACTERISTICS AND PARAMETERS
C
      WRITE (IO,50)
   50 FORMAT (1H1,////,44X,'PROCESS CHARACTERISTICS',//,58X,'CCOST = CAP
     1ITAL COST, DOLLARS',/,58X,'COSTO = OPERATING + MAINTENANCE COST, C
     2ENTS/1000 GAL.',/,58X,'ACOST = AMORTIZATION COST, CENTS/1000 GAL.'
     3,/,58X,'TCOST = TOTAL TREATMENT COST, CENTS/1000 GAL.',//)
      DO 610 I=1,20
      IF (IP(I)) 60,610,60
   60 KK=IP(I)
      GO TO (70,90,110,610,610,140,160,180,200,220,240,270,300,320,350,3
     170,390,410,440,480,510,530,560,580), KK
C
C
C                PREL
C
   70 WRITE (IO,80) I,DMATX(1,I),CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(
     1I,1),DMATX(16,I)
   80 FORMAT (1X,1HP,I2,2X,'PRELIMINARY',6X,'IPREL',40X,'CCOST',4X,'COST
     1O',4X,'ACOST',4X,'TCOST',6X,'ECF',/,6X,'TREATMENT',6X,F9.1,36X,F9.
     20,3F9.3,F9.2,//)
      GO TO 610
C
C
C                PRSET
C
   90 WRITE (IO,100) I,(DMATX(J,I),J=1,3),(OMATX(J,I),J=1,3),CCOST(I,1),
```

```
     1COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(16,I),CCOST(I,2),COSTO(I,2)
     2,ACOST(I,2),TCOST(I,2),DMATX(15,I)
  100 FORMAT (1X,1HP,I2,2X,'PRIMARY',11X,'FRPS',5X,'URPS',5X,'HPWK',6X,'
     1GPS',6X,'APS',5X,'PGPM',/,6X,'SEDIMENTATION',2X,F9.2,3F9.1,F9.3,F9
     2.0,//,68X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,57X,
     3'SETTLER',2X,F9.0,3F9.3,F9.2,//,57X,'SLUDGE',3X,F9.0,3F9.3,F9.2,/,
     457X,'PUMPS',//)
      GO TO 610
C
C
C                   AERFS
C
  110 WRITE (IO,120) I,(DMATX(J,I),J=1,10),(OMATX(J,I),J=1,10)
  120 FORMAT (1X,1HP,I2,2X,'ACTIVATED SLUDGE-',2X,'BOD',5X,'MLSS',5X,'DE
     1GC',3X,'CAER20',7X,'DO',3X,'AEFF20',5X,'URSS',6X,'GSS',5X,'HEAD',5
     2X,'ALMD',/,6X,'FINAL SETTLER',2X,F9.1,F9.0,8F9.2,//,24X,'BOD2',4X,
     3'DOSAT',5X,'XRSS',6X,'AFS',5X,'CAER',5X,'CEDR',5X,'VAER',5X,'VNIT'
     4,4X,'MLASS',4X,'MLBSS',/,21X,2F9.1,F9.4,2F9.2,3F9.3,2F9.0/)
      WRITE (IO,130) (OMATX(J,I),J=11,20),CCOST(I,1),COSTO(I,1),ACOST(I,
     11),TCOST(1,1),DMATX(16,I),CCOST(I,2),COSTO(1,2),ACOST(I,2),TCOST(I
     2,2),DMATX(15,I),CCOST(I,3),COSTO(I,3),ACOST(I,3),TCOST(I,3),DMATX(
     314,I),CCOST(I,4),COSTO(I,4),ACOST(I,4),TCOST(I,4),DMATX(13,I)
  130 FORMAT (22X,'MLNBSS',4X,'MLDSS',4X,'MLISS',5X,'FOOD',4X,'RTURN',5X
     1,'CNIT',4X,'ARCFD',4X,'BSIZE',4X,'CFPGL',7X,'QR',/,21X,3F9.0,F9.1,
     22F9.3,2F9.0,F9.2,F9.3,//,68X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCO
     3ST',6X,'ECF',/,57X,'AERATOR',2X,F9.0,3F9.3,F9.2,//,57X,'BLOWER',3X
     4,F9.0,3F9.3,F9.2,//,57X,'SLUDGE',3X,F9.0,3F9.3,F9.2,/,57X,'PUMPS',
     5//,57X,'FINAL',4X,F9.0,3F9.3,F9.2,/,57X,'SETTLER',//)
      GO TO 610
C
C
C                   DIG
C
  140 WRITE (IO,150) I,(DMATX(J,I),J=1,2),(OMATX(J,I),J=1,5),CCOST(I,1),
     1COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(16,I)
  150 FORMAT (1X,1HP,I2,2X,'SINGLE STAGE',8X,'TD',5X,'TDIG',4X,'C1DIG',4
     1X,'C2DIG',5X,'VDIG',6X,'CH4',6X,'CO2',/,6X,'ANAEROBIC',6X,2F9.1,F9
     2.3,F9.0,F9.3,2F9.0,/,6X,'DIGESTION',/,68X,'CCOST',4X,'COSTO',4X,'A
     3COST',4X,'TCOST',6X,'ECF',/,66X,F9.0,3F9.3,F9.2,//)
      GO TO 610
C
C
C                   VACF
C
  160 WRITE (IO,170) I,(DMATX(J,I),J=1,10),(OMATX(J,I),J=1,3),CCOST(I,1)
     1,COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(16,I)
  170 FORMAT (1X,1HP,I2,2X,'VACUUM',13X,'VFL',5X,'HPWK',6X,'TSS',4X,'IVA
     1CF',4X,'FECL3',6X,'CAO',4X,'CFECL',5X,'CCAO',4X,'DPOLY',4X,'CPOLY'
     2,/,6X,'FILTRATION',5X,F9.2,2F9.0,F9.1,2F9.2,2F9.4,F9.2,F9.4,//,26X
     3,'WP',6X,'AVF',5X,'PSDD',22X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCO
     4ST',6X,'ECF',/,21X,2F9.1,F9.0,18X,F9.0,3F9.3,F9.2,//)
      GO TO 610
C
C
C                   THICK
C
  180 WRITE (IO,190) I,(DMATX(J,I),J=1,4),(OMATX(J,I),J=1,2),CCOST(I,1),
     1COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(16,I)
  190 FORMAT (1X,1HP,I2,2X,'GRAVITY',12X,'TRR',6X,'TSS',6X,'GTH',5X,'GST
     1H',5X,'ATHM',6X,'WRT',/,6X,'THICKENING',5X,F9.2,F9.0,3F9.1,F9.2,//
     2,68X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,66X,F9.0,
     33F9.3,F9.2,//)
      GO TO 610
C
C
C                   ELUT
```

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C                                                                       PRT12500
  200 WRITE (IO,210) I,(DMATX(J,I),J=1,5),OMATX(1,I),CCOST(I,1),COSTO(I,PRT12600
     11),ACOST(I,1),TCOST(I,1),DMATX(16,I)                              PRT12700
  210 FORMAT (1X,1HP,I2,2X,'ELUTRIATION',8X,'ERR',6X,'TSS',6X,'WRE',7X,'PRT12800
     1GE',6X,'GES',7X,'AE',/,21X,F9.2,F9.0,3F9.1,F9.0,//,68X,'CCOST',4X,PRT12900
     2'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,66X,F9.0,3F9.3,F9.2,//)  PRT13000
      GO TO 610                                                         PRT13100
C                                                                       PRT13200
C                                                                       PRT13300
C                     SBEDS                                             PRT13400
C                                                                       PRT13500
  220 WRITE (IO,230) I,(DMATX(J,I),J=1,2),OMATX(1,I),CCOST(I,1),COSTO(I,PRT13600
     11),ACOST(1,1),TCOST(I,1),DMATX(16,I)                              PRT13700
  230 FORMAT (1X,1HP,I2,2X,'SAND DRYING',7X,'SOUT',6X,'TSS',6X,'ASB',22XPRT13800
     1,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,6X,'BEDS',11XPRT13900
     2,F9.2,2F9.0,18X,F9.0,3F9.3,F9.2,//)                               PRT14000
      GO TO 610                                                         PRT14100
C                                                                       PRT14200
C                                                                       PRT14300
C                     TRFS                                              PRT14400
C                                                                       PRT14500
  240 WRITE (IO,250) I,(DMATX(J,I),J=1,9),(OMATX(J,I),J=1,4)            PRT14600
  250 FORMAT (1X,1HP,I2,2X,'TRICKLING',10X,'BOD',5X,'DEGC',7X,'HQ',4X,'SPRT14700
     1AREA',5X,'URSS',5X,'XRSS',3X,'RECYCL',6X,'GSS',5X,'HEAD',/,6X,'FILPRT14800
     2TER-',8X,F9.1,4F9.2,F9.4,3F9.1,/,6X,'FINAL SETTLER',/,25X,'AFS',6XPRT14900
     3,'VOL',4X,'FAREA',4X,'DEPTH',/,21X,F9.2,2F9.0,F9.2,/)             PRT15000
      WRITE (IO,260) CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(1PRT15100
     16,I),CCOST(I,2),COSTO(I,2),ACOST(I,2),TCOST(I,2),DMATX(15,I),CCOSTPRT15200
     2(I,3),COSTO(I,3),ACOST(I,3),TCOST(I,3),DMATX(14,I)                PRT15300
  260 FORMAT (68X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,57PRT15400
     1X,'FILTER',3X,F9.0,3F9.3,F9.2,//,57X,'FINAL',4X,F9.0,3F9.3,F9.2,/,PRT15500
     257X,'SETTLER',//,57X,'SLUDGE',3X,F9.0,3F9.3,F9.2,/,57X,'PUMPS',//)PRT15600
      GO TO 610                                                         PRT15700
C                                                                       PRT15800
C                                                                       PRT15900
C                     CHLOR                                             PRT16000
C                                                                       PRT16100
  270 WRITE (IO,280) I,(DMATX(J,I),J=1,5),(OMATX(J,I),J=1,3)            PRT16200
  280 FORMAT (1X,1HP,I2,2X,'CHLORINATION-',5X,'DCL2',5X,'TCL2',5X,'CCL2'PRT16300
     1,5X,'DSO2',5X,'CSO2',5X,'BVOL',5X,'CUSE',5X,'SUSE',/,6X,'DECHLORINPRT16400
     2ATION',1X,F9.2,F9.1,3F9.2,F9.0,2F9.2,/)                           PRT16500
      WRITE (IO,290) CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(1PRT16600
     16,I),CCOST(I,2),COSTO(I,2),ACOST(I,2),TCOST(I,2),DMATX(15,I),CCOSTPRT16700
     2(I,3),COSTO(I,3),ACOST(I,3),TCOST(I,3),DMATX(14,I)                PRT16800
  290 FORMAT (68X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,57PRT16900
     1X,'CONTACT',2X,F9.0,3F9.3,F9.2,/,57X,'BASIN',//,57X,'CL2 FEED',1X,PRT17000
     2F9.0,3F9.3,F9.2,/,57X,'SYSTEM',//,57X,'SO2 FEED',1X,F9.0,3F9.3,F9.PRT17100
     32,/,57X,'SYSTEM',//)                                              PRT17200
      GO TO 610                                                         PRT17300
C                                                                       PRT17400
C                                                                       PRT17500
C                     TFLOT                                             PRT17600
C                                                                       PRT17700
  300 WRITE (IO,310) I,(DMATX(J,I),J=1,7),(OMATX(J,I),J=1,3),CCOST(I,1),PRT17800
     1COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(16,I)                      PRT17900
  310 FORMAT (1X,1HP,I2,2X,'FLOTATION',10X,'TRR',6X,'TSS',6X,'GTH',5X,'GPRT18000
     1STH',5X,'HPWK',4X,'DPOLY',4X,'CPOLY',/,6X,'THICKENING',5X,F9.2,F9.PRT18100
     20,5F9.2,//,24X,'ATHM',7X,'XN',4X,'ATHM1',22X,'CCOST',4X,'COSTO',4XPRT18200
     3,'ACOST',4X,'TCOST',6X,'ECF',/,21X,3F9.1,18X,F9.0,3F9.3,F9.2,//)  PRT18300
      GO TO 610                                                         PRT18400
C                                                                       PRT18500
C                                                                       PRT18600
C                     MHINC                                             PRT18700
C                                                                       PRT18800
  320 WRITE (IO,330) I,(DMATX(J,I),J=1,9),(OMATX(J,I),J=1,5)            PRT18900
  330 FORMAT (1X,1HP,I2,2X,'MULTIPLE HEARTH',5X,'ML',5X,'NINC',5X,'HPWK'PRT19000
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     1,5X,'SPER',7X,'WV',7X,'HV',5X,'TYPE',7X,'FC',6X,'CNG',/,6X,'INCINEPRT19100
     2RATION',3X,7F9.1,2F9.3,//,25X,'FHA',5X,'WFYR',5X,'PSDD',4X,'ECOST'PRT19200
     3,4X,'FCOST',/,21X,5F9.0,/)                                        PRT19300
      WRITE (IO,340) CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(1PRT19400
     16,I)                                                              PRT19500
  340 FORMAT (68X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,66PRT19600
     1X,F9.0,3F9.3,F9.2,//)                                             PRT19700
      GO TO 610                                                         PRT19800
C                                                                       PRT19900
C                                                                       PRT20000
C                        RWP                                            PRT20100
C                                                                       PRT20200
  350 WRITE (IO,360) I,DMATX(1,I),OMATX(1,I),CCOST(I,1),COSTO(I,1),ACOSTPRT20300
     1(I,1),TCOST(I,1),DMATX(16,I)                                      PRT20400
  360 FORMAT (1X,1HP,I2,2X,'RAW WASTEWATER',4X,'HEAD',7X,'QP',31X,'CCOSTPRT20500
     1',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,6X,'PUMPING',8X,2F9.PRT20600
     22,27X,F9.0,3F9.3,F9.2,//)                                         PRT20700
      GO TO 610                                                         PRT20800
C                                                                       PRT20900
C                                                                       PRT21000
C                        SHT                                            PRT21100
C                                                                       PRT21200
  370 WRITE (IO,380) I,DMATX(1,I),OMATX(1,I),CCOST(I,1),COSTO(I,1),ACOSTPRT21300
     1(I,1),TCOST(I,1),DMATX(16,I)                                      PRT21400
  380 FORMAT (1X,1HP,I2,2X,'SLUDGE HOLDING',6X,'TD',5X,'VSHT',31X,'CCOSTPRT21500
     1',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,6X,'TANKS',10X,2F9.1PRT21600
     2,27X,F9.0,3F9.3,F9.2,//)                                          PRT21700
      GO TO 610                                                         PRT21800
C                                                                       PRT21900
C                                                                       PRT22000
C                        CENT                                           PRT22100
C                                                                       PRT22200
  390 WRITE (IO,400) I,(DMATX(J,I),J=1,8),(OMATX(J,I),J=1,5),CCOST(I,1),PRT22300
     1COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(16,I)                      PRT22400
  400 FORMAT (1X,1HP,I2,2X,'CENTRIFUGATION',5X,'CRR',6X,'TSS',5X,'HPWK',PRT22500
     15X,'XCEN',5X,'POLY',4X,'CPOLY',5X,'GPMN',4X,'CNMIN',/,21X,F9.2,F9.PRT22600
     20,3F9.1,2F9.2,F9.1,//,24X,'CGPM',5X,'DSOL',6X,'AFC',4X,'CSIZE',7X,PRT22700
     3'CN',/,21X,F9.0,F9.1,F9.5,2F9.1,//,68X,'CCOST',4X,'COSTO',4X,'ACOSPRT22800
     4T',4X,'TCOST',6X,'ECF',/,66X,F9.0,3F9.3,F9.2,//)                  PRT22900
      GO TO 610                                                         PRT23000
C                                                                       PRT23100
C                                                                       PRT23200
C                        AEROB                                          PRT23300
C                                                                       PRT23400
  410 WRITE (IO,420) I,(DMATX(J,I),J=1,8),(OMATX(J,I),J=1,4)            PRT23500
  420 FORMAT (1X,1HP,I2,2X,'AEROBIC',13X,'XL',5X,'XAFS',6X,'DTA',5X,'TSSPRT23600
     11',5X,'TSS2',5X,'BOD2',6X,'GSS',5X,'HEAD',/,6X,'DIGESTION',6X,2F9.PRT23700
     20,F9.1,2F9.0,F9.1,2F9.2,//,24X,'VAER',5X,'ACFM',4X,'QPUMP',6X,'AFSPRT23800
     3',/,21X,F9.3,F9.0,2F9.2,/)                                        PRT23900
      WRITE (IO,430) CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(1PRT24000
     16,I),CCOST(I,2),COSTO(I,2),ACOST(I,2),TCOST(I,2),DMATX(15,I),CCOSTPRT24100
     2(I,3),COSTO(I,3),ACOST(I,3),TCOST(I,3),DMATX(14,I),CCOST(I,4),COSTPRT24200
     3O(I,4),ACOST(I,4),TCOST(I,4),DMATX(13,I)                          PRT24300
  430 FORMAT (68X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,57PRT24400
     1X,'AERATOR',2X,F9.0,3F9.3,F9.2,//,57X,'BLOWER',3X,F9.0,3F9.3,F9.2,PRT24500
     2//,57X,'SLUDGE',3X,F9.0,3F9.3,F9.2,/,57X,'PUMPS',//,57X,'FINAL',4XPRT24600
     3,F9.0,3F9.3,F9.2,/,57X,'SETTLER',//)                              PRT24700
      GO TO 610                                                         PRT24800
C                                                                       PRT24900
C                                                                       PRT25000
C                        POSTA                                          PRT25100
C                                                                       PRT25200
  440 WRITE (IO,450) I,(DMATX(J,I),J=1,13),(OMATX(J,I),J=1,7)           PRT25300
  450 FORMAT (1X,1HP,I2,2X,'POST AERATION',4X,'ITYPE',8X,'L',5X,'DOIN',5PRT25400
     1X,'DOUT',7X,'TL',7X,'ID',7X,'TW',4X,'AERFO',4X,'HPHRO',6X,'ALT',/,PRT25500
     221X,2F9.0,5F9.1,F9.3,2F9.2,//,23X,'CFMDF',4X,'DIFFT',7X,'DD',5X,'VPRT25600
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     3AER',6X,'CFM',7X,'HP',5X,'TMIN',6X,'VMG',4X,'AERFF',5X,'CLEN',/,21
     4X,3F9.1,F9.3,F9.0,2F9.2,F9.4,F9.3,F9.2,/)
      WRITE (IO,460) (OMATX(J,I),J=8,13)
  460 FORMAT (25X,'HP1',7X,'XN',6X,'THP',4X,'WIDTH',4X,'DEPTH',5X,'TLEN'
     1,/,21X,F9.2,F9.1,F9.2,2F9.1,F9.2,/)
      WRITE (IO,470) CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(1
     16,I),CCOST(I,2),COSTO(I,2),ACOST(I,2),TCOST(I,2),DMATX(15,I)
  470 FORMAT (68X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,57
     1X,'BASIN',4X,F9.0,3F9.3,F9.2,//,57X,'AIR',6X,F9.0,3F9.3,F9.2,/,57X
     2,'SUPPLY',//)
      GO TO 610
C
C
C                     EQUAL
C
  480 WRITE (IO,490) I,(DMATX(J,I),J=1,5),(OMATX(J,I),J=1,14)
  490 FORMAT (1X,1HP,I2,2X,'EQUALIZATION',6X,'IAER',6X,'RLW',4X,'COSTL',
     15X,'HEAD',5X,'IMAT',4X,'WIDTH',5X,'AREA',5X,'VUMG',5X,'VOMG',7X,'V
     2T',/,21X,2F9.1,F9.3,2F9.1,F9.2,F9.4,3F9.4,//,23X,'SAREA',7X,'HP',6
     3X,'HP1',7X,'XN',6X,'THP',4X,'PLAND',4X,'CLAND',5X,'VAER',5X,'ECFM'
     4,/,21X,F9.1,2F9.2,F9.1,2F9.2,F9.0,F9.3,F9.0,/)
      WRITE (IO,500) CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(1
     16,I),CCOST(I,2),COSTO(I,2),ACOST(I,2),TCOST(I,2),DMATX(15,I),CCOST
     2(I,3),COSTO(I,3),ACOST(I,3),TCOST(I,3),DMATX(14,I),CCOST(I,4),COST
     3O(I,4),ACOST(I,4),TCOST(I,4),CCOST(I,5),COSTO(I,5),ACOST(I,5),TCOS
     4T(I,5)
  500 FORMAT (68X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,57
     1X,'AERATED',2X,F9.0,3F9.3,F9.2,/,57X,'POND/TANK',//,57X,'AIR',6X,F
     29.0,3F9.3,F9.2,/,57X,'SUPPLY',//,57X,'PUMPING',2X,F9.0,3F9.3,F9.2,
     3/,57X,'SYSTEM',//,57X,'FLOW',5X,F9.0,3F9.3,/,57X,'MEASURING',//,57
     4X,'POND',5X,F9.0,3F9.3,/,57X,'LINING',//)
      GO TO 610
C
C
C                     DIG2
C
  510 WRITE (IO,520) I,(DMATX(J,I),J=1,3),OMATX(1,I),CCOST(I,1),COSTO(I,
     11),ACOST(I,1),TCOST(I,1),DMATX(16,I)
  520 FORMAT (1X,1HP,I2,2X,'SECOND STAGE',7X,'TRR',6X,'TSS',7X,'TD',5X,'
     1VDIG',13X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,6X,'
     2ANAEROBIC',6X,F9.2,F9.0,F9.1,F9.3,9X,F9.0,3F9.3,F9.2,/,6X,'DIGESTI
     3ON',//)
      GO TO 610
C
C
C                     LANDD
C
  530 WRITE (IO,540) I,(DMATX(J,I),J=1,5),(OMATX(J,I),J=1,9)
  540 FORMAT (1X,1HP,I2,2X,'LAND DISPOSAL OF',2X,'TAYR',7X,'SP',5X,'DIST
     1',7X,'TS',5X,'YRSL',/,6X,'LIQUID SLUDGE',2X,3F9.2,F9.0,F9.1,//,25X
     2,'TYT',5X,'TTYR',5X,'TRKN',6X,'SLV',5X,'TONS',4X,'ALAND',4X,'DLAND
     3',6X,'COL',6X,'AFT',/,21X,3F9.0,3F9.2,2F9.0,F9.5,/)
      WRITE (IO,550) CCOST(I,1),COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(1
     16,I),CCOST(I,2),COSTO(I,2),ACOST(I,2),TCOST(I,2),DMATX(15,I),CCOST
     2(I,3),COSTO(I,3),ACOST(I,3),TCOST(I,3)
  550 FORMAT (68X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,57
     1X,'STORAGE',2X,F9.0,3F9.3,F9.2,/,57X,'LAGOON',//,57X,'TRUCKING',1X
     2,F9.0,3F9.3,F9.2,//,57X,'INTEREST',1X,F9.0,3F9.3,/,57X,'ON LAND',/
     3/)
      GO TO 610
C
C
C                     LIME
C
  560 WRITE (IO,570) I,(DMATX(J,I),J=1,2),(OMATX(J,I),J=1,2),CCOST(I,1),
     1COSTO(I,1),ACOST(I,1),TCOST(I,1),DMATX(16,I)
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  570 FORMAT (1X,1HP,I2,2X,'LIME ADDITION',4X,'DLIME',4X,'CLIME',5X,'PPD
     1L',5X,'DTON',13X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',6X,'ECF'
     2,/,6X,'TO SLUDGE',6X,F9.1,F9.2,F9.1,F9.2,9X,F9.0,3F9.3,F9.2,//)
      GO TO 610
C
C
C                RBC
C
  580 WRITE (IO,590) I,(DMATX(J,I),J=1,9),(OMATX(J,I),J=1,10)
  590 FORMAT (1X,1HP,I2,2X,'ROTATING',11X,'BOD',4X,'XNSTG',5X,'DEGC',4X,
     1'QPABI',4X,'QPANI',6X,'GSS',5X,'BODN',6X,'TSS',5X,'CPDY',/,6X,'BIO
     2LOGICAL',5X,2F9.1,3F9.2,2F9.1,2F9.2,/,6X,'CONTACTOR-',/,6X,'FINAL
     3SETTLER',5X,'QPAB',5X,'QPAN',4X,'APSTG',5X,'AREA',4X,'FNSTG',4X,'R
     4NSTG',4X,'RATIO',5X,'PREM',5X,'QPAT',6X,'AFS',/,21X,2F9.2,2F9.0,2F
     59.2,F9.3,F9.2,F9.3,F9.1,/)
      WRITE (IO,600) (OMATX(J,I),J=11,17),CCOST(I,1),COSTO(I,1),ACOST(I,
     11),TCOST(I,1),DMATX(16,I),CCOST(I,2),COSTO(I,2),ACOST(I,2),TCOST(I
     2,2),DMATX(15,I)
  600 FORMAT (24X,'PDSD',5X,'URSS',5X,'NTRN',4X,'NSHFT',4X,'COSTM',4X,'C
     1OSTE',4X,'COSTL',/,21X,F9.1,F9.3,2F9.1,3F9.0,//,68X,'CCOST',4X,'CO
     2STO',4X,'ACOST',4X,'TCOST',6X,'ECF',/,57X,'CONTACTOR',F9.0,3F9.3,F
     39.2,//,57X,'FINAL',4X,F9.0,3F9.3,F9.2,/,57X,'SETTLER',//)
  610 CONTINUE
C
C
C            OUTPUT FORMAT FOR COSTS OF MISCELLANEOUS FACILITIES
C
      WRITE (IO,620) CCOST(20,1),COSTO(20,1),ACOST(20,1),TCOST(20,1)
  620 FORMAT (6X,'ADMINISTRATIVE',48X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'
     1TCOST',/,6X,'AND LABORATORY',46X,F9.0,3F9.3,//)
      WRITE (IO,630) CCOST(20,2),COSTO(20,2),ACOST(20,2),TCOST(20,2)
  630 FORMAT (6X,'GARAGE',56X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST',/
     1,6X,'AND SHOP',52X,F9.0,3F9.3,//)
      WRITE (IO,640) DMATX(9,20),CCOST(20,3),COSTO(20,3),ACOST(20,3),TCO
     1ST(20,3)
  640 FORMAT (6X,'LABORATORY',8X,'XLAB',40X,'CCOST',4X,'COSTO',4X,'ACOST
     1',4X,'TCOST',/,6X,'OPERATION',6X,F9.1,36X,F9.0,3F9.3,//)
      WRITE (IO,650) CCOST(20,4),COSTO(20,4),ACOST(20,4),TCOST(20,4)
  650 FORMAT (6X,'YARDWORK',54X,'CCOST',4X,'COSTO',4X,'ACOST',4X,'TCOST'
     1,/,6X,'OPERATION',51X,F9.0,3F9.3,//)
C
C
C            OUTPUT FORMAT FOR TOTAL PLANT COST
C
      WRITE (IO,660) (OMATX(J,20),J=17,20)
  660 FORMAT (1H1,//////,54X,'TOTAL PLANT COST',///,39X,'TOTAL CAPITAL C
     1OST = ',F10.0,' DOLLARS',16X,'TOT',//34X,'TOTAL AMORTIZATION COST
     2= ',F10.3,' CENTS/1000 GALLONS',5X,'TAMM',//,41X,'TOTAL O + M COST
     3 = ',F10.3,' CENTS/1000 GALLONS',5X,'TOPER',//,37X,'TOTAL TREATMEN
     4T COST = ',F10.3,' CENTS/1000 GALLONS',5X,'TOTAL',/////)
      WRITE (IO,670) (DMATX(J,20),J=1,10),(OMATX(J,20),J=1,12)
  670 FORMAT (7X,'CCI',9X,'WPI',10X,'RI',9X,'YRS',9X,'DHR',9X,'PCT',10X,
     1'DA',7X,'CCINT',8X,'XLAB',8X,'CKWH',//,3F12.3,F12.1,F12.2,F12.3,F1
     22.0,2F12.2,F12.3,/////,5X,'RATIO',8X,'TCAP',8X,'YARD',9X,'TCC',7X,
     3'XLAND',9X,'ENG',7X,'SUBT1',8X,'FISC',7X,'SUBT2',8X,'XINT',//,F12.
     43,9F12.0,///,6X,'ACRE',10X,'AF',//,F12.2,F12.5)
      RETURN
      END
```

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16. ABSTRACT

This document contains a portion of the material used for the Short Course on the Applications of Computer Programs in Preliminary Design of Wastewater Treatment Facilities. The short course lectures appear in Section I of the report which is under separate cover. Section II, contained herein, contains the users' manual and program listing for the Executive Program for Preliminary Design of Wastewater Treatment Systems. The manual describes the use of the program and subroutines. Several examples show appropriate input and expected output for a variety of applications. In addition, the theoretical basis for the calculations are shown in the form of conventional mathematical and equivalent fortran equations. The program listing includes the main program and each of 27 subroutines, representing different treatment processes, energy consumption, and cost calculations.

17. KEY WORDS AND DOCUMENT ANALYSIS

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*Models	*Cost effectiveness	Preliminary design	
Sewage treatment	Mathematical models	Computer program	
Design	Sewage treatment	Design engineering	
*Cost estimates	Water pollution	Sanitary engineering	

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