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Water

Computer-Assisted Procedure for the Design and Evaluation of Wastewater Treatment System

Users Guide

EPA/CE REVIEW NOTICE

This report has been reviewed by the U.S. Environmental Protection Agency (EPA) and by the U.S. Army Corps of Engineers (CE) and approved for publication.

Approval does not signify that the contents necessarily reflect the views and policies of EPA or CE, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

The three reports listed below were prepared in conjunction with the EPA/CE interagency agreement in 1976 to expand and upgrade the CAPDET model. These reports are:

Part I.	Design of Major Systems Wastewater Treatment Facilities
Part II.	Design of Small Systems Wastewater Treatment Facilities
Part III.	Computer Assisted Procedure for the Design and Evaluation of Wastewater Treatment Systems (CAPDET) -- User's Guide

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CAPDET was originally developed by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi in 1974. The Environmental Protection Agency (EPA) and Corps of Engineers (CE) entered into an interagency agreement in 1976 to expand and upgrade the CAPDET to the needs of both the EPA Construction Grants Program and the urban area comprehensive planning program in which CE was involved.

This user's guide was produced by Mississippi State University.

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ENGINEERING AND DESIGN

Design of Wastewater Treatment Facilities

Part I. Design of Major Systems Wastewater Treatment Facilities

Part II. Design of Small Systems Wastewater Treatment Facilities

Part III. Computer Assisted Procedure for the Design and Evaluation of Wastewater Treatment Systems (CAPDET) -- User's Guide

Table of Contents

	Subject	Paragraph	Page
CHAPTER 1.	INTRODUCTION		
	Purpose	1-1	1-1
	Applicability	1-2	1-1
	References	1-3	1-1
	Scope	1-4	1-1
CHAPTER 2.	MODEL DESCRIPTION		
	Definitions	2-1	2-1
	Program Organization	2-2	2-1
	Input Data	2-3	2-4
	Unit Process Specification	2-4	2-4
	Title Card	2-5	2-8
	Scheme Description	2-6	2-8
	Waste Influent Characteristics	2-7	2-13
	Desired Effluent Characteristics	2-8	2-16
	Unit Cost Data	2-9	2-16
	Program Control Cards	2-10	2-19
	Cost Analysis in the Computerized Design Process	2-11	2-22
CHAPTER 3.	UNIT PROCESS SPECIFICATIONS		
	General	3-1	3-1
	Aerated Lagoon	3-2	3-4
	Aerobic Digestion	3-3	3-6
	Anaerobic Digestion	3-4	3-8
	Anion Exchange	3-5	3-10
	Carbon Adsorption	3-6	3-12
	Cascade Aeration	3-7	3-14
	Cation Exchange	3-8	3-16
	Centrifugation	3-9	3-18
	Chlorination	3-10	3-20
	Coagulation	3-11	3-22
	Comminution	3-12	3-24
	Complete Mix Activated Sludge	3-13	3-26

Subject	Paragraph	Page
Contact Stabilization Activated Sludge	3-14	3-28
Costs Override	3-15	3-30
Counter Current Ammonia Stripping	3-16	3-34
Cross Current Ammonia Stripping	3-17	3-36
Denitrification	3-18	3-38
Drying Beds	3-19	3-42
Dummy Process	3-20	3-44
Equalization	3-21	3-48
Extended Aeration Activated Sludge	3-22	3-50
Facultative Aerated Lagoon	3-23	3-52
Filter Press	3-24	3-54
Filtration	3-25	3-56
Flocculation	3-26	3-62
Flotation	3-27	3-64
Fluidized Bed Incineration	3-28	3-66
Gravity Thickening	3-29	3-68
Grit Removal	3-30	3-70
High Rate Activated Sludge	3-31	3-72
Lagoons	3-32	3-74
Microscreening	3-33	3-76
Multiple Hearth Incineration	3-34	3-78
Neutralization	3-35	3-80
Nitrification	3-36	3-82
Overland Flow Land Treatment	3-37	3-86
Oxidation Ditch Activated Sludge	3-38	3-88
Plug Flow Activated Sludge	3-39	3-90
Post Aeration	3-40	3-92
Pressure Filtration	3-41	3-94
Primary Clarification	3-42	3-96
Primary Clarification (Coagulation)	3-43	3-100
Primary Clarification (Two Stage Lime Treatment)	3-44	3-104
Pure Oxygen Activated Sludge	3-45	3-108
Rapid Infiltration Land Treatment	3-46	3-110
Recarbonation	3-47	3-112
First Stage Recarbonation	3-48	3-114
Second Stage Recarbonation	3-49	3-116
Screening	3-50	3-118
Secondary Clarification (activated Sludge)	3-51	3-120
Secondary Clarification (Nitrification/ Denitrification)	3-52	3-122
Secondary Clarification (Trickling Filter)	3-53	3-124
Slow Infiltration Land Treatment	3-54	3-126
Sludge Flotation	3-55	3-128
Sludge Hauling and Land Filling	3-56	3-130
Step Aeration Activated Sludge	3-57	3-132
Trickling Filtration	3-58	3-134
Vacuum Filtration	3-59	3-136
Wet Oxidation	3-60	3-138

APPENDIX A. BASIC PROCEDURE FOR USING CAPDET

APPENDIX B. EXAMPLE PROBLEM OUTPUT

CHAPTER I

INTRODUCTION

1-1. Purpose. This manual provides guidance for the selection of wastewater treatment processes and systems, and criteria for the design of wastewater treatment facilities using the Computer Assisted Procedure for the Design and Evaluation of Wastewater Treatment Systems (CAPDET).

1-2. Applicability. The provisions of this manual are applicable to Corps of Engineers Districts and Divisions, the U.S. Environmental Protection Agency, other Federal and State agencies, and private firms concerned with the design and cost effective analysis of new and upgraded wastewater treatment facilities for civil and public works and military construction projects.

1-3. References.

a. EM 1110-2-501, Part 1, Design of Wastewater Treatment Facilities.

b. EM 1110-2-501, Part 2 (Draft), Design of Small Systems Wastewater Treatment Facilities.

c. EPA-430/9-75-003, Cost of Wastewater Treatment by Land Application.

d. EPA 430/9-77-013, MCD-37, Construction Costs for Municipal Wastewater Treatment Plants: 1973-1977.

e. EPA 430/9-77-014, MCD-38, Construction Costs for Municipal Wastewater Conveyance Systems: 1973-1977.

f. EPA 430/9-77-015, MCD-39, Analysis of Operations & Maintenance Costs for Municipal Wastewater Treatment Systems.

1-4. Scope.

a. The user's guide contains detailed instruction for coding data for the CAPDET model. This computer-based design procedure can be used to select viable process trains to meet a given effluent criteria and will rank the selected trains according to least annual cost. Cost and design data are included for 0.3 to 500 million gallons per day (mgd) systems.

b. Available characterization data do not always include all of the input parameters required for certain processes. Therefore, typical default data have been included in the program to be used in the absence of user specified values. The default data provided for each unit process are average values and may need adjustment to accurately reflect site-specific or waste-specific conditions.

c. The program contains a library of unit processes that may be used to treat a waste stream. Individual unit processes comprising a waste treatment scheme may be supplied with the appropriate design parameters pertinent to each process or the default values included in the program may be used. The program is sufficient in size and flexibility to allow for the processing of up to four general types of treatment schemes (e.g. physical-chemical, biological, land treatment, etc.)

d. When a treatment scheme is analyzed, the influent waste stream is processed in turn by each unit process on the liquid line. The treatment processes use the effluent of the previous process for their influent. Those processes producing sludge automatically output the sludge into one of two sludge lines (primary or secondary). These sludges may be processed separately or they may be mixed together. Figure 1-1 presents the organization chart for a treatment scheme.

e. The sequence of analysis for the processes of a waste stream involves analyzing all of the liquid line processes first, then processing the secondary sludge line, and finally processing the primary sludge line. Once the sequence is finished for a given process train, the effluent may be checked against a preset effluent criteria. Those trains not meeting the desired effluent specifications are immediately discarded, while those meeting the desired effluent specifications are ranked in order by least annual cost. The costs are determined by a separate cost routine which estimates the capital and operating and maintenance (O&M) costs for each unit process and performs an average annual cost analysis on each train over the design life as the basis for economic comparison.

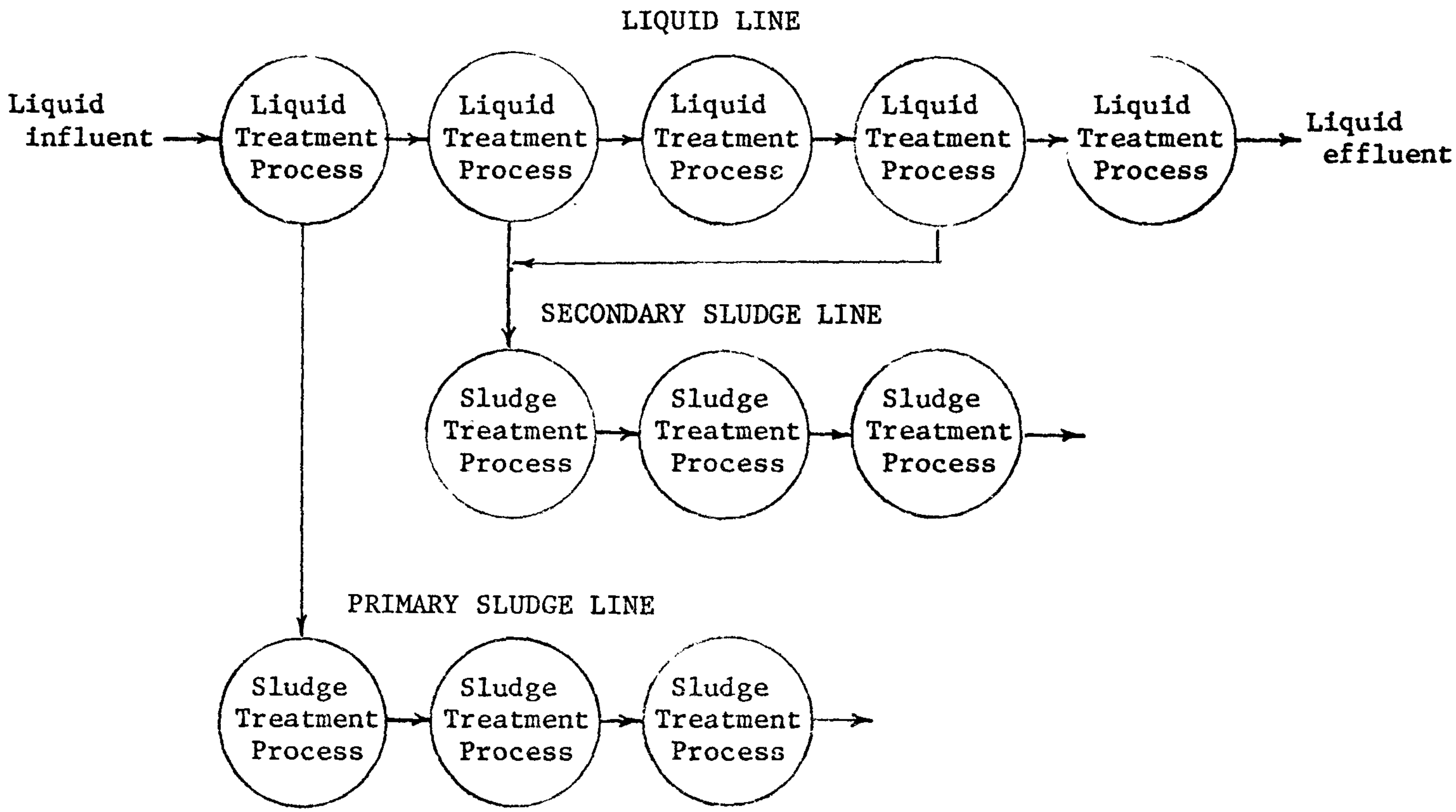

Figure 1-1. Organization of a Typical Treatment Scheme

CHAPTER 2

MODEL DESCRIPTION

2-1. Definitions.

a. Unit Process. A unit process is a single unique unit or group of parallel units of the same type. Examples of unit processes are bar screens, comminutors, grit chambers, contact stabilization processes, and secondary clarifiers.

b. Treatment Process. A treatment process is a sequence of one or more unit processes which are automatically linked together by CAPDET. For example, the preliminary treatment process consists of the unit processes bar screens, grit chambers, and comminutors linked in sequence. The contact stabilization treatment process consists of the contact stabilization unit process and a secondary clarifier. The filtration treatment process consist of merely the filtration unit process.

c. Block. A block is a treatment process location. The user of CAPDET may specify several alternative treatment processes for each treatment process location or block.

d. Scheme. A treatment scheme consists of the blocks on the liquid line, the secondary sludge line, and the primary sludge line.

e. Train. A train is similar to a scheme except that each block contains only one treatment process. A scheme may define several possible trains. CAPDET will automatically produce all trains specified in the treatment scheme by selecting all combinations of the alternatives in the blocks.

2-2. Program Organization.

a. This program allows the user to specify various types of unit processes for the treatment of wastewaters. A treatment process consists of one or more of these unit processes. The combination of unit processes into treatment processes is accomplished automatically by the CAPDET program. Treatment processes may then be assembled in sequence to form a treatment scheme. A scheme organization chart is shown in Figure 2-1 and a typical scheme is shown in Figure 2-2. A maximum of four treatment schemes may be specified. Each scheme contains a liquid line, a secondary sludge line, and a primary sludge line. A total of 20 blocks may be specified in each scheme. Each block may contain up to 10 alternative treatment processes.

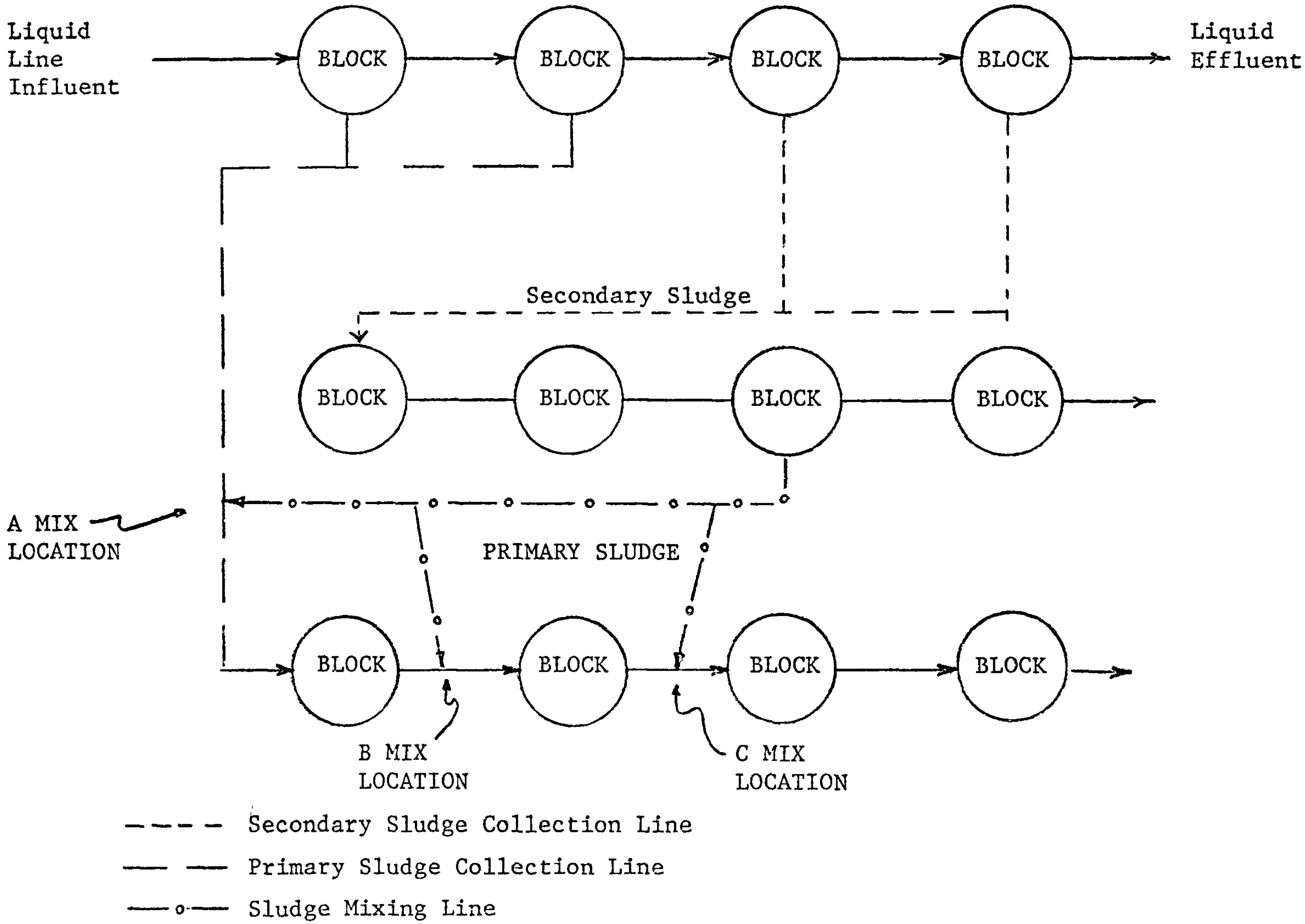

Figure 2-1. Scheme organization chart

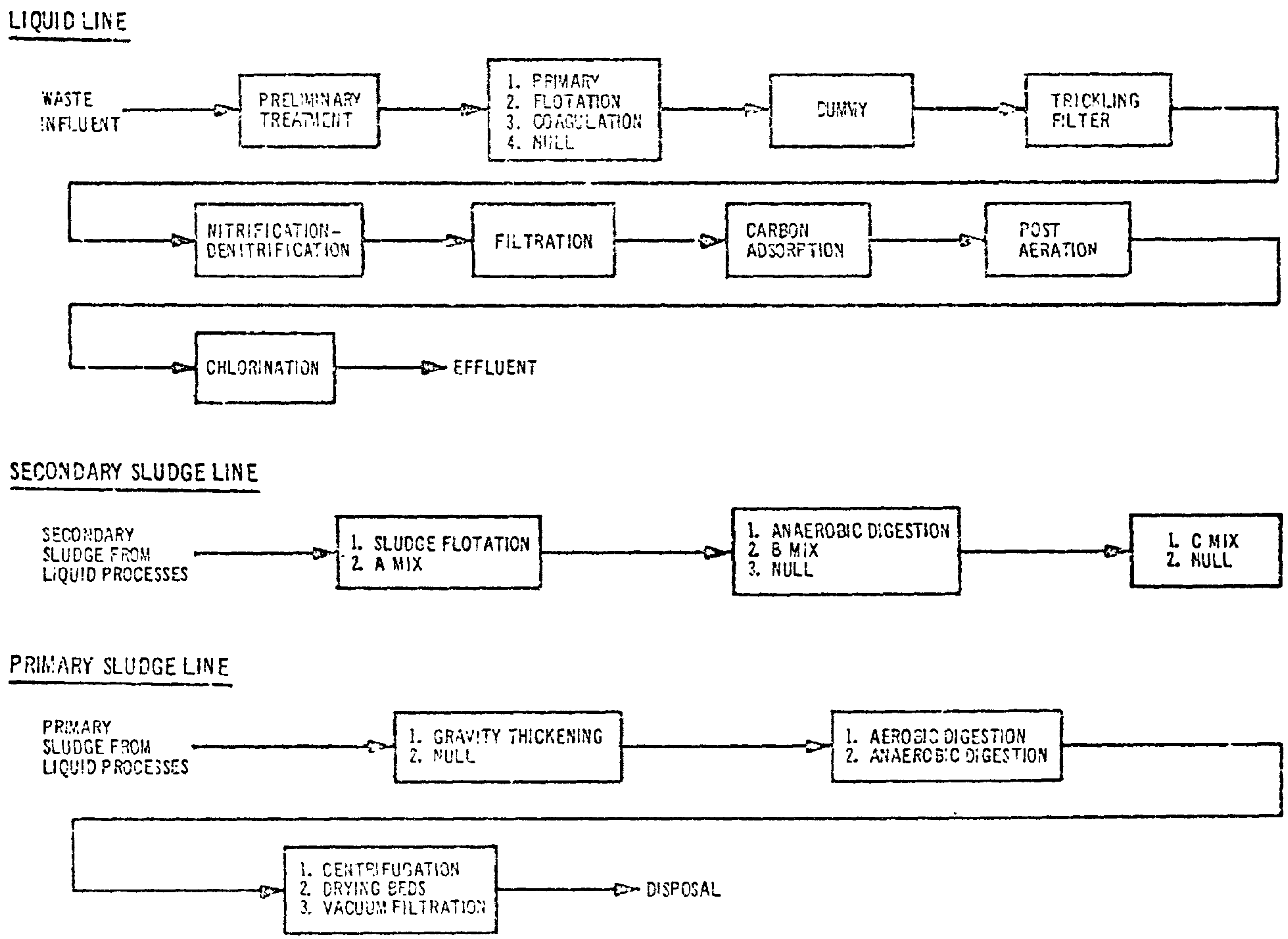

Figure 2-2. A typical scheme. This represents one scheme and 576 trains (or variations) of that scheme. The program will evaluate all 576 trains but will save only the 100 most cost-effective.

b. A train consists of one treatment process from each block connected together in the sequence of the blocks. The program examines all combinations of treatment processes in the series of blocks and determines the cost for each train. The trains are saved in the computer and ranked according to least equivalent annual cost. If desired, the user may have the effluent checked against desired effluent characteristics. Those trains not meeting the desired effluent characteristics will be discarded. A maximum of 100 trains will be saved.

c. Two types of output may be obtained. The first output lists the cost data for up to the 100 most cost-effective trains. The user may also specify which of these trains (or all if he chooses) he desires to investigate further. The second output gives detailed unit process design information for all chosen trains. Optionally, this output may include the quantities of materials required for construction.

2-3. Input data.

Data for this program consist of seven major divisions.

a. Unit process specifications.

b. Title card.

c. Scheme descriptions.

d. Waste influent characteristics.

e. Desired effluent characteristics.

f. Unit cost data.

g. Program control.

For an outline of program input, the user may refer to the "Basic Procedure for Using CAPDET" in Appendix A. The following sections outline the complete procedure required to describe a proposed treatment scheme and obtain the desired output from CAPDET.

2-4. Unit Process Specification.

a. The data cards used in the specification of a unit process consist of a key word in the first six columns of the card followed by the required numeric data in columns 7-80. The numeric data may be placed in any of the allowed columns but must be in the order shown for that particular card. No other numeric characters may be placed in columns 7-80.

For purposes of this description, numeric characters are taken as the numerals 0-9, the minus sign (-), the plus sign (+), and the decimal point or period (.). Any other characters may be used in these columns to allow the user to identify the data items. Note, however, that the computer ignores these alpha descriptions and requires a specific order for the data on a card. The key word (columns 1-6) must appear exactly as shown on the card description[a].

b. The specification of a unit process begins with the process header card which names the process and terminates with an END card.

c. Data may be supplied for three separate modifications of each unit process. The three modifications are numbered 0, 1, and 2. If the modification number is omitted on the unit process header card, modification 0 will be assumed. Default data have been included in the program for modification zero. These data may be changed by the user by specifying a unit process header card, data cards for the items the user wishes to change, and an END card. If the user desires the use of modification 1 or 2 of a unit process, complete data for that modification of the unit process must be specified. Default data or user specified data must be available for each of the unit processes which will be used by the treatment processes specified on the BLOCK cards.

d. The following unit processes may be specified:

Header Card Key Word	Unit Processes
A SECO	Secondary clarification (activated sludge)
AERATE	Aerated lagoon
AEROBI	Aerobic digestion
ANAERO	Anaerobic digestion
ANION	Anion exchange
C PRIM	Primary clarification (coagulation)
CARBON	Carbon adsorption

[a]The input may be in the form of cards or teletype lines. Since a line is equivalent to a card, the format described also applies to lines of input.

Header Card Key Word	Unit Processes
CASCAD	Cascade aeration
CATION	Cation exchange
CENTRI	Centrifugation
CHLORI	Chlorination
COAGUL	Coagulation
COMMIN	Comminution
COMPLE	Complete mix activated sludge
CONTAC	Contact stabilization activated sludge
COSTS	User specified costs for processes
COUNTE	Counter current ammonia stripping
CROSS	Cross current ammonia stripping
DENITR	Denitrification
DRYING	Drying beds
DUMMY	User specified process
EQUALI	Equalization
EXTEND	Extended aeration activated sludge
FACULT	Facultative aerated lagoon
FILTRA	Filtration
FIRST	First stage recarbonation (lime treatment)
FLOCCU	Flocculation
FLOTAT	Flotation
FLTR P	Filter press
FLUIDI	Fluidized bed incineration

Header Card Key Word	Unit Processes
GRAVIT	Gravity thickening
GRIT R	Grit removal
HAULIN	Sludge hauling and land filling
HIGH R	High-rate activated sludge
L SECO	Secondary clarification (two-step lime clarification)
LAGOON	Lagoons (stabilization ponds)
MICROS	Microscreening
MULTIP	Multiple hearth incineration
N SECO	Secondary clarification (nitrification-denitrification)
NEUTRA	Neutralization
NITRIF	Nitrification
OVERLA	Overland flow land treatment
OXIDAT	Oxidation ditch
PLUG F	Plug flow activated sludge
POST A	Post aeration
PRESSU	Pressure filtration
PRIMAR	Primary clarification
PURE O	Pure oxygen activated sludge
RAPID	Rapid infiltration land treatment
RECARB	Recarbonation
SCREEN	Screening
SECOND	Second stage recarbonation (lime treatment)
SLOW I	Slow infiltration land treatment

Header Card Key Word	Unit Processes
SLUDGE	Sludge flotation
STEP A	Step aeration activated sludge
T SECO	Secondary clarification (trickling filters)
TRICKL	Trickling filtration
VACUUM	Vacuum filtration
WET OX	Wet oxidation

e. The data cards for each of the unit processes are described in Chapter 3. An xx.x shown on these cards indicates that a numeric value must be supplied. The last card for each unit process is an END card.

2-5. Title Card.

a. A title card should be placed after the END card of the last unit process specification and prior to the LIQUID LINE card of the first scheme description. This title card allows an identification to be given at the top of each sheet of output. The card has the word TITLE in the first five columns followed by the desired description.

b. If the user wishes to completely rely on the default data, he should begin the data input with a TITLE card, and should not specify modification numbers on the BLOCK cards.

2-6. Scheme Description.

a. The third major division of input is the desired scheme descriptions. This input begins with the liquid line of the first scheme.

b. Each scheme description must begin with a LIQUID LINE card and may contain a SECONDARY SLUDGE LINE card and a PRIMARY SLUDGE LINE card. Inputs immediately following each of these line cards are BLOCK cards describing the treatment processes to be considered in that block. As many as 10 treatment processes may be tried in each block. A total of 20 blocks may be used in each treatment scheme.

c. To eliminate the need for the user to continually link together unit processes that are often used in combination, treatment processes of one or more unit processes have been defined (e.g. secondary clarification following activated sludge).

d. Treatment processes consist of one or more unit processes (including the pseudo unit processes such as A MIX, B MIX, C MIX, and NULL). Only treatment process key words are used on the BLOCK cards.

e. Sludge treatment processes can only be used in conjunction with the secondary or primary sludge lines. Liquid processes can be used on the liquid line only. The NULL process can be used on any line. MIX processes can be used on the secondary sludge line only. Treatment processes are designated at a particular block by placing the six-character key word and one-character modification number describing that process in a position on the block card. The block card starts with the six-character key word "BLOCK " in columns 1-6, followed by the first treatment process key word and modification number in the seven column position beginning in column 11. Subsequent treatment process key words and modification numbers are placed in succeeding seven character fields.

f. Listed below are the various treatment processes and the associated key words describing the unit processes which comprise the treatment process. The first thirteen are sludge treatment processes, the last four are pseudo processes, and the others are liquid treatment processes.

	Treatment Process Key Words	Treatment Process	Key Words for Associated Unit Processes
Sludge	AEROBI	Aerobic digestion	AEROBI
	ANAERO	Anaerobic digestion	ANAERO
	CENTRI	Centrifugation	CENTRI
	DRYING	Drying beds	DRYING
	FLTR P	Filter press	FLTR P
	FLUIDI	Fluidized bed incineration	FLUIDI
	GRAVIT	Gravity thickening	GRAVIT
	HAULIN	Hauling and land filling	HAULIN

	Treatment Process Key Words	Treatment Process	Key Words for Associated Unit Processes
Sludge	MULTIP	Multiple hearth incineration	MULTIP
	PRESSU	Pressure filtration	PRESSU
	SLUDGE	Sludge flotation	SLUDGE
	VACUUM	Vacuum filtration	VACUUM
	WET OX	Wet oxidation	WET OX
Liquid			
	AERATE	Aerated lagoon	AERATE
	ANION	Anion exchange	ANION
	CARBON	Carbon adsorption	CARBON
	CASCAD	Cascade aeration	CASCAD
	CATION	Cation exchange	CATION
	CHLORI	Chlorination	CHLORI
	COAGUL	Coagulation	COAGUL, C PRIM
	COMBIN	Combined nitrification-denitrification	NITRIF, N SECO, DENITR, N SECO
	COMPLE	Complete mix activated sludge	COMPLE, A SECO
	CONTAC	Contact stabilization activated sludge	CONTAC, A SECO
	COUNTE	Counter current ammonia stripping	COUNTE
	CROSS	Cross current ammonia stripping	CROSS
	DITCH	Ditch irrigation land treatment	DITCH
	DUMMY	User specified process	DUMMY
	EQUALI	Equalization	EQUALI
	EXTDEN	Extended aeration with DENITRIFICATION	EXTDEN, A SECO, DENITR, N SECO

	Treatment Process Key Words	Treatment Process	Key Words for Associated Unit Processes
Liquid	EXTEND	Extended aeration activated sludge	EXTEND, A SECO
	FACULT	Facultative aerated lagoon	FACULT
	FILTRA	Filtration	FILTRA
	FLOOD	Flood irrigation land treatment	FLOOD
	FLOTAT	Flotation	FLOTAT
	HIGH R	High-rate activated sludge	HIGH R, A SECO
	LAGOON	Lagoon	LAGOON
	MICROS	Microscreening	MICROS
	NEUTRA	Neutralization	NEUTRA
	NITRIF	Nitrification	NITRIF, N SECO
	OVERLA	Overland flow land treatment	OVERLA
	OXIDAT	Oxidation ditch	OXIDAT, A SECO
	PLUG F	Plug flow activated sludge	PLUG F, A SECO
	POST A	Post aeration	POST A
	PRELIM	Preliminary treatment	GRIT R, SCREEN, COMMIN
	PRIMAR	Primary clarification	PRIMAR
	PURE O	Pure oxygen activated sludge	PURE O, A SECO
	RAPID	Rapid infiltration land treatment	RAPID
	RECARB	Recarbonation	RECARB
	SPRAY	Spray irrigation land treatment	SPRAY
	STEP A	Step aeration activated sludge	STEP A, A SECO
	TRANSM	Transmission and pumping	TRANSM
	TRICKL	Trickling filtration	TRICKL, T SECO

	Treatment Process Key Words	Treatment Process	Key Words for Associated Unit Processes
Liquid	TWO ST	Two-stage lime treatment	FLOCCU, L SECO, FIRST, SECOND
Pseudo			
	A MIX	Secondary and primary sludge mixing	NONE
	B MIX	Secondary and primary sludge mixing	NONE
	C MIX	Secondary and primary sludge mixing	NONE
	NULL	No process	NONE

g. A treatment process of a given modification number consists of one or more unit processes with the same modification number. For example, if the user wishes to specify modification 1 of the treatment process Extended Aeration, he must have supplied data for the associated unit processes Extended Aeration (EXTEND) and Secondary Clarification (A SECO).

h. The mixing process, A MIX, B MIX, or C MIX, is used to mix the secondary sludge line into the primary sludge line before the first, second, or third block on the primary sludge line, respectively (fig. 2-1). The presence of a MIX block in a process train will cause processing of the secondary line to be terminated at that point. The NULL block is used to allow the option of a "no process" in a block of the train.

i. A typical treatment scheme was shown in figure 2-2. The data cards describing that scheme are shown in figure 2-3. Up to four treatment schemes may be described.

COLUMN	1	11	Mod No. 18	Mod No. 25	Mod No. 32
	LIQUID LINE				
	BLOCK	PRELIM			
	BLOCK	PRIMAR	FLOTAT	COAGUL	NULL
	BLOCK	DUMMY			
	BLOCK	TRICKL			
	BLOCK	COMBIN			
	BLOCK	FILTRA			
	BLOCK	CARBON			
	BLOCK	POST A			
	BLOCK	CHLORI			
	SECONDARY	SLUDGE LINE			
	BLOCK	SLUDGE	A MIX		
	BLOCK	ANAERO	B MIX	NULL	
	BLOCK	C MIX	NULL		
	PRIMARY SLUDGE LINE				
	BLOCK	GRAVIT	NULL		
	BLOCK	AEROBI	ANAERO		
	BLOCK	CENTRI	DRYING	VACUUM	

Figure 2-3. Scheme description format

2-7. Waste Influent Characteristics.

a. The fourth major division of input is the waste influent characteristics. The statement of waste influent characteristics begins with a header card containing the key word WASTE in the first five columns. The individual characteristic cards are in the same format as the Unit Process Specification cards. Numeric data cannot begin before column 7. The characteristic cards listed below may be used. The better the characterizations of the waste, the better will be the results of the model. However, all 20 waste influent specification cards need not be included in order for the program to operate. NOTE: the waste characterization data must be given in the units indicated.

Waste Influent Characteristic Cards

WASTE INFLUENT CHARACTERISTICS

MINIMUM FLOW		xx.x	MGD
AVERAGE FLOW		xx.x	MGD
MAXIMUM FLOW		xx.x	MGD
TEMPERATURE		xx.x	DEG CENT
SUSPENDED SOLIDS		xx.x	MG/L
VOLATILE SOLIDS		xx.x	% OF SUSPENDED
SETTLEABLE SOLIDS		xx.x	MG/L
BOD5		xx.x	MG/L
SBOD5 (SOLUBLE)		xx.x	MG/L
COD		xx.x	MG/L
SCOD (SOLUBLE)		xx.x	MG/L
PH		xx.x	
CATIONS		xx.x	MG/L
ANIONS		xx.x	MG/L
PO4	(as P)	xx.x	MG/L
TKN	(as N)	xx.x	MG/L
NH3	(as N)	xx.x	MG/L
NO2	(as N)	xx.x	MG/L
NO3	(as N)	xx.x	MG/L
OIL AND GREASE		xx.x	MG/L

b. The order of the waste characteristic cards is not important.

c. Default data describing a typical municipal waste have been included in the program. Waste influent characteristics not specified by the user will be taken from these default data. The user must specify the average flow, as no default value is supplied for this data item. If minimum or maximum flows are not specified, they will be set equal to the average flow automatically.

d. The data included in the program are shown below:

TEMPERATURE	18 DEG CENT
SUSPENDED SOLIDS	200 MG/L
VOLATILE SOLIDS	60 %
SETTABLE SOLIDS	15 MG/L
BOD5	250 MG/L
SBOD SOLUBLE	75 MG/L
COD	500 MG/L
SCOD SOLUBLE	400 MG/L
PH	7.6
CATIONS	160 MG/L
ANIONS	160 MG/L
PO4	18 MG/L
TKN	45 MG/L
NH3	25 MG/L
NO2	0.0 MG/L
NO3	0.0 MG/L
OIL AND GREASE	80 MG/L

2-8. Desired Effluent Characteristics.

a. The fifth major division of input data is the statement of the desired effluent characteristics. Only those characteristics the user wishes to have checked need be specified in the input. If the user does not wish to have any effluent characteristics checked, he need only list the header card.

b. The specification of the individual effluent characteristics is the same as for the waste influent and will not be repeated here. The header card must contain the key word DESIRE in the first six columns and may be specified as follows:

DESIRED EFFLUENT CHARACTERISTICS

c. The input of desired effluent characteristics is terminated with the unit cost header card "UNIT COST." This header card must contain the key word UNIT C in the first six columns.

d. There are no default data for the Desired Effluent characteristics included in the program.

2-9. Unit Cost Data.

a. The sixth major division of input data is the unit cost data. This section begins with the header card "UNIT COST DATA" and ends with an "END" card. The unit cost data cards which may be specified are listed below with their associated units.

Unit Cost Data Cards

UNIT COST DATA		
BUILDING COST	xx.x	$/SQ FT
WALL CONCRETE	xx.x	$/CU YD
SLAB CONCRETE	xx.x	$/CU YD
EXCAVATION COST	xx.x	$/CU YD
MARSHALL AND SWIFT INDEX[a]	xx.x	
CRANE RENTAL	xx.x	$/HR
CANOPY ROOF COST	xx.x	$/SQ FT
LABOR RATE	xx.x	$/HR

(Continued)

Unit Cost Data Cards (Continued)

OPERATOR II LABOR RATE	xx.x	$/HR
ELECTRICITY COST	xx.x	$/KWHR
CHEMICALS LIME = xx.x ALUM = xx.x IRON = xx.x		
POLYMER = xx.x		$/LB
ENGINEERING NEWS RECORD INDEX	xx.x	
HANDRAIL COST	xx.x	$/FT
PIPE COST INDEX xx.x INSTALLATION LABOR RATE xx.x		$/HR
EIGHT INCH PIPE COSTS PIPE = xx.x		$/FT
BEND = xx.x $/UNIT Tee = xx.x $/UNIT VALVE = xx.x $/UNIT		
LARGE CITY EPA INDEX[b]	xx.x	
SMALL CITY EPA INDEX[b]	xx.x	
BLOWERS[c] COSTBS = xx.x COSTSBM = xx.x COSTSBL = xx.x		
LAND COST	xx.x	$/ACRE
MISCELLANEOUS COST	xx.x	PERCENT
ADMINISTRATIVE/LEGAL COST	xx.x	PERCENT
201 PLANNING COST	xx.x	PERCENT
INSPECTION COST	xx.x	PERCENT
CONTINGENCY COST	xx.x	PERCENT
PROFIT AND OVERHEAD COST	xx.x	PERCENT
TECHNICAL COST	xx.x	PERCENT
SPECIAL FOUNDATIONS[d]		
PUMPING (INFLUENT)[d]		
OUTFALL PUMPING[d]		

(continued)

DIFFUSED OUTFALL[d]

END

---

[a]Available from Chemical Engineering magazine.

[b]Use large city or small city index, but not both - default is First Quarter 1977 Small City EPA Index.

[c]COSTSBS = Cost of standard 3000 scfm @ 8 psig capacity rotary positive displacement blower - default value = $16,000.

COSTSBM = Cost of Standard 12,000 scfm @ 8 psig capacity vertically-split multistage centrifugal blower - default value = $45,000.

COSTSBL = Cost of standard 50,000 scfm @ 8 psig capacity pedestal-type single-stage centrifugal blower - default value = $300,000.

[d]Optional cards which should be used only when the indicated facilities are required.

b. Default data for the unit cost items included in the program are listed below:

```
BUILDING COSTS                                  40.0             $/SQ FT
EXCAVATION                                      1.15             $/CU YD
WALL CONCRETE                                   300.00           $/CU YD
SLAB CONCRETE                                   200.00           $/CU YD
MARSHALL AND SWIFT INDEX                        491.6
CRANE RENTAL                                    40.00            $/HR
CANOPY ROOF      10.0 $/SQFT
LABOR RATE                                      6.00             $/HR
OPERATOR II LABOR RATE                          6.00             $/HR
ELECTRICITY                                     0.04             $/KHR
CHEMICAL COST LIME 0.02 $/LB ALUM 0.10 $/LB IRON 0.18 $/LB POLYMER 1.0
ENGINEERING NEWS RECORD COST INDEX 2470.0
HAND RAIL              25.20 $/FT
PIPE COST INDEX 241.0  PIPE INSTALLATION LABOR RATE 10.0  $/HR
EIGHT INCH PIPE COST PIPE 7.41 BEND 70.88 TEE 104.90 VALVE 1099.0
LARGE CITY EPA INDEX 132.0
MISCELLANEOS NONCONSTRU COSTS 5.0 %
ADMIN/LEGAL   2.0 %
201 PLANNING    3.5 %
INSPECTION    2.0 %
CONTINGENCIES     8.00 %
PROFIT AND OVERHEAD    22.0 %
TECHNICAL COSTS    2.0 %
LAND COSTS      1000.00    $/ACRE
```

2-10. Program Control Cards.

a. The seventh and final major division of input is the control cards. This section begins with the header card "CONTROL CARDS" and will be terminated with the control card "GO."

b. Program control cards use the same format as the Unit Process Specification cards. The following control cards may be used:

CONTROL CARDS

ANALYZE

LIST TOTAL OF XXX TRAINS

OUTPUT QUANTITIES

PRINT DESIGNS FOR TRAIN NO X, X, X, . . . X.

SUMMARY ONLY

GO I = xx.x NY = xx.x

c. The GO card should be the last card included in the data. The "GO" card is required as it causes the program to begin its execution phase. The letters GO must appear in columns 1 and 2 of the card with all other data beginning no sooner than column 7. The sequence of the two numeric data values must be specified as shown. Both the interest rate and amortization period must be specified as no default data are provided for these two values. The data required on the GO card consist of:

I - annual interest rate, percent

NY - amortization period, years

d. All other output control cards are optional. Under the "LIST T" option, a specified number of trains are listed with capital, O&M, and equivalent annual costs. The "PRINT" option will provide detailed design and cost data for each treatment process within each specified train. Either or both options may be included for each run. The ANALYZE card causes unit process design data to be printed on the first pass through the computer in the order in which they are initially processed, i.e., prior to economic ranking or checking for desired effluent quality. The OUTPUT QUANTITIES will cause the quantities computed for estimate costing to be printed. These quantities include such items as volume of excavation, quantity of reinforced concrete and the annual energy requirement. The SUMMARY ONLY card will defeat the printing of design data and quantity output and will allow only the cost summary sheet for each train to be printed. The cost summaries will be printed only for those trains which would have had design data printed if this card was not present.

e. Figure 2-4 shows the total input needed to make the program run. The user should refer to the detailed procedure for data input in Appendix A.

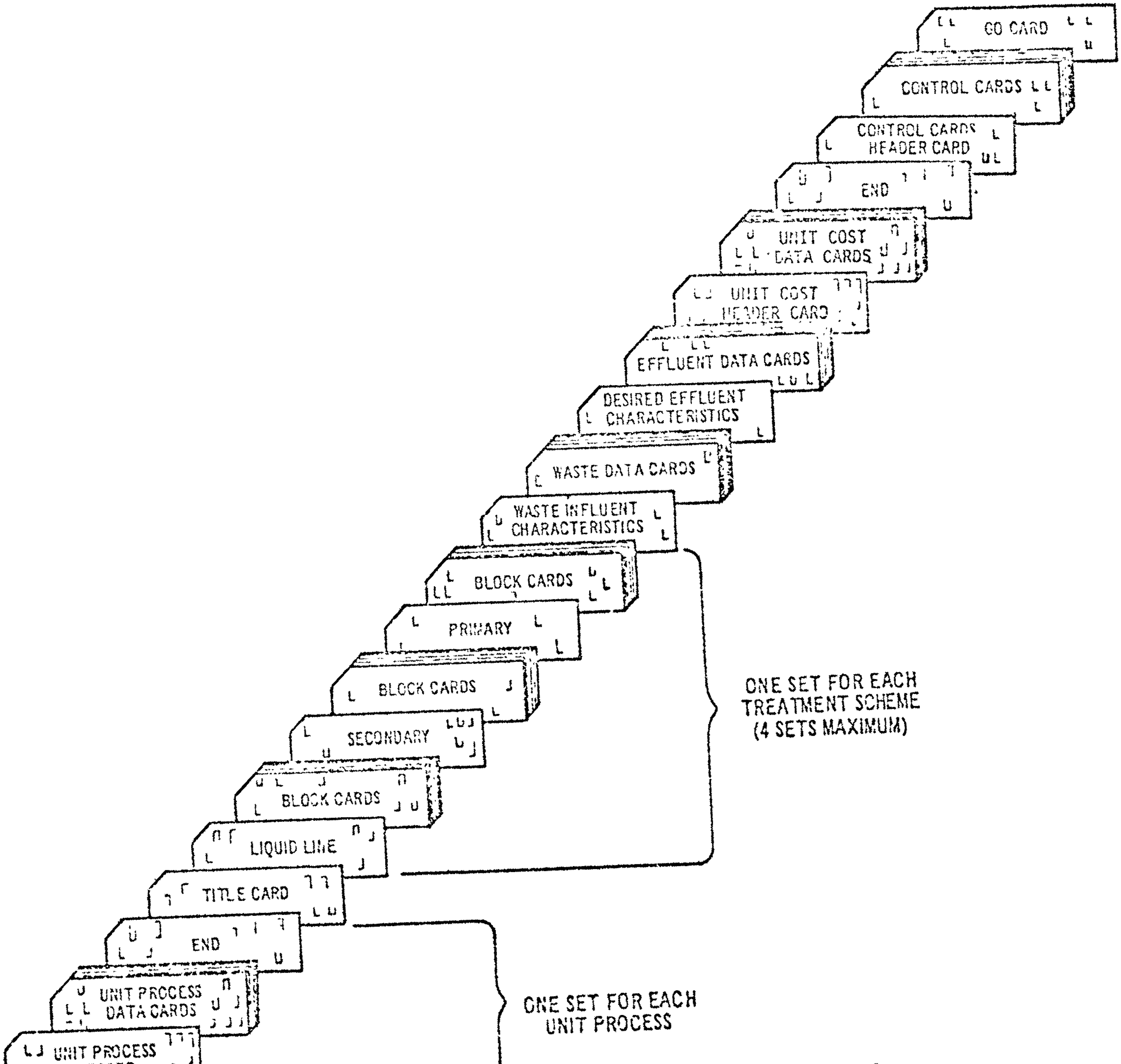

Figure 2-4. Input data cards

2-11. Cost Analysis in the Computerized Design Process.

a. The user through the use of the "GO" control card inputs the interest rate and design life into the program. These parameters are described in 2-10c.

b. The annual interest rate is used to amortize the capital cost and compute the equivalent annual cost to determine the most cost-effective process train. The design life pertains to the period over which the design is evaluated for cost-effectiveness.

c. Cost data for the unit processes used in the process train are stored in the program. These cost data form the basis for an analysis of the capital, O&M, and equivalent annual costs of the process trains.

d. To allow for unique site-specific problems, the user may elect to input locally generated costs for some or all unit processes. These cost data will then override the cost equations or cost estimate formulations used in the model. The format for the user specified costs for each process is shown in Chapter 3.

e. The output of the program is generally a listing of the process trains that meet the desired effluent criteria in order of increasing average annual cost. The capital, O&M, and equivalent annual costs are listed for each process train. A more detailed cost analysis of individual processes in a particular train is available through the "PRINT" control card.

CHAPTER 3

UNIT PROCESS SPECIFICATIONS

3-1. a) General. This chapter contains the specific input data for each unit process. Each line of data that may be included for a particular unit process is listed along with the proper units. Each line of data under each unit process in this chapter corresponds to one card or line of input to the model. It is permissible to interchange whole lines of data; however, within each line the data must be typed in the order shown. The unit process name (header card) and the END card must be the first and last lines or cards for each unit process.

b) Estimate Costing. This is a new approach to planning level costing. For each process a typical configuration and method of construction has been assumed. Using these assumptions, quantities are calculated and costs extended by multiplying by unit costs supplied by the user. This allows the user to update the cost base to his specific location and to the current year by inputting the current unit prices. The user requests the use of this costing technique by including an ESTIMATE card in the input data for each unit process.

c) ESTIMATE Card. The ESTIMATE card which may optionally be included in the unit process input data specifies that estimate type costing is to be used for the particular process. In general, the data on this card will include the cost of one or more 'standard size' items of equipment. Costs of the required sizes of these items of equipment will be generated within the program. If the user elects to specify the costs of these items, he should use the current cost of the standard size unit. If these costs are omitted from the ESTIMATE card or are specified as zero, the program will use the ~~first~~ quarter 1977 cost updated by the Marshall and Swift equipment cost index specified in the unit cost input.

d) Parametric Costing. If Estimate costing is not specified costs will be computed using parametric equations obtained from various sources. Where applicable the Dames and Moore equations will be used. These costs will be updated to the current year using the EPA construction cost index. Parametric cost equations are not available for all processes thus some costs will be indicated as zero. For this reason, extreme care should be used in evaluating costs generated using the parametric equations.

(This page left blank intentionally.)

e) Default Data. Default data have been included within the program for modification zero of all unit processes included within CAPDET. Thus, for modification zero of these processes it is necessary to include data only for those data items the user wishes to change. To change one or more data items the user should specify a unit process header card for modification zero of the process followed by data cards for those items the user wishes to change. An END card will conclude input of data for that process. The user will have to include an ESTIMATE card in the input for any process which he changes if he wishes to retain estimate type costing, as changing any item of data will revert that process to parametric costing unless otherwise specified. Estimate costing is the default option if no data are entered for the process. This default may be defeated and the process reverted to parametric costing by including a header card and an END card for the particular process.

NOTE: No data have been included in the program for modifications one or two of the unit processes. Complete data must be supplied by the user if he uses either of these modifications.

3-2. <u>Aerated Lagoon</u> (See page 7-205 of Design Manual).

a. Design Parameters

Eckenfelder's Approach

K	Reaction rate constant, 0.0007-0.002 ℓ/mg-hr.
A	Fraction of BOD synthesized, ≈0.73.
A^{∇}	Fraction of BOD oxidized for energy, ≈ 0.52.
B	Endogenous respiration rate (oxygen basis) ≈ 0.075/day.
B^{∇}	Endogenous respiration rate (sludge basis) ≈ 0.15/day.
THETA	Temperature Coefficient ≈ 1.035.
ALPHA	0_2 transfer in waste/0_2 transfer in water, ≈0.9.
BETA	0_2 saturation in waste/0_2 saturation in water, ≈0.9.
HP	Horsepower per 1000 gallons. Horsepower required to keep solids in suspension ≥ 0.06 hp/1000 gal.
STE	Standard transfer efficiency.

Mechanical Aerators ≈ 2.0-3.5 lb 0_2/hp-hr

High Speed ≈ 2.0
Slow Speed ≈ 3.5

Diffused Aerator ≈ 6.0-11.0%

Coarse bubble ≈ 6.0
Fine bubble ≈ 11.0

b. Default Data

```
ESTIMATF
LINFR         1.00 PFR SQ FT
SUMMER TEMPERATURE                    30          CENT
WINTER TEMPERATURE                    10          CENT
EFFLUENT SOLUBLE BOD                  20          MG/I
CONSTANTS   K=0.001 A=0.50 AP=0.53  B=0.06 BP=0.15 THETA=1.035
MECHANICAL AERATION ALPHA=0.9 BETA=0.9 HP=0.014 HP/TG STF=3.5 LB O/HP
```

c. Aerated Lagoon Unit Process Data Cards.

AERATED LAGOON MOD xx

SUMMER WATER TEMPERATURE xx.x DEG CENT

WINTER WATER TEMPERATURE xx.x DEG CENT

EFFLUENT SOLUBLE BOD xx.x MG/L

CONSTANTS K=xx.x A=xx.x A^{∇}=xx.x B^{∇}=xx.x THETA=xx.x

MECHANICAL AERATION ALPHA[a]=xx.x BETA=xx.x HP=xx.x HP/TG
STE = xx.x LB 0/HP-HR

DIFFUSED AERATION ALPHA[a]=xx.x BETA=xx.x AF[b]=xx.x CFM/TG
STE = xx.x PERCENT

ESTIMATE[c] COSTSA=xx.x $

LINER UPILL=xx.x $/SQ FT

END

---

[a]Use mechanical or diffused; not both

[b]AF (minimum air flow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

[c]COSTSA = Cost of standard 5-hp aerator - default value = $13,960.

3-3. Aerobic Digestion (See page 7-277 of Design Manual)

a. Design Parameters

Detention time, days at 20°C
  Activated sludge only ≈ 12-16 days
  Activated sludge from plant without primary settling ≈ 16-18 days
  Primary sludge plus activated or trickling filter sludge ≈ 18-22 days
Detention time should be increased for temperatures below 20°C

Volatile solids destroyed: 40 percent is common but it increases with temperature and retention time from approximately 33 to 70 percent

Mixed Liquor solids ≈ 12000 mg/ℓ

Solids in digested sludge ≈ 2.5 percent

ALPHA O_2 transfer in waste/O_2 transfer in water ≈ 0.9

BETA O_2 saturation in waste/O_2 saturation in water ≈ 0.9

Standard Transfer Efficiency ≈ 6.0-11.0%

Coarse bubble≈6.0
Fine bubble≈11.0

b. Default Data

```
ESTIMATE
DIFFUSED
DETENTION TIME                          15        DAYS
VOLATILE SOLIDS DESTROYED               50        PERCENT
MIXED LIQUOR SOLIDS                     12000     MG/L
SOLIDS IN DIGESTED SLUDGE               2.5       PERCENT
CONSTATNTS    ALPHA=0.9   BETA=0.9
STANDARD TRANSFER EFFICIENCY            12.0       PERCENT
TEMPERATURE                             20        CENT
```

c. Aerobic Digestion Unit Process Data Cards

AEROBIC DIGESTION MOD xx		
DETENTION TIME	xx.x	DAYS
VOLATILE SOLIDS DESTROYED	xx.x	PERCENT
MIXED LIQUOR SOLIDS	xx.x	MG/L
SOLIDS IN DIGESTED SLUDGE	xx.x	PERCENT
DIFFUSED AERATION[a]		
MECHANICAL AERATION[a]		
CONSTANT ALPHA = xx.x BETA = xx.x		
STANDARD TRANSFER EFFICIENCY	xx.x	PERCENT
TEMPERATURE	xx.x	DEG CENT
ESTIMATE[b] SSXSA=xx.x	COSTPD=xx.x	COSTPH=ss.s
END		

---

[a]Use mechanical or diffused; not both.

[b]SSXSA = Cost of standard slow-speed pier-mounted 20-hp aerator default value = $16,300.

COSTPD = Cost of standard 12.0 scfm coarse-bubble diffuser - default value = $6.50.

COSTPH = Cost of standard 550 scfm swing arm diffuser - default value = $5,000.

3-4. Anaerobic Digestion (see page 7-291 of Design Manual)

a. Design Parameters.

Specific gravity ≈ 1.05
Percent volatile solids destroyed (See Figure 3-1 provided below) ≈ 40-60 percent
Concentration of solids in digester ≈ 3-7 percent
Detention time ≈ 15-70 days
U Heat Loss Coefficient ≈ 0.18 BTU/hr/ft^2/^{o}F

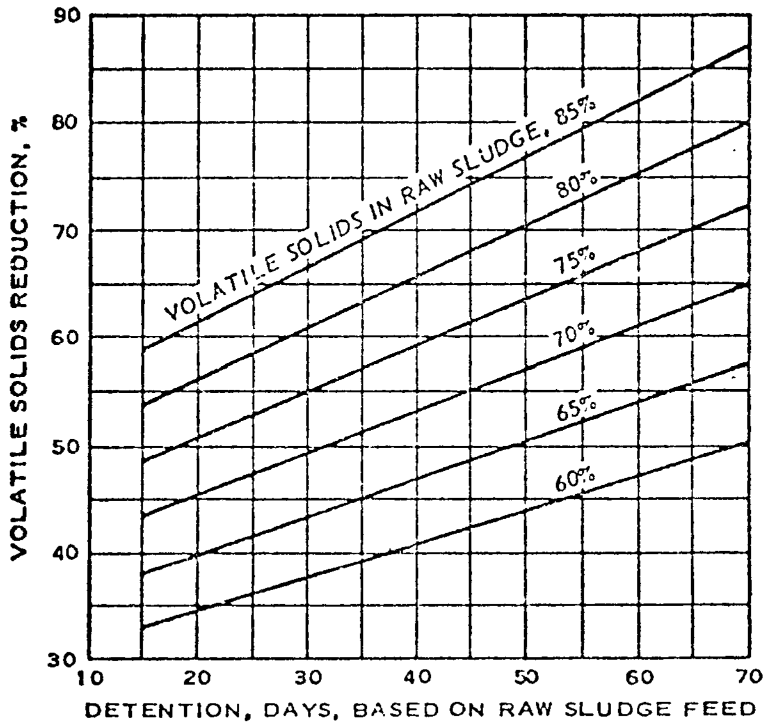

Figure 3-1. Reduction in volatile solids in raw sludge, for detentions from 15 to 70 days, T=85 to 95^{o}F.

b. Default Data

```
SOUTHFRN U S
FSTIMATF
SPFCIFIC GRAVITY                        1.05
PFRCENT VS DFSTROYFD                    50               PERCENT
CONCENTRATION IN DIGESTER               5                PERCENT
TEMPERATURE    RAW=70    DIGESTER=100   AIR=40           DEG F
DETENTION TIME                          15               DAYS
DEPTH                                   25               FT
CONSTANT                                U=0.18           BTU HR/SQFT/F
```

c. Anaerobic Digestion Unit Process Data Cards

ANAEROBIC DIGESTION MOD xx		
SPECIFIC GRAVITY	xx.x	
PERCENT VS DESTROYED	xx.x	PERCENT
CONCENTRATION IN DIGESTER	xx.x	PERCENT
TEMPERATURE RAW = xx.x = xx.x Air= XX.X		DEG F
DETENTION TIME	xx.x	DAYS
DEPTH[a]	xx.x	FT
CONSTANT	U = xx.x	BTU/HR/ SQFT/DEG F
AREAS WALL[a] = xx.x FLOOR = xx.x Cover xx.x		SQFT
SOUTHERN UNITED STATES[b]		
MIDDLE UNITED STATES[b]		
NORTHERN UNITED STATES[b]		
ESTIMATE[c] SFLOCO = xx.x CGCUS = xx.x HRHXS = xx.x CGSES = xx.x CSPUMP = xx.x		
END		

---

[a]List areas or depths, not both.

[b]Use only one of Southern, Middle, or Northern cards - default is Southern United States.

[c]SFLOCO = Cost of standard 70-foot diameter floating cover - default value = $71,000.

CGCUS = Cost of standard 60-foot diameter gas circulation unit - default value = $32,000.

HRHXS = Cost of standard 1 million Btu/hour heating unit - default value = $49,000.

CGSES = Cost of standard 2-inch diameter gas safety equipment - default value = $7,100

CSPUMP = Cost of standard size sludge pump (8- gpm @ 70 feet of head) - default value = $2,500.

3-5. <u>Anion Exchange</u> (see page 6-43 of Design Manual)

a. Design Parameters

Treatment flow rate, 2-5 gpm/ft^3

Regenerant flow rate, 1-2 gpm/ft^3

Rinsing flow rate, 0.5-1.5 gpm/ft^3

Amount of rinse water, 30-120 gal/ft^3

Column depth, 24-30 inches minimum

Amount of backwash water, ≈ 100 gal/ft^3

Backwash water rate, ≈ 15 gpm/ft^3

Resin exchange capacity, lb/ft^3 (consult manufacturer specifications)

Regenerant dose, level, concentration, and specific gravity (consult resin manufacturer specifications)

b. Default Data

```
EFFLUENT CONCENTRATION                      2          MG/L
RESIN EXCHANGE CAPACITY                     4          LB/CFT
REGENERATE    DOSE=12 LB/CFT  LEVEL=7.5 LB/CFT   CONC=7.5 PER   SG=1.0
FLOW RATES   TREAT=3  REGENT=1.5  RINSE=1.0  GPM/CFT
HOURS PER DAY                               8          HOURS
AMOUNT OF RINSE WATER                       60         G/CFT
COLUMN DEPTH                                24         INCHES
BACKWASH   AMOUNT= 100  G/CFT   RATE= 10 GPM/CFT
```

c. Anion Exchange Unit Process Data Cards

ANION EXCHANGE	MOD xx		
EFFLUENT CONCENTRATION		xx.x	MG/L
RESIN EXCHANGE CAPACITY		xx.x	LB/CFT
REGENERANT DOSE = xx.x LB/CFT LEVEL = xx.x LB/CUFT CONC = xx.x% SG = xx.x			
FLOW RATES TREAT = xx.x REGEN = xx.x RINSE = xx.x			GPM/CFT
HOURS PER DAY		xx.x	HOURS
AMOUNT OF RINSE WATER		xx.x	G/CFT
COLUMN DEPTH		xx.x	INCHES
BACKWASH AMOUNT = xx.x G/CFT	RATE =	xx.x	GPM/CFT
END			

3-6. Carbon Adsorption (see page 6-3 of Design Manual)

a. Design Parameters

Carbon Requirements

Tertiary treatment ≈ 250-350 16/million gal

Secondary treatment ≈ 500-1800 16/million gal

Hydraulic loading, 4-8 gpm/ft^2

Contact time, 30-60 min.

Backwash rate, 10-15 gpm/ft^2

Backwash time, ≈ 15 min.

Adsorption capacity (from laboratory study)

Rate Constant (from laboratory study)

b. Default Data

CARBON REQUIREMENTS	300	LB/MG
HYDRAULIC LOADING	6	GPM/SQFT
CONTACT TIME	45	MINUTES
BACKWASH RATE= 15 GPM/SQFT	TIME= 10 MIN	
ADSORPTION CAPACITY	4	LB/CFT
BREAKPOINT CONCENTRATION	5	MG/L
RATE CONSTANT	12	

c. Carbon Adsorption Unit Process Data Cards

CARBON ADSORPTION	MOD xx		
CARBON REQUIREMENTS		xx.x	LB/MG
HYDRAULIC LOADING		xx.x	GPM/SQFT
CONTACT TIME		xx.x	MIN
BACKWASH RATE = xx.x GPM/SQFT TIME =		xx.x	MIN
ADSORPTION CAPACITY		xx.x	LB/CFT
BREAKPOINT CONCENTRATION		xx.x	MG/L
RATE CONSTANT		xx.x	
END			

3-7. <u>Cascade Aeration</u> (see page 5-165 of Design Manual)

a. Design Parameters

Free weir indicates a free fall aeration process.

Step weir is a series of free falls. A step weir reduces the required head as it increases the oxygen transfer efficiency.

b. Default Data

```
DISSOLVED OXYGEN        INITIAL= 2.0     FINAL= 5.0   MG/L
FREE WEIR
TEMPERATURE                        18          DEG CENT
```

c. Cascade Aeration Unit Process Data Cards

CASCADE AERATION	MOD xx		
DISSOLVED OXYGEN	INITIAL = xx.x	FINAL = xx.x	MG/L
FREE WEIRS[a]			
STEP WEIRS[a]			
TEMPERATURE	xx.x DEG CENT		
END			

---

[a]Use free or step; not both.

3-8. <u>Cation</u> <u>Exchange</u> (see page 6-43 of Design Manual)

a. Design Parameters

Treatment flow rate, 2-5 gpm/ft^3

Regenerant flow rate, 1-2 gpm/ft^3

Rinsing flow rate, 0.5-1.5 gpm/ft^3

Amount of rinse water, 30-120 gal/ft^3

Column depth, 24-30 inches minimum

Amount of backwash water, ≈ 100 gal/ft^3

Backwash water rate, ≈ 15 gpm/ft^3

Resin exchange capacity, lb/ft^3 (consult manufacturer specifications)

Regenerant dose, level, concentration, and specific gravity (consult resin manufacturer specifications)

b. Default Data

```
EFFLUENT CONCENTRATION                 2          MG/I
RESIN EXCHANGE CAPACITY                4          LB/CFT
REGENERATE DOSE=12 LB/CFT   LEVEL=7.5 LB/CFT   CONC=7.5 PER   SG=1.04
FLOW RATES  TREAT=3   REGEN =1.5   RINSE=1.0      GPM/CFT
HOURS PER DAY                          8          HOURS
AMOUNT OF RINSE WATER                  50         G/CFT
COLUMN DEPTH                           24         INCHES
BACKWASH   AMOUNT=100.0 G/CFT   RATE=10 GPM/CFT
```

c. Cation Exchange Unit Process Data Cards

```
CATION EXCHANGE     MOD xx

EFFLUENT CONCENTRATION                          xx.x           MG/L

RESIN EXCHANGE CAPACITY                         xx.x           LB/CFT

REGENERANT DOSE = xx.x  LB/CFT Level = xx.x LB/CUFT
           CONC = xx.x % SG = xx.x

FLOW RATES TREAT = xx.x  REGEN = xx.x
           RINSE = xx.x                                        GPM/CFT

HOURS PER DAY                                   xx.x           HOURS

AMOUNT OF RINSE WATER                           xx.x           G/CFT

COLUMN DEPTH                                    xx.x           INCHES

BACKWASH AMOUNT = xx.x  GAL/CUFT RATE= xx.x                    GPM/CFT

END
```

3-9. <u>Centrifugation</u> (see page 5-131 of Design Manual)

a. Design Parameters

Power requirement for centrifuge≈ 0.5-2.0 hp/gpm

Excess capacity factors≈ 1.25

Chemical dosage≈ 10.0% of dry weight of solids

b. Default Data

ESTIMATE		
POWER REQUIREMENT	1.0	HP/GPM
HOURS PER DAY	8	HOURS
DAYS PER WEEK	5	DAYS
NUMBER OF UNITS	2.0	UNITS
EXCESS CAPACITY FACTOR	1.25	
CHEMICAL DOSE	10	PERCENT DRY

c. Centrifugation Unit Process Data Cards

CENTRIFUGATION	MOD xx		
POWER REQUIREMENT		xx.x	HP/GPM
HOURS PER DAY		xx.x	HOURS
DAYS PER WEEK		xx.x	DAYS
NUMBER OF UNITS		xx.x	UNITS
EXCESS CAPACITY FACTOR		xx.x	PERCENT
CHEMICAL DOSE		xx.x	PERCENT DRY WT
ESTIMATE[a]	COSTSC	= xx.x	
END			

---

[a]COSTSC = Cost of standard 50-hp centrifuge - default value = $165,000

3-10. Chlorination (see page 6-35 of Design Manual)

a. Design Parameters

Contact time should not be less than 15 minutes at peak flow.

Typical chlorine dosages for disinfection and odor control are shown in Table 3-1.

Table 3-1. Typical Chlorine Dosages for Disinfection and Odor Control

Effluent from	Dosage Range mg/ℓ
Untreated wastewater (prechlorination)	6 to 25
Primary sedimentation	5 to 20
Chemical precipitation plant	2 to 6
Trickling filter plant	3 to 15
Activated sludge plant	2 to 8
Multimedia filter following activated sludge plant	1 to 5

b. Default Data

ESTIMATE	100	$/TON
CONTACT TIME	30	MIN
CHLORINE DOSE	10	MG/l

c. Chlorination Unit Process Data Cards

CHLORINATION	MOD xx		
CONTACT TIME		xx.x	MIN
CHLORINE DOSE		xx.x	MG/L
NUMBER OF TANKS		xx	
ESTIMATE[a]	CHLCOST = xx.x $/TON	COSTCLE xx.x	
END			

---

[a]CHLCOST = Cost of chlorine - no default value.

COSTCLE = Cost of standard 2000 lb/day chlorinator default value = $2,700.

3-11. Coagulation (see page 6-17 of Design Manual)

a. Design Parameters

Detention time in rapid mix basin≈ 1.0-3.0 minutes
Detention time in flocculator≈ 15-60 minutes

Coagulant	Coagulant Dose (mg/ℓ)	Optimum Ph
Lime	200.0 - 500.0	10.0 - 11.0
Alum	50.0 - 100.0	5.0 - 6.5
Iron Salts	100.0 - 250.0	5.0 - 6.5

b. Design Parameters

```
ESTIMATE
DETENTION TIME      RAPID MIX=2.0     FLOCCULATOR=45    MIN
OPTIMIUM PH                              10.5
COAGULANT DOSE                           100         MG/l
LIME
```

c. Coagulation Unit Process Data Cards

COAGULATION[a]	MOD xx			
DETENTION TIME	RAPID MIX = xx.x	FLOCCULATOR = xx.x		MIN
OPTIMUM PH	xx.x			
COAGULANT DOSE	xx.x			MG/L
LIME[b]				
ALUM[b]				
IRON SALTS[b]				
ESTIMATE[c]	COSTCL[d] = xx.x			
END				

---

[a] User must also specify primary clarification (coagulation).

[b] Use only one of lime, alum, or iron salts cards - default is lime.

[c] If estimate costing is requested, pricing will be based on a combined flocculator and clarifier and separate prices for the clarifier will not be calculated. With parametric costing, the costs of both units will be calculated separately.

[d] COSTCL = Cost of standard 60-foot diameter upflow clarifier - default value = $110,000.

3-12. Comminution (see page 5-29 of Design Manual)

a. Default Data

NUMBER OF UNITS	2

b. Comminution Unit Process Data Cards

COMMINUTION[a]	MOD xx	
NUMBER OF UNITS		xx
END		

[a]This process used with preliminary treatment.

3-13. <u>Complete</u> <u>Mix</u> <u>Activated</u> <u>Sludge</u> (see page 7-37 of Design Manual)

a. Design Parameters

Eckenfelder's Approach

Reaction rate constants

- k, BOD removal rate constant≈ 0.0007-0.002 ℓ/mg/hr
- a, fraction of BOD synthesized ≈0.73
- a^{∇}, fraction of BOD oxidized for energy ≈ 0.52
- b, endogenous rate (oxygen basis) ≈ 0.075/day
- b^{∇}, endogenous rate (sludge basis) ≈ 0.15/day
- f, nonbiodegradable fraction of VSS in influent ≈ 0.40
- f^{∇}, degradable fraction of the MLVSS ≈ 0.53

F/M ratio ≈ 0.3 - 0.6

Mixed liquor suspended solids≈ 3000 - 6000 mg/ℓ
Mixed liquor volatile solids≈ 2100 - 4200 mg/ℓ
Temperature correction coefficient≈ 1.0 - 1.04
Effluent BOD soluble ≈ 10 mg/ℓ

ALPHA O_2 transfer in waste/O_2 in water≈ 0.90

BETA O_2 saturation in waste/O_2 saturation in water≈ 0.90

HP Horsepower per 1000 gallons ≥ 0.10 hp/1000 gal

STE Standard transfer efficiency

Mechanical Aerators≈ 2.0 - 3.5 16 O_2/hp-hr

High Speed≈ 2.0
Slow Speed≈ 3.5

Diffused Aerator≈ 6.0 - 11.0%

Coarse bubble≈ 6.0
Fine bubble ≈ 11.0

b. Default Data

```
ESTIMATE
CONSTANTS  K=0.00135 A=0.73 AP=0.52 B=0.075 BP=0.15 F=0.4 FP=0.53
F/M RATIO                                0.5        LB BOD/LB VSS
MIXED LIQUOR     SS=4500     VS=3150               MG/L
TEMPERATURE COEFFICIENT                  1.035
EFFLUENT BOD SOLUBLE                     30         MG/L
DIFFUSED AERATION ALPHA=0.9 BETA=0.9 AP=0.0 CPM/TG STE=12   PERCE
```

c. Complete Mix Activated Sludge Unit Process Data Cards

```
COMPLETE MIX ACTIVATED SLUDGE[a]    MOD xx
CONSTANTS K = xx.x  A = xx.x  A∇ = xx.x  B∇ = xx.x  F = xx.x
          F∇ = xx.x
F/M RATIO                           xx.x          LB BOD/LB VSS
MIXED LIQUOR SS = xx.x  VS = xx.x                 MG/L
TEMPERATURE COEFFICIENT             xx.x
EFFLUENT BOD SOLUBLE                xx.x          MG/L
MECHANICAL AERATION ALPHA[b] = xx.x  BETA = xx.x  HP = xx.x
          HP/TG  STE = xx.x  LB O/HP-HR
DIFFUSED AERATION ALPHA[b] = xx.x  BETA = xx.x  AF[c] = xx.x
          CFM/TG  STE = xx.x PER
ESTIMATE[d] SSXSA = xx.x  COSTPD = xx.x  COSTPH = xx.x
          COSTPS = xx.x
END
```

---

[a] User must also specify secondary clarification (activated sludge).

[b] Use mechanical or diffused, not both.

[c] AF (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

[d] SSXSA = Cost of standard slow-speed pier-mounted 20-hp aerator - default value = $16,300.

COSTPD = Cost of standard 12.0 scfm coarse-bubble diffuser - default value = $6.50.

COSTPH = Cost of standard 550 scfm swing arm diffuser - default value = $5,000.

COSTPS = Cost of standard 3000 gpm pump and driver unit - default value = $17,250.

3-14. Contact Stabilization Activated Sludge (see page 7-15 of Design Manual)

a. Design Parameters

	Contact Tank	Stabilization Tank
Contact time, hrs	0.5 - 1.0	2.0 - 4.0
Mixed liquor SS, mg/ℓ	2500–3500	4000–8000

Percent volatile ≈ 70 percent

Oxygen Required ≈ 1.25 - 1.50 lb O_2/lb BOD removed/day

Sludge Production ≈ 0.2 - 0.4 lb solids/lb BOD removed/day

f^{∇}, nonbiodegradable fraction of VSS ≈ 0.53

Effluent BOD soluble ≈ 10 mg/ℓ

ALPHA O_2 transfer in waste/O_2 transfer in water ≈ 0.90

BETA O_2 saturation in waste/O_2 saturation in water ≈ 0.90

HP Horsepower per 1000 gallons ≥ 0.10 hp/1000 gal

STE Standard transfer efficiency

Mechanical Aerators ≈ 2.0 - 3.5 16 O_2/hp-hr
 High Speed ≈ 2.0
 Slow Speed ≈ 3.5

Diffused Aerator ≈ 6.0 - 11.0%
 Coarse bubble ≈ 6.0
 Fine bubble ≈ 11.0

b. Default Data

```
ESTIMATE
AERATION TIME CONTACT 1.0     STABILIZATION  3    HOURS
MIXED LIQUOR   SS   CONTACT=3000   STABILIZATION=6000      MG/L
PERCENT VOLATILE                    70         PERCENT
OXYGEN REQUIRED                     1.25       LB O/LB BOD/DAY
SLUDGE PRODUCTION                   0.3        LB/LB BOD/DAY
CONSTANTS                           FP=0.5
EFFLUENT BOD SOLUBLE                10         MG/L
DIFFUSED AERATION ALPHA=0.9 BETA=0.9 AP=0.0 CPM/TG STE=12   PERCEN
```

c. Contact Stabilization Activated Sludge Unit Process Data Cards

CONTACT STABILIZATION ACTIVATED SLUDGE[a] MOD xx		
AERATION TIME CONTACT = xx.x STAB BASIN = xx.x		HOURS
MIXED LIQUOR SS CONTACT = xx.x STAB BASIN = xx.x		MG/L
PERCENT VOLATILE	xx.x	PERCENT
OXYGEN REQUIRED	xx.x	LB O/LB BOD/DAY
SLUDGE PRODUCTION	xx.x	LB SOLID/LB BOD/DAY
CONSTANT F^{∇} = xx.x		FRACTION
EFFLUENT BOD SOLUBLE	xx.x	MG/L

MECHANICAL AERATION ALPHA[b] = xx.x BETA = xx.x
HP = xx.x HP/TG STE = xx.x LB O/HP-HR

DIFFUSED AERATION ALPHA[b] = xx.x BETA = xx.x
AF[c] = xx.x CFM/TG STE = xx.x PER

ESTIMATE[d] SSXSA = xx.x COSTPD = xx.x COSTPH = xx.x
COSTPS = xx.x

END

---

[a]User must also specify secondary clarification (activated sludge).

[b]Use mechanical or diffused, not both.

[c]AF (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

[d]SSXSA = Cost of standard slow-speed pier-mounted 20-hp aerator - default value = $16,300.

COSTPD = Cost of standard 12.0 scfm coarse-bubble diffuser - default value = $6.50.

COSTPH = Cost of standard 550 scfm swing arm diffuser - default value = $5,000.

COSTPS = Cost of standard 3000 gpm pump and driver unit - default value = $17,250.

3-15. Costs Overrides

a. To allow for unique site-specific problems, the user may elect to input locally generated costs for some or all unit processes. Within the Unit Specification Section, the user has the option to insert, under the COSTS header card, costs of unit processes for which the user has more accurate data than that generated by the CAPDET model. There are four values required for each process. The first item of data is present day capital cost in dollars, the second item is the number of operational man-hours per year associated with the process, the third item is the number of maintenance man-hours per year required, and the fourth item is the supply cost in present day dollars per year.

b. The COSTS section is loaded with the value -1 in all four data items. These values are simply space fillers which represent no cost override options. To override CAPDET cost estimates the user would substitute the four items for the -1's.

EXAMPLE:

COSTS				
AERATED LAGOON	-1	-1	-1	1200
AEROBIC DIGESTION	86870	700	400	0
PRIMARY CLARIFICATION	0	0	0	0
END				

This example shows three unit processes which will use the cost override option. Only the supply cost is overridden for the lagoon. This might be done in the cases where electric rates are extremely high. All aerobic digestion CAPDET values are overridden with actual figures for cost and man-hours required. In the last process, primary clarification, all costs are overridden with zeroes. This may be used when studying treatment plant expansion, where it is necessary to evaluate the characteristics of the waste stream through the existing facility but it is unnecessary to include the existing processes in the system cost evaluation.

C. Cost Override Data Cards

	CAPITAL COST $	OPERATION MAN-HOURS HR/YEAR	MAINT MAN-HOURS HR/YEAR	SUPPLY COST $/YEAR
COSTS				
A SECONDARY CLARIFICATION (ACTIVATED SLUDGE)	xx.x	xx.x	xx.x	xx.x
AERATED LAGOON	xx.x	xx.x	xx.x	xx.x
AEROBIC DIGESTION	xx.x	xx.x	xx.x	xx.x
ANAEROBIC DIGESTION	xx.x	xx.x	xx.x	xx.x
ANION EXCHANGE	xx.x	xx.x	xx.x	xx.x
C PRIMARY CLARIFICATION (COAGULATION)	xx.x	xx.x	xx.x	xx.x
CARBON ADSORPTION	xx.x	xx.x	xx.x	xx.x
CASCADE AERATION	xx.x	xx.x	xx.x	xx.x
CATION EXCHANGE	xx.x	xx.x	xx.x	xx.x
CENTRIFUGATION	xx.x	xx.x	xx.x	xx.x
CHLORINATION	xx.x	xx.x	xx.x	xx.x
COAGULATION	xx.x	xx.x	xx.x	xx.x
COMMINUTORS	xx.x	xx.x	xx.x	xx.x
COMPLETE MIX ACTIVATED SLUDGE	xx.x	xx.x	xx.x	xx.x
CONTACT STABILIZATION	xx.x	xx.x	xx.x	xx.x
COUNTER CURRENT AMMONIA STRIPPING	xx.x	xx.x	xx.x	xx.x
CROSS CURRENT AMMONIA STRIPPING	xx.x	xx.x	xx.x	xx.x

[a]List only those lines describing the unit process whose cost functions are to be replaced.

[b]If any value is changed in a line all other values must be reset to -1.0.

c. Cost Override Data Cards (Continued)

	CAPITAL COST $	OPERATION MAN-HOURS HR/YEAR	MAINT MAN-HOURS HR/YEAR	SUPPLY COST $/YEAR
DENITRIFICATION	xx.x	xx.x	xx.x	xx.x
DIFFUSED AERATION	xx.x	xx.x	xx.x	xx.x
DRYING BEDS	xx.x	xx.x	xx.x	xx.x
DUMMY PROCESS	xx.x	xx.x	xx.x	xx.x
EQUALIZATION	xx.x	xx.x	xx.x	xx.x
EXTENDED AERATION ACTIVATED SLUDGE	xx.x	xx.x	xx.x	xx.x
FACULTATIVE LAGOON	xx.x	xx.x	xx.x	xx.x
FILTRATION	xx.x	xx.x	xx.x	xx.x
FIRST-STAGE RECARBONATION	xx.x	xx.x	xx.x	xx.x
FLOCCULATOR	xx.x	xx.x	xx.x	xx.x
FLUIDIZED BED INCINERATION	xx.x	xx.x	xx.x	xx.x
FLOTATION	xx.x	xx.x	xx.x	xx.x
FLTR PRESS	xx.x	xx.x	xx.x	xx.x
GRAVITY THICKENING	xx.x	xx.x	xx.x	xx.x
GRIT REMOVAL & SCREENS & FLOW MEASUREMENT	xx.x	xx.x	xx.x	xx.x
HAULING AND LAND FILLING	xx.x	xx.x	xx.x	xx.x
HIGH RATE ACTIVATED SLUDGE	xx.x	xx.x	xx.x	xx.x
L CLARIFICATION (LIME TREATMENT)	xx.x	xx.x	xx.x	xx.x
LAGOONS	xx.x	xx.x	xx.x	xx.x
MECHANICAL AERATION	xx.x	xx.x	xx.x	xx.x
MICROSCREENING	xx.x	xx.x	xx.x	xx.x
MULTIPLE HEARTH INCINERATION	xx.x	xx.x	xx.x	xx.x
N SECONDARY CLARIFICATION (NITRIFY-DENITRIFY)	xx.x	xx.x	xx.x	xx.x
NEUTRALIZATION	xx.x	xx.x	xx.x	xx.x
NITRIFICATION	xx.x	xx.x	xx.x	xx.x
OVERLAND FLOW LAND TREATMENT	xx.x	xx.x	xx.x	xx.x

c. Cost Override Data Cards (Continued)

	CAPITAL COST $	OPERATION MAN-HOURS HR/YEAR	MAINT MAN-HOURS HR/ YEAR	SUPPLY COST $/YEAR
OXIDATION DITCH	xx.x	xx.x	xx.x	xx.x
PLUG FLOW ACTIVATED SLUDGE	xx.x	xx.x	xx.x	xx.x
POST AERATION	xx.x	xx.x	xx.x	xx.x
PRESSURE FILTRATION	xx.x	xx.x	xx.x	xx.x
PRIMARY CLARIFICATION	xx.x	xx.x	xx.x	xx.x
PURE OXYGEN ACTIVATED SLUDGE	xx.x	xx.x	xx.x	xx.x
RAPID INFILTRATION LAND TREATMENT	xx.x	xx.x	xx.x	xx.x
RECARBONATION	xx.x	xx.x	xx.x	xx.x
RECYCLE PUMPING (ACTIVATED SLUDGE)	xx.x	xx.x	xx.x	xx.x
SCREENS	xx.x	xx.x	xx.x	xx.x
SECOND STAGE RECARBONATION	xx.x	xx.x	xx.x	xx.x
SLUDGE FLOTATION	xx.x	xx.x	xx.x	xx.x
SLOW IRRIGATION LAND TREATMENT	xx.x	xx.x	xx.x	xx.x
STEP AERATION ACTIVATED SLUDGE	xx.x	xx.x	xx.x	xx.x
T SECONDARY CLARIFICATION (TRICKLING FILTER)	xx.x	xx.x	xx.x	xx.x
TRICKLING FILTRATION	xx.x	xx.x	xx.x	xx.x
VACUUM FILTRATION	xx.x	xx.x	xx.x	xx.x
WET OXIDATION	xx.x	xx.x	xx.x	xx.x

3-16. Counter Current Ammonia Stripping (see page 6-25 of Design Manual)

a. Design Parameters

Liquid loading rate ≈ 500-1000 lb water/hr/ft^2

Gas loading rate ≈ 2-4 times liquid loading rate (consult manufacturer for packing characteristics)

Lime Dosage ≈ 200-500 mg/ℓ

Height of transfer unit (consult manufacturer specifications)

Ammonia concentration in air at top of tower ≈ 0.02-0.05 mg/ℓ

Desired effluent quality ≈2.0-8.0 mg/ℓ

b. Default Data

DESIRED EFFLUENT QUALITY	2.0	MG/L
LIQUID LOADING RATE	600	LB/HR/SQFT
GAS LOADING RATE	1800	LB/HR/SQFT
LIME DOSE	200	MG/L
HEIGHT OF TRANSFER UNIT	15	FEET
AMMONIA CONCENTRATION IN AIR LEAVING TOWER	0.03	MG/L

c. Counter Current Ammonia Stripping Unit Process Data Cards

COUNTER CURRENT AMMONIA STRIPPING MOD xx		
DESIRED EFFLUENT QUALITY	xx.x	MG/L
LIQUID LOADING RATE	xx.x	LB/HR/SQFT
GAS LOADING RATE	xx.x	LB/HR/SQFT
LIME DOSE	xx.x	MG/L
HEIGHT OF TRANSFER UNIT	xx.x	FT
AMMONIA CONCENTRATION IN AIR TOP OF TOWER	xx.x	MG/L
END		

3-17. Cross Current Ammonia Stripping (see page 6-25 of Design Manual)

a. Design Parameters

Liquid loading rate $\simeq$500-1000 lb water/hr/ft^2

Gas loading rate $\simeq$2-4 times liquid loading rate (consult manufacturer for packing characteristics)

Lime dosage $\approx$200-500 mg/ℓ

Height of transfer unit (consult manufacturer specifications)

Ammonia concentration in air at the top of tower $\simeq$ 0.02-0.05 mg/ℓ

Desired effluent quality $\approx$ 2.0-8.0 mg/ℓ

b. Default Data

DESIRED EFFLUENT QUALITY	2.0	MG/L
LIQUID LOADING RATE	600	LB/HR/SQFT
GAS LOADING RATE	1800	LB/HR/SQFT
LIME DOSE	200	MG/L
HEIGHT OF TRANSFER UNIT	15	FT

c. Cross Current Ammonia Stripping Unit Process Data Cards

CROSS CURRENT AMMONIA STRIPPING	MOD xx	
DESIRED EFFLUENT QUALITY	xx.x	MG/L
LIQUID LOADING RATE	xx.x	LB/HR/SQFT
GAS LOADING RATE	xx.x	LB/HR/SQFT
LIME DOSE	xx.x	MG/L
HEIGHT OF TRANSFER UNIT	xx.x	FT
AMMONIA CONCENTRATION IN AIR TOP OF TOWER	xx.x	MG/L
END		

3-18. Denitrification (see page 7-253) of Design Manual)

a. Design Parameters

Mixed liquor volatile solids ≈1200-2000 mg/ℓ
Dissolved oxygen≈ 2.0 mg/ℓ
Nitrate loading rate (see Figures 3-2 and 3-3 based on winter temperature and MLVSS)
Efficiency (removal based on pH; see Table 3-2)

Table 3-2. Effect of pH on Denitrification

pH	Condition
At 6.5 $\leq$ pH $\leq$ 7.5	Optimum
At 6.3 $\leq$ pH $\leq$ 6.5 At 7.5 $\leq$ pH $\leq$ 7.7	90% of optimum
At 5.6 $\leq$ pH $\leq$ 6.3 At 7.7 $\leq$ pH $\leq$ 8.6	50% of optimum

b. Default Data

MIXED LIQUOR VS	2000	MG/l
WINTER TEMPERATURE	10	DEG CENT
NITRATE LOADING	20	LB/TCFT/DAY
DISSOLVED OXYGEN	4	MG/l
EFFICIENCY	90	PERCENT

c. Denitrification (Biological) Unit Process Data Cards

DENTRIFICATION[a]	MOD	xx	
MIXED LIQUOR	VS =	xx.x	MG/L
WINTER TEMPERATURE		xx.x	DEG CENT
NITRATE LOADING		xx.x	LB/TCFT/D
DISSOLVED OXYGEN		xx.x	MG/L
EFFICIENCY		xx.x	PERCENT
END			

[a]This process used with combined nitrification-denitrification and can not be used independently.

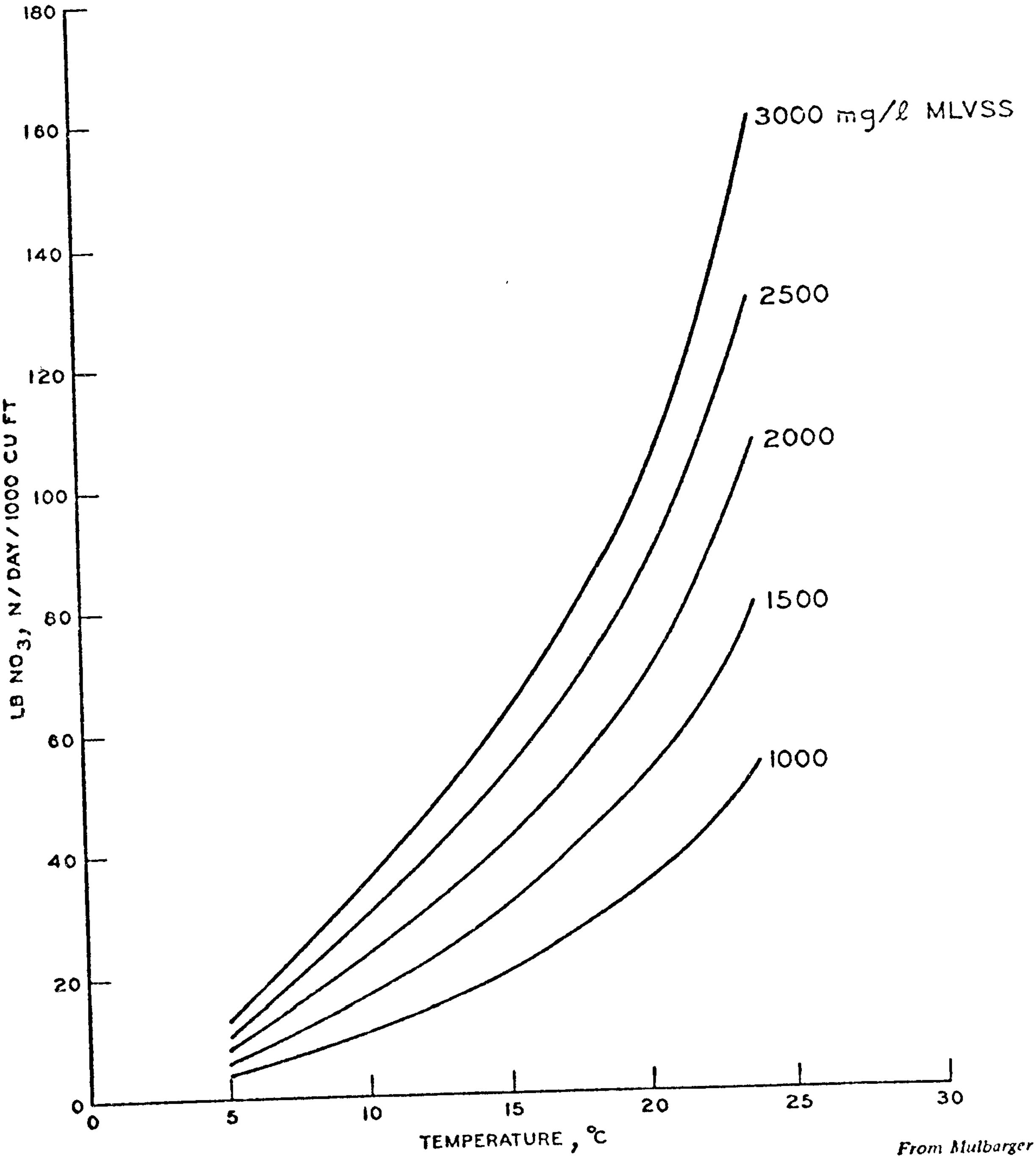

Figure 3-2. Permissible denitrification tank loadings.

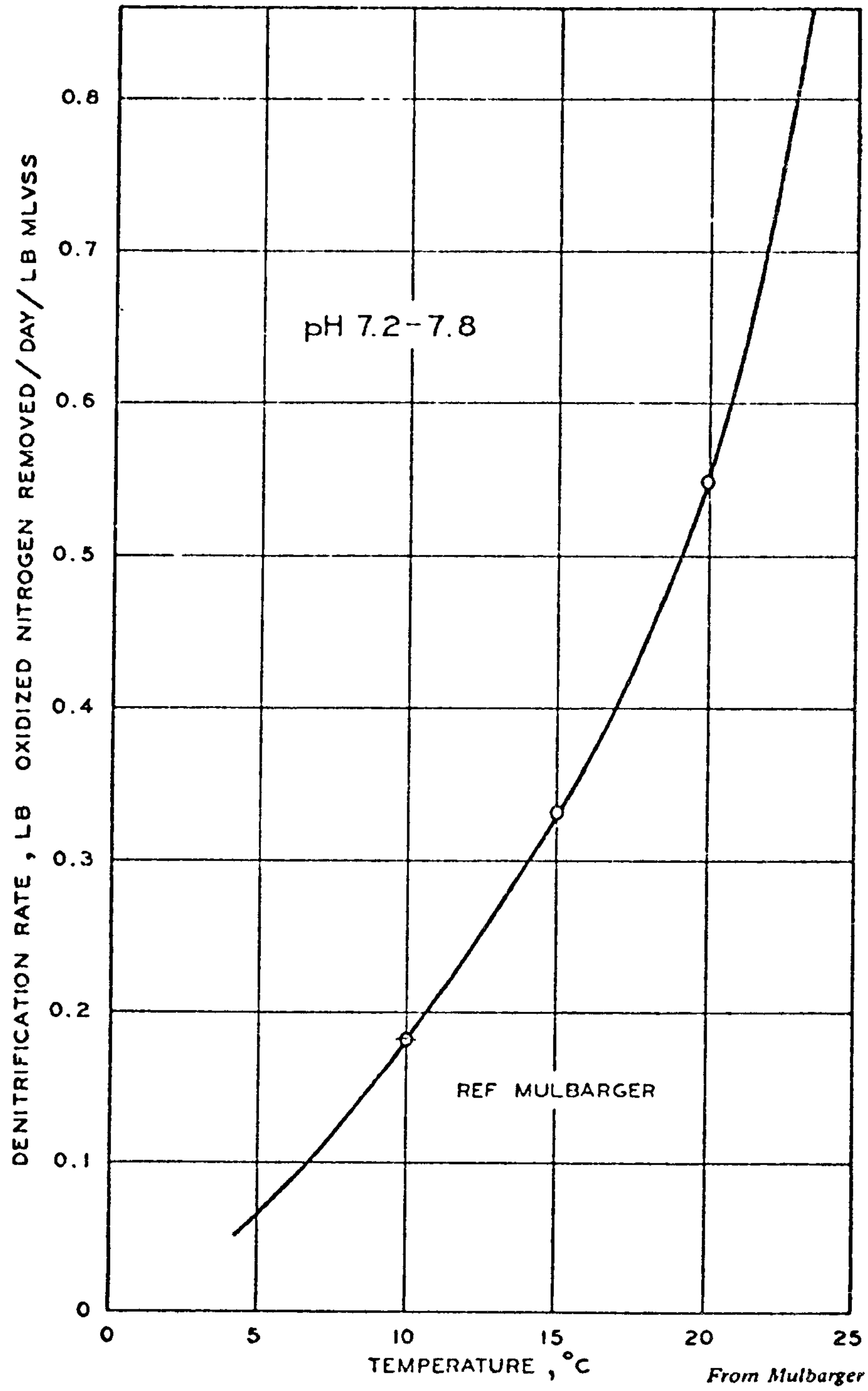

Figure 3-3. Effect of temperature upon rate of denitrification.

3-19. Drying Beds (see page 5-149 of Design Manual)

a. Design Parameters

Depth of sludge applied ≈8-12 inches

Time to drain≈ 1-8 days

Drained solids content after T days≈ 15-25%

Final solids content ≈30%

Evaporation rate (available from U.S. Weather Bureau)

Rainfall during wet month (available from U.S. Weather Bureau)

Correction for evaporation rate for sludge ≈0.75

Fraction of rainfall absorbed by sludge ≈0.57

b. Default Data

```
ESTIMATE                                        INCHES
DEPTH                                       12  [redacted]
TIME TO DRAIN                                2  DAYS
FINAL SOLIDS                                50  %
DRAIN SOLIDS                                20  %
EVAPORATION RATE                             5  IN/MO
RAINFALL                                     3  IN/MO
CORRECTION FOR EVAPORATION                0.75
FRACTION ABSORBED                         0.50
NUMBER OF SECTIONS                           4
```

c. Drying Beds Unit Process Data Cards

DRYING BEDS	MOD	xx	
DEPTH APPLIED		xx.x	INCHES
TIME TO DRAIN		xx.x	DAYS
DRAINED SOLIDS		xx.x	PERCENT
FINAL SOLIDS		xx.x	PERCENT
EVAPORATION RATE		xx.x	IN/MO.
RAINFALL		xx.x	IN/MO.
CORRECTION FOR EVAPORATION		xx.x	
FRACTION ABSORBED		xx.x	
NUMBER OF SECTIONS		xx.x	

ESTIMATE[a] PIPE COSTS = xx.x xx.x xx.x COSAND = xx.x
COGRVL = xx.x

END

---

[a]Pipe costs for 4-, 6-, 8-inch perforated clay pipe in place, $/FT - default values are $2.15, $2.75, and $4.25 per foot respectively.

COSAND = Cost of sand in place, $/Cu Yd - default value = $5.90.

COGRVL = Cost of gravel in place, $/Cu YD - default value = $4.30.

3-20. Dummy Process

a. In certain situations, the user may wish to adjust the waste characteristics at some point within the train (to simulate side flows, new processes, etc.). For these cases, the DUMMY process is available. The DUMMY process is a liquid line process and is listed on the BLOCK card with the key word DUMMY. The data cards for the DUMMY process are shown on the following page. The parameters of flow, temperature, and pH are set to describe the waste stream at that point in the train. All other waste characteristic parameters are modified as percent reductions of that particular parameter from the value it possessed as influent to the DUMMY process. The cost data are user input and the data card is of the same format as the cost override card. The sludge lines can be modified to indicate sludge production at that point in the train, by inputting values for volume of sludge, percent solids of sludge, and volatile portion of the sludge. If the sludge cards are included, all three values must be present and in the proper order.

b. The schematic description of a process in CAPDET is shown in Figure 3-4. Q_i, C_i, T_i, and pH_i are waste descriptors which are either input by the user, if it is at the head of the plant, or are effluent characteristics generated by the flow through previous processes. Since for the DUMMY process there is no standard design and cost formulation within CAPDET, the user must simulate the effect of the process on the waste stream. This is done by setting Q_i, T_i, pH_i, sludge volumes, costs, and describing the C_e's as percent reductions of the C_i's.

c. Dummy Process Data Cards

DUMMY PROCESS

MINIMUM FLOW	xx.x	MGD
AVERAGE FLOW	xx.x	MGD
MAXIMUM FLOW	xx.x	MGD
TEMPERATURE	xx.x	DEG
SUSPENDED SOLIDS	xx.x	PER RED
VOLATILE SOLIDS	xx.x	PER RED
BOD5	xx.x	PER RED
BOD5 SOLUBLE	xx.x	PER RED
COD	xx.x	PER RED
COD SOLUBLE	xx.x	PER RED
PH	xx.x	UNITS
CATIONS	xx.x	PER RED
ANIONS	xx.x	PER RED
TKN	xx.x	PER RED
PO4	xx.x	PER RED
NH3	xx.x	PER RED
SETTLEABLE SOLIDS	xx.x	PER RED
OIL AND GREASE	xx.x	PER RED
NO2	xx.x	PER RED
NO3	xx.x	PER RED

PRIMARY SLUDGE xx.x GAL/DAY xx.x PER SOLIDS xx.x
PER VOLATILE

SECONDARY SLUDGE xx.x GAL/DAY xx.x PER SOLIDS xx.x
PER VOLATILE

COSTS xx.x CAPITAL xx.x OPER MAN HRS xx.x MAINT MAN HRS xx.x
SUPPLY COST
END

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Q = FLOW
C = CONCENTRATION OF VARIOUS WASTE DESCRIPTORS
T = TEMPERATURE

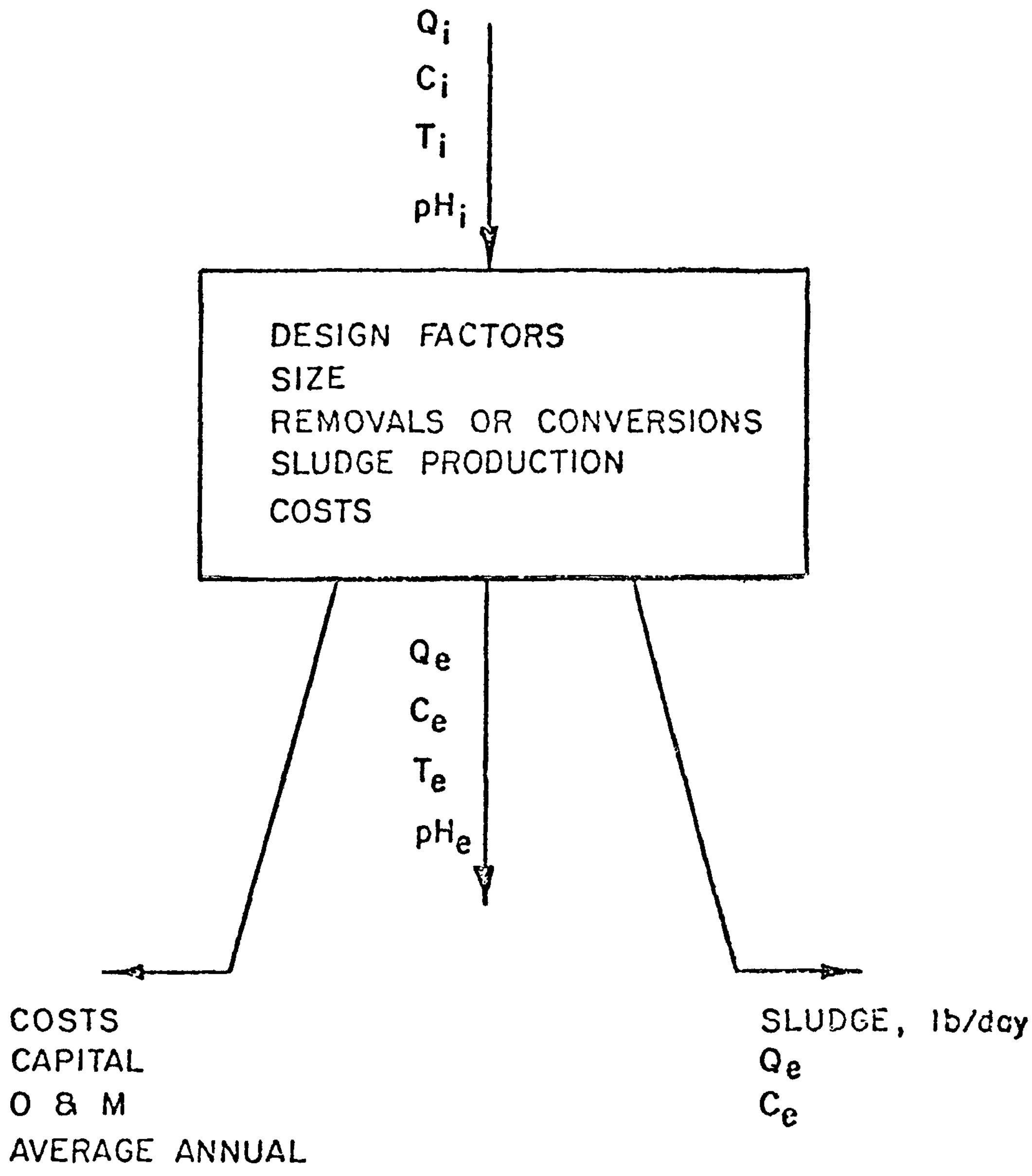

Figure 3-4. A schematic description of a CAPDET unit process

3-21. Equalization (see page 5-33 of Design Manual)

a. Design Parameters

Detention time (dependent on the fluctuation cycle) ≈ 0.1-0.7 days
Mixing requirements ≈ 0.02-0.04 hp/1000 gal
Air requirements ≈ 5-20 cfm/cubic foot
Oxygen concentration (minimum) in tank ≈ 2.0 mg/ℓ
ALPHA O_2 transfer in waste/O_2 transfer in water≈ 0.90
BETA O_2 saturation in waste/O_2 saturation in water ≈0.90
STE Standard transfer efficiency

Mechanical Aerators≈ 2.0-3.5 lb O_2/hp-hr

High Speed≈ 2.0
Slow Speed≈ 3.5

Diffused Aerator≈ 6.0-11.0%

Coarse bubble≈6.0
Fine bubble≈11.0

b. Default Data

DETENTION TIME	0.5	DAYS
MIXING REQUIREMENTS	0.03	HP/TG
AIR REQUIREMENTS	15	CFM/CFT
ALPHA	0.9	
BETA	0.9	
STANDARD TRANSFER EFFICIENCY	3.4	LB O/HP HR
OXYGEN CONCENTRATION IN TANK	2	MG/I

c. Equalization Unit Process Data Cards

EQUALIZATION	MOD	xx	
DETENTION TIME		xx.x	DAYS
MIXING REQUIREMENTS		xx.x	HP/TG
AIR REQUIREMENTS		xx.x	CFM/CFT
ALPHA		xx.x	
BETA		xx.x	
STANDARD TRANSFER EFFICIENCY		xx.x	LB O/HP-HR
OXYGEN CONCENTRATION IN TANK		xx.x	MG/L
END			

3-22. <u>Extended Aeration Activated Sludge</u> (see page 7-95 of Design Manual)

a. Design Parameters

Eckenfelder's Approach
Reaction rate constants

k, BOD removal rate constant≈0.0007-0.002 ℓ/mg/hr
a, fraction of BOD synthesized≈0.73
a^{∇}, fraction of BOD oxidized for energy≈0.52
b, endogenous rate (oxygen basis)≈0.075/day
b^{∇}, endogenous rate (sludge basis)≈0.15/day
f, nonbiodegradable fraction of VSS in influent≈0.40
f^{∇}, degradable fraction of the MLVSS≈0.53
a_o, fraction of BOD5 synthesized to degradable solids≈ 0.77a≈0.56

F/M ratio≈0.05-0.15
Mixed liquor suspended solids≈3000-6000 mg/ℓ
Mixed liquor volatile solids≈2100-4200 mg/ℓ
Temperature correction coefficient≈1.0-1.04
Effluent BOD soluble≈10 mg/ℓ
ALPHA O_2 transfer in waste/O_2 transfer in water≈0.90
BETA O_2 saturation in waste/O_2 saturation in water≈0.90
HP Horsepower per 1000 gallons ≥0.10 hp/1000 gal
STE Standard transfer efficiency

Mechanical Aerators≈2.0-3.5 lb O_2/hp-hr
High Speed≈2.0
Slow Speed≈3.5
Diffused Aerator≈6.0-11.0%
Coarse bubble≈6.0
Fine bubble≈11.0

b. Default Data

```
ESTIMATE CONSTANTS       K=0.0012 A=0.73 AP=0.52 B=0.075 BP=0.15 F=0.4 FP=0.53 AO=0.56
F/M RATIO                                     0.1     LB BOD/LB VSS
MIXED LIQUOR       SS=3500   VS=2000                  MG/l
TEMPERATURE COEFFICIENT                       1.03
EFFLUENT BOD SOLUBLE                          5       MG/l
DIFFUSED AERATION ALPHA=0.9 BETA=0.9 AP=0.0 CFM/TG STE=12   PERCENT
```

c. Extended Aeration Activated Sludge Unit Process Data Cards

EXTENDED AERATION ACTIVATED SLUDGE[a] MOD xx

CONSTANTS K=xx.x A=xx.x $\overset{\nabla}{A}$=xx.x B=xx.x $\overset{\nabla}{B}$=xx.x F=xx.x
$\overset{\nabla}{F}$=xx.x AO=xx.x

F/M RATIO xx.x LB BOD/LB VSS

MIXED LIQUOR SS = xx.x VS =xx.x MG/L

TEMPERATURE COEFFICIENT xx.x

EFFLUENT BOD SOLUBLE xx.x MG/L

MECHANICAL AERATION ALPHA[b]=xx.x BETA=xx.x HP=xx.x HP/TG
STE=xx.x LB O/HP-HR

DIFFUSED AERATION ALPHA[b]=xx.x BETA=xx.x AF[c]=xx.x CFM
STE=xx.x PERCENT

ESTIMATE[d] SSXSA = xx.x COSTPD = xx.x COSTPH = xx.x
COSTPS = xx.x

END

---

[a]User must also specify secondary clarification (activated sludge).

[b]Use mechanical or diffused, not both.

[c]AF (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

[d]SSXSA = Cost of standard slow-speed pier-mounted 20-hp aerator-default value = $16,300.

COSTPD = Cost of standard 12.0 scfm coarse-bubble diffuser-default value = $6.50.

COSTPH = Cost of standard 550 scfm swing arm diffuser-default value = $5,000.

COSTPS = Cost of standard 3000 gpm pump and driver unit - default value = $17,250.

3-23. Faculative Aerated Lagoon (see page 7-223 of Design Manual)

a. Design Parameters

K, reaction rate constant≈0.5-1.0 per day (avg 0.75)

$\overset{\nabla}{a}$, fraction of BOD oxidized for energy≈0.90-1.40

THETA, temperature correction coefficient≈1.075

Effluent soluble BOD≈10 mg/ℓ

Suspended solids in effluent≈50-150 mg/ℓ

ALPHA O_2 transfer in waste/O_2 in water≈0.90

BETA O_2 saturation in waste/O_2 saturation in water≈0.90

HP Horsepower per 1000 gallons≥0.10 hp/1000 gal

STE Standard transfer efficiency

Mechanical Aerators≈2.0-3.5 lb O_2/hp-hr

High speed≈2.0
Slow speed≈3.5

Diffused Aerator≈6.0-11.0%

Coarse bubble≈6.0
Fine bubble≈11.0

b. Default Data

```
SUMMER TEMPERATURE                        30          CENT
WINTER TEMPERATURE                        10          CENT
EFFLUENT SOLUBLE BOD                      30          MG/l
CONSTANTS             K=0.5    AP=1.2    THETA=1.075
SUSPENDED SOLIDS IN EFFLUENT              150         MG/l
MECHANICAL AERATION ALPHA=0.9 BETA=0.9 HP=0.01 HP/TG STE=3.5 LB O/HP HR
```

c. Facultative Aerated Lagoon Unit Process Data Cards

FACULTATIVE AERATED LAGOON	MOD xx	
SUMMER TEMPERATURE	xx.x	DEG CENT
WINTER TEMPERATURE	xx.x	DEG CENT
EFFLUENT SOLUBLE BOD	xx.x	MG/L

CONSTANTS K = xx.x A^{∇} = xx.x THETA = xx.x

SUSPENDED SOLIDS IN EFFLUENT	xx.x	MG/L

MECHANICAL AERATION ALPHA[a]=xx.x BETA=xx.x HP=xx.x HP/TG
STE=xx.x LB O/HP-HR

DIFFUSED AERATION ALPHA[a]=xx.x BETA=xx.x AF[b]=xx.x CFM/TG
STE=xx.x PERCENT

END

---

[a]Use mechanical or diffused, not both.

[b]AF (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

3-24. Filter Press

a. Design Parameters

Cake solids content≈35-50%
Density of cake (see Table 3-3 for typical specific gravities)
Chamber volume (see manufacturer specifications) ≈ 1.0-2.0 ft^3
Hours operation per day≈8-16 hours
Cycle time of filter≈2.0 hours

Table 3-3. Normal Quantities of Sludge Produced by Different Treatment Processes

Wastewater Treatment Process	Gallons Sludge/ mg Treated	Solids Percent	Sludge Specific Gravity
Primary sedimentation			
Undigested	2,950	5.0	1.02
Digested in separate tanks	1,450	6.0	1.03
Trickling filter	745	7.5	1.025
Chemical precipitation	5,120	7.5	1.03
Primary sedimentation and activated sludge			
Undigested	6,900	4.0	1.02
Digested in separate tanks	2,700	6.0	1.03
Activated sludge			
Waste sludge	19,400	1.5	1.005
Septic tanks, digested	900	10.0	1.04
Imhoff tanks, digested	500	15.0	1.04

b. Default Data

CAKE SOLIDS CONTENT	45.0 PERCENT
DENSITY OF CAKE	65.0 LB/CUFT
CHAMBER VOLUME	2.0 CUFT
HOURS OF OPERATION	8.0 HOURS
CYCLE TIME	2.0 HOURS

c. Filter Press Unit Process Data Cards

FLTR PRESS[a]	MOD xx	
CAKE SOLIDS CONTENT	xx.x	PERCENT
DENSITY OF CAKE	xx.x	LB/CUFT
CHAMBER VOLUME	xx.x	CUFT
HOURS OPERATION PER DAY	xx.x	HRS
CYCLE TIME	xx.x	HRS
END		

---

[a]The user must spell the process name 'FLTR' PRESS as shown to insure the proper input for the Filter Press process.

3-25. Filtration (see page 5-93 of Design Manual)

a. Design Parameters (for general design characteristics see Table 3-4)

Filter media characteristics (see Table 3-5)

Loading rate, dual media≈2-10 gpm/ft^2; multi media≈ 2-12 gpm/ft^2

K, coefficient of permeability≈ 6

POR, porosity≈0.50 for anthracite and≈ 0.40 for sand

DIA, particle diameter or effective size (Table 3-5)

SF, shape factor≈6.0 for spherical or 8.5 for crushed granules

SG, specific gravity ≈1.67 for anthracite or 2.65 for sand

Sixty percent finer size of the sand≈ 0.75 mm

Density of water ≈62.4 lb/ft^3

Viscosity of water ≈1.009 centipoises

Porosity of unexpanded bed≈ 0.40

b. Default Data

```
ESTIMATE
LOADING RATE                               2          G/M/SQFT
APPROACH VELOCITY                          0.005      FT/SEC
LAYERS      NUMBER=4   (FOLLOW WITH ONE CARD PER LAYER TOP TO BOTTOM)
D=1.00 K=6 POR=0.50 DIA=0.0046 SF=7.0 SG=1.40      (ANTHRACITES)
D=1.90 K=5 POR=0.40 DIA=0.0020 SF=8.5 SG=2.65      (SAND)
D=1.00 K=4 POR=0.47 DIA=0.0010 SF=8.0 SG=3.85      (GARNET SANDS)
D=1.00 K=6 POR=0.60 DIA=0.0500 SF=6.0 SG=6.00      (GRAVEL)
SIXTY PERCENT FINER SIZE                   0.75       MM
SPECIFIC WEIGHT OF SAND                    165.4      LB/CFT
DENSITY OF WATER                           62.4       LBM/CUFT
KINEMATIC VISCOSITY (PGM WILL COMPUTE UNLESS VALUE SPECIFIED)  SQFT/SEC
POROSITY OF BED                            0.4
EXPANDED DEPTH                             5          FEET
NUMBERS OF TROUGHS                         50         THOUGHS
WIDTH OF TROUGHS                           1          FEET
UNDERDRAIN DEPTH                           1          FEET
HEAD LOSS IN UNDERDRAIN                    1          FEET
OPERATING DEPTH OF WATER ABOVE SAND                   3          FEET
HEIGHT OF TROUGH FROM UNDERDRAIN           6.5        FEET
BACKWASH TIME                              10         MINUTES
FREEBOARD                                  1          FEET
ABSOLUTE VISCOSITY OF WATER                1.0087     CENTIPOISES
```

c. Filtration Unit Process Data Cards

FILTRATION MOD xx		
LOADING RATE	xx.x	G/MSQFT
APPROACH VELOCITY	xx.x	FT/SEC
LAYERS[a] NUMBER = xx.x (follow with one card/layer top to bottom) D=xx.x FT K=xx.x POR=xx.x DIA=xx.x FT SF=xx.x SG=xx.x		
SIXTY PERCENT FINER SIZE	xx.x	MM
SPECIFIC WEIGHT OF SAND	xx.x	LB/CFT
DENSITY OF WATER	xx.x	LBS/CFT
KINEMATIC VISCOSITY (may be specified or will be calculated if left blank)	xx.x	SQFT/SEC
POROSITY OF BED	xx.x	
EXPANDED DEPTH	xx.x	FT
NUMBER OF TROUGHS	xx.x	
WIDTH OF TROUGHS	xx.x	FT
UNDERDRAIN DEPTH	xx.x	FT
HEAD LOSS IN UNDERDRAIN	xx.x	FT
OPERATING DEPTH OF WATER ABOVE SAND	xx.x	FT
HEIGHT OF TROUGH FROM UNDERDRAIN	xx.x	FT
BACKWASH TIME	xx.x	MIN
FREEBOARD	xx.x	FT
ABSOLUTE VISCOSITY OF WATER	xx.x	CENTIPOISES
ESTIMATE[b] COSF = xx.x COSTPS = xx.x		
END		

---

[a]The "LAYERS" card must be followed immediately with one card per layer in the order of top to bottom. These cards have no key word. They must contain the depth (ft), permeability, porosity, mean diameter (ft), shape factor, and specific gravity for the layers in the order shown.

[b]COSF=Cost of standard 784 square ft filter unit-default value= $165,000.
COSTPS=Cost of standard 3000 gpm pump and driver unit-default value=$17,250.

Table 3-4. General Features of Construction and Operation of Conventional Slow and Rapid Sand Filters

Feature	Slow Sand Filters	Rapid Sand Filters
Rate of filtration	1 to 3 to 10 mgad	100 to 125 cc 300 mgad
Size of bed	Large, half acre	Small, 1/100to 1/10 acre
Depth of bed	12 in. of gravel; 42 in. of sand, usually reduced to no less than 24 in. by scraping	18 in. of gravel; 30 in. of sand or less; not reduced by washing
Size of sand	Effective size 0.25 to 0.3 to 0.35 mm; coefficient of nonuniformity 2 to 2.5 to 3	0.45 mm and higher; coefficient of nonuniformity 1.5 and lower, depending on underdrainage system
Grain size distribution of sand in filter	Unstratified	Stratified with smallest or lightest grains at top and coursest or heaviest at bottom
Underdrainage system	Split tile laterals laid in coarse stone and discharging into tile or concrete main drains	(1) Perforated pipe laterals discharging into pipe mains; (2) porous plates above inlet box; (3) porous blocks with included channels
Loss of head	0.2 ft initial to 4 ft final	1 ft initial to 8 or 9 ft final
Length of run between cleanings	20 to 30 to 60 days	12 to 24 hr
Penetration of suspended matter	Superficial	Deep
Method of cleaning	(1) Scraping off surface layer of sand and washing and storing cleaned sand for periodic resanding of bed; (2) washing surface sand and sand in place by washer traveling over sand bed	Dislodging and removing suspended matter by upward flow or back-washing, which fluidizes the bed. Possible use of water or air jets, or mechanical rakes to improve scour
Amount of wash water used in cleaning sand	0.2 to 0.6 percent of water filtered	1 to 4 to 6 percent of water filtered

(Continued)

Table 3-4. General Features of Construction and Operation of Conventional Slow and Rapid Sand Filters (Concluded)

Feature	Slow Sand Filters	Rapid Sand Filters
Preparatory treatment of water	Generally none	Coagulation, flocculation, and sedimentation
Supplementary treatment of water	Chlorination	Chlorination
Cost of construction, U.S.	Relatively high	Relatively low
Cost of operation	Relatively low where sand is cleaned in place	Relatively high
Depreciation cost	Relatively low	Relatively high

From Fair, Geyer, and Okun, 1958

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Table 3-5. Typical Design Data for Dual-Media and Multimedia Filters

Characteristic	Value: Range	Value: Typical
Dual-Media		
Anthracite		
Depth, in.	8 to 24	18.0
Effective size, mm	0.8 to 2.0	1.2
Uniformity coefficient	1.4 to 1.8	1.5
Sand		
Depth, in.	10 to 24	12.0
Effective size, mm	0.3 to 0.8	0.5
Uniformity coefficient	1.2 to 1.6	1.4
Filtration rate, gpm/ft^2	2 to 10	6.0
Multimedia		
Anthracite		
Depth, in.	8 to 20	15.0
Effective size, mm	1.0 to 2.0	1.4
Uniformity coefficient	1.4 to 1.8	1.5
Sand		
Depth, in.	8 to 16	12.0
Effective size, mm	0.4 to 0.8	0.6
Uniformity coefficient	1.2 to 1.6	1.4
Garnet[a]		
Depth, in.	2 to 4	3.0
Effective size, mm	0.2 to 0.6	0.3
Uniformity coefficient		1.0
Filtration rate, gpm/ft^2	2 to 12	6.0

[a]Garnet becomes intermixed with sand and anthracite.

From Metcalf and Eddy, 1972

3-26. <u>Flocculation</u> (see page 6-17 of Design Manual)

a. Design Parameters

Lime dosage (determine from jar test)≈200-500 mg/ℓ

Optimum Ph (determine from jar test)≈10-11

Detention time for flash mix basin≈ 1.0 - 3.0 minutes

Detention time for flocculator basin≈ 15.0 - 60.0 minutes

b. Default Data

```
LIME                                          DOSE=100   MG/L
DETENTION TIME     FLASH MIX=3    FLOCCULATOR=45      MIN
OPTIMUM PH                                    10.5
```

c. Flocculation Unit Process Data Cards

FLOCCULATION	MOD xx			
LIME DOSE	xxx			MG/L
DETENTION TIME	FLASH MIX xxx	FLOCCULATOR xxx		MIN
OPTIMUM PH	xxx			
END				

3-27. Flotation (see page 5-41 of Design Manual)

a. Design Parameters

Air pressure≈ 40-70 psig

Detention time in float tank≈ 0.25-0.5 hrs

Solid loading (determine from laboratory tests)

Hydraulic loading≈ 1.0-4.0 gal/min/ft^2

Recycle time in pressure tank≈ 1.0-3.0 min

Percent removal of solids (determine from bench test)≈ 80.0

Air/solids ratio (determine from laboratory test)

Float concentration (determine from bench test)≈ 5.0%

Removal of BOD (determine from bench test)

Removal of COD (determine from bench test)

Removal of TKN (determine from bench test)

b. Default Data

```
ESTIMATE
AIR PRESSURE                                  40        PSIG
DETENTION TIME IN FLOAT TANK                  0.5       HRS
SOLID LOADING                                 15        LB/SQFT/DAY
HYDRAULIC LOADING                             3.5       GPM/SQFT
RECYCLE TIME IN PRESS TANK                    3.0       MIN
PERCENT REMOVAL OF SOLIDS                     85        PERCENT
AIR/SOLIDS RATIO                              0.02
FLOAT CONCENTRATION                           3         PERCENT
REMOVAL    BOD=30    COD=30    TKN=10                   PERCENT
```

c. Flotation Unit Process Data Cards

FLOTATION	MOD	xx	
AIR PRESSURE[a]		xx.x	PSIG
DETENTION TIME IN FLOAT TANK		xx.x	HRS
SOLID LOADING		xx.x	LB/SQFT/DAY
HYDRAULIC LOADING		xx.x	GPM/SQFT
RECYCLE TIME IN PRESS TANK[a]		xx.x	MIN
PERCENT REMOVAL OF SOLIDS		xx.x	PERCENT
AIR/SOLIDS RATIO		xx.x	
FLOAT CONCENTRATION		xx.x	PERCENT
REMOVAL BOD = xx.x	COD =	xx.x TKN = xx.x	PERCENT
Estimate[b] COSTFS = xx.x			
END			

---

[a]Use with recycle only.

[b]COSTFS = Cost of standard 350 square foot air flotation unit - default value = $44,200

3-28. Fluidized Bed Incineration (see page 5-189 of Design Manual)

a. Design Parameters

Sludge analysis (determine from bench tests)

Carbon content ≈ 43.6%
Hydrogen content ≈ 6.4%
Oxygen content ≈ 33.4%
Sulfur content ≈ 0.3%

Fuel analysis (use reported values for desired fuel; typical values for fuel oil are provided)

Carbon content ≈ 87.3%
Hydrogen content ≈ 12.6%
Oxygen content ≈ 0.0%
Sulfur content ≈ 1.0%

Heat value of fuel (use reported value for desired fuel), for fuel oil ≈18,000 BTU/lb

Operating temperature of preheater unit ≈1000-1200°F

Sand to sludge ratio ≈ 3.0-8.0

Detention time ≈ 10.0-60.0 sec

b. Default Data

```
HOURS PER DAY                            8 HOURS
DAYS PER WEEK                            5
SLUDGE ANALYSIS                C=59.8   H=9.4   O=27.5   S=1.0
FUEL ANALYSIS                  C=87.3   H=12.6   O=0.0   S=1.0
HEAT VALUE OF FUEL                18000 BTU/LB
OPERATING TEMPERATURE                1000 DEGREES F
AMBIENT TEMPERATURE                  75 DEGREES F
SAND TO SLUDGE RATIO                 6.0 LB/LB/HR
SPECIFIC WEIGHT OF SAND               110 LB/CUFT
DETENTION TIME                       60 SECONDS
ELECTRIC POWER COST                  0.04  $/KWHR
ESTIMATE
```

c. Fluidized Bed Incineration Unit Process Data Cards

FLUIDIZED BED INCINERATION		MOD xx			
HOURS PER DAY	xx.x				
DAYS PER WEEK	xx.x				
SLUDGE ANALYSIS[a] C=xx.x	H=xx.x	O=xx.x	S=xx.x		PERCENT
FUEL ANALYSIS[a] C=xx.x	H=xx.x	O=xx.x	S=xx.x		PERCENT
HEAT VALUE OF FUEL	xx.x				BTU/LB
OPERATING TEMPERATURE	xx.x				DEG F
AMBIENT TEMPERATURE	xx.x				DEG F
SAND TO SLUDGE RATIO	xx.x				
SPECIFIC WEIGHT OF SAND	xx.x				LB/CUFT
DETENTION TIME	xx.x				SECONDS
ELECTRIC POWER COST	xx.x				DOLLARS/KWHR
ESTIMATE[b] COSTFI = xx.x					
END					

---

[a] C = Carbon content
H = Hydrogen content
O = Oxygen content
S = Sulfur content

[b] COSTFI = Cost of standard 15-foot diameter incinerator - default value = $1,100,000.

3-29. Gravity Thickening (see page 5-57 of Design Manual)

a. Design Parameters

Underflow concentration (determine from bench test)
Mass loading rate (See Table 3-6.)
Settling velocity (determine from lab test with results similar to Figure 3.5)
Initial height (determine from lab test with results similar to Figure 3.5)
Intercept (determine from lab test with results similar to Figure 3.5)

Table 3-6. Concentrations of Unthickened and Thickened Sludges and Solids Loadings for Mechanical Thickeners

Type of Sludge	Sludge, Solid, Percent		Solids Loading for Mechanical Thickeners lb/ft²/day
	Unthickened	Thickened	
Separate sludges			
Primary	2.5 to 5.5	8.0 to 10.0	20 to 30
Trickling filter	4.0 to 7.0	7.0 to 9.0	8 to 10
Modified aeration	2.0 to 4.0	4.3 to 7.9	7 to 18
Activated	0.5 to 1.2	2.5 to 3.3	4 to 18
Combined sludges			
Primary and trickling filter	3.0 to 6.0	7.0 to 9.0	12 to 20
Primary and modified aeration	3.0 to 4.0	8.3 to 11.6	12 to 20
Primary and activated	2.6 to 4.8	4.6 to 9.0	8 to 16

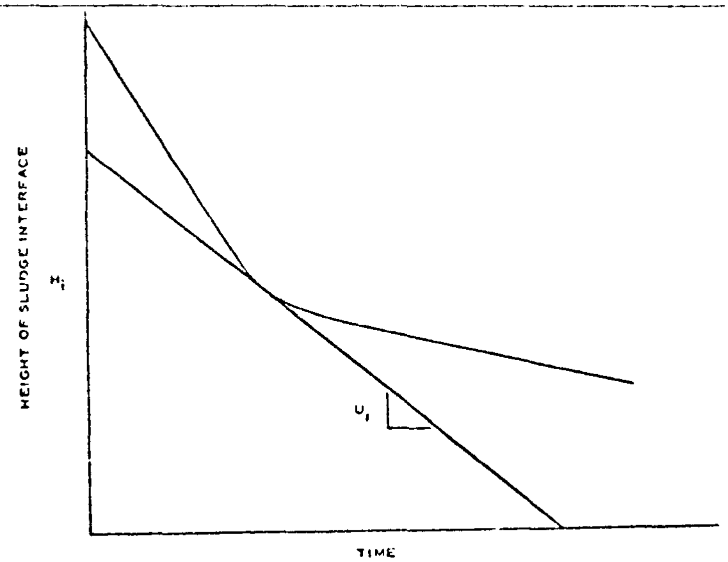


Figure 3-5. Typical settling curve from laboratory test.

b. Default Data

ESTIMATE		
UNDERFLOW CONCENTRATION	5	PERCENT
MASS LOADING	10	LB/SQFT/DAY
DEPTH	9	FEET
NUMBER OF TANKS	2	

c. Gravity Thickening Unit Process Data Cards

GRAVITY THICKENING	MOD xx	
UNDERFLOW CONCENTRATION	xx.x	PERCENT
MASS LOADING[a]	xx.x	LB/SQFT/DAY
DEPTH	xx.x	FT
NUMBER OF TANKS	xx	
SETTLING VELOCITY[a]	xx.x	FT/DAY
INITIAL HEIGHT[a]	xx.x	FT
INTERCEPT[a]	xx.x	FT
ESTIMATE[b] COSTTS = xx.x		
END		

[a]List either mass loading or the three parameters: settling, velocity, initial height, and intercept; not both.

[b]COSTTS = Cost of standard 90-foot diameter thickener-default value = $82,500.

3-30. Grit Removal (see page 5-3 of Design Manual)

a. Design Parameters

Specific gravity of particles ≈2.65

Particle size (see Table 3-7)

Table 3-7. Grit Settling Velocities

Particle Size		Settling Velocity			Area Required
Mesh	mm	ft/min	gpd/ft^2	mgd/ft^2	ft^2/million gal
18	0.833	14.7	160,000	0.1600	6.3
20	0.595	10.5	114,500	0.1145	8.7
35	0.417	7.4	80,100	0.0801	12.5
48	0.295	5.2	56,700	0.0567	17.7
65[a]	0.208	3.7	40,000	0.0400	25.0
100	0.147	2.6	28,200	0.0282	35.5
150	0.105	1.8	20,200	0.0202	49.5

From Metcalf and Eddy, 1972

[a] Minimum particle size desirable for removal.

Depth≈ 1.0 foot
Current allowance ≈1.70
Manning coefficient ≈0.03
Aerated grit chamber design parameters
- Air supply - 3 cfm/ft of tank length
- Air diffusers - located 2 to 3 ft above tank bottom on one side of tank
- Surface velocity - 1.5 to 2 fps
- Tank floor velocity - 1 to 1.5 fps
- Grit collectors - air lift pumps to decanting channels, grit conveyors or grit pumps
- Detention time - 2 to 3 min
- Efficiency - 100% removal of 65-mesh grit

From Metcalf and Eddy, 1972

b. Default Data

```
ESTIMATE
PARTICLE SIZE                                   0.2          MM
SPECIFIC GRAVITY                                2.65
HORIZONTAL FLOW                VMAX=1.25 VAVE=1.00           FPS
NUMBER OF UNITS                                 2
DEPTH                                           4            FT
CURRENT ALLOWANCE                               1.7
MANNING COEFFICIENT                             0.035
VOLUME OF GRIT                                  4            CFT/MG
```

c. Grit Removal Unit Process Data Cards

GRIT REMOVAL[a]	MOD xx		
PARTICLE SIZE		xx.x	MM
SPECIFIC GRAVITY		xx.x	
HORIZONTAL FLOW[b]	VMAX=xx.x	VAVG=xx.x	FPS
AERATED[b]	VMAX=xx.x	VAVG=xx.x	FPX
NUMBER OF UNITS		xx.x	
DEPTH[c]		xx.x	FT
WIDTH[c]		xx.x	FT
CURRENT ALLOWANCE		xx.x	
MANNING COEFFICIENT		xx.x	
VOLUME OF GRIT		xx.x	CFT/MG
DETENTION TIME[d]		xx.x	MIN
AIR SUPPLY[d]		xx.x	CFM/FT
ESTIMATE[e]			
END			

---

[a]This process is part of preliminary treatment.

[b]Use horizontal flow or aerated, not both.

[c]Use depth or width card, not both.

[d]Use with aerated flow only.

[e]The ESTIMATE card in Grit Removal specifies estimate pricing for Preliminary Treatment which includes Grit Removal, Comminutors, and Bar Screens.

3-31. High-rate Activated Sludge (see page 7-129 of Design Manual)

a. Design Parameters

Eckenfelder's Approach
Reaction rate constants

a, fraction of BOD synthesized ≈0.73

a^∇, fraction of BOD oxidized for energy ≈0.52

b, endogenous rate (oxygen basis) ≈0.075/day

b^∇, endogenous rate (sludge basis) ≈0.15/day

f, nonbiodegradable fraction of VSS in influent ≈0.40

f^∇, degradable fraction of the MLVSS ≈0.53

F/M ratio ≈1.5 - 5.0

Mixed liquor suspended solids ≈200 - 1000 mg/ℓ

Mixed liquor volatile solids ≈140 - 700 mg/ℓ

Temperature correction coefficient ≈1.0 - 1.04

Effluent BOD soluble ≈10 mg/ℓ

ALPHA O_2 transfer in waste/O_2 transfer in water ≈0.90

BETA O_2 saturation in waste/O_2 saturation in water ≈0.90

HP Horsepower per 1000 gallons ≥0.10 hp/1000 gal

STE Standard transfer efficiency

Mechanical Aerators ≈2.0 - 3.5 lb O_2/hp-hr

High speed ≈2.0
Slow speed ≈3.5

DIFFUSED AERATOR ≈6.0 - 11.0%

Coarse bubble ≈6.0
Fine bubble ≈11.0

b. Default Data

```
ESTIMATE
CONSTANTS  A=0.7 AP=0.53 B=0.075 BP=0.15 F=0.4 FP=0.53
F/M RATIO                              1.0       LB BOD/LB VSS
MIXED LIQUOR     SS=6000   VS=4500                 MG/L
TEMPERATURE COEFFICIENT                1.035
EFFLUENT BOD SOLUBLE                   20         MG/L
DIFFUSED AERATION ALPH=0.9 BETA=0.9 AF=0.0 CFM/TG STE=12  PERCENT
```

c. High Rate Activated Sludge Unit Process Data Cards

HIGH RATE ACTIVATED SLUDGE[a] MOD xx

CONSTANTS A=xx.x $\overset{\nabla}{A}$=xx.x B=xx.x $\overset{\nabla}{B}$=xx.x F=xx.x $\overset{\nabla}{F}$=xx.x

F/M RATIO xx.x LB BOD/LB VSS

MIXED LIQUOR SS=xx.x VS=xx.x MG/L

TEMPERATURE COEFFICIENT xx.x

EFFLUENT BOD SOLUBLE xx.x MG/L

MECHANICAL AERATION ALPHA[b]=xx.x BETA=xx.x HP=xx.x HP/TG
STE=xx.x LB O/HP-HR

DIFFUSED AERATION ALPHA[b]=xx.x BETA=xx.x AF[c]=xx.x CFN/TG
STE=xx.x PER

ESTIMATE[d] SSXSA=xx.x COSTPD-xx.x COSTPH=xx.x COSTPS=ss.s

END

---

[a]User must also specify secondary clarification (activated sludge).

[b]Use mechanical or diffused, not both.

[c]AF (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

[d]SSXSA - Cost of standard slow-speed pier-mounted 20-hp aerator - default value = $16,300.

COSTPD = Cost of standard 12.0 scfm coarse-bubble diffuser - default value = $6.50.

COSTPH = Cost of standard 550 scfm swing arm diffuser - default value = $5,000.

COSTPS = Cost of standard 3000 gpm pump and driver unit - default value = $17,250.

3-32. Lagoons (see page 7-307 of Design Manual)

a. Design Parameters (see Table 3-8)

Table 3-8. Design Parameters for Stabilization Ponds.

Parameter	Type of Pond			
	Aerobic[a]	Facultative	Facultative	Anaerobic
Flow regime	Intermittently mixed	--	Mixed surface layer	--
Pond size, acres	<10 multiples	2 to 10 multiples	2 to 10 multiples	0.5 to 2.0 mult
Operation[b]	Series or parallel	Series or parallel	Series or parallel	Series
Detention time, days[b]	10 to 40	7 to 30	7 to [illegible]	20 to 50
Depth, ft	3 to 4	3 to 6	3 to 8	8 to 15
pH	6.5 to 10.5	6.5 to 9.0	6.5 to 8.5	6.8 to 7.2
Temperature range, °C	0 to 40	0 to 50	0 to 50	6 to 50
Optimum temperature, °C	20	20	20	30
BOD_5 loading, lb/acre/day[c]	60 to 120[d]	15 to 50	30 to [illegible]	200 to 50(
BOD_5 conversion	60 to 70	60 to 70	60 to 70	50 to 70
Principal conversion products	Algae, CO_2, bacterial cell tissue	Algae, CO_2, CH_4, bacterial cell tissue	CO_2, CH_4, bacterial cell tissue	CO_2, CH_4, bacte cell tissue
Algal concentration, mg/ℓ	80 to 200	40 to 160	[illegible]	--
Effluent suspended solids, mg/ℓ[e]	140 to 340	160 to 400	110 to 340	80 to 16(

(a) Conventional aerobic ponds designed to maximize the amount of oxygen produced rather than the amount of a produced.

(b) Depends on climatic conditions.

(c) Typical values (much higher values have been applied at various loadings). Loading values are often spec by state control agencies.

(d) Some states limit this figure to 50 or less.

(e) Includes algae, microorganisms, and residual influent suspended solids. Values are based on an influent ble BOD_5 of 200 mg/ℓ and, with the exception of the aerobic ponds, an influent suspended-solids concentrat of 200 mg/ℓ.

From Metcalf and Edd

b. Default Data

```
DEPTH                 6     FT
BOD LOADING           50    LB/ACRE/DAY
EFFLUENT SS           50    MG/L
```

c. Lagoons Unit Process Data Cards

LAGOONS	MOD xx		
DEPTH		xx.x	FT
BOD LOADING		xx.x	LB/ACRE/DAY
EFFLUENT SS		xx.x	MG/L
END			

3-33. Microscreening (see page 5-139 of Design Manual)

a. Design Parameters

Initial resistance of clean filter fabric (see manufacturer specifications) ≈ 0.25-0.50 feet
Filterability index of influent (determine from bench test) ≈ 1.50-2.50
Number of Units ≈2
Speed of strainer ≈4.0-7.0 rev/min

Table 3-9. Suggested Removals from Secondary Effluents by Microscreens

Fabric Aperture microns	Anticipated Removal, % Suspended Solids	BOD	Flow, gpm/ft^2 of Submerged Area
23	70 to 80	60 to 70	6.7
35	50 to 60	40 to 50	10.0

From Culp and Culp, 1971

Table 3-10. Microscreen Sizes Available from Glenfield and Kennedy

Drum Sizes, ft		Motors, bhp		Approximate Ranges of Capacity, mgd	Recommended Maximum Flow for Tertiary Sewage Applications, mgd	
Diameter	Width	Drive	Wash Pump		23 microns	35 microns
5	1	1/2	1	0.05 to 0.5	0.075	0.11
5	3	3/4	3	0.3 to 1.5	0.20	0.30
7-1/2	5	2	5	0.8 to 4	0.70	1.00
10	10	4	7-1/2	3 to 10	2.00	3.00

From Culp and Culp, 1971

Table 3-11. Microscreen-Sizes (Zurn Industries)

Drum Sizes, ft		Screen Area
Diameter	Width	ft^2
4	2	24
4	4	48
6	4	72
6	6	108
6	8	144
10	10	3.5

From Culp and Culp, 1971

b. Default Data

INITIAL RESISTANCE	1.8	FT
SPEED OF STRAINER	1.0	REV/MIN

c. Microscreening Unit Process Data Cards

MICROSCREENING MOD xx		
NUMBER OF UNITS[a]	xx.x	UNITS
INITIAL RESISTANCE	xx.x	FT
FILTERABILITY INDEX[a]	xx.x	
SPEED OF STRAINER	xx.x	REV/MIN
END		

[a]Value will be calculated if input is left blank.

3-34. Multiple Hearth Incineration (see page 5-177 of Design Manual)

a. Design Parameters

Wet sludge loading rate ≈7.0-12.0 $lb/hr/ft^2$ @ 20-25% total solids

b. Default Data

WET SLUDGE LOADING RATE	10.0 #/HR/SQFT
DAYS PER YEAR OPERATION	260.0 DAYS
ESTIMATE	

c. Multiple Hearth Incineration Unit Process Data Cards

MULTIPLE HEARTH INCINERATION	MOD xx	
WET SLUDGE LOADING RATE	xx.x	LB/HR/SQFT
DAYS PER YEAR OPERATION	xx.x	DAYS
ESTIMATE[a] COSTIS = xx.x		
END		

[a]COSTIS = Cost of standard 1580-square foot incinerator - default value = $1,190,000.

3-35. Neutralization (see page 6-55 of Design Manual)

a. Design Parameters

Buffer capacity (determine from titration curves) ≈ pound of reagent per gallon of waste required to neutralize the waste to the desired pH.

Degree of mixing (see manufacturer specifications) ≈ 0.2-0.4 hp/1000 gallons

Mixing time (see manufacturer specifications) ≈5.0-10.0 min

b. Default Data

BUFFER CAPACITY	0.1	LB/GAL
DEGREE OF MIXING	0.3	HP/TG
MIXING TIME	5	MIN

c. Neutralization Unit Process Data Cards

NEUTRALIZATION MOD xx		
BUFFER CAPACITY	xx.x	LB/GAL
DEGREE OF MIXING	xx.x	HP/TG
MIXING TIME	xx.x	MIN
END		

3-36. <u>Nitrification</u> (see page 7-253 of the Design Manual)

a. Design Parameters

Effluent ammonia

Mixed liquor volatile SS ≈1200-2000 mg/ℓ

Ammonia loading (see Figure 3-6)

Correction for pH≈ 60-70% (see Figure 3-7 DM)

ALPHA O_2 transfer in waste/O_2 transfer in water≈0.90

BETA O_2 saturation in waste/O_2 saturation in water≈0.90

HP Horsepower per 1000 gallons ≥0.10 hp/1000 gal

STE Standard transfer efficiency

Mechanical Aerators ≈2.0-3.5 lb O_2/hp-hr
High speed ≈2.0
Slow speed ≈3.5

Diffused Aerator ≈6.0-11.0%
Coarse bubble≈ 6.0
Fine bubble ≈11.0

b. Default Data

```
WINTER TEMPERATURE                       10         DEG CENT
EFFLUENT AMMONIA                         2.0        MG/l
MIXED LIQUOR                             VS=2000    MG/l
AMMONIA LOADING                          10         LB/TCFT/DAY
DIFFUSED AERATION ALPHA=0.9 BETA=0.9 AF=0.0 CFM/TG STE=12  PER
CORRECTION FACTOR FOR PH                 0.8
```

c. Nitrification Unit Process Data Cards

NITRIFICATION[a]

WINTER TEMPERATURE	xx.x	DEG CENT
EFFLUENT AMMONIA	xx.x	MG/L
MIXED LIQUOR VS=xx.x		MG/L
AMMONIA LOADING	xx.x	LB/TCFT/DAY

MECHANICAL AERATION ALPHA[b]=xx.x BETA=xx.x HP=xx.x
HP/TG STE=xx.x LB/HP-HR

DIFFUSED AERATION ALPHA[b]=xx.x BETA=xx.x AF[c]=xx.x
CFM/TG STE=xx.x PER

CORRECTION FOR PH xx.x

END

---

[a]User must also specify secondary clarification (nitrify-dentrify).

[b]Use mechanical or diffused, not both.

[c]AF (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

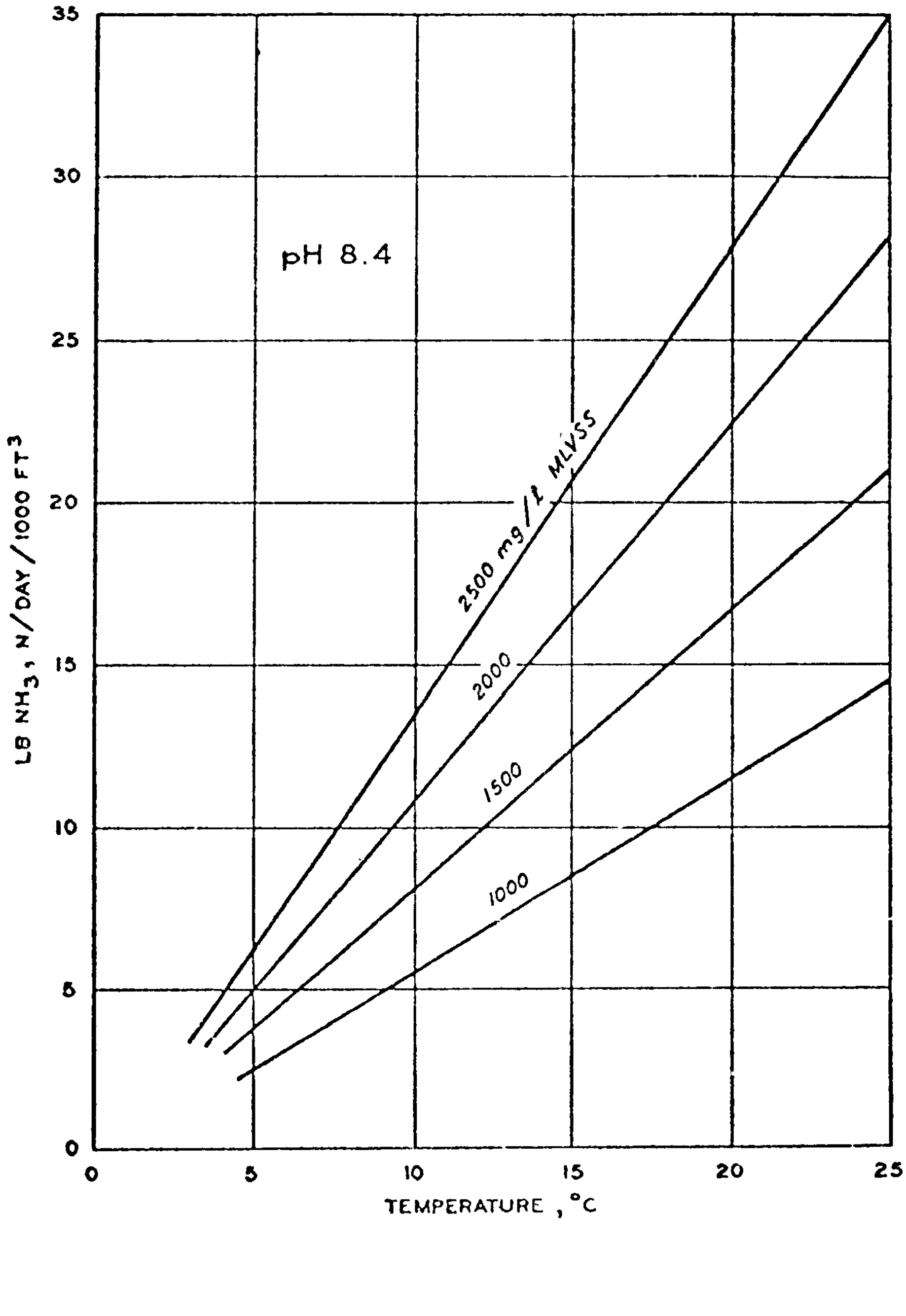


Figure 3-6. Permissible nitrification tank loadings.

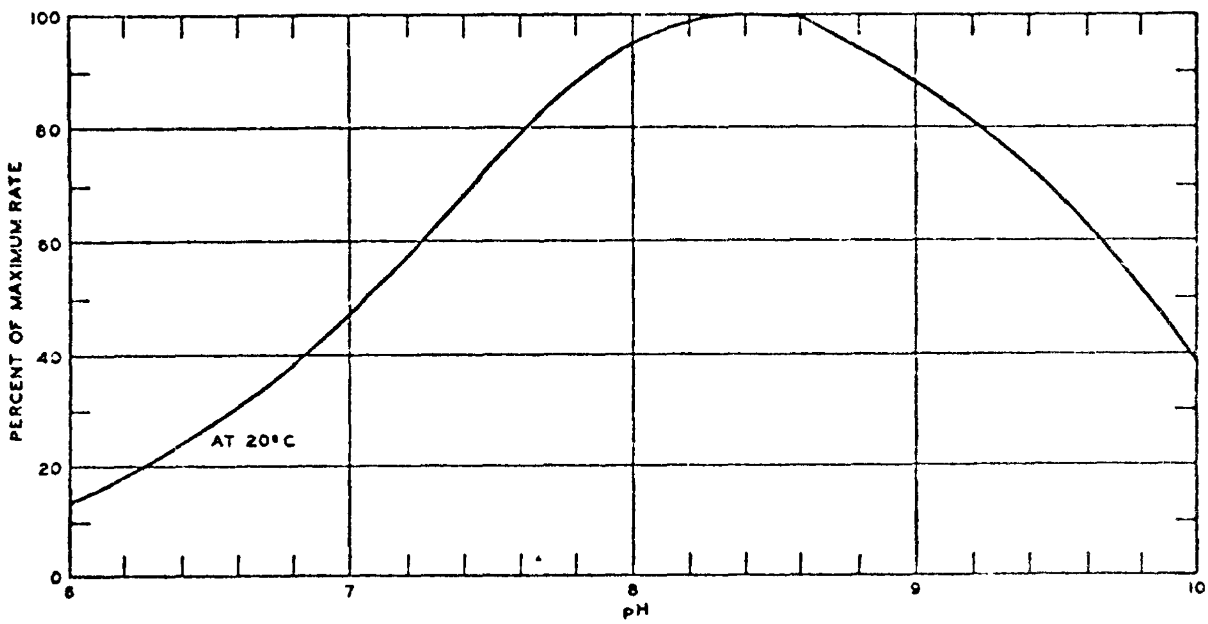


Figure 3-7. Percent of maximum rate of nitrification at constant temperature versus pH.

3-37. Overland Flow Land Treatment

a. Design Parameters

Application rate≈2.5-6.0 in/wk (screened wastewater)

Application rate≈6.0-16.0 in/wk (lagoon or secondary effluent)

Runoff (site dependent)≈0.0 in/wk

Spray evaporation (percent of application rate)≈2.0-8.0%

Percolate of soil (percent of application rate)≈8.0%

Buffer zone (site dependent)≈0.0-500.0 ft

Slope≈2.0-8.0% (over 8.0% requires finished slopes)

Fraction of nitrogen loading denitrified≈75.0-90.0%

Ammonia volatilization≈0.0

Removal of phosphorus≈50.0%

NW Number of recovery wells

WDIA Diameter of recovery wells

DW Depth of recovery wells

PS Cost of standard 3000 gpm pump and driver unit - default value = $17,250.00

SP Cost of 12-inch welded steel pipe in-place - default value = $12.80 per feet

SV Cost of 12-inch butterfly value - default value = $952.10

CS Cost of 6-15 gpm impact type rotor pop-up full circle sprinkler - default value = $61.65

CG Cost of clearing and grubbing - default value = $3000.00 per acre

MW Cost of 4-inch water well - default value = $8.00 per foot

SC Cost of 24-inch reinforced concrete drain pipe - default value = $10.20 per foot

b. Default Data

```
APPLICATION RATE                          5.0    IN/WEEK
PRECIPITATION RATE                        0.8    IN/WEEK
EVAPOTRANSPIRATION RATE                   0.4    IN/WEEK
RUNOFF                                    0.0    IN/WEEK
WASTEWATER GENERATION PERIOD            364.0    DAYS/YR
FIELD APPLICATION PERIOD                 52.0    WEEKS/YR
SPRAY EVAPORATION RATE                    5.0    PERCENT
PERCOLATE RATE OF SOIL                    8.0    PERCENT
NO STORAGE
GRAVITY PIPE RECOVERY SYSTEM
BUFFER ZONE                               0.0    FEET
CURRENT GROUND COVER    FOREST   20.0 %  BRUSH 30.0 %  PASTURE 50.0%
SLOPE                                     2.0    PERCENT
MONITORING WELLS                        9 WELLS  AT 10 FT/WELL
FENCING                                   2.75   $/FT
FRACTION DENITRIFIED                     90.0    PERCENT OF APPLIED N
AMMONIA VOLATILIZATION                    0.0    PERCENT OF APPLIED N
REMOVAL OF PHOSPHORUS                    80.0    PERCENT OF APPLIED P
DAYS PER WEEK OPERATION                   7.0    DAYS/WEEK
HOURS PER DAY OPERATION                   8.0    HOURS/DAY
ESTIMATE
```

c. Overland Flow Land Treatment Unit Process Data Cards

OVERLAND FLOW LAND TREATMENT	MOD xx	
APPLICATION RATE	xx.x	IN/WK
PRECIPITATION RATE	xx.x	IN/WK
EVAPOTRANSPIRATION RATE	xx.x	IN/WK
RUNOFF	xx.x	IN/WK
WASTEWATER GENERATION PERIOD	xx.x	DAYS/YR
FIELD APPLICATION PERIOD	xx.x	DAYS/YR
SPRAY EVAPORATION	xx.x	PERCENT
PERCOLATE OF SOIL	xx.x	PERCENT
NO STORAGE[a]		
STORAGE[a,b] (MINIMUM)	xx.x	DAYS/YR
LINER REQUIRED[b]	xx.x	$/SQ FT
EMBANKMENT PROTECTION[b]	xx.x	$/CU YD
GRAVITY PIPE RECOVERY SYSTEM[c]		
OPEN CHANNEL RECOVERY SYSTEM[c]		
BUFFER ZONE WIDTH	xx.x	FT
CURRENT GROUND COVER	FOREST xx.x% BRUSH xx.x%	PASTURE xx.x%
SLOPE OF LAND	xx.x	PERCENT
MONITORING WELLS NO.=xx.x	DEPTH/WELL xx.x	FT
FENCING	xx.x	$/FT
FRACTION DENITRIFIED	xx.x	PERCENT
AMMONIA VOLATILIZATION	xx.x	PERCENT
REMOVAL OF PHOSPHORUS	xx.x	PERCENT
HOURS PER DAY OPERATION	xx.x	HOURS
DAYS PER WEEK OPERATION	xx.x	DAYS

ESTIMATE PS xx.x SP xx.x SV xx.x CS xx.x CG xx.x MW xx.x SC xx.x

END

---

[a]Use no storage or storage, not both.

[b]Liner or embankment protection should only be used with storage.

[c]Use gravity pipe or open channel, not both.

3-38. Oxidation Ditch Activated Sludge (see page 7-235 of Design Manual)

a. Design Parameters

Reaction rate constants

k, BOD removal rate constant≈0.0007-0.002 ℓ/mg/hr

a, fraction of BOD synthesized≈0.73

a^{∇}, fraction of BOD oxidized for energy≈0.52

b, endogenous rate (oxygen basis)≈0.075/day

b^{∇}, endogenous rate (sludge basis)≈0.15/day

f, nonbiodegradable fraction of VSS in influent≈0.40

f^{∇}, degradable fraction of the MLVSS≈0.53

a_o, fraction of BOD_5 synthesized to degradable solids≈0.56

F/M ratio≈0.03-0.10

Mixed liquor suspended solids≈4000-8000 mg/ℓ

Mixed liquor volatile solids≈2800-5600 mg/ℓ

Temperature correction coefficient≈1.0-1.03

Effluent BOD soluble≈10 mg/ℓ

ALPHA O_2 transfer in waste/O_2 transfer in water≈0.90

BETA O_2 saturation in waste/O_2 saturation in water≈0.90

HP Horsepower per 1000 gallons ≥0.10 hp/1000 gal

STE Standard transfer efficiency

Mechanical Aerators≈2.0-3.5 lb O_2/hp-hr

High speed≈2.0
Slow speed≈3.5

Diffused Aerator≈6.0-11.0%

Coarse bubble≈6.0
Fine bubble ≈11.0

b. Default Data

```
ESTIMATE
CONSTANTS K=0.0012 A=0.7 AP=0.5 B=0.075 BP=0.15 F=0.4 FP=0.5 AO=0.76
F/M RATIO                                 0.065      LB BOD/LB VSS
MIXED LIQUOR       SS=6000        VS=3750            MG/l
TEMPERATURE COEFFICIENT                   1.035
EFFLUENT BOD SOLUBLE                      10         MG/l
MECHANICAL AERATION   ALPHA=0.9 BETA=0.9 HP=0.08 STE=3.5    LB O/HP HR
```

c. Oxidation Ditch Activated Sludge Unit Process Data Cards

OXIDATION DITCH ACTIVATED SLUDGE[a]

CONSTANTS K=xx.x A=xx.x A^{∇}=xx.x B=xx.x B^{∇}=xx.x F=xx.x

F^{∇}=xx.x AO=xx.x

F/M RATIO xx.x LB BOD/LB VSS

MIXED LIQUOR SS=xx.x MG/L

TEMPERATURE COEFFICIENT xx.x

EFFLUENT BOD SOLUBLE xx.x MG/L

MECHANICAL AERATION ALPHA[b]=xx.x BETA=xx.x HP=xx.x HP/TG

STE=xx.x LB O/HP-HR

DIFFUSED AERATION ALPHA[b]=xx.x BETA=xx.x AF[c]=xx.x CFM/TG

STE=xx.x PER

ESTIMATE[d] COSTDS = xx.x COSTPS = xx.x

END

---

[a]User must also specify secondary clarification (activated sludge).

[b]Use mechanical or diffused, not both.

[c]AD (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

[d]COSTDS = Cost of standard 42-inch diameter by 20-foot rotor - default value = $15,340.

COSTPS = Cost of standard 3000 gpm pump and driver unit - default value = $17,250.

3-39. <u>Plug Flow Activated Sludge</u> (see page 7-13 of Design Manual)

a. Design Parameters

Eckenfelder's Approach

Reaction rate constants

k, BOD removal rate constant≈0.0007-0.002 ℓ/mg/hr

a, fraction of BOD synthesized≈0.73

a^{∇}, fraction of BOD oxidized for energy≈0.52

b, endogenous rate (oxygen basis)≈0.075/day

b^{∇}, endogenous rate (sludge basis)≈0.15/day

f, nonbiodegradable fraction of VSS in influent≈0.40

f^{∇}, degradable fraction of the MLVSS≈0.53

F/M ratio≈0.2-0.4

Mixed liquor suspended solids≈1500-3000 mg/ℓ

Mixed liquor volatile solids≈1050-2100 mg/ℓ

Temperature correction coefficient≈1.0-1.03

Effluent BOD soluble≈10 mg/ℓ

ALPHA O_2 transfer in waste/O_2 transfer in water≈0.90

BETA O_2 saturation in waste/O_2 saturation in water≈0.90

HP Horsepower per 1000 gallons≥0.10 hp/1000 gal

STE Standard transfer efficiency

Mechanical Aerators≈2.0-3.5 lb O_2/hp-hr
High speed≈2.0
Slow speed≈3.5

Diffused Aerator≈6.0-11.0%
Coarse bubble≈6.0
Fine bubble≈11.0

b. Default Data

```
ESTIMATE
CONSTANTS K=0.00135 A=0.73 AP=0.52 B=0.075 BP=0.15 F=0.4 FP=0.53
F/M RATIO                             0.3          LB BOD/LB VSS
MIXED LIQUOR      SS=2500      VS=1750             MG/L
TEMPERATURE COEFFICIENT               1.03
EFFLUENT BOD SOLUBLE                  5            MG/L
DIFFUSED AERATION ALPHA=0.9 BETA=0.9 AP=0.0 CPM/TG STE=12   PERCENT
```

c. Plug Flow Activated Sludge Unit Process Data Cards

PLUG FLOW ACTIVATED SLUDGE[a]   MOD xx

CONSTANTS K=xx.x A=xx.x A^{∇}=xx.x B=xx.x B^{∇}=xx.x F=xx.x
F^{∇}=xx.x

F/M RATIO   xx.x   LB BOD/LB VSS

MIXED LIQUOR SS=xx.x   VS=xx.x   MG/L

TEMPERATURE COEFFICIENT   xx.x

EFFLUENT BOD SOLUBLE   xx.x   MG/L

MECHANICAL AERATION ALPHA[b]=xx.x BETA=xx.x HP=xx.x HP/TG
STE=xx.x LB O/HP-HR

DIFFUSED AERATION ALPHA[b]=xx.x BETA=xx.x AF[c]=xx.x CFM/TG
STE=xx.x PER

ESTIMATE[d] SSXSA = xx.x COSTPD = xx.x COSTPH = xx.x
COSTPS = xx.x

END

---

[a]User must also specify secondary clarification (activated sludge).

[b]Use mechanical or diffused, not both.

[c]AF (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

[d]SSXSA = Cost of standard slow-speed pier-mounted 20-hp aerator-default value = $16,300.

COSTPD = Cost of standard 12.0 scfm coarse-bubble diffuser - default value = $6.50.

COSTPH = Cost of standard 550 scfm swing arm diffuser - default value = $5,000.

COSTPS = Cost of standard 3000 gpm pump and driver unit - default value = $17,250.

3-40. Post Aeration (see page 5-159 of Design Manual)

a. Design Parameters

Detention time≈5.0-10.0 min

Air flow≈20.0-30.0 cfm/1000 gal

Dissolved oxygen (determine initial DO from standard tables based on summer temperature)

Final dissolved oxygen≈2.0 mg/ℓ

ALPHA O_2 transfer in waste/O_2 transfer in water≈0.90

BETA O_2 saturation in waste/O_2 saturation in water≈0.90

HP Horsepower per 1000 gallons≥0.10 hp/1000 gal

STE Standard transfer efficiency

Mechanical Aerators≈2.0-3.5 lb O_2/hp-hr
High speed≈2.0
Slow speed≈3.5

Diffused Aerator≈6.0-11.0%
Coarse bubble≈6.0
Fine bubble≈11.0

b. Default Data

```
MECHANICAL AERATION ALPH=0.9 BETA=0.9 HP=0.1 HP/TG STE=6.5 LB O/HP HF
DETENTION TIME                      30          MIN
DISSOLVED OXYGEN      INITIAL=2.0     FINAL=5.0     MG/L
```

c. Post Aeration Unit Process Data Cards

POST AERATION MOD xx

MECHANICAL AERATION ALPHA[a]=xx.x BETA=xx.x HP=xx.x
HP/TG STE=xx.x LB O/HP-HR

DIFFUSED AERATION ALPHA[a]=xx.x BETA=xx.x AF[b]=xx.x
CFM/TG STE=xx.x PER

DETENTION TIME xx.x MIN

DISSOLVED OXYGEN INITIAL = xx.x FINAL = xx.x MG/L

END

---

[a] Use mechanical or diffused, not both.

[b] AF (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

3-41. Pressure Filtration

a. Design Parameters

Density of cake≈70.0-80.0 lb/ft^3
Solids loading rate (determine from lab tests)≈5.0-8.0 $lb/ft^2/hr$
Operating schedule≈8.0-16.0 hours/day
Cake solids content (see Table 3-12)

Table 3-12. Normal Quantities of Sludge Produced by Different Treatment Processes

Wastewater Treatment Process	Gallons Sludge / MG Treated	Solids %	Sludge Specific Gravity
Primary sedimentation			
Undigested	2950	5.0	1.02
Digested in separate tanks	1450	6.0	1.03
Trickling filter	745	7.5	1.025
Chemical precipitation	5120	7.5	1.03
Primary sedimentation & activated sludge			
Undigested	6900	4	1.02
Digested in separate tanks	2700	6	1.03
Activated Sludge			
Waste sludge	19400	1.5	1.005
Septic tanks, digested	900	10	1.04
Imhoff tanks, digested	500	15	1.04

From Metcalf & Eddy, Inc., 19

b. Default Data

```
CAKE SOLIDS CONTENT        5.0   PERCENT
DENSITY OF CAKE           75.0   PERCENT
OPERATING SCHEDULE         8.0   HOURS/DAY
SOLIDS LOADING RATE        6.0   LB/SQFT/HR
```

c. Pressure Filtration Unit Process Data Cards

PRESSURE FILTRATION	MOD xx	
CAKE SOLIDS CONTENT	xx.x	PERCENT
DENSITY OF CAKE	xx.x	LB/CUFT
OPERATING SCHEDULE	xx.x	HOURS/DAY
SOLIDS LOADING RATE	xx.x	LBS/SQFT/HR
END		

3-42. Primary Clarification (see page 5-67 of Design Manual)

a. Design Parameters

Sidewater depth 7.0-12.0 ft
Underflow concentration of solids≈4.0-6.0%
Weir overflow rate≈10,000-15,000 gal/day/ft
Surface overflow rate (see Table 3-13)

Table 3-13. Recommended Surface-Loading Rates for Various Suspensions

Suspension	Loading Rate, gpd/ft^2 Range	Peak Flow
Untreated wastewater	600 to 1200	1200
Alum floc[a]	360 to 600	600
Iron floc[a]	540 to 800	800
Lime floc[a]	540 to 1200	1200

[a]Mixed with the settleable suspended solids in the untreated wastewater and colloidal or other suspended solids swept out by the floc.

From Metcalf and Eddy, Inc., 1971

Specific gravity of sludge (see Table 3-14)

Table 3-14. Specific Gravity of Raw Sludge Produced From Various Types of Sewage

Type of Sewerage System	Strength of Sewage	Specific Gravity
Sanitary	Weak	1.02
Sanitary	Medium	1.03
Combined	Medium	1.05
Combined	Strong	1.07

From Metcalf and Eddy, Inc., 1971

Suspended solids removal (see figure 3-8)
BOD removal (see Figure 3-9)

b. Default Data

```
CIRCULAR CLARIFIER
ESTIMATE
SURFACE OVERFLOW RATE                          1000        G/D/SQFT
SIDE WATER DEPTH                               9           FEET
SPECIFIC GRAVITY                               1.05
UNDERFLOW CONCENTRATION                        4           PERCENT
REMOVAL       SOLIDS=50      BOD=36            COD=50      TKN=5      PO=5   PERCENT
WEIR OVERFLOW RATE                             15000       G/D/FT
```

c. Primary Clarification Unit Process Data Cards

PRIMARY CLARIFICATION		
SURFACE OVERFLOW RATE	xx.x	G/D/SQFT
SIDEWATER DEPTH	xx.x	FT
SPECIFIC GRAVITY	xx.x	
UNDERFLOW CONCENTRATION	xx.x	PERCENT
REMOVAL SOLIDS=xx.x BOD=xx.x COD=xx.x TKN=xx.x PO=xx.x		PERCENT
WEIR OVERFLOW RATE	xx.x	G/D/FT
RECTANGULAR CLARIFIER[a]		
CIRCULAR CLARIFIER[a]		
ESTIMATE[b] STANDARD MECHANISM COST=xx.x		
END		

[a]Use rectangular or circular clarifier, not both-default is circular clarifier.

[b]Rectangular clarifier-cost of standard 20-foot by 120-foot clarifier mechanism-default value = $42,000.

Circular clarifier - cost of standard 90-foot diameter clarifier mechanism-default value = $75,000.

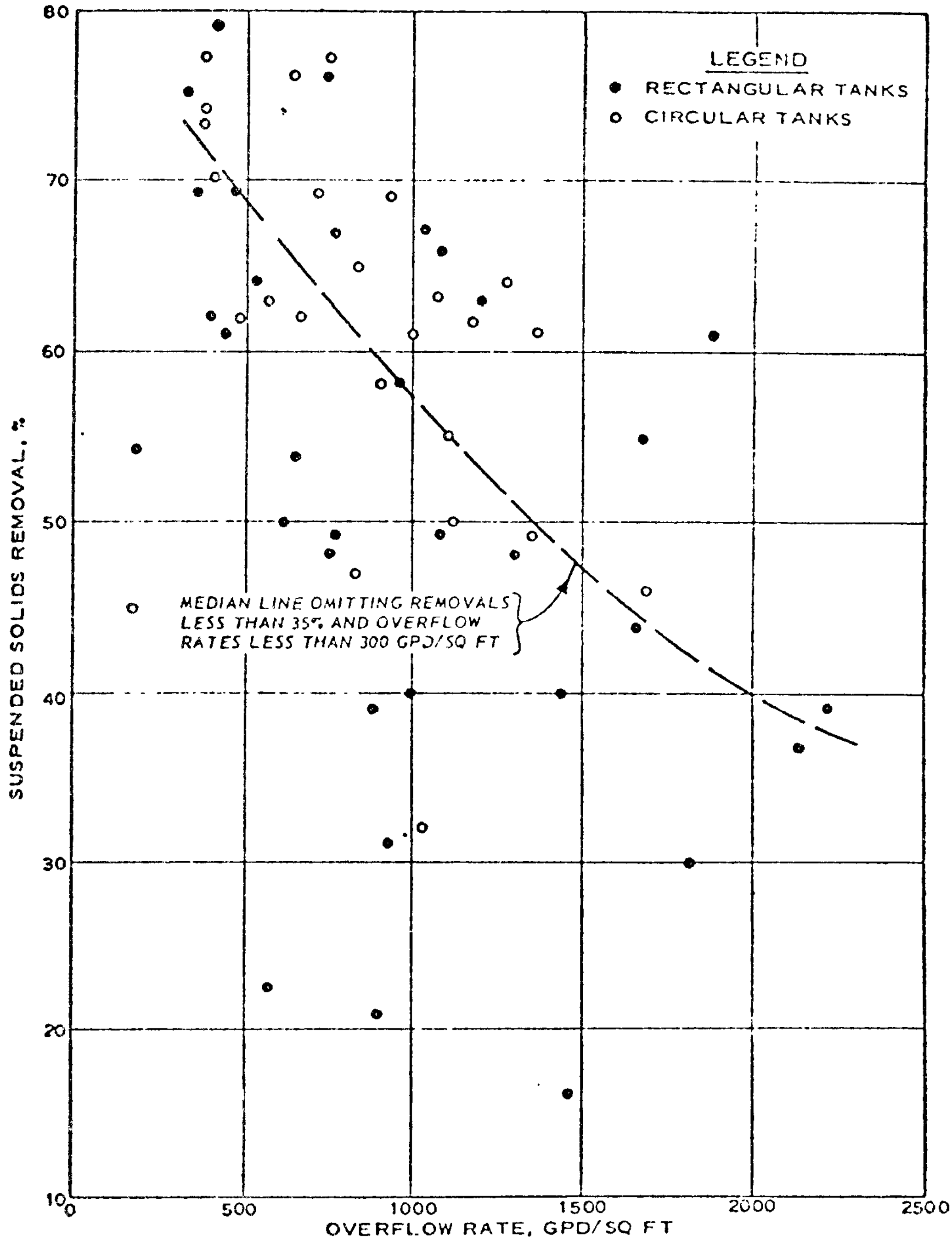


Figure 3-8. Suspended solids removal versus overflow rate for primary clarifiers.

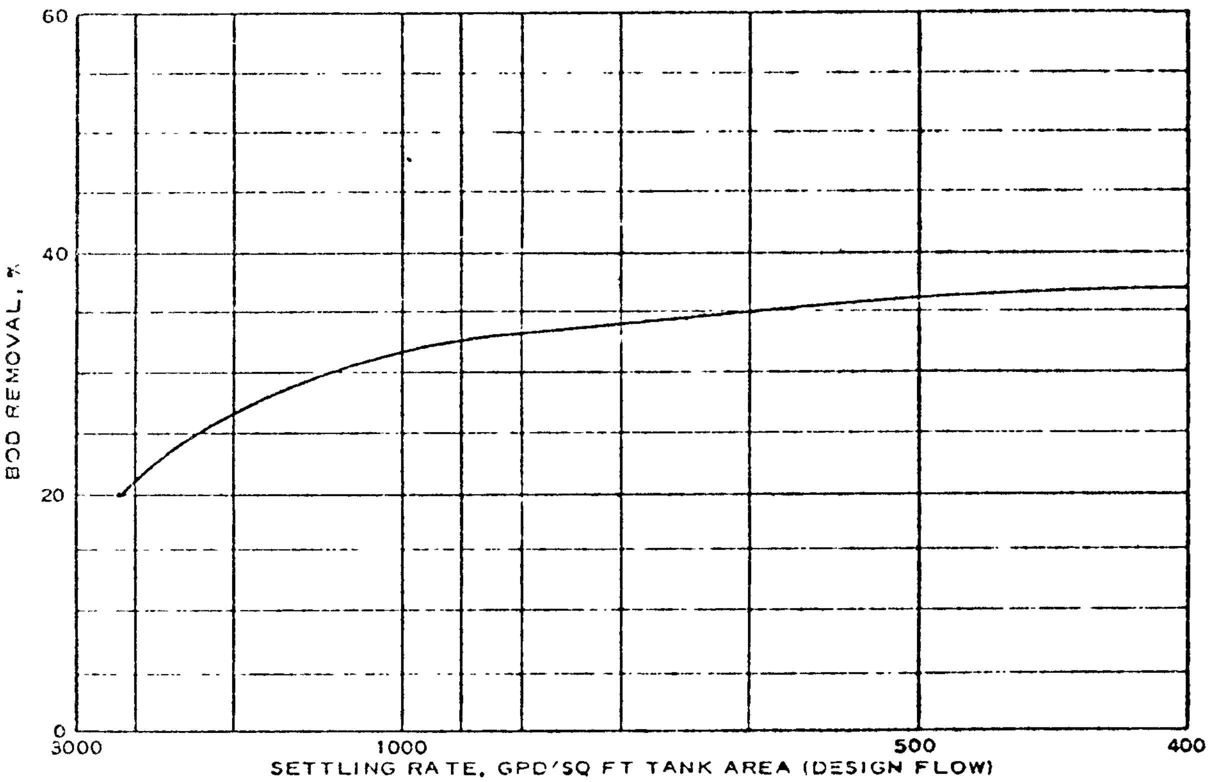


Figure 3-9. BOD removal rate in primary clarifier.

3-43. Primary Clarification (coagulation;see page 5-67 of Design Manual)

a. Design Parameters

Sidewater depth≈7.0-12.0 ft
Underflow concentration of solids≈4.0-6.0%
Weir overflow rate≈10,000-15,000 gal/day/ft
Surface overflow rate (see Table 3-15)

Table 3-15. Recommended Surface-Loading Rates for Various Suspensions

Suspension	Loading Rate, gpd/ft^2 Range	Peak Flow
Untreated wastewater	600 to 1200	1200
Alum floc[a]	360 to 600	600
Iron floc[a]	540 to 800	800
Lime floc[a]	540 to 1200	1200

[a]Mixed with the settleable suspended solids in the untreated wastewater and colloidal or other suspended solids swept out by the floc.
From Metcalf and Eddy, Inc., 1971

Specific gravity of sludge (see Table 3-16)

Table 3-16. Specific Gravity of Raw Sludge Produced from Various Types of Sewage

Type of Sewerage System	Strength of Sewage	Specific Gravity
Sanitary	Weak	1.02
Sanitary	Medium	1.03
Combined	Medium	1.05
Combined	Strong	1.07

From Metcalf and Eddy, Inc., 1971

Suspended solids removal (see Figure 3-10)
BOD removal (see Figure 3-11)

b. Default Data

```
SURFACE OVERFLOW RATE                 500        G/D/SQFT
SIDE WATER DEPTH                      9          FEET
SPECIFIC GRAVITY                      1.05
UNDERFLOW CONCENTRATION               4          PERCENT
REMOVAL    SS=90   BOD=60   COD=60    TKN=40    PO=50  PERCENT
WEIR OVERFLOW RATE                    15         G/D/FT
```

c. Primary Clarification (Coagulation) Unit Process Data Cards

```
C PRIMARY CLARIFICATION (COAGULATION)[a]   MOD   xx
SURFACE OVERFLOW RATE          xx.x         G/SQFT/DAY
SIDEWATER DEPTH                xx.x         FT
SPECIFIC GRAVITY               xx.x
UNDERFLOW CONCENTRATION        xx.x         PERCENT
REMOVAL SS=xx.x  BOD[d]=xx.x  COD=xx.x  TKN=xx.x    PERCENT
WEIR OVERFLOW RATE             xx.x         G/FT/DAY
RECTANGULAR CLARIFIER[b]
CIRCULAR CLARIFIER[b]
ESTIMATE[c]  STANDARD MECHANISM COST = xx.x
END
```

---

[a] This process is used as part of the coagulation process.

[b] Use rectangular or circular clarifier, not both. Default is circular clarifier.

[c] Rectangular clarifier - cost of standard 20-foot by 120-foot clarifier mechanism - default value = $42,000.

Circular clarifier - cost of standard 90-foot diameter clarifier mechanism - default value = $75,000.

[d] BOD removal rate is rate of removal of non-soluble BOD5.

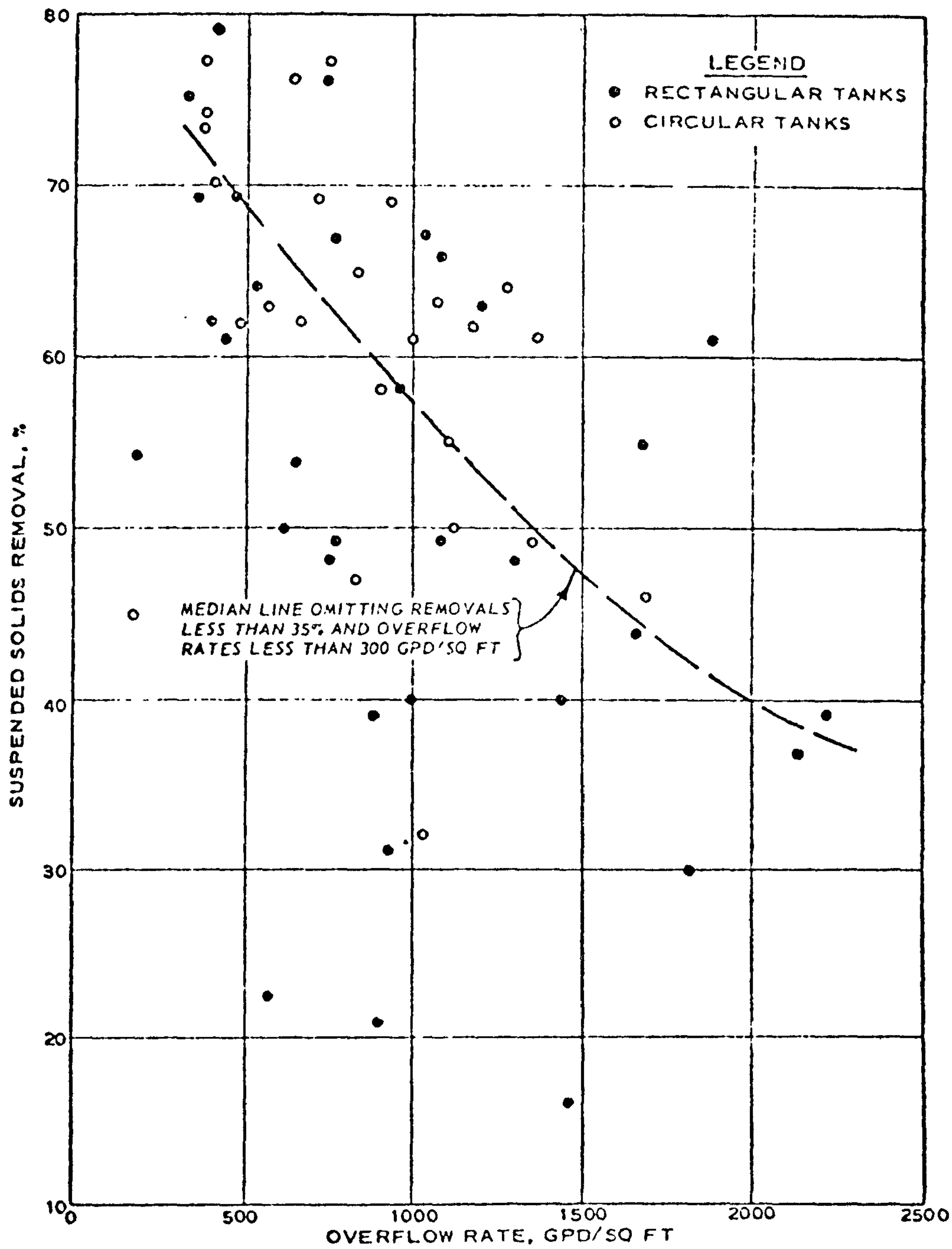


Figure 3-10. Suspended solids removal versus overflow rate for primary clarifiers.

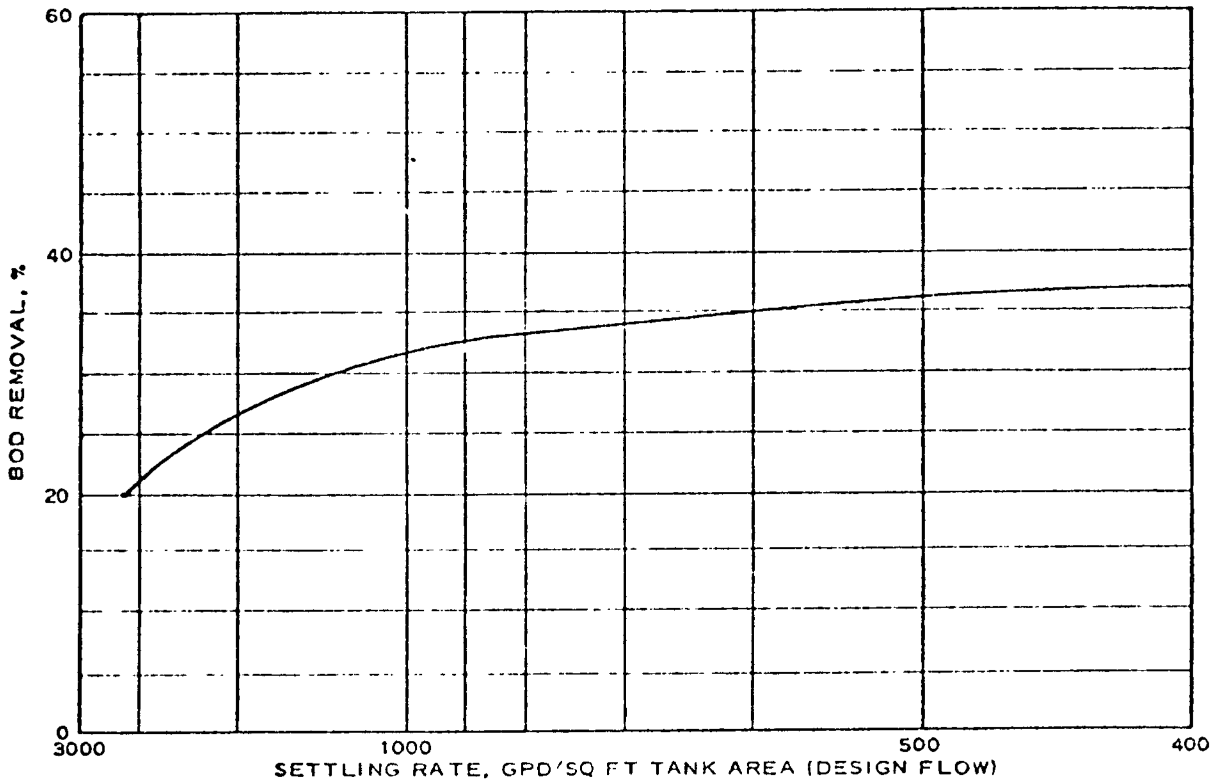


Figure 3-11. BOD removal rate in primary clarifier.

3-44. Primary clarification (Two Stage Lime Treatment; see page 5-67 of Design Manual)

a. Design Parameters

Sidewater depth 7.0-12.0 ft
Underflow concentration of solids 4.0-6.0%
Weir overflow rate 10,000-15,000 gal/day/ft
Surface overflow rate (see Table 3-17)

Table 3-17. Recommended Surface-Loading Rates for Various Suspensions

Suspension	Loading Rate, gpd/ft^2 Range	Loading Rate, gpd/ft^2 Peak Flow
Untreated wastewater	600 to 1200	1200
Alum floc[a]	360 to 600	600
Iron floc[a]	540 to 800	800
Lime floc[a]	540 to 1200	1200

[a]Mixed with the settleable suspended solids in the untreated wastewater and colloidal or other suspended solids swept out by the floc.

From Metcalf and Eddy, Inc., 1971

Specific gravity of sludge (see Table 3-18)

Table 3-18. Specific Gravity of Raw Sludge Produced from Various Types of Sewage

Type of Sewerage System	Strength of Sewage	Specific Gravity
Sanitary	Weak	1.02
Sanitary	Medium	1.03
Combined	Medium	1.05
Combined	Strong	1.07

From Metcalf and Eddy, Inc., 1971

Suspended solids removal (see Figure 3-12)
BOD removal (see Figure 3-13)

b. Default Data

```
ESTIMATE
SURFACE OVERFLOW RATE                 1000      G/SQFT/DAY
SIDE WATER DEPTH                      9         FEET
SPECIFIC GRAVITY                      1.03
UNDERFLOW CONCENTRATION               1.00      PERCENT
REMOVAL  SS=80  BOD=85  COD=85  TKN=30  PO=80     PERCENT
WEIR OVERFLOW RATE                    15000     G/FT/DAY
```

c. Primary Clarification (Two-Stage Lime Treatment) Unit Process Data Cards

L PRIMARY CLARIFICATION (TWO-STAGE LIME TREATMENT)		MOD xx
SURFACE OVERFLOW RATE	xx.x	G/SQFT/DAY
SIDEWATER DEPTH	xx.x	FT
SPECIFIC GRAVITY	xx.x	
UNDERFLOW CONCENTRATION	xx.x	PERCENT
REMOVAL SOLIDS = xx.x BOD = xx.x COD = xx.x TKN = xx.x PO = xx.x		PERCENT
WEIR OVERFLOW RATE	xx.x	G/FT/DAY
RECTANGULAR CLARIFIER[a]		
CIRCULAR CLARIFIER[a]		
ESTIMATE[b] STANDARD MECHANISM COST = xx.x		
END		

---

[a]Use rectangular or circular clarifier, not both - default is circular clarifier.

[b]Rectangular clarifier - cost of standard 20-foot by 120-foot clarifier mechanism - default value = $42,000.

Circular clarifier - cost of standard 90-foot diameter clarifier mechanism - default value = $75,000.

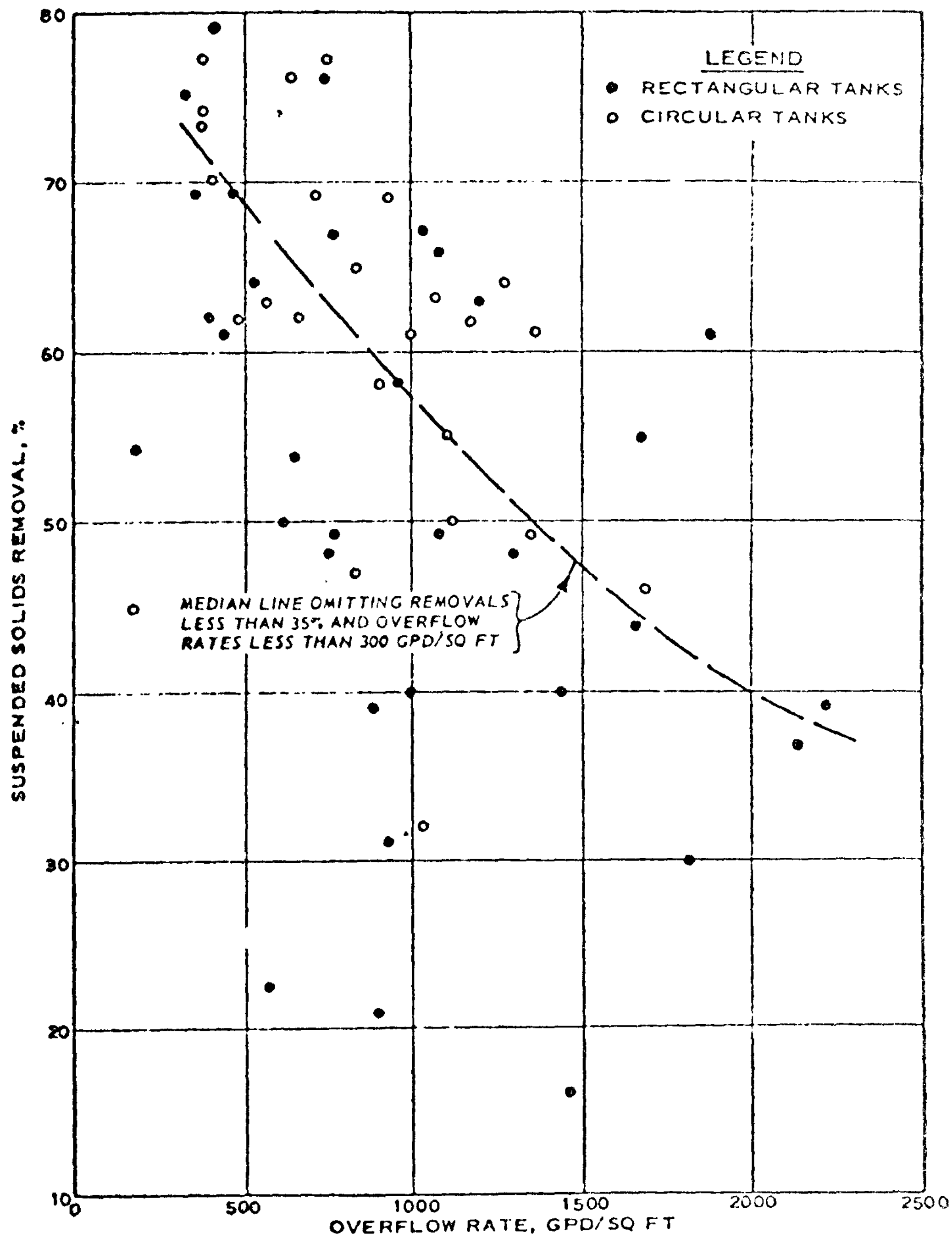


Figure 3-12. Suspended solids removal versus overflow rate for primary clarifiers.

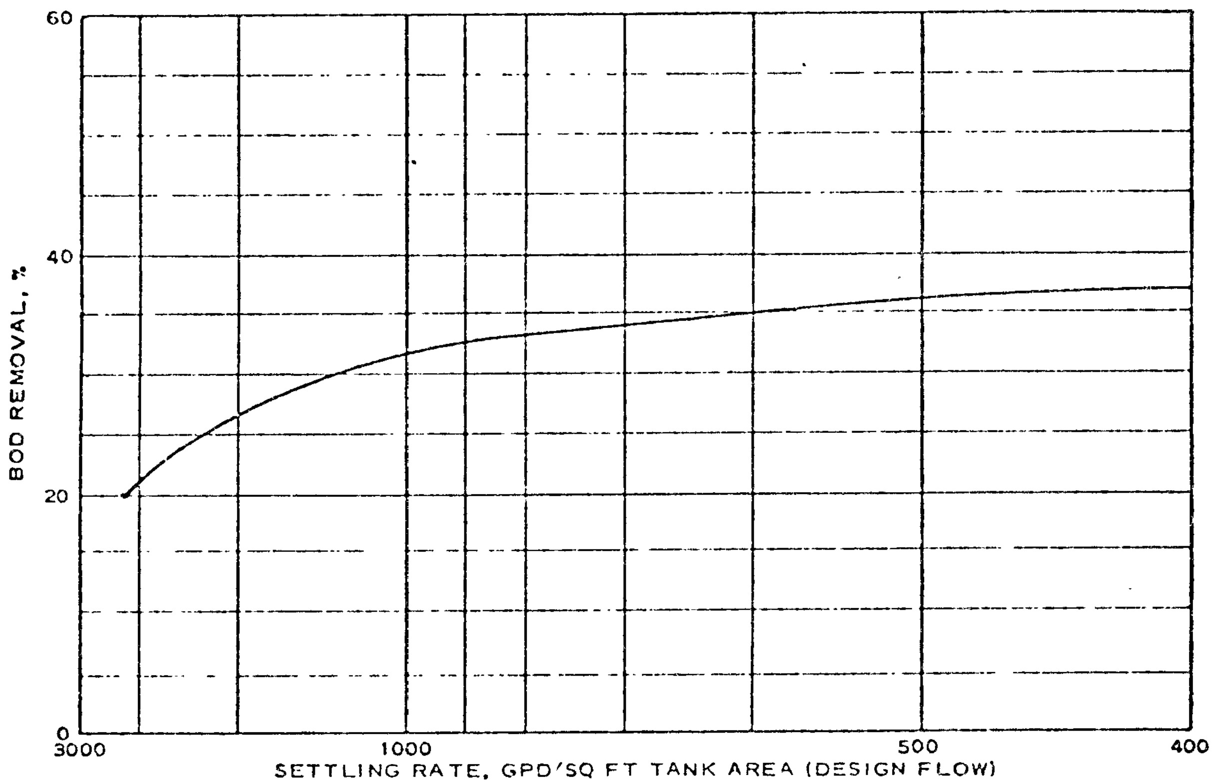


Figure 3-13. BOD removal rate in primary clarifier.

3-45. Pure Oxygen Activated Sludge (see page 7-171 of Design Manual)

a. Design Parameters

Eckenfelder's Approach

Reaction rate constants

k, BOD removal rate constant≈0.0007-0.002 ℓ/mg/hr

a, fraction of BOD synthesized≈0.73

a^{∇}, fraction of BOD oxidized for energy≈0.52

b, endogenous rate (oxygen basis)≈0.075/day

b^{∇}, endogenous rate (sludge basis)≈0.15/day

f, nonbiodegradable fraction of VSS in influent≈0.40

f^{∇}, degradable fraction of the MLVSS≈0.53

F/M ratio≈0.25-1.0

Mixed liquor suspended solids≈4000-7000 mg/ℓ

Mixed liquor volatile solids≈3200-5600 mg/ℓ

Temperature correction coefficient≈1.0-1.03

Effluent BOD soluble≈10 mg/ℓ

ALPHA O_2 transfer in waste/O_2 transfer in water≈0.90

BETA O_2 saturation in waste/O_2 saturation in water≈0.70

HP Horsepower per 1000 gallons≥0.10 hp/1000 gal

STE Standard transfer efficiency

Mechanical Aerators≈2.0-3.5 lb O_2/hp-hr
High speed ≈2.0
Slow speed ≈3.5

Diffused Aerator 6.0-11.0%
Coarse bubble≈6.0
Fine bubble≈11.0

b. Default Data

```
ESTIMATE
CONSTANTS  K=0.00135 A=0.73 AP=0.52 B=0.075 BP=0.15 F=0.40 FP=0.53
F/M RATIO                              0.625     LB BOD/LB VSS
MIXED LIQUOR      SS=7000      VS=5500           MG/L
TEMPERATURE COEFFICIENT                1.03
EFFLUENT BOD SOLUBLE                   5         MG/L
MECHANICAL AERATION ALPHA=0.9 BETA=0.9 HP=0.0 HP/TG STE=3.5 LB O/HP HR
```

c. Pure Oxygen Activated Sludge Unit Process Data Cards

```
PURE OXYGEN ACTIVATED SLUDGE[a]   MOD  xx
CONSTANTS  K=xx.x  A=xx.x  A∇=xx.x  B=xx.x  B∇=xx.x  F=xx.x
           F∇=xx.x
F/M RATIO                          xx.x              LB BOD/LB VSS
MIXED LIQUOR SS=xx.x            VS=xx.x              MG/L
TEMPERATURE COEFFICIENT            xx.x
EFFLUENT BOD SOLUBLE               xx.x              MG/L
MECHANICAL AERATION ALPHA[b]=xx.x  BETA=xx.x  HP=xx.x  HP/TG
  STE=xx.x LB O/HP-HR
DIFFUSED AERATION ALPHA[b]=xx.x  BETA=xx.x  AF[c]=xx.x  CFM/TG
  STE=xx.x  PER
ESTIMATE[d] SSXSA = xx.x  COSTSP = xx.x  COSTSCR = xx.x
  COSTPS = xx.x
END
```

[a] User must also specify secondary clarification (activated sludge).

[b] Use mechanical or diffused, not both.

[c] AF (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

[d] SSXSA = Cost of standard slow-speed pier-mounted 20-hp aerator - default value = $16,300.

COSTSP = Cost of standard 10-ton PSA oxygen generation unit - default value = $800,000.

COSTSCR = Cost of standard 50-ton cryogenic oxygen generation unit - default value = $1,900,000.

COSTPS = Cost of standard 3000 gpm pump and driver unit - default value = $17,250.

3-46. Rapid Infiltration Land Treatment

a. Design Parameters

Application rate≈4.0-150.0 in/wk

Runoff (site dependent)≈0.0

Buffer zone (site dependent)≈0.0-500.0 ft

Slope is not critical but values over 8.0% require excessive earthwork

Fraction of nitrogen loading denitrified≈30.0-60.0%

Ammonia volatilization≈0.0%

Removal of phosphorus≈90.0%

NW Number of recovery wells

WDIA Diameter of recovery wells

DW Depth of recovery wells

SP Cost of 12-inch welded steel pipe in-place - default value = \$12.80 per foot

BV Cost of 12-inch butterfly valve - default value = \$952.10

PP Cost of 6-inch perforated PVC pipe default value = \$6.94 per foot

CP Cost of 24-inch concrete Class III pipe - default value = \$10.20 per foot

WW Cost of 4-inch water well - default value = \$8.00 per foot

RW Cost of 4-inch recovery well - default value = \$8.00 per foot

PS Cost of standard 3000 gpm pump and driver unit - default value = \$17,250.

b. Default Data

APPLICATION RATE	35.0	IN/WEEK
PRECIPITATION RATE	0.8	IN/WEEK
EVAPOTRANSPIRATION RATE	0.4	IN/WEEK
RUNOFF	0.0	IN/WEEK
WASTEWATER GENERATION PERIOD	364.0	DAYS/YR
FIELD APPLICATION PERIOD	52.0	WEEKS/YR
NO RECOVERY SYSTEM		
BUFFER ZONE	0.0	FEET
MONITORING WELLS	9 WELLS	AT 10 FT/WELL
FENCING	2.75	\$/FT
FRACTION DENITRIFIED	45.0	PERCENT OF APPLIED N
AMMONIA VOLATILIZATION	0.0	PERCENT OF APPLIED N
REMOVAL OF PHOSPHORUS	90.0	PERCENT OF APPLIED P
ESTIMATE		

c. Rapid Infiltration Land Treatment Unit Process Data Cards

RAPID INFILTRATION LAND TREATMENT	MOD xx	
APPLICATION RATE	xx.x	IN/WK
PRECIPITATION RATE	xx.x	IN/WK
EVAPOTRANSPIRATION RATE	xx.x	IN/WK
RUNOFF	xx.x	IN/WK
WASTEWATER GENERATION PERIOD	xx.x	DAYS/YR
FIELD APPLICATION PERIOD	xx.x	WKS/YR
NO RECOVERY SYSTEM[a]		
UNDERDRAIN RECOVERY SYSTEM[a]		
RECOVERY WELLS SYSTEM[a]	NW xx.x WDIA xx.x IN	DW xx.x FT
BUFFER WIDTH	xx.x	FT
MONITORING WELLS NO = xx.x	DEPTH/WELL = xx.x	FT
FENCING	xx.x	$/FT
FRACTION DENITRIFIED	xx.x	PERCENT
AMMONIA VOLATILIZATION	xx.x	PERCENT
REMOVAL OF PHOSPHORUS	xx.x	PERCENT

ESTIMATE SP xx.x BV xx.x PP xx.x CP xx.x WW xx.x RW xx.x PS xx.x

END

[a]Use recovery wells, underdrains, or no recovery system, but no more than one.

3-47. Recarbonation (see page 6-61 of Design Manual)

a. Design Parameters

Detention time≈15.0-30.0 min

Alkalinity of hydroxide (determine from waste characterization study)≈50.0 mg/ℓ

Alkalinity of carbonate (determine from waste characterization study)≈150.0 mg/ℓ

b. Default Data

```
DETENTION TIME                        15          MIN
ALKALINITY     HYDROXIDE=50     CARBONATE=150        MG/L
```

c. Recarbonation Unit Process Data Cards

RECARBONATION	MOD xx		
DETENTION TIME	xx.x		MIN
ALKALINITY	HYDROXIDE=xx.x	CARBONATE=xx.x	MG/L
END			

3-48. First Stage Recarbonation (see page 6-61 of Design Manual)

a. Design Parameters

Detention time≈15.0-30.0 min

Alkalinity of hydroxide (determine from waste characterization study)≈50.0 mg/ℓ

Alkalinity of carbonate (determine from waste characterization study≈150.0 mg/ℓ

b. Default Data

```
DETENTION TIME                         15          MIN
ALKALINITY     HYDROXIDE=50       CARBONATE=150     MG/L
```

c. First Stage Recarbonation Unit Process Data Cards

FIRST STAGE RECARBONATION	MOD	xx	
DETENTION TIME	xx.x		MIN
ALKALINITY	HYDROXIDE=xx.x	CARBONATE=xx.x	MG/L
END			

3-49. Second Stage Recarbonation (see page 6-61 of Design Manual)

a. Design Parameters

Detention time≈15.0-30.0 min

Alkalinity of hydroxide (determine from waste characterization study)≈50.0 mg/ℓ

Alkalinity of carbonate (determine from waste characterization study)≈150.0 mg/ℓ

b. Default Data

```
DETENTION TIME                                15          MIN
ALKALINITY      HYDROXIDE=50           CARBONATE=150           MG/L
```

c. Second Stage Recarbonation Unit Process Data Cards

SECOND STAGE RECARBONATION	MOD	xx	
DETENTION TIME	xx.x		MIN
ALKALINITY	HYDROXIDE=xx.x	CARBONATE=xx.x	MG/L
END			

3-50. <u>Screening</u> (see page 5-19 of Design Manual)

a. Design Parameters

Bar shape factor
  Sharp-edged rectangular bars≈2.42
  Rectangular bars with semi-circular upstream face≈1.83
  Circular bars≅1.79
  Rectangular bars with both ends semi-circular≈1.67
  Rectangular bars with semi-circular upstream face and tapered symmetrical circular downstream face≈0.76
Bar screen width (see Table 3-19)
Bar screen spacing (see Table 3-19)
Bar screen slope (see Table 3-19)
Approach velocities (see Table 3-19)

Table 3-19. General Characteristics of Bar Screens

Item	Hand Cleaned	Mechanically Cleaned
Bar screen size		
Width, in.	1/4 to 5/8	1/4 to 5/8
Depth, in.	1 to 3	1 to 3
Spacing, in.	1 to 2	5/8 to 3
Slope from vertical, deg	30 to 45	o to 30
Approach velocity, fps	1 to 2	2 to 3
Allowable head loss, in.	6	6

b. Default Data

```
MECHANICALLY CLEANED                        DEPTH=1        FEET
BARS  WIDTH=0.25 IN   SPACE=1.5 IN   SLOPE=30 DEG   SHAPE FACT=2.42
VELOCITIES  APPROACH=2.5  MAX=3.0    AVE=2.5        FPS
```

c. Screening Unit Process Data Cards

```
SCREENING[a]            MOD   xx

MECHANICALLY CLEANED[b]           WIDTH=xx.x               FT

MANUALLY CLEANED[b]               WIDTH=xx/x               FT

BARS WIDTH=xx.x  IN SPACE=xx.x  IN SLOPE=xx.x  DEG
  SHAPE FACTOR=xx.x

VELOCITIES APPROACH=xx.x  MAX=xx.x  AVG=xx.x           FT/SEC

END
```

---

[a]This process is part of preliminary treatment.

[b]Use mechanically cleaned or manually cleaned, not both.

3-51. Secondary clarification (Activated Sludge; see page 5-83 of Design Manual)

a. Design Parameters

Solids loading rate≈12.0-30.0 lb/ft^2/day

Surface overflow rate (small plants≤ 1.0 mgd)≈ <600 gal/ft^2/day

Surface overflow rate (large plants≥ 1.0 mgd)≈ <800 gal/ft^2/day

Underflow concentration≈0.8-1.2%

Weir overflow rate≈10,000-15,000 gal/ft/day

Sidewater depth≈7.0-12.0 ft

Specific gravity of sludge (see Table 3-20)

Table 3-20. Specific Gravity of Raw Sludge Produced from Various Types of Sewage

Type of Sewerage System	Strength of Sewage	Specific Gravity
Sanitary	Weak	1.02
Sanitary	Medium	1.03
Combined	Medium	1.05
Combined	Strong	1.07

From Metcalf and Eddy, Inc., 197

b. Default Data

ESTIMATE		
RECTANGULAR		
SOLID LOADING TIME	15	LB/SQFT/DAY
SURFACE OVERFLOW RATE (MAXIMUM)	800	G/SQFT/DAY
SPECIFIC GRAVITY OF SLUDGE	1.03	
UNDERFLOW CONCENTRATION	1.0	PERCENT
WEIR OVERFLOW RATE (MAXIMUM)	15000	G/D/FT
SIDE WATER DEPTH	9	FEET
EFFLUENT SUSPENDED SOLIDS	20	MG/L

c. Secondary Clarification (Activated Sludge)[a] Unit Process Data Cards

A SECONDARY CLARIFICATION (ACTIVATED SLUDGE)	MOD xx	
SOLID LOADING RATE	xx.x	LB/SQFT/DAY
SURFACE OVERFLOW RATE	xx.x	G/SQFT/DAY
SPECIFIC GRAVITY OF SLUDGE	xx.x	
UNDERFLOW CONCENTRATION	xx.x	PERCENT
WEIR OVERFLOW RATE	xx.x	G/FT/DAY
SIDEWATER DEPTH	xx.x	FT
EFFLUENT SUSPENDED SOLIDS	xx.x	MG/L
RECTANGULAR CLARIFIER[b]		
CIRCULAR CLARIFIER[b]		
ESTIMATE[c] STANDARD MECHANISM COST = xx.x		
END		

---

[a]This process is used with all activated sludge processes. It need be specified only once.

[b]Use rectangular or circular clarifier, not both - default is circular clarifier.

[c]Rectangular clarifier - cost of standard 20-foot by 120-foot clarifier mechanism - default value = $42,000.

Circular clarifier - cost of standard 90-foot diameter clarifier mechanism - default value = $75,000.

3-52. Secondary Clarification (Nitrify-Denitrify; see page 5-83 of Design Manual)

a. Design Parameters

Solids loading rate≈12.0-30.0 lb/ft^2/day

Surface overflow rate≈<600 gal/ft^2/day

Underflow concentration≈0.8-1.2%

Weir overflow rate≈10,000-15,000 gal/ft/day

Sidewater depth≈7.0-12.0 ft

f^∇, degradable fraction of the MLVSS≈0.53

Specific gravity of sludge (see Table 3-21)

Table 3-21. Specific Gravity of Raw Sludge Produced from Various Types of Sewage

Type of Sewerage System	Strength of Sewage	Specific Gravity
Sanitary	Weak	1.02
Sanitary	Medium	1.03
Combined	Medium	1.05
Combined	Strong	1.07

From Metcalf and Eddy, Inc., 1971

b. Default Data

SOLID LOADING RATE	15	LB/SQFT/DAY
SURFACE OVERFLOW RATE (MAXIMUM)	1000	G/SQFT/DAY
SPECIFIC GRAVITY OF SLUDGE	1.03	
UNDERFLOW CONCENTRATION	1.0	PERCENT
WEIR OVERFLOW RATE (MAXIMYM)	15000	G/D/FT
SIDE WATER DEPTH	9	FEET
EFFLUENT SUSPENED SOLIDS ESTIMATE	20	MG/l

c. Secondary Clarification (Nitrify/Denitrify)[a] Unit Process Data Cards

N SECONDARY CLARIFICATION (NITRIFY/DENITRIFY)	MOD	xx
SOLID OVERFLOW RATE (MAXIMUM)	xx.x	LB/SQFT/DAY
SURFACE LOADING RATE	xx.x	G/SQFT/DAY
CONSTANT F^{∇} = xx.x		FRACTION
SPECIFIC GRAVITY OF SLUDGE	xx.x	
UNDERFLOW CONCENTRATION	xx.x	PERCENT
WEIR OVERFLOW RATE (MAXIMUM)	xx.x	G/FT/DAY
SIDEWATER DEPTH	xx.x	FT
EFFLUENT SUSPENDED SOLIDS	xx.x	MG/L
RECTANGULAR CLARIFIER[b]		
CIRCULAR CLARIFIER[b]		
ESTIMATE[c] STANDARD MECHANISM COST = xx.x		
END		

---

[a]This process is used with the nitrification process and with the combined nitrivication/denitrification process. It need be specified only once.

[b]Use rectangular or circular clarifier, not both - default is circular clarifier.

[c]Rectangular clarifier - cost of standard 20-foot by 120-foot clarifier mechanism - default value = $42,000.

Circular clarifier - cost of standard 90-foot diameter clarifier mechanism - default value = $75,000.

3-53. Secondary Clarification (Trickling Filters; see page 5-83 of Design Manual)

a. Design Parameters

Solids loading rate≈12.0-30.0 lb/ft^2/day

Surface overflow rate (small plants≤ 1.0 mgd)≈ <600 gal/ft^2/day

Surface overflow rate (large plants≥ 1.0 mgd)≈ <800 gal/ft^2/day

Underflow concentration≈2.0-4.0%

Weir overflow rate≈10,000-15,000 gal/ft/day

Sidewater depth≈7.0-12.0 ft

Mixed liquor volatile solids≈1000-2500 mg/ℓ

Specific gravity of sludge (see Table 3-22)

Table 3-22. Specific Gravity of Raw Sludge Produced from Various Types of Sewage

Type of Sewerage System	Strength of Sewage	Specific Gravity
Sanitary	Weak	1.02
Sanitary	Medium	1.03
Combined	Medium	1.05
Combined	Strong	1.07

From Metcalf and Eddy, Inc., 1971

b. Default Data

ESTIMATE

SOLID LOADING RATE	15	LB/SQFT/DAY
SURFACE OVERFLOW RATE (MAXIMUM)	1000	G/SQFT/DAY
SPECIFIC GRAVITY OF SLUDGE	1.03	
UNDERFLOW CONCENTRATION	1.0	PERCENT
WEIR OVERFLOW RATE (MAXIMUM)	15000	G/D/FT
SIDE WATER DEPTH	9	FEET
EFFLUENT SUSPENDED SOLIDS	20	MG/L
MIXED LIQUOR VSS	800	MG/L

c. Secondary Clarification (Trickling Filters)[a] Unit Process Data Cards

T SECONDARY CLARIFICATION (TRICKLING FILTERS)	MOD	xx
SOLID LOADING RATE	xx.x	LB/SQFT/DAY
SURFACE OVERFLOW RATE (MAXIMUM)	xx.x	G/SQFT/DAY
SPECIFIC GRAVITY OF SLUDGE	xx.x	
UNDERFLOW CONCENTRATION	xx.x	PERCENT
WEIR OVERFLOW RATE (MAXIMUM)	xx.x	G/FT/DAY
SIDEWATER DEPTH	xx.x	FT
EFFLUENT SUSPENDED SOLIDS	xx.x	MG/L
MIXED LIQUOR VS	xx.x	MG/L

RECTANGULAR CLARIFIER[b]

CIRCULAR CLARIFIER[b]

ESTIMATE[c] STANDARD MECHANISM COST = xx.x

END

---

[a]This process is part of the trickling filtration process.

[b]Use rectangular or circular clarifier, not both - default is circular clarifier.

[c]Rectangular clarifier - cost of standard 20-foot by 120-foot clarifier mechanism - default value = $42,000.

Circular clarifier - cost of standard 90-foot diameter clarifier mechanism - default value = $75,000.

3-54. Slow Infiltration Land Treatment

a. Design Parameters

Average Application rate≈0.5-4.0 in/wk

Maximum Application rate≈0.10-0.50 in/hr

Runoff (site dependent)≈0.0

Buffer zone (site dependent)≈0.0-500.0 ft

Fraction of nitrogen loading denitrified≈15.0-25.0%

Ammonia volatilization≈0.0%

Removal of phosphorus≈80.0%

Slope on cultivated land≲20.0%

Slope on noncultivated land≲40.0%

NW Number of recovery wells

WDIA Diameter of recovery wells

DW Depth of recovery wells

PS Cost of standard 3000 gpm pump and driver unit - default value = $17,250.0

SP Cost of 12-inch welded steel pipe in-place - default value = $12.80 per foot

SV Cost of 12-inch butterfly valve - default value = $952.10

EN Cost of 6-15 gpm impact type rotor pop-up full circle sprinkler - default value = $61.65

CG Cost of clearing and grubbing - default value = $3000.00 per acre

MW Cost of 4-inch water well - default value = $8.00 per foot

PC Cost of center pivot 100 acre sprinkler system - default value = $27,690.00

b. Default Data

```
FORAGE GRASSES
APPLICATION RATE            AVERAGE  2.0 IN/WEEK  MAXIMUM  0.20 IN/HR
PRECIPITATION RATE                     0.8   IN/WEEK
EVAPOTRANSPIRATION RATE                0.4   IN/WEEK
RUNOFF                                 0.0   IN/WEEK
WASTEWATER GENERATION PERIOD         364.0   DAYS/YR
FIELD APPLICATION PERIOD              52.0   WEEKS/YR
SOLID SET PIPING AND PUMPING
NO STORAGE
NO RECOVERY SYSTEM
BUFFER ZONE                            0.0   FEET
CURRENT GROUND COVER   FOREST   20.0 %  BRUSH 30.0 %  PASTURE 50.0%
SLOPE                                  2.0   PERCENT
MONITORING WELLS                     9 WELLS AT 10 FT/WELL
FENCING                                2.75  $/FT
FRACTION DENITRIFIED                  20.0   PERCENT OF APPLIED N
AMMONIA VOLATILIZATION                 0.0   PERCENT OF APPLIED N
REMOVAL OF PHOSPHORUS                 80.0   PERCENT OF APPLIED P
DAYS PER WEEK OPERATION                7.0   DAYS/WEEK
HOURS PER DAY OPERATION                8.0   HOURS/DAY
ESTIMATE
```

c. Slow Infiltration Land Treatment Unit Process Data Cards

SLOW INFILTRATION LAND TREATMENT		MOD	xx	
FORAGE GRASSES[a]				
CORN[a]				
APPLICATION RATE	AVERAGE xx.x	IN/WEEK	MAXIMUM xx.x	IN/HOUR
PRECIPITATION RATE		xx.x		IN/WK
EVAPOTRANSPIRATION RATE		xx.x		IN/WK
RUNOFF		xx.x		IN/WK
WASTEWATER GENERATION PERIOD		xx.x		DAYS/YR
FIELD APPLICATION PERIOD		xx.x		WKS/YR
SOLID SET PIPING[a]				
CENTER PIVOT PIPING[a]				
NO STORAGE[b]				
STORAGE[b,c] (MINIMUM)		xx.x		DAYS/YEAR
LINER REQUIRED[c]		xx.x		$/SQFT
EMBANKMENT PROTECTION[c]		xx.x		$/CUFT
NO RECOVERY SYSTEM[d]				
UNDERDRAIN RECOVERY SYSTEM[d]				
BUFFER WIDTH		xx.x		FT
CURRENT GROUND COVER	FOREST xx.x%	BRUSH xx.x%	PASTURE	xx.x%
SLOPE		xx.x		PERCENT
MONITORING WELLS	NO = xx.x	DEPTH/WELL = xx.x		FT
FENCING		xx.x		$/FT
FRACTION DENITRIFIED		xx.x		PERCENT
AMMONIA VOLITILIZATION		xx.x		PERCENT
SOIL RETENTION		xx.x		PERCENT
HOURS PER DAY OPERATION		xx.x		HOURS
DAYS PER WEEK OPERATION		xx.x		DAYS

ESTIMATE PS xx.x SP xx.x SV xx.x EN xx.x CG xx.x MW xx.x PC xx.x

END

---

[a]Use solid set or center pivot, not both.

[b]Use storage or no storage, not both.

[c]Liner or embankment protection should only be used with storage.

[d]Use underdrain or no recovery, not both.

3-55. Sludge Flotation (see page 5-41 of Design Manual)

a. Design Parameters

Air pressure≃40-70 psig

Detention time in float tank≈0.25-0.5 hrs

Solid loading (determine from laboratory tests)

Hydraulic loading≈1.0-4.0 gal/min/ft^2

Recycle time in pressure tank≈1.0-3.0 min

Percent removal of solids (determine from bench test)≈80.0

Air/solids ratio (determine from laboratory test)

Float concentration (determine from bench test)≈5.0%

Removal of BOD (determine from bench test)

Removal of COD (determine from bench test)

Removal of TKN (determine from bench test)

Polymer dosage required≃10.0 lb/ton dry solids

b. Default Data

ESTIMATE		
AIR PRESSURE	60	PSIG
DETENTION TIME IN FLOAT TANK	3	HRS
SOLID LOADING	8	LB/SQFT/DAY
HYDRAULIC LOADING	2.5	GPM/SQFT
RECYCLE TIME IN PRESS TANK	2	MIN
PERCENT REMOVAL OF SOLIDS	85	PERCENT
AIR/SOLIDS RATIO	0.02	
FLOAT CONCENTRATION	3	PERCENT
POLYMER REQUIRED	1 LB/TON	

c. Sludge Flotation Unit Process Data Cards

SLUDGE FLOTATION	MOD	xx	
AIR PRESSURE		xx.x	PSIG
DETENTION TIME IN FLOAT TANK		xx.x	HRS
SOLID LOADING		xx.x	LB/SQFT/DAY
HYDRAULIC LOADING		xx.x	GPM/SQFT
RECYCLE TIME IN PRESS TANK		xx.x	MIN
PERCENT REMOVAL OF SOLIDS		xx.x	PERCENT
AIR/SOLIDS RATIO		xx.x	
FLOAT CONCENTRATION		xx.x	PERCENT
POLYMER REQUIRED		xx.x	LB/TON

ESTIMATE[a] COSTFS = xx.x

END

---

[a]COSTFS = Cost of standard 350-square foot air flotation unit - default value = $44,200.

3-56. Sludge Hauling and Landfilling (see page 5-169 of Design Manual)

a. Design Parameters

Distance to disposal site (based on local conditions)

Hours per day working schedule≈6.0-8.0 hours

Loading time per vehicle≈0.2-2.0 hrs

Hauling time (based on local conditions)

b. Default Data

```
DISTANCE TO DISPOSAL SITE        10 MILES
HOURS PER DAY                     8 HOURS
LOADING TIME PER VEHICLE            0.75 HOURS
HAULING TIME PER TRIP             1.0 HOUR
ESTIMATE        0.0   8000   $/YR
```

c. Sludge Hauling and Landfilling Unit Process Data Cards

HAULING AND LAND FILLING	MOD	xx	
DISTANCE TO DISPOSAL SITE		xx.x	MILES
HOURS PER DAY		xx.x	HOURS
LOADING TIME PER VEHICLE		xx.x	HOURS
HAULING TIME PER TRIP		xx.x	HOURS

ESTIMATE[a] COSTSSV=xx.x CYC=xx.x[b] CPCY=xx.x[b] CPT=xx.x[b]

END

---

[a]COSTSSV = Cost of standard 22 cubic yard vehicle - default value = $51,700.

CYC = Constant annual charge for landfill, $/year.

CPCY = Cost of sludge disposal per cubic yard, $/Cu Yd.

CPT = Cost of sludge disposal per ton, $/ton.

[b]One of the three land fill charges must be specified; the other must be specified as 0.0.

3-57. Step Aeration Activated Sludge (see page 7-69 of Design Manual)

a. Design Parameters

Eckenfelder's Approach

Reaction rate constants

k, BOD removal rate constant≃0.0007-0.002 ℓ/mg/hr

a, fraction of BOD synthesized≃0.73

a^{∇}, fraction of BOD oxidized for energy≃0.52

b, endogenous rate (oxygen basis)≈0.075/day

b^{∇}, endogenous rate (sludge basis)≈0.15/day

f, nonbiogradable fraction of VSS in influent≈0.40

f^{∇}, degradable fraction of the MLVSS≃0.53

F/M ratio≈0.2-0.4

Mixed liquor suspended solids≃2000-3500 mg/ℓ

Mixed liquor volatile solids≃1400-2450 mg/ℓ

Temperature correction coefficient≈1.0-1.04

Effluent BOD soluble≃10 mg/ℓ

ALPHA O_2 transfer in waste/O_2 transfer in water≈0.90

BETA O_2 saturation in waste/O_2 saturation in water≃0.90

HP Horsepower per 1000 gallons≥ 0.10 hp/1000 gal

STE Standard transfer efficiency

Mechanical Aerators≈2.0-3.5 lb O_2/hp-hr
High speed≈2.0
Slow speed≈3.5

Diffused Aerator≃6.0-11.0%
Coarse bubble≈6.0
Fine bubble≃11.0

b. Default Data

```
ESTIMATE
CONSTANTS K=0.0012 A=0.73 AP=0.52 B=0.075 BP=0.15 F=0.4 FP=0.53
F/M RATIO                          0.3           LB BOD/LB VSS
MIXED LIQUOR   SS=2500   VS=1750                 MG/l
TEMPERATURE COEFFICIENT            1.035
EFFLUENT BOD SOLUBLE               5             MG/l
MECHANICAL AERATION ALPHA=0.9 BETA=0.9 HP=0.0 HP/TG STE=3.5 LB O/HP HR
```

c. Step Aeration Activated Sludge Unit Process Data Cards

STEP AERATION ACTIVATED SLUDGE[a] MOD xx

CONSTANTS K=xx.x A=xx.x A^∇=xx.x B=xx.x B^∇=xx.x F=xx.x F^∇=xx.x

F/M RATIO xx.x LB BOD/LB VSS

MIXED LIQUOR SS=xx.x VS=xx.x MG/L

TEMPERATURE COEFFICIENT xx.x

EFFLUENT BOD SOLUBLE xx.x MG/L

MECHANICAL AERATION ALPHA[b]=xx.x BETA=xx.x HP=xx.x HP/TG
STE=xx.x LB O/HP-HR

DIFFUSED AERATION ALPHA[b]=xx.x BETA=xx.x AF[c]=xx.x CFM/TG
STE=xx.x PER

ESTIMATE[d] SSXSA = xx.x COSTPH = xx.x COSTPS = xx.x

END

---

[a] User must also specify secondary clarification (activated sludge).

[b] Use mechanical or diffused, not both.

[c] AF (minimum airflow) specifies a lower limit on airflow. Model will calculate actual airflow and compare it with input value. Higher value will be output. Input zero for AF to obtain calculated value only.

[d] SSXSA = Cost of standard slow-speed pier-mounted 20-hp aerator - default value = $16,300.

COSTPH = Cost of standard 550 scfm swing arm diffuser - default value = $5,000.

COSTPS = Cost of standard 3000 gpm pump and driver unit - default value = $17,250.

3-58. Trickling Filtration (see page 7-3 of Design Manual)

a. Design Parameters

Desired effluent≈BOD 15.0-30.0 mg/ℓ

Recirculation ratio≈1.00-1.20

b. Default Data

```
ESTIMATE      FILTER MEDIA COST 3.0 $/CUFT
DESIRED EFFLUENT 30.0        MG/L
RECIRCULATION RATIO      1.2
```

c. Trickling Filtration Unit Process Data Cards

TRICKLING FILTRATION[a]	MOD	xx	
DESIRED EFFLUENT BOD_5		xx.x	MG/L
RECIRCULATION RATIO		xx.x	
ESTIMATE[b] UPFM=xx.x $/CUFT	CODAS=xx.x	COSTPS=xx.x	
END			

---

[a] User should also specify secondary clarification (trickling filters).

[b] UPFM = Cost of selected plastic media per cubic foot, installed - default value = $2.50 per cubic foot.

CODAS = Cost of standard 50-foot diameter distributor arm - default value = $39,000.

COSTPS = Cost of standard 3000 gpm pump and driver unit - default value = $17,250.

3-59. Vacuum Filtration (see page 5-119 of Design Manual)

a. Design Parameters

Chemical dosage 1.0%
Hours per day 8.0-16.0 hrs
Loading rate (see Table 3-23)

Table 3-23. Expected Performance of Vacuum Filters Handling Properly Conditioned Sludge

Type of Sludge	Yield, $lb/ft^2/hr$
Fresh solids	
Primary	4 to 12
Primary plus trickling filter	4 to 8
Primary plus activated	4 to 5
Activated (alone)	2.5 to 3.5
Digested solids (with or without elutriation)	
Primary	4 to 8
Primary plus trickling filter	4 to 5
Primary plus activated	4 to 5

From Simpson, 1964

b. Default Data

```
ESTIMATE
CHEMICAL DOSE                  10         PERCENT DRY WT
DAYS PER WEEK                  5          DAYS
HOURS PER DAY                  8          HOURS
LOADING RATE           3.5     LB/SQFT/HR
```

c. Vacuum Filtration Unit Process Data Cards

VACUUM FILTRATION	MOD	xx	
CHEMICAL DOSE		xx.x	PERCENT DRY WT
DAYS PER WEEK		xx.x	DAYS
HOURS PER DAY		xx.x	HOURS
LOADING RATE		xx.x	LB/SQFT/HR
ESTIMATE[a] COSTSF=xx.x			
END			

---

[a]COSTSF = Cost of standard 300-square foot vacuum filter - default value = $150,000.

3-60. Wet Oxidation

a. Design Parameters

Sludge COD≈20.0-40.0 mg/ℓ

Saturated stream pressure (determine from standard steam tables; see Figure 3-14 below)≈600.0-3000.0 psia

Specific volume of saturate steam (determine from standard steam tables; see Figure 3-14 below)≈1.446 ft^3/lb @ 450°F

COD removed≈60.0-90.0%

Temperature of reactor 250.0-700.0°F

Retention time (from Figure 3-14)

Temperature	Pressure	Specific Volume
572F	1300.0	0.33
482F	600.0	0.77
392F	220.0	2.00
302F	67.00	6.50
212F	14.697	26.80

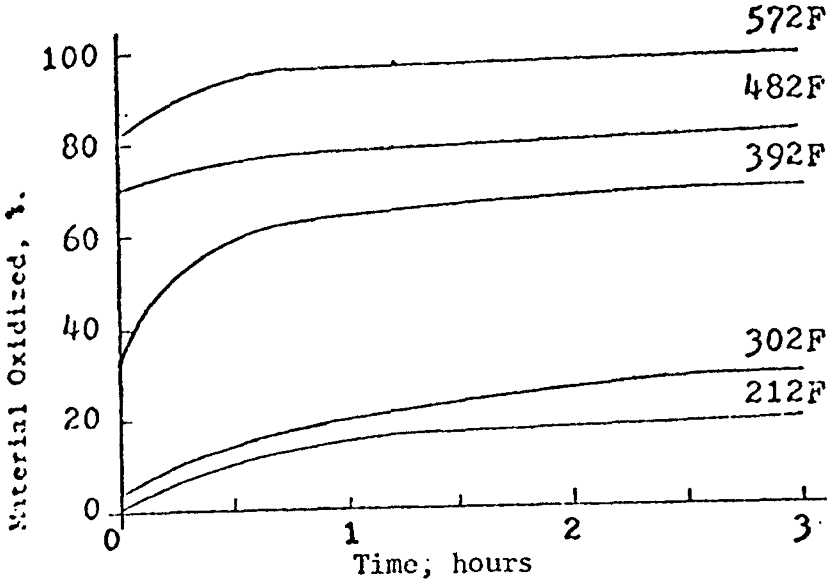


Figure 3-14. Material Oxidized Versus Time at Various Temperatures.

b. Default Data

SLUDGE COD	30.0	MG/L
SATURATED STEAM PRESSURE	600.0	PSIA
SPECIFIC VOLUME OF STEAM	0.77	CUFT/LB
COD REMOVED	75.0	PERCENT
TEMPERATURE	482.0	DEGREES F
RETENTION TIME	1.0	HOURS

c. Wet Oxidation Unit Process Data Cards

WET OXIDATION MOD xx		
SLUDGE COD	xx.x	GM/L
SATURATED STEAM PRESSURE	xx.x	PSIA
SPECIFIC VOLUME OF SATURATE STEAM	xx.x	CUFT/LB
RETENTION TIME	xx.x	HOURS
COD REMOVED	xx.x	GM/L
TEMPERATURE OF REACTOR	xx.x	DEG F
END		

APPENDIX A

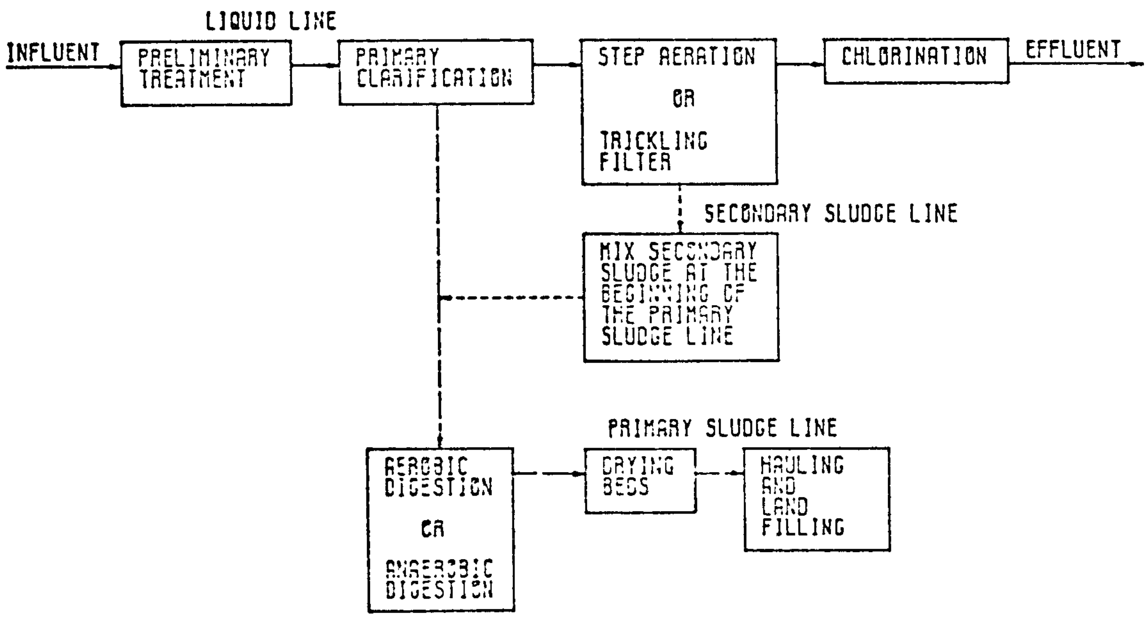
BASIC PROCEDURE FOR USING CAPDET

A-1. This section provides the user with a comprehensive outline of a recommended procedure for using the CAPDET program. The ten recommended steps are intended to illustrate to the user the logical sequence of events which will allow the user to accurately describe a proposed treatment scheme to the CAPDET program.

BASIC PROCEDURE FOR USING CAPDET

1. From the list on page 2-9 select those treatment processes which are to be investigated. Make a sketch showing the treatment scheme including in each treatment process block those options or alternatives to be used.

EXAMPLE:



2. For each treatment process selected, list the unit process key words associated with the treatment processes and identify the unit process involved by referring to the list on page 2-3.

EXAMPLE:

Treatment Process Key Word	Associated Unit Process Key Words	Unit Process Name
PRELIM	GRIT R SCREEN COMMIN	Grit Removal Bar Screens Communition
PRIMAR	PRIMAR	Primary Clarification
STEP A	STEP A A SECE	Step Aeration Secondary Clarification (Activated Sludge)
TRICKL	TRICKL T SECO	Trickling Filter Secondary Clarification (Trickling Filter)
CHLORI	CHLORI	Chlorination
A MIX	None	None
AEROBI	AEROBI	Aerobic digestion
ANAERO	ANAERO	Anaerobic digestion
DRYING	DRYING	Drying beds
HAULIN	HAULIN	Sludge hauling and land filling

3. In Chapter 3 review the default data supplied for modification zero for each of the unit processes you have listed in 2 above. For each process in which you wish to change data code a unit process header card for the process and data for those items you wish to change. Close the input for each process with an END card. Be sure to include an ESTIMATE card if you wish to retain estimate type costing.

EXAMPLE: After examining the default data you wish to change the sidewater depth of the primary clarifier and the rainfall for drying beds, code the following data.

```
PRIMARY CLARIFICATION
SIDEWATER DEPTH              10.0            FEET
ESTIMATE
END
DRYING BEDS
RAINFALL                     6               IN/MO
ESTIMATE
END
```

4. Code a TITLE card.

EXAMPLE:

```
TITLE EXAMPLE PROBLEM
```

5. Refer to the sketch in 1 above and code the scheme description as outlined in section 2-5.

EXAMPLE:

```
LIQUID LINE
BLOCK     PRELIM
BLOCK     PRIMAR
BLOCK     STEP A TRICKL
BLOCK     CHLORI
SECONDARY SLUDGE LINE
BLOCK     A MIX
PRIMARY SLUDGE LINE
BLOCK     AEROBI ANAERO
BLOCK     DRYING
BLOCK     HAULIN
```

6. Examine the default data for the waste influent (page 2-15) and select those items you wish to change. Code a waste influent header card and data cards for those items you wish to change.

EXAMPLE: After examining the waste influent default data you wish to change the BOD5 to 300 mg/l and the oil and grease to zero. You wish an average flow of 10 mgd. You should code the following:

WASTE INFLUENT

AVERAGE FLOW	10.0	MGD
BOD5	300	MG/L
OIL AND GREASE	0	MG/L

7. Code a desired effluent header card and data for those items you wish checked. Those trains that do not meet the specified effluent values will be discarded. If you have specified only a few trains you should use this option with care as over-rigid specifications may cause all of the alternative trains to be discarded.

EXAMPLE: As only four trains have been specified in this sample problem, no desired characteristics will be specified. This will allow all four trains to be retained. You may examine them for effectiveness after they are printed. In this case we will only have to code the desired effluent header card as follows:

DESIRED EFFLUENT CHARACTERISTICS

8. Review the unit cost default data (page 2-19) and select those items you wish to change. Code these data items following a unit cost header card and terminate this input with an END card.

EXAMPLE: You wish to change the building costs, excavation costs, concrete costs, and the Marshall and Swift and EPA indices. You should code the following:

UNIT COSTS		
BUILDING	42.0	$/SQFT
EXCAVATION	1.75	$/CUYD
WALL CONCRETE	275.0	$/CUYD
SLAB CONCRETE	230.0	$/CUYD
MARSHALL AND SWIFT	490.0	
SMALL CITY EPA INDEX	140.0	
END		

9. Refer to section 2-7 and select the type of output you desire. Code the appropriate output control cards followed by the GO card.

EXAMPLE: You desire the cost information for all four trains and complete design information including construction quantities for the most cost effective train. You should code the following:

CONTROL CARDS		
LIST	4	TRAINS
PRINT TRAIN NO 1		
OUTPUT QUANTITIES		
GO	I = 6.625	30 YEARS

10. Assemble all data in the order coded above and submit to the CAPDET program.

EXAMPLE: The complete data list for the example coded above would be:

```
PRIMARY CLARIFICATION
SIDEWATER DEPTH                          10.0          FEET
ESTIMATE
END
DRYING BEDS
RAINFALL                                 6             IN/MO
ESTIMATE
END
TITLE EXAMPLE PROBLEM
LIQUID LINE
BLOCK     PRELIM
BLOCK     PRIMAR
BLOCK     STEP A TRICKL
BLOCK     CHLORI
SECONDARY SLUDGE LINE
BLOCK     A MIX
PRIMARY SLUDGE LINE
BLOCK     AEROBI ANAERO
BLOCK     DRYING
BLOCK     HAULIN
WASTE INFLUENT
AVERAGE FLOW                             10.0          MGD
BOD5                                     300           MG/L
OIL AND GREASE                           0             MG/L
DESIRED EFFL ... CHARACTERISTICS
UNIT COSTS
BUILDING                                 42.0          $/SQFT
EXCAVATION                               1.75          $/CUYD
WALL CONCRETE                            275.0         $/CUYD
SLAB CONCRETE                            230.0         $/CUYD
MARSHALL AND SWIFT                       490.0
SMALL CITY EPA INDEX                     140.0
END
CONTROL CARDS
LIST                                     4             TRAINS
PRINT TRAIN NO 1
OUTPUT QUANTITIES
GO            I=6.625      30 YEARS
```

APPENDIX B

CAPDET EXAMPLE PROBLEM OUTPUT

B-1. This section provides the user with the output of the example problem outlined in Appendix A.

COST ANALYSIS INPUT PARAMETERS

INTEREST RATE	6.62 %
PLANNING PERIOD	30 YRS
WAGE RATE	6.00 $/HR

UNIT PRICES AND COSTS INDICES

I	BUILDING	42.00	$/SQ FT
I	EXCAVATION	1.75	$/CU YD
I	WALL CONCRETE	275.00	$/CU YD
I	SLAB CONCRETE	230.00	$/CU YD
I	MARSHALL AND SWIFT INDEX	490.00	
D	CRANE RENTAL	40.00	$/HR
I	EPA CONSTRUCTION COST INDEX	140.00	
D	CANOPY ROOF	10.00	$/SQ FT
D	LABOR RATE	6.00	$/HR
D	OPERATOR CLASS II	6.00	$/HR
D	ELECTRICITY	.04	$/KWHR
D	CHEMICAL COSTS		
	LIME	.02	$/LB
	ALUM	.10	$/LB
	IRON SALTS	.18	$/LB
	POLYMER	1.00	$/LB
D	ENGINEERING NEWS RECORD COST INDEX	2470.00	
D	HANDRAIL	25.20	$/FT
D	PIPE COST INDEX	241.00	
D	PIPE INSTALLATION LABOR RATE	10.00	$/HR
D	EIGHT INCH PIPE	7.41	$/FT
D	EIGHT INCH PIPE BEND	70.88	$/UNIT
D	EIGHT INCH PIPE TEE	104.90	$/UNIT
D	EIGHT INCH PIPE VALVE	1099.00	$/UNIT

EXAMPLE PROBLEM

```
TRAIN NO    1

LIQUID     PREL   0   PRIM   0   TRIC   0   CHLO   0
SECONDARY A MI    0
PRIMARY    AERO   0   DRYI   0   HAUL   0
CAPITAL COST                       $19,674,405.
OPERATING   MAINTENANCE COST          $288,548.
EQUIVALENT ANNUAL COST                     $1,869,273.

TRAIN NO    2

LIQUID     PREL   0   PRIM   0   TRIC   0   CHLO   0
SECONDARY A MI    0
PRIMARY    ANAE   0   DRYI   0   HAUL   0
CAPITAL COST                       $21,003,101.
OPERATING   MAINTENANCE COST          $290,269.
EQUIVALENT ANNUAL COST                     $1,969,374.
TRAIN NO    3

LIQUID     PREL   0   PRIM   0   STEP   0   CHLO   0
SECONDARY A MI    0
PRIMARY    AERO   0   DRYI   0   HAUL   0
CAPITAL COST                       $25,873,662.
OPERATING   MAINTENANCE COST          $803,408.
EQUIVALENT ANNUAL COST                     $3,069,861.

TRAIN NO    4

LIQUID     PREL   0   PRIM   0   STEP   0   CHLO   0
SECONDARY A MI    0
PRIMARY    ANAE   0   DRYI   0   HAUL   0
CAPITAL COST                       $30,023,492.
OPERATING   MAINTENANCE COST          $804,813.
EQUIVALENT ANNUAL COST                     $3,401,366.
```

INFLUENT

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	200.00	BOD5	300.00	TKN	45.00
AVERAGE	10.0000	VOLATILE	60.00 %	BOD5S	75.00	NH3	25.00
MINIMUM	10.0000	SETTLEABLE	15.00	COD	500.00	NO2	.00
				CODS	400.00	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	18.00		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	.00	.00
% SOLIDS	.00	.00
% VOLATILE	.00	.00

```
EXAMPLE PROBLEM                                                              TRAIN NO    1

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *

MECHANICALLY CLEANED BAR SCREEN

D BAR SIZE                                        .250+00 IN
D BAR SPACING                                     .150+01 IN
D SLOPE OF BARS FROM HORIZONTAL                   .300+02 DEG
  HEAD LOSS THROUGH SCREEN                        .206-01 FT
D APPROACH VELOCITY                               .250+01 FPS
D AVERAGE FLOW THROUGH VELOCITY                   .250+01 FPS
D MAXIMUM FLOW THROUGH VELOCITY                   .300+01 FPS
  SCREEN CHANNEL WIDTH                            .616+01 FT
D AVERAGE CHANNEL DEPTH                           .100+01 FT

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

```
* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
HORIZONTAL FLOW GRIT CHAMBER

  MAXIMUM FLOW                                  .154+02 CFS
  AVERAGE FLOW                                  .154+02 CFS
  MINIMUM FLOW                                  .154+02 CFS
  TEMPERATURE                                   .180+02 DEG C
D MAXIMUM FLOW THROUGH VELOCITY                 .125+01 FPS
D AVERAGE FLOW THROUGH VELOCITY                 .100+01 FPS
D SIZE SMALL. PART. 100% REMOVED                .200+00 MM
D SPECIFIC GRAVITY OF PARTICLE                  .265+01
D NUMBER OF UNITS                               .200+01
  MAXIMUM FLOW/UNIT                             .770+01 CFS
D WIDTH OF CHANNEL                              .154+01 FT
D DEPTH OF CHANNEL                              .400+01 FT
  LENGTH OF CHANNEL                             .108+03 FT
  SETTLING VELOCITY OF PARTICLE                 .785-01 FPS
  SLOPE OF CHANNEL BOTTOM                       .947-03
D ALLOWANCE FOR CURRENTS                        .170+01
D DETENTION TIME                                .867+02 SEC
D MANNING COEFFICIENT                           .350-01
  VOLUME OF GRIT                                .400+02 CUFT/DA

* * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
```

EXAMPLE PROBLEM TRAIN NO 1

* *

COMMINUTION

D NUMBER OF UNITS	.200+01	UNITS
DRUM DIAMETER	.250+02	INCHES
DRUM RPM	.250+02	REV/MIN
AVERAGE SLOT WIDTH	.380+00	INCHES
HORSEPOWER/UNIT	.150+01	HP
STANDARD HEIGHT	.579+01	FEET
STANDARD NET WEIGHT	.210+04	POUNDS

* *

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	200.00	BOD5	300.00	TKN	45.00
AVERAGE	10.0000	VOLATILE	60.00 %	BOD5S	75.00	NH3	25.00
MINIMUM	10.0000	SETTLEABLE	15.00	COD	500.00	NO2	.00
				CODS	400.00	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	18.00		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	.00	.00
% SOLIDS	.00	.00
% VOLATILE	.00	.00

EXAMPLE PROBLEM TRAIN NO 1

* *

PRIMARY CLARIFIER

CIRCULAR CLARIFIER

D OVERFLOW RATE	.100+04	GD/SQFT
SURFACE AREA	.100+05	SQFT
I SIDE WATER DEPTH	.100+02	FT
DETENTION TIME	.180+01	HOURS
SOLID LOADING	.167+01	PSF/D
D WEIR LOADING	.150+05	GD/FT
WEIR LENGTH	.667+03	FEET
VOLUME OF SLUDGE PRODUCED	.238+05	GAL/DAY
D SUSPENDED SOLIDS REMOVAL	.500+02	%
D BOD REMOVAL	.360+02	%
NUMBER OF TANKS	.100+01	UNITS
D COD REMOVAL	.500+02	%
D TKN REMOVAL	.500+01	%
D PO4 REMOVAL	.500+01	%

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EXAMPLE PROBLEM TRAIN NO 1

QUANTITIES FOR SEDIMENTATION

CIRCULAR CLARIFIER

PRIMARY CLARIFIER		
EXCESS CAPACITY FACTOR	.192+01	
CALCULATED SURFACE AREA	.100+05	SQFT
ADJUSTED SURFACE AREA	.192+05	SQFT
AVERAGE DAILY WASTEWATER FLOW	.100+02	MGD
NUMBER OF CIRCULAR CLARIFIERS	2	
NUMBER OF BATTERIES	1	
SURFACE AREA PER UNIT	.960+04	SQFT
DIAMETER OF UNIT	.111+03	FT
EARTHWORK REQUIRED	.269+06	CUFT
SIDEWATER DEPTH	.100+02	FT
THICKNESS OF THE SLAB	.104+02	INCHES
WALL THICKNESS	.120+02	INCHES
TOTAL QUANTITY OF R.C. WALL REQUIRED	.824+04	CUFT
TOTAL QUANTITY OF R.C. SLAB REQUIRED	.189+05	CUFT
MAINTENANCE MANPOWER REQUIRED	.839+03	MAN-HOURS/YR
OPERATION MANPOWER REQUIRED	.152+04	MAN-HOURS/YR
ELECTRICAL ENERGY REQUIRED	.119+05	KWHR/YR

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	100.00	BOD5	219.00	TKN	44.00
AVERAGE	10.0000	VOLATILE	60.00 %	BOD5S	75.00	NH3	25.00
MINIMUM	10.0000	SETTLEABLE	.00	COD	450.00	NO2	.00
				CODS	400.00	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	17.10		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	23809.52	.00
% SOLIDS	4.00	.00
% VOLATILE	60.00	.00

EXAMPLE PROBLEM TRAIN NO 1

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TRICKLING FILTRATION

REMOVAL EFFICIENCY	.863+02 %
TOTAL VOLUME	.109+06 CUFT
TOTAL SURFACE AREA	.184+05 SQFT
DEPTH	.118+02 FT
D RECIRCULATION RATIO	.120+01
DIAMETER/UNIT	.108+03 FT
NUMBER OF UNITS	.200+01 UNITS

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EXAMPLE PROBLEM TRAIN NO 1

QUANTITIES FOR TRICKLING FILTER

NUMBER OF TOWERS	2	
VOLUME PER FILTER TOWER	.109+06	CU FT
DEPTH OF TOWER	.118+02	FT
DIAMETER OF FILTER TOWER	.108+03	FT
TOTAL NUMBER OF POSTS	640	
TOTAL LENGTH OF PRECAST BEAMS	.101+05	FT
TOTAL R.C. WALL IN PLACE	.136+05	CU FT
TOTAL R.C. SLAB IN PLACE	.123+05	CU FT
TOTAL EARTHWORK REQUIRED	.254+06	CU FT
AVERAGE DAILY WASTEWATER FLOW	.100+02	MGD
ELECTRICAL ENERGY REQUIRED	.192+06	KWHR/YR
OPERATIONAL MANPOWER	.520+03	MAN-HOUR/YR
MAINTENANCE MAN-HOURS	.407+03	MAN-HOUR/YR

EXAMPLE PROBLEM TRAIN NO 1

QUANTITIES FOR INTERMEDIATE PUMPING

AVERAGE DAILY WASTEWATER FLOW	.100+02 MGD
DESIGN CAPACITY PER PUMP	.417+04 GPM
NUMBER OF PUMPS	3
NUMBER OF BATTERIES	1
AREA OF PUMP BUILDING	.877+03 SQ FT
VOLUME OF EARTHWORK REQUIRED	.701+04 CU FT
FIRM PUMPING CAPACITY	.120+02 MGD
OPERATING MANPOWER REQUIRED	.677+03 MAN-HOURS/YR
MAINTENANCE MANPOWER REQUIRED	.572+03 MAN-HOURS/YR
ELECTRICAL ENERGY REQUIRED	.666+06 KWHR/YR

EXAMPLE PROBLEM

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SECONDARY CLARIFIER

CIRCULAR CLARIFIER

D	SOLIDS LOADING RATE	.150+02 LB/SQFT/D
	SURFACE OVERFLOW RATE	.100+04 G/SQFT/D
	DETENTION TIME	.355+01 HOURS
D	WEIR OVERFLOW RATE	.150+05 G/FT/D
D	TANK SIDEWATER DEPTH	.900+01 FEET
	WEIR LENGTH	.147+04 FEET
	VOLUME OF WASTED SLUDGE	.800+04 G/DAY
D	UNDERFLOW CONCENTRATION	.100+01 %
	TOTAL SURFACE AREA	.220+05 SQFT
	NUMBER OF TANKS	.100+01 UNITS

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QUANTITIES FOR SEDIMENTATION

CIRCULAR CLARIFIER

SECONDARY CLARIFIER		
EXCESS CAPACITY FACTOR	.193+01	
CALCULATED SURFACE AREA	.220+05	SQFT
ADJUSTED SURFACE AREA	.425+05	SQFT
AVERAGE DAILY WASTEWATER FLOW	.100+02	MGD
NUMBER OF CIRCULAR CLARIFIERS	2	
NUMBER OF BATTERIES	1	
SURFACE AREA PER UNIT	.212+05	SQFT
DIAMETER OF UNIT	.165+03	FT
EARTHWORK REQUIRED	.697+06	CUFT
SIDEWATER DEPTH	.900+01	FT
THICKNESS OF THE SLAB	.101+02	INCHES
WALL THICKNESS	.115+02	INCHES
TOTAL QUANTITY OF R.C. WALL REQUIRED	.106+05	CUFT
TOTAL QUANTITY OF R.C. SLAB REQUIRED	.399+05	CUFT
MAINTENANCE MANPOWER REQUIRED	.136+04	MAN-HOURS/YR
OPERATION MANPOWER REQUIRED	.244+04	MAN-HOURS/YR
ELECTRICAL ENERGY REQUIRED	.189+05	KWHR/YR

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	30.00	TKN	30.80
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	15.00	NH3	30.80
MINIMUM	10.0000	SETTLEABLE	.00	COD	45.00	NO2	.00
				CODS	22.50	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	11.97		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	23809.52	8000.00
% SOLIDS	4.00	1.00
% VOLATILE	60.00	80.00

EXAMPLE PROBLEM TRAIN NO 1

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CHLORINATION

MAXIMUM FLOW	.100+02	MGD
AVERAGE FLOW	.100+02	MGD
D CONTACT TIME	.300+02	MIN
TOTAL VOLUME	.208+06	GAL
AVERAGE CHLORINE REQUIREMENT	.834+03	LB/DAY
PEAK CHLORINE REQUIREMENT	.834+03	LB/DAY
COLIFORM REDUCTION	.996+02	%

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EXAMPLE PROBLEM   TRAIN NO 1

QUANTITIES FOR DISINFECTION

NUMBER OF CHLORINATORS AND EVAPORATORS	1	
CHLORINATION BUILDING AREA	.220+03	SQFT
NUMBER OF CHLORINE CYLINDERS	13	
AREA OF CHLORINE STORAGE BUILDING	.182+04	SQFT
AVERAGE DAILY WASTEWATER FLOW MGD	.100+02	MGD
VOLUME OF EARTHWORK REQUIRED	.144+05	CUFT
VOLUME OF R.C. FOR WALLS	.565+04	CUFT
VOLUME OF R.C. FOR SLAB	.307+04	CUFT
CHLORINE REQUIREMENT PER YEAR	.152+03	TONS/YR
OPERATIONAL LABOR	.145+04	MAN-HOURS/YR
MAINTENANCE MANPOWER REQUIRED	.363+03	MAN-HOURS/YR
ELECTRICAL ENERGY REQUIRED	.131+06	KWH/YR
CHLORINE REQUIREMENT	.834+03	LB/DAY
O & M MATERIAL AND SUPPLY COSTS	.313+01	PERCENT

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	30.00	TKN	30.80
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	15.00	NH3	30.80
MINIMUM	10.0000	SETTLEABLE	.00	COD	45.00	NO2	.00
				CODS	22.50	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	11.97		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	23809.52	8000.00
% SOLIDS	4.00	1.00
% VOLATILE	60.00	80.00

EXAMPLE PROBLEM TRAIN NO 1

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**** SECONDARY SLUDGE LINE MIXED INTO PRIMARY SLUDGE LINE ****

INFLUENT

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	30.00	TKN	30.80
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	15.00	NH3	30.80
MINIMUM	10.0000	SETTLEABLE	.00	COD	45.00	NO2	.00
				CODS	22.50	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	11.97		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	31809.52	.00
% SOLIDS	3.25	.00
% VOLATILE	61.55	.00

EXAMPLE PROBLEM TRAIN NO 1

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AEROBIC DIGESTION

	RAW SLUDGE SPECIFIC GRAVITY	.105+01	
D	DETENTION TIME	.150+02	DAYS
D	VOLATILE SOLIDS DESTROYED	.500+02	%
D	MIXED LIQUOR SOLIDS	.120+05	MG/L
D	SOLIDS IN DIGESTED SLUDGE	.250+01	%
D	ALPHA	.900+00	
D	BETA	.900+00	
D	STANDARD TRANSFER EFFICIENCY	.120+02	%
	DIGESTER VOLUME	.477+06	GAL
	VOLATILE SOLIDS LOADING	.872-01	#VS/CUFT/D
	SOLIDS ACCUMULATED PER DAY	.626+04	#/DA
	DIGESTER CAPACITY	.478+05	#
	VOLUME OF WASTED SLUDGE	.218+06	GAL
	SOLIDS RETENTION TIME	.763+01	DAYS
	OXYGEN REQUIREMENT	.556+04	#/DAY
	AIR SUPPLY	.602+02	CFM/TCFT

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EXAMPLE PROBLEM TRAIN NO 1

QUANTITIES FOR ACTIVATED SLUDGE PROCESSES: MECHANICAL AERATION SYSTEMS

COMPLETELY MIXED FLOW	
AVERAGE DAILY FLOW	.318-01 MGD
TOTAL NUMBER OF TANKS	2
NUMBER OF AERATORS PER TANK	1
NUMBER OF BATTERIES OF UNITS	1
CAPACITY OF EACH INDIVIDUAL AERATOR	.400+02 HP
WATER DEPTH OF THE AERATION TANKS	.120+02 FT
WIDTH OF AERATION TANK	.589+02 FT
LENGTH OF AERATION TANK	.589+02 FT
PIPING GALLERY WIDTH	.200+02 FT
QUANTITY OF EARTHWORK REQUIRED	.673+05 CUFT
WIDTH OF THE PLATFORM	.812+01 FT
TOTAL QUANTITY OF R.C. SLAB	.143+05 CUFT
TOTAL QUANTITY OF R.C. WALL	.118+05 CUFT
HANDRAIL LENGTH	.405+03 FT
TOTAL CAPACITY OF AERATION EQUIPMENT	.800+02 HP
OPERATIONAL MANPOWER REQUIRED	.124+04 MAN-HOURS/YR
MAINTENANCE MANPOWER REQUIRED	.622+03 MAN-HOURS/YR
ELECTRICAL ENERGY FOR OPERATION	.536+06 KWHR/YR
O AND M MATERIAL AND SUPPLY COST	.237+01 PERCENT

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	30.00	TKN	30.80
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	15.00	NH3	30.80
MINIMUM	10.0000	SETTLEABLE	.00	COD	45.00	NO2	.00
				CODS	22.50	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	11.97		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	28586.67	.00
% SOLIDS	2.50	.00
% VOLATILE	44.46	.00

EXAMPLE PROBLEM   TRAIN NO 1

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SLUDGE DRYING BEDS

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  TOTAL SURFACE AREA REQUIRED    .193+06 SQ FT
D INITIAL DEPTH OF SLUDGE        .120+02 INCHES
D FINAL PERCENT SOLIDS           .500+02
  BED HOLDING TIME               .380+02 DAYS
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EXAMPLE PROBLEM TRAIN NO 1

QUANTITIES FOR DRYING BED

TOTAL DRYING BED SURFACE AREA	.193+06 SQ FT
NUMBER BEDS	33
SURFACE AREA OF EACH INDIVIDUAL BED	.585+04 SQ FT
LENGTH OF EACH BED	.293+03 FT
VOLUME OF EARTHWORK REQUIRED	.937+06 CU FT
VOLUME R.C. IN-PLACE FOR DIVIDING WALL	.570+05 CU FT
VOLUME OF R.C. IN-PLACE FOR TRUCK TRACKS	.290+05 CU FT
VOLUME OF SAND	.145+06 CU FT
VOLUME OF GRAVEL	.193+06 CU FT
CLAY PIPE DIAMETER	.800+01 IN
TOTAL LENGTH CLAY PIPE	.193+05 FT
SLUDGE SOLIDS PER DAY	.298+01 TONS/DAY
OPERATION MANPOWER REQUIRED	.318+04 MAN-HOURS/YR
MAINTENANCE MANPOWER REQUIRED	.159+04 MAN-HOURS/YR

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	30.00	TKN	30.80
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	15.00	NH3	30.80
MINIMUM	10.0000	SETTLEABLE	.00	COD	45.00	NO2	.00
				CODS	22.50	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	11.97		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	3783.53	.00
% SOLIDS	17.00	.00
% VOLATILE	44.46	.00

EXAMPLE PROBLEM   TRAIN NO 1

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SLUDGE HAULING AND LAND FILLING

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  VOLUME OF SLUDGE HAULED                  .187+02 CUYD/DAY
  TRUCK CAPACITY                           .190+02 CUYD
D ROUND TRIP TIME TO DISPOSAL SITE         .100+01 HRS
D TRUCK LOADING TIME                       .750+00 HRS
D HOURS OF OPERATION PER DAY               .800+01 HRS
  TONS OF SLUDGE HAULED PER DAY            .166+02 TONS
D DISTANCE TO DISPOSAL SITE                .100+02 MILES
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EXAMPLE PROBLEM   TRAIN NO 1

QUANTITIES FOR SLUDGE HAULING AND LANDFILL

TOTAL SLUDGE VOLUME HAULED	.187+02	CU YD/DAY
MAXIMUM ANTICIPATED LANDFILL DOWNTIME	.300+02	DAYS
ANTICIPATED SLUDGE STORAGE HEIGHT	.800+01	FT
SLUDGE STORAGE SHED AREA	.190+04	SQ FT
WIDTH OF SLUDGE STORAGE SHED SLAB	.308+02	FT
LENGTH OF SLUDGE STORAGE SHED SLAB	.616+02	FT.
VOLUME OF EARTHWORK	.534+04	CU FT
VOLUME OF SLAB CONCRETE	.232+04	CU FT
SURFACE AREA OF CANOPY ROOF	.190+04	SQ FT
DISTANCE TO DISPOSAL SITE	.100+02	MILES
ROUND TRIP HAUL DISTANCE	.200+02	MILES
TONS OF SLUDGE HAULED PER DAY	.166+02	TONS/DAY
OPERATION MANPOWER REQUIRED	.293+03	MAN-HOURS/YR
ROUND TRIPS PER DAY PER TRUCK	.100+01	
DISTANCE TRAVELED PER YEAR PER TRUCK	.500+04	MILES/YR
MAINTENANCE AND MATERIAL SUPPLY COST	.650+01	PERCENT

LIQUID CHARACTERISTICS

FLOW	(MGD)	SOLIDS	(MG/L)		(MG/L)		(MG/L)
MAXIMUM	10.0000	SUSPENDED	20.00	BOD5	30.00	TKN	30.80
AVERAGE	10.0000	VOLATILE	80.00 %	BOD5S	15.00	NH3	30.80
MINIMUM	10.0000	SETTLEABLE	.00	COD	45.00	NO2	.00
				CODS	22.50	NO3	.00
TEMP	18.0 C	OIL & GREASE	.00	PO4	11.97		
PH	7.60	CATIONS	160.00				
		ANIONS	160.00				

SLUDGE CHARACTERISTICS

	PRIMARY	SECONDARY
VOLUME (GAL/D)	.00	.00
% SOLIDS	.00	.00
% VOLATILE	.00	.00

EXAMPLE PROBLEM TRAIN NO 1

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AVERAGE [illegible] FLOW 10.00 MGD

LIQUID [illegible] PRIM 0 TRIC 0 CHLO 0
SECONDARY [illegible]
PRIMARY [illegible] DRYI 0 HAUL 0

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COST SUMMARY

UNIT	CAPITAL COST $	AMMORT COST $/YR	OPER LABOR COST $/YR	MAINT LABOR COST $/YR	POWER COST $/YR	MATERIAL COST $/YR	CHEMICAL COST $/YR
PRELIMIN	[illegible]	11018	11132	4701	1859	3983	0
PRIM CLA	[illegible]	36192	8821	4129	476	5566	0
T SEC CL	[illegible]	60373	14224	6700	756	9286	0
TRIC FIL	[illegible]	91048	3026	2004	7678	8313	0
PUMPING	[illegible]	16554	3939	2815	26652	1288	0
CHLORINA	[illegible]	25535	8415	1788	5250	20610	0
AERO DIG	[illegible]	38558	7235	3061	21444	1378	0
DRY BEDS	[illegible]	93088	18496	7817	0	7590	0
HAUL	[illegible]	45038	1705	0	0	10746	0
TOTAL	[illegible]	417458	76996	33018	64118	68764	0

DIRECT COST
MOBILIZATION 639000 $
SITE [illegible] 991290 $
SITE [illegible] 1289798 $
CONT[illegible] 632606 $
YARD [illegible] 1012143 $
RA[illegible] 1493826 $
LAB [illegible] 1638576 $
ADMIN [illegible] 188887 $
PROF[illegible] 2763577 $

TOTAL 10649703 $ TOTAL CONSTRUCTION COST 15325292 $

INDIRECT COSTS
MI[illegible] 766264 $
ADMIN [illegible] 306505 $
[illegible] 536385 $
[illegible] 880934 $
[illegible] 306505 $
CONT[illegible] 1226023 $
[illegible] 306505 $

TOTAL 4329121 $

LAND COST 19992 $ (20. ACRES)

ADMINISTRATI[illegible] 22731 $/YR
LABORATOR[illegible] 22919 $/YR

CAPITAL [illegible] 19674405 $
OPERATI[illegible] 288548 $/YR
EQUIVALENT [illegible] COST 1869273 $/YR