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Use of Microcomputers to Aid Wastewater Treatment Plant Operations

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Technical Completion Report Research Project G-829-24

Arkansas Water Resources Research Center
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ABSTRACT

This report presents the development of a microcomputer based data management system for wastewater treatment plants. The relational database model was shown to be well suited for data management applications in wastewater treatment plants. A general data management system was developed for use with a microcomputer using a commercially available relational database management system. Use of the developed system requires no special computer training. The system was tailored for use at the wastewater treatment plant at Springdale, Arkansas. The capabilities of the system were demonstrated with actual data from the Springdale plant.

David G. Parker and Sandra C. Parker

Completion Report to the U.S. Department of the Interior, Washington, D.C., September, 1984.

KEYWORDS -- Wastewater treatment/database management/microcomputer/ relational database.

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INTRODUCTION

Data management at wastewater treatment plants requires a method of storing, accessing, and processing data by some regular and consistent means. Data are required for permit reports, process control, and design of facilities.

Typical plant data consists of laboratory analysis and plant operating data. Manual management of plant data requires many hours each week even in small plants.

It has been known for some time that computerized data management systems are a cost-effective method for data management in the larger plants, although many of the larger plants still do not use computerized systems. In the past, the complexity and cost of computerized data management has prevented all but the largest municipal treatment plants from incorporating computers for data management.

If a low cost microcomputer could handle the data management needs of a wastewater treatment plant, then computerized data management would be available for treatment plants for the relatively low price of a microcomputer. Besides being easy to operate, a microcomputer-based data management system for treatment plants would have to meet the specialized data-handling requirements of a particular plant.

The system would have to be user-friendly. A menu-driven format would be required for entry, editing, and reporting of data. The system would need some means of checking data during entry to avoid entry of invalid data types. The system should be able to expand with the plant rather than become obsolete.

Such a system could increase plant efficiency through more efficient process control, cut time presently spent on data management, and minimize the chance for errors in management of plant data.

A. Purpose and Objectives

The objective of this research is to develop a general data management system for wastewater treatment plants that will operate on a microcomputer and may be tailored for use at a specific plant. The system will allow the operator to store, update, retrieve, and process data. The operator will need no special computer training to use the system. Plant operating costs may be reduced by reducing the amount of time devoted to data management. Improved capability to analyze data may lead to improved plant performance.

The general data management system developed by this research operates on a microcomputer. A series of application programs were written for use with a commercially available database management software package.

The system uses a menu-driven format in which the operator selects the operation to be performed from a menu on the computer screen. The operator may enter data, edit data, obtain reports, and output data for use with programs independent of the system. Error checking on data entry allows the operator to input only the type of data that has been specified for a particular parameter. Parameters may be restricted to numbers or text. Reports may include data or results of calculations from data for any specified range of dates. Independent programs may be developed as the need arises to process data for special needs.

The system was tailored for use at the Springdale, Arkansas wastewater treatment plant. Actual data from the Springdale plant was used to demonstrate the capability of the data management system. A plotting program was written in BASIC to demonstrate how the system may be interfaced with independent programs.

B. Related Research or Activities

This review focuses on the use of computerized database management system (DBMS) as a data management tool. The first part of the review is a general description of database structure and organization and a detailed description of the relational model - the basis for a relatively new and powerful DBMS known as a relational DBMS. The relational model is discussed because the DBMS chosen for this project is a relational DBMS. The second part of the review is a description of applications for and capabilities of computerized DBMS presently in use in wastewater treatment plants.

Database Representation

A database was defined by Martin (15) as a collection of related data stored independently of programs that use the data. The database is structured in a form that allows addition, modification, deletion, and retrieval of data within the database. In 1982 approximately 15,000 databases were in use in the United States. (4)

The database structure provides a foundation for development of future applications. Database structures may be catagorized as hierarchical, network, or relational. (15)

The hierarchical structure may be thought of as a tree structure composed of elements called nodes which reside at various levels within the tree. Nodes may consist of segments of data or pointers used to describe the physical organization of an index. Only one element, called the root, may reside at the uppermost level of the tree. Every node except the root is related to a node at a higher level called the parent. No node may have more than one parent. Each node may be related to one or more nodes at a lower level, called children. Figure 1 illustrates the hierarchical or tree structure. Node 1, the root, is the parent of node 2. Nodes 4 and 5 are children of node 2. (15)

The network structure also consists of nodes residing at various levels. The difference between the network structure and the tree structure is that in a network structure, a node may be linked to any other node. Figure 2 shows a network structure where one or more nodes have multiple parents. (15)

The structure of a relational database is similar to that of two-dimensional tables. These tables are known as relations. Each column in a relation contains a distinct type of data. Columns in a relation are known as attributes or domains. Each attribute in a relation has a name which may be used to describe the type of data found in the column. Rows in a relation are not stored in any particular order. Figure 3 shows a relation named SUPPLY with the attributes' supplier, part, project, and quantity. The tabular structure of the relational database is an advantage for database users since the user may visualize data organized as simple tables rather than trees or networks. (5)

The Relational Model

In 1970, E. F, Codd defined a relation in the mathematical sense as follows: "Given sets S1, S2, ..., Sn, (not necessarily distinct), R is a relation on these n sets if it is a set of n-tuples [rows] each of which has its first element from S1, its second element from S2, and so on... as defined above, R is said to have degree n." (5) The relation SUPPLY in Figure 3 is a relation of degree 4 containing five rows of data which reflects the shipments in progress of parts from specified suppliers to specified projects in specified quantities. (5)

Codd defined a relational database as a time-varying collection of data which can be accessed and updated as a collection of time-varying tabular relations of various degrees defined on a set of domains (6). Codd proposed a set of rules to distinguish a relational system from other systems. To be considered relational,

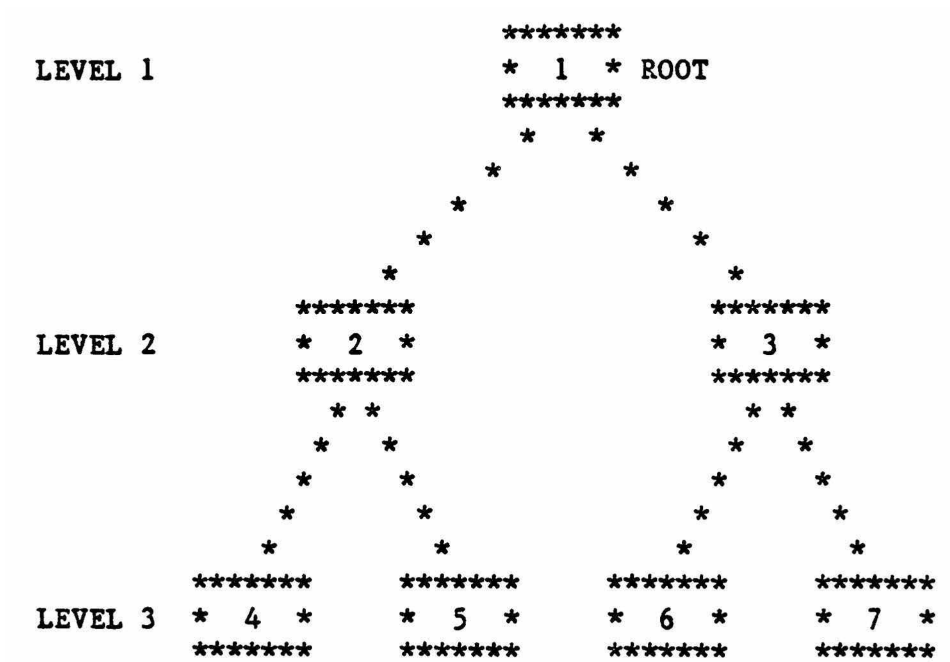

FIGURE 1

TYPICAL HIERARCHICAL STRUCTURE

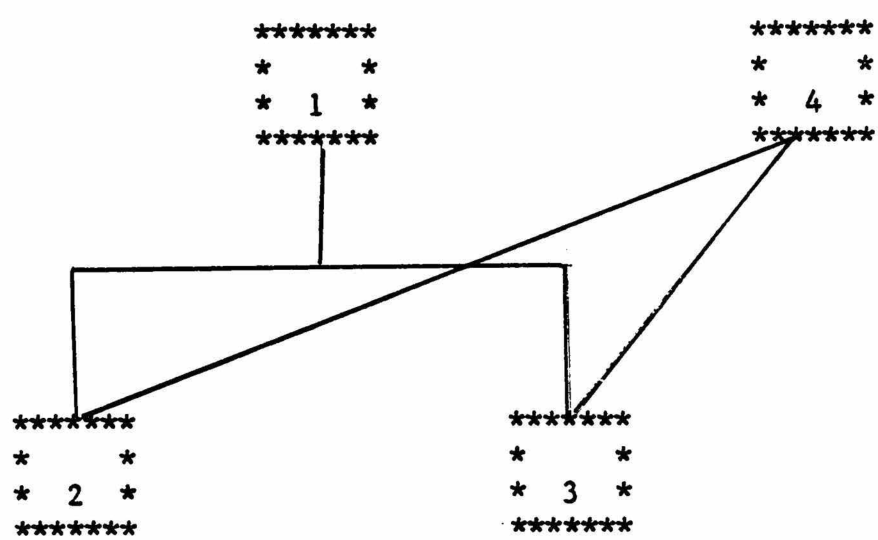

FIGURE 2

SIMPLE NETWORK STRUCTURE

SUPPLY	(SUPPLIER	PART	PROJECT	QUANTITY)
	1	2	5	17
	1	3	5	23
	2	3	7	9
	2	7	5	4
	4	1	1	12

FIGURE 3

TYPICAL RELATION

a database system must follow the structure of the relational model, and support a data sublanguage with relational processing capability. (6,7)

Relational Processing

The relational processing capability was developed in response to three principal problems. First, existing systems forced users to think in terms of complex concepts having nothing to do with data retrieval and manipulation. Second, existing systems did not support set processing. Rather than using commands to process multiple records or an entire file at one time, users were forced to think in terms of iterative loops. Third, the needs of users interacting directly with databases could never be anticipated fully. Existing systems frequently became obsolete due to a lack of ability to change or grow. (7)

In 1979, Hutt (10) defined nine relational commands used in a relational database management system developed in 1973 for the British Broadcasting Corporation. Hutt asserted that a database management system could support relational processing using even fewer than nine commands. Codd said that the minimal relational processing capability required to qualify a system as relational is the ability to support the set processing algebra (relational) commands PROJECT, JOIN, and SELECT. (7)

Data Sublanguages

According to Schmidt, the "classical" language requirements for a relational processing language are: (a) primitive instructions for altering relations at the level of individual tuples (rows) by insertion, deletion, and modification, and (b) powerful retrieval facilities operating on relations at the level of sets of tuples by using relational calculus-and algebra-oriented query languages. (18)

In 1979, Codd named seven general purpose database management systems designed according to the relational models that were in use for large data banks with concurrent users (6). In 1984, King reported that over twenty similar data sublanguages have been developed for relational database operations using personal computers alone. (13)

The Relational Commands

Codd chose the commands PROJECT, JOIN, and SELECT as the minimal relational processing capabilities of a relational database system because these commands represent a set of algebra operations which play a key role in deriving relations from other relations. Codd summarized each operation with an example as shown below. (5)

The PROJECT Command

The PROJECT command selects specified columns from a relation, forms a new relation using only the specified columns, and removes any duplicate rows from the new relation. Figure 4 shows the projection of new relation from the relation supply. Notice that two columns and a duplicate row were deleted in the new relation.

SUPPLY	(SUPPLIER	PART	PROJECT	QUANTITY)
	1	2	5	17
	1	3	5	23
	2	3	7	9
	2	7	5	4
	4	1	1	12

SUPPLY (3,1)	(PROJECT	SUPPLIER)
	5	1
	5	2
	1	4
	7	2

FIGURE 4

TYPICAL PROJECT

The JOIN Command

The JOIN command combines rows and columns from two relations with some common attribute (column) without a loss of data. In Figure 5, the second degree relations R and S are said to be joinable if a 3rd degree relation U may be formed so that both relations R and S could be formed from a PROJECT performed on relation U. Figure 5 shows the relations R and S and two possible JOINS of R and S.

The SELECT Command

A subset of a relation is also a relation. The SELECT Command, also known as RESTRICT, may be used to generate a relation that is a subset of an existing relation. A relation S may be used to generate a subset of relation R through the restriction of R by S. Figure 6 shows the use of the SELECT command to generate the subset R' from R through the restriction of R by S represented by the statement $R' = R(2,3) \mid (1,2)S$.

Normalization

Attributes in a relation may be either independent of other attributes in the relation or functionally dependent on other attributes in the relation. If a value X is associated with a value Y and for any given value of X there exists only one valid value of Y, then Y is functionally dependent on X. If no person has more than one address, then the address can be said to be functionally dependent on the person. (12)

R (SUPPLIER	PART)
1	1
2	1
2	2

S (PART	PROJECT)
1	1
1	2
2	1

R*S (SUPPLIER	PART	PROJECT)
1	1	1
1	1	2
2	1	1
2	1	2
2	2	1

U (SUPPLIER	PART	PROJECT)
1	1	2
2	1	1
2	2	1

FIGURE 5

TYPICAL JOINS

R	(s	p	j)
	1	a	A
	2	a	A
	2	a	B
	2	b	A
	2	b	B

S	(p	j)
	a	A
	c	B
	b	B

R'	(s	p	j)
	1	a	A
	2	a	A
	2	b	B

R' = R(2,3) | (1,2)S

FIGURE 6

TYPICAL SELECT

Normalization refers to a set of rules that provide guidelines for the logical design of relational database structures (12). The normalization rules permit the designer to simplify relations containing functionally dependent attributes. (5)

Codd observed that a relation composed of independent attributes may be represented by a two-dimensional array in which the ordering of rows is insignificant and all rows contain the same number of elements. (5) This concept is known as first normal form (3).

Attributes in relations may be termed key or nonkey. A nonkey attribute should provide a fact about a key attribute. When a nonkey attribute is a fact about a subset of a key attribute, the relation is said to violate second normal form. Kent gave an example of second normal form illustrated in Figure 7. (12)

The attributes PART and WAREHOUSE go together to form a key in the relation in Figure 7. The second normal form is violated because WAREHOUSE-ADDRESS is a fact about WAREHOUSE, a subset of the key PART and WAREHOUSE. Several problems with this relation are as follows: The warehouse address is repeated in every row that refers to a part stored in the warehouse. If the warehouse address were to change, every record must be changed. If there were no parts stored in a warehouse, there would be no rows in which to keep the warehouse's address. In Figure 7, Kent shows how the relation may be made into two relations which satisfy the normalization rules. (12)

Third normal form is similar to second normal form. According

UNNORMALIZED

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

PART      WAREHOUSE QUANTITY  WAREHOUSE-ADDRESS
.....key...........
```

NORMALIZED

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

          PART      WAREHOUSE QUANTITY
          .....key...........

          WAREHOUSE WAREHOUSE-ADDRESS
          .....key...........
```

FIGURE 7

SECOND NORMAL FORM

to third normal form, a key attribute must not be a fact that describes another nonkey attribute rather than a key attribute. (12)

The fourth normal form is violated when an attempt is made to assign more than one value to an attribute in a particular row. The fifth normal form is violated when data is stored redundantly and could be constructed when needed from other information. (12)

Codd proposed a method for normalization of a data structure using a tree structure to identify functionally dependent attributes and key attributes. The only restrictions of this normalization process are that the functionally dependent attributes can be shown as a collection of tree structures and no primary key attribute violates the fourth normal form. (5,12)

Database Management System

Large water quality databases are helpful in determining trends in the water pollution field. Data on water quality is generated by many agencies, municipalities and researchers, but is frequently hard to locate. (8)

Martin defined a database management system (DBMS) as the collection of software required for using a database (15). Several large DBMS were developed to handle data required under Public Law 93-523, the Safe Drinking Water Act of 1974 (SDWA). The Model States Information System (MSIS), a large, decentralized, automated information management system, was developed to assist states in complying with the SDWA. The Federal Reporting Data System (FRDS) is a centralized database of public water supply information used by Environmental Protection Agency (EPA) personnel to monitor state compliance with the SDWA. (9)

The University of Michigan Computer System supports a time-sharing system that can be accessed through local telephone numbers in about 100 cities in the United States and Canada. In the University of Michigan DBMS, users employ conversational English-type commands to search for and retrieve data from a database. (8)

Federal regulations concerning development of industrial waste pretreatment programs prompted the Metropolitan District Commission in Boston to develop a computerized DBMS. In 1980 the Metropolitan District Commission provided sewerage for 43 communities and over 6,000 industries. The Metropolitan District DBMS has been used in a variety of ways to meet the industrial waste pretreatment requirements of the Environmental Protection Agency. (2)

The Metropolitan District DBMS is capable of revising discharge limitations for industries, checking industrial waste data for compliance with pretreatment standards, keeping track of industrial permits, maintaining required compliance schedules, generating reports required by the Environmental Protection Agency, and providing access to stored wastewater data. (2)

Jones and Sullivan (11) discussed the benefits of using microcomputers for database management and process control in industrial waste treatment plants. Until the recent development of the microcomputer as a relatively powerful and inexpensive data management tool, the high cost and complexity of computerization discouraged smaller plants from investing in a computer DBMS.

The usual equipment for a microcomputer-based DBMS consists of a microcomputer with keyboard and video display screen, two floppy disk drives, and a printer. The system may be updated as needed at a reasonable expense and is highly reliable. (11)

In the system described by Jones and Sullivan, (11) data was logged on input sheets to be input to the computer manually from the keyboard. Entering data interactively in response to prompts on the screen requires little or no knowledge of computer programming by the operator.

Several large municipal plants use systems that permit automatic and direct data entry from a remote sensor to the computer. Jones and Sullivan identified three advantages of manual data input over automated data input: 1) remote sensors for automatic data entry are extremely expensive and require additional interfacing and data entry programs within the computer, 2) the present problems with reliability and accuracy of remote sensors require frequent maintenance often exceeding the cost in time and money of manual lab tests, and 3) manual data entry forces the operator to observe data on a daily basis and gives the operator more insight to plant operating parameters. (11)

Process control programs utilize the database to perform calculations to predict plant performance or generate operating parameters to assist the operator in making operational decisions. Jones and Sullivan described six process control programs for an industrial wastewater treatment plant treating a plastics manufacturing waste. Using wastewater data collected at specific sites within the plant, the process control programs provided organic overload control, chemical coagulant feed control, mixed-liquor suspended solids (MLSS) control, sludge volume index (SVI) calculations, zone settling velocity computations, and final clarifier computations. (11)

Jones and Sullivan suggested additional time, labor and money-saving uses for microcomputers at industrial waste treatment plants as follows: (11)

1) Mathematical Modeling of the Plant: A theoretical mathematical model of the plant allows an operator to predict plant performance and response under a variety of flow and loading situations.

2) Maintenance Program: Maintenance records maintained by the computer may be used to generate a weekly maintenance schedule.

3) Inventory: An inventory file of major equipment provides a quick way of locating and identifying equipment type or characteristics such as size or capacity.

4) Operator Training: A number of operator training pro-

grams are being developed for microcomputers. Computerized training can provide powerful reinforcement of conventional instruction.

5) Other: Statistical trends and National Pollutant Discharge Elimination System (NPDES) reports could be generated from the database.

Sands and Hasit (17) presented a case study of a DBMS designed for processing data concerning the quality and quantity of waste effluent from an oil refinery located in the Greater Philadelphia area. The refinery was using a time-sharing DBMS designed for petroleum industries to produce reports on the quality and quantity of wastewater from the refinery. Reports were generated for the sewage authority treating the waste and for NPDES reports.

At some point the refinery was required to extend the DBMS capacity to handle data on fugitive emissions. Updating the existing database appeared to be expensive and inefficient. Three alternative DBMS considered by the company involved; a) using the refinery's central computer, b) using a word processor, and c) using a microcomputer. The company found the microcomputer to be the most economical and powerful alternative and eventually transferred all database management functions to the microcomputer. (17)

Different databases were formed for fugitive emissions, wastewater quality and quantity, and NPDES data. The DBMS was set up on the microcomputer with the ability to enter data, edit existing data, generate monthly reports, generate yearly reports, and perform the relational command SELECT for different databases. (17)

A recent expansion of the Norfolk, Nebraska wastewater treatment plant included a microcomputer, printer, and data management programs for the microcomputer. Using the microcomputer as a management tool, the plant has consistently met NPDES requirements. The programs in use at the Norfolk plant provide data management, process control, time management, and maintenance. (14)

METHODS AND PROCEDURES

Equipment: The following is a list of the equipment required to implement the system developed in this research. Total cost of the system is approximately $3,500 to $4,000:

Computer: IBM PC with two floppy disk drives, 256 K RAM memory, and a monochrome monitor.

Printer: Epson MX-100

Software: R:BASE Series 4000 Relational Database Management system by MICRORIM (16).

Description of Software: R:BASE 4000 is a fully relational commercially available relational database management system. R:BASE supports the relational processing commands JOIN, SELECT, PROJECT, and others. A total of 39 different commands are available for use in R:BASE. R:BASE can handle up to 100 billion records of data and process up to 40 files at one time. R:BASE features prompt screens for direct processing, a report writer, and limited programmability.

The major part of this research involved developing application programs which utilized R:BASE 4000 as the data management system.

Description of the Database Management System:

This section consists of two parts. The first part describes typical methods by which data is managed at the Springdale, Arkansas wastewater treatment plant. The second part describes the database management system developed in this research, shows how the system was tailored to the Springdale plant, compares the two systems, and demonstrates use of the DBMS with actual data from the Springdale plant.

Present System: Data in the Springdale plant comes from direct measurements, laboratory analysis of samples, and from calculations on existing data. Figure 8 shows the relationship between different data types in the Springdale plant and the sequence in which data is obtained.

An example of data obtained by direct measurement is plant flow data. Daily flow measurements are read from a continuous totalizing meter and recorded on a monthly operating report showing monthly totals, averages, maximums, and minimums. Figure 9 shows a portion of the monthly operating report including flow for August, 1983.

Data from laboratory analysis is typically reported from the laboratory on a special form. The data is then logged daily on

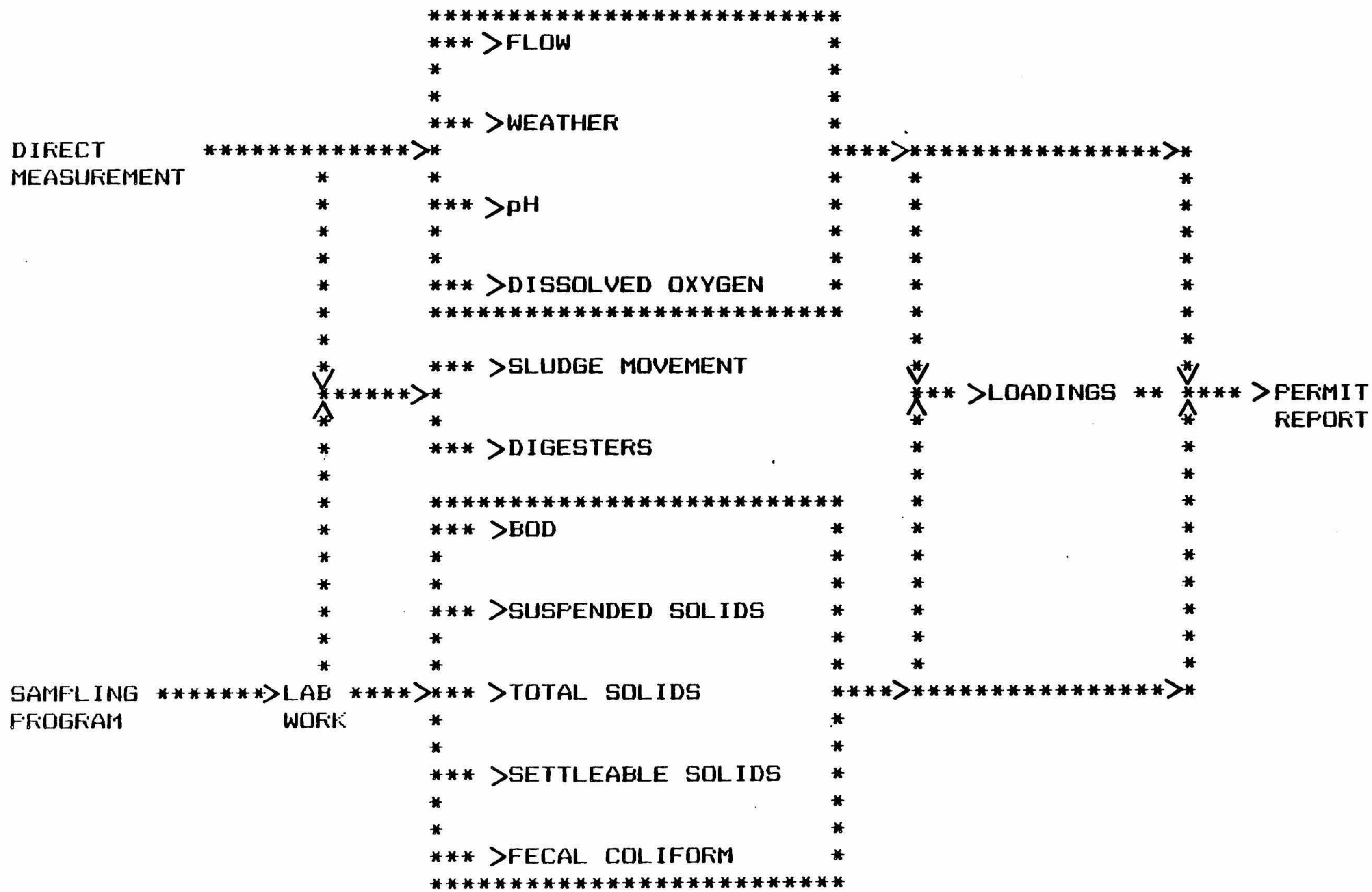

TABLE 8

DATA MANAGEMENT SCHEME AT SPRINGDALE PLANT

DATE	FLOW DATA RATE MAXIMUM 1000 gal/min	FLOW DATA RATE MINIMUM 1000 gal/min	TOTAL M.G.D.	WEATHER DATA RAINFALL IN.	HIGH °F	LOW °F	B.O.D. 5 DAY MG/L INFLUENT	PRIMARY EFF.	INTERMEDIATE EFF.	EFFLUENT	PERCENT REDUCTION	7-day Avg	SUSPENDED SOLIDS MG/L INFLUENT	PRIMARY EFF.	INTERMEDIATE EFF.	EFFLUENT	PERCENT REDUCTION	7 day Avg
1	7.8	1.7	6.9	–	102	68	518	207	28	14	97		330	125	20	15	95	
2	7.0	2.3	6.7	–	104	68	578	231	43	17	97		360	215	20	10	97	
3	7.3	2.2	6.9	–	102	73	623	240	48	14.3	98		315	85	18	2	97	
4	7.1	2.2	6.7	–	106	73	420	198	41	9.4	98		250	85	22	13	95	
5	6.2	2.1	5.8	–	102	67	533	222	50	11.3	98		300	90	40	14	95	
6	3.7	1.9	4.0	–	100	70	615	141	43	9.3	98		260	75	24	9	97	
7	7.6	1.4	5.7	1.7	88	67	147	52	16	9.3	94	13.1	195	70	22	17	91	11.4
8	7.8	2.0	7.0	.2	102	64	428	165	26	9	98	11.4	255	85	20	10	96	10.7
9	7.6	2.2	7.3	–	104	64	488	258	33	11.3	98	10.5	240	90	26	5	98	10
10	7.1	2.4	6.9	–	107	65	548	246	49	12	98	10.3	305	105	20	7	98	10.7
11	7.6	2.1	7.2	–	107	73	443	234	45	9.8	98	10.2	275	100	36	17	94	10
12	6.2	2.5	6.1	–	99	72	480	255	49	9.5	98	10.4	470	110	38	11	98	10.7
13	4.6	1.7	4.5	–	101	75	758	177	52	5.7	99	9.5	460	80	44	15	97	11.3
14	3.6	1.5	3.7	–	99	67	264	78	23	4.4	98	8.8	165	40	26	10	94	10.8
15	7.5	1.7	6.7	–	105	66	630	222	24	10.4	98	9.9	285	85	26	8	97	11.7
16	8.0	2.0	7.3	–	102	68	600	261	59	16.5	97	9.4	340	115	38	14	96	10.7
17	7.2	3.3	7.0	–	102	73	563	231	63	12.9	98	[illegible]	790	120	44	17	98	10.4
18	7.7	3.0	7.0	–	99	70	555	234	57	15.3	97	10.6	290	115	50	17	94	11.7
19	6.1	2.0	5.9	–	99	67	615	240	54	10.3	98	10.7	395	115	34	12	97	13.1
20	3.9	1.7	4.0	–	96	69	278	147	63	10.6	96	11.4	–	105	34	11	–	13.1
21	3.6	1.5	3.6	–	98	66	189	57	20	11.9	94	12.5	220	65	16	8	96	13.5
22	7.2	1.8	6.4	–	105	68	413	147	17	8.7	98	12.3	185	60	20	5	97	13.1
23	6.8	2.0	6.1	–	102	70	420	186	23	7.5	98	11.[illegible]	270	50	14	5	98	10.8
24	7.6	2.0	7.1	–	97	68	435	177	23	8.6	98	10.4	265	80	28	10	96	9.9
25	7.1	2.5	7.0	–	106	68	435	192	36	10.9	97	9.7	245	80	26	4	98	8.[illegible]
26	6.2	3.3	6.0	–	110	68	623	213	43	9	99	9.6	280	65	20	5	98	6.[illegible]
27	4.3	1.8	4.2	–	107	69	315	132	38	7.3	97	9.4	220	80	32	16	93	7.5
28	9.7	1.5	4.9	1.1	100	67	186	63	18	7.3	96	8.8	225	75	20	14	94	8.4
29	8.2	3.4	7.7	.4	96	66	315	177	12	5.3	98	8.3	160	65	16	2	99	8.0
30	7.5	2.2	7.2	trace	102	66	533	204	47	9.3	98	8.5	300	145	40	18	94	9.8
31	7.5	2.3	7.8	.31	97	65	488	242	57	10.6	98	8.8	315	125	30	10	97	9.8
TOTAL	208.3	62.2	191.6	3.71	3136	2115	14376	5869	1201	321.4	[illegible]		8975	3100	874	332	2886	
MAX	8.5	2.5	7.8	1.7	107	73	758	262	63	17.7	99		790	215	50	17	99	
MIN	3.6	1.4	3.6	.2	87	64	147	52	13	4.4	94		160	40	14	2	91	
AVG.	6.7	2.0	6.2	.11	101	68	464	177	39	10.3	97		299	94	28	10.7	96	

FIGURE 9

MONTHLY OPERATING REPORT FOR SPRINGDALE PLANT

a form with other data of the same type for one month. The daily log is used to compile the monthly operating report for the data item. Figure 10 shows the laboratory report for BOD5 for two days. Figure 11 shows the daily log of BOD5 obtained from the laboratory reports. The portion of the monthly operating report in Figure 9 shows the daily values of BOD5 as well as the monthly total, average, maximum, and minimum values. Also shown in Figure 9 for BOD5 are the values for percent reduction and seven day average. Percent reduction is a value calculated from other BOD5 data on the monthly report by the equation.

EQ 1 $\% \text{ reduction} = [(\text{influent} - \text{effluent}) / \text{influent}] \times 100$

where influent and effluent values are expressed as concentrations in mg/1. Seven day averages are running averages consisting of the arithmetic average of effluent BOD5 for a particular date and the six days immediately preceding. Figure 9 shows similar columns under the heading Suspended Solids. Suspended Solids data are calculated and reported in the same manner as described for BOD5.

An example of a monthly report item derived from calculations performed on direct measurements is the flow to primary digesters 1 and 2 shown under the heading Sludge Movement in the portion of the monthly operating report shown in Figure 12. The flow to each primary digester is calculated from data logged in the sludge pump records shown in Figures 13 and 14. The six sludge pumps named in Figures 13 and 14 may operate in several flow schemes to pump

SPRINGDALE WASTEWATER PLANT

SPRINGDALE, ARKANSAS 72764

5 DAY B.O.D. REPORT

General Information	INIT.	BOT. NO.	VOL. ML.	Samp ML.	Collection Point	INIT. D.O.	FIN. D.O.	DEPL. D.O.	MG/L
Sample Type:		27	300.0	Blank		7.3	7.2		
24 Hr. Flow		36	298.0	2.0	Raw	3.9		3.4	x150 510 > 518
Proportional Comp.		41	"	"	"	3.8		3.5	x150 525
Sample Date:		42	295.0	5.0	Primary	3.8		3.5	x60 210 > 207
8-1-83		64	"	"	"	3.9		3.4	x60 204
Date And Time		69	285.0	15.0	[illegible]	5.9		1.4	x20 29 > 28
Sample Set Up:		72	"	"	"	5.9		1.4	x20 28
7:30 P.M. A.M. 8-2		100	294.0	6.0	Seed	7.4	5.7	1.7	÷6x20 .6 > 23%
By: [illegible]		102	291.0	9.0	"	7.3	5.0	2.3	÷9x20 .5 > 32%
Date And Time		107	288.0	12.0	"	7.2	4.5	2.7	÷12x20 .5 38%
Sample Analyzed:			DUPLICATE Final Blank			7.5/7.5			
9:30 P.M. A.M. 8-7			Seed Depletion			.5			
By: [illegible]		110	260.0	40.0	Final	7.0	5.2	1.8	x7.5 13.5 > 14
		115	250.0	50.0	"	7.0	4.6	2.4	x6 14.4
		Seeded by 2% Primary							
Sample Type:		7	300.0	Blank		7.1	6.9		
24 Hr. Flow		17	298.0	2.0	Raw	3.3		3.8	x150 570 > 578
Proportional Comp.		21	"	"	"	3.2		3.9	x150 585
Sample Date:		43	295.0	5.0	Primary	3.2		3.9	x60 234 > 231
8-2-83		50	"	"	"	3.3		3.8	x60 228
Date And Time		59	285.0	15.0	[illegible]	4.9		2.2	x20 44 > 43
Sample Set Up:		62	"	"	"	5.0		2.1	x20 42
8:00 P.M. A.M. 8-2		63	294.0	6.0	Seed	7.0	4.1	2.9	÷6x20 1.0 > 41%
By: [illegible]		68	291.0	9.0	"	6.9	2.7	4.2	÷9x20 .9 > 61%
Date And Time		71	288.0	12.0	"	6.9	1.0	5.9	÷12x20 1.0 86%
Sample Analyzed:			Final Blank			7.3/7.3			
8:45 P.M. A.M. 8-8			Seed Depletion			1.0			
By: [illegible]		74	260.0	40.0	Final	6.3	3.8	2.5	x7.5 18.7 > 17.7
		97	250.0 DUPLICATE	50.0		6.3	3.5	2.8	x6 16.8
		Seeded by 2% Primary							

FIGURE 10

LAB REPORT OF BOD5

SPRINGDALE WASTEWATER PLANT

SPRINGDALE, ARKANSAS 72764

DAILY OPERATING ANALYSIS

DATE	MG/L B.O.D. 5 DAY				MG/L SOLIDS SUSPENDED				MG/L SOLIDS TOTAL			
	Raw	Prim.	Int.	Final	Raw	Prim.	Int.	Final	Raw	Prim.	Int.	Final
1	518	201	28	14	330	125	30	15	1140		405	450
2	578	231	43	17.7	360	215	20	10	815		380	415
3	623	246	48	14.3	315	85	18	2	800		365	385
4	420	198	41	9.4	250	85	22	13	680		370	390
5	533	222	30	11.3	300	90	40	14	845		445	420
6	615	141	43	9.3	260	75	24	9	760		445	495
7	147	52	16	9.3	195	70	22	17	460		370	460
8	428	165	26	9	255	85	20	10	710		320	390
9	485	258	33	11.3	240	90	26	5	755		350	380
10	548	246	49	12	305	105	20	7	740		390	435
11	443	234	45	9.8	275	100	36	17	695		400	415
12	480	255	49	9.5	480	110	38	11	1385		435	405
13	758	177	52	5.7	460	80	44	15	765		455	430
14	204	78	23	4.4	165	40	26	10	435		400	450
15	630	222	24	10.4	285	85	26	8	1035		450	460
16	600	261	57	16.5	340	115	35	14	925		485	475
17	563	231	63	12.9	790	120	44	17	800		455	435
18	565	234	57	15.3	290	115	50	17	730		415	405
19	615	240	54	10.3	345	115	34	13	860		430	405
20	278	147	63	10.6	—	105	34	11	940		485	440
21	189	57	20	11.9	220	65	16	8	510		395	445
22	415	147	17	8.1	185	60	20	5	665		380	435
23	420	186	23	7.5	270	50	14	5	665		350	415
24	435	177	23	9.6	265	80	28	10	680		355	390
25	435	192	36	10.9	245	80	26	4	750		355	375
26	623	213	43	9	250	65	20	5	570		380	370
27	315	132	38	9.3	220	80	32	16	630		420	435
28	186	63	18	7.3	225	75	20	14	540		395	455
29	315	177	13	5.3	160	65	16	2	630		320	360
30	533	204	47	9.3	300	145	40	18	785		400	445
31	488	282	57	10.6	315	125	30	10	755		395	375

MONTH August YEAR 1983

FIGURE 11

DAILY LOG FROM SPRINGDALE PLANT

SLUDGE MOVEMENT						CHEMICAL AND BIOLOGICAL												
		% Solids		% Vol.		PRIMARY DIGESTERS NO'S 1 AND 2									SECONDARY DIGESTER			
GALLONS X 1000 TO P. DIGESTER #1	GALLONS X 1000 TO P. DIGESTER #2	Thickeners 1 & 2	Thickeners 3 & 4	Thickeners 1 & 2	Thickeners 3 & 4	VOL. ACIDS #1 MG/L	VOL. ACIDS #2 MG/L	ALKALINITY #1 MG/L	ALKALINITY #2 MG/L	TOTAL GALLONS X 1000 TO DIGESTERS	P.H. #1	TEMP. #1	P.H. #2	TEMP. #2	P.H.	TEMP.	% Solids Bottom	% Vol. Bottom
65.2		2.7		63						65.2	7.4		7.5		7.5			
69.1		2.0		75		300	320	3800	4560	69.1	7.2		7.4		-		5.1	37
58.7		2.0		60						58.7	7.2		7.3		-		5.4	46
57.9		3.1		65						57.9	7.2		7.3		7.3		5.6	46
55.6		4.0		72						55.6	7.2		7.4		7.3			
55.3		4.0		68						55.3	7.4		7.5		7.4			
56.5		3.0		67						56.5	7.4		7.5		7.4			
49.9		4.5		62		200	245	3640	4200	49.9	7.2		7.5		-		5.1	41
45.7		4.5		71						45.7	7.2		7.5		7.4		5.4	80
45.2		4.2		71						45.2	7.3		7.5		7.3		5.1	61
44.8		2.2		67						44.8	7.3		7.4		7.4			
45.6		3.2		66						45.6	7.4		7.5		7.5			
48.9		3.0		67						48.9	7.4		7.4		7.4			
55.0		3.0		80						55.0	7.5		7.5		7.2			
57.9		2.7		75						57.9	7.4		7.4		7.5			
58.4		3.2		69		325	320	3520	4280	58.4	7.6		7.6		7.5			
58.0		3.4		65						58.0	7.4		7.4		7.4			
68.1		3.1		67						68.1	7.3		7.4		7.4			
67.0		2.6		69						67.0	7.3		7.4		7.5			
71.8		3.0		70						71.8	7.4		7.4		7.4			
82.1		2.5		64						82.1	7.2		7.3		7.3			
84.1		2.6		58						84.1	7.2		7.4		7.4			
84.2		5.9		34		225		3520		84.2	7.2		7.4		7.4			
69.0		3.0		60			225		2540	69.0	7.2		7.3		7.4			
56.8		3.4		57						56.8	7.3		7.4		7.4			
51.5		3.1		61						51.5	7.3		7.5		7.5			
52.1		3.0		70						52.1	7.5		7.6		7.5			
52.5		2.0		70						52.5	7.3		7.4		7.4			
54.8		1.4		50						54.8	7.3		7.4		7.4			
52.9		3.6		67						52.9	7.4		7.4		7.4			
52.6		3.9		64		195	205	3000	3200	52.6	7.4		7.5		7.4			
1834.2		102.8		2024		1245	1315	17,480	18,780	1834.2	227.3		230.1		220.3		31.7	311
84.2		5.9		80		325	320	3800	4560	84.2	7.6		7.6		7.5		5.6	80
44.8		2.0		34		195	205	3000	2540	44.8	7.2		7.3		7.3		5.1	37
59.1		3.3		65		249	262	3196	3756	59.1	7.3		7.4		7.4		5.3	52

FIGURE 12

MONTHLY OPERATING REPORT FOR SPRINGDALE PLANT

SLUDGE PUMP RECORDS

Date	SLUDGE PUMP # East				SLUDGE PUMP # West				SLUDGE PUMP # 2 reactor			
	Stroke in Inches	Present Reading	Previous Reading	Gallons Per 24 Hrs.	Stroke in Inches	Present Reading	Previous Reading	Gallons Per 24 Hrs.	Stroke in Inches	Present Reading	Previous Reading	Gallons Per 24 Hrs.
1	82	47350.7	47186.4	13,472.6	82	55600.5	55425.8	14,325.4	82	34311.6	34174.1	11,275
2		47528.3	47350.7	14,563.2		55785.0	55600.5	15,125		34464.2	34311.6	12,541.2
3		47691.4	47528.3	13 374.2		55954.9	55785.0	13,931.8		34597.2	34464.2	10,578
4		47868.3	47691.4	14,505		56137.4	55954.9	14,965		34734.1	34597.2	11,225
5		48036.4	47868.3	13,784		56314.7	56137.4	14,539		34868.0	34734.1	10,980
6		48209.7	48036.4	14,211		56493.7	56314.7	14,678		35005.8	34868.0	11,300
7		48367.0	48209.7	12,898.6		56659.9	56493.7	13,628.4		35184.0	35005.8	14,612.4
8		48507.0	48367.0	11,480		56835.7	56659.9	14,415.6		35291.5	35184.0	8,815
9		48588.9	48507.0	6,715.8		56982.0	56835.7	11,996.6		35425.6	35291.5	10,996.2
10		48671.2	48588.9	6,748		57130.9	56982.0	12 209		35563.7	35425.6	11,324
11		48750.8	48671.2	6,527		57275.0	57130.9	11,816		35701.7	35563.7	11,316
12		48833.3	48750.8	6,765		57421.9	57275.0	12,045.8		35842.8	35701.7	11,570.2
13		48930.6	48833.3	7,978.6		57568.5	57421.9	12,021.2		35981.0	35842.8	11,332.4
14		49071.4	48930.6	11,545.6		57716.3	57568.5	12,119.6		36128.5	35981.0	12,095
15		49208.3	49071.4	11,225.8		57862.6	57716.3	11,996.6		36366.7	36128.5	19,532.4
16		49348.5	49208.3	11,496.4		58011.1	57862.6	12,177		36524.3	36366.7	12,923.2
17		494920	49348.5	11 767		58164.0	58011.1	12,537		36679.8	36524.3	12,751
18		49659.7	49492.0	13,751		58339.5	58164.0	14,391		36839.9	36679.8	13,128
19		49820.6	49659.7	13,193.8		58507.6	58339.5	13,784.2		36979.9	36839.9	11,480
20		50011.9	49820.6	15,686.6		58703.7	58507.6	16,080.2		37113.4	36979.9	10,947
21		50239.4	50011.9	18,655		58938.6	58703.7	19,261.8		37286.5	37113.4	14,194.2
22		50466.2	50239.4	18,597.6	→	59170.0	58938.6	18,974.8		37473.1	37286.5	15,301.2
23		50702.4	50466.2	19,368.4		59416.1	59170.0	20,180.2		37666.3	37473.1	15,842.4
24		50847.6	50702.4	11,906		59640.9	59416.1	18,433		37929.8	37666.3	21,607
25		50990.4	50847.6	11,709		59874.7	59640.9	19,171		38046.3	37929.8	9,553
26		51132.2	50990.4	11,627.6		60106.6	59874.7	19,015.8		38202.4	38046.3	12,800.2
27		51272.5	51132.2	11,504.6		60336.2	60106.6	18,827.2		38299.9	38202.4	7,995
28		51416.1	51272.5	11,775.2		60513.6	60336.2	14,546.8		38435.7	38299.9	11,135.6
29		51563.0	51416.1	12,045.5		60645.1	60513.6	10,783		38580.4	38435.7	11,865.4
30		51705.6	51563.0	11,693.2		60765.5	60645.1	9,872.8		38717.3	38580.4	11,226.8
31		518510	51705.6	11,922		608649	60765.5	8150		38857.6	38717.3	11,504

MONTH AUGUST YEAR 1983

TABLE 13

DAILY SLUDGE PUMP LOG

SLUDGE PUMP RECORDS

Date	SLUDGE PUMP # North				SLUDGE PUMP # South				SLUDGE PUMP # 1 [illegible]			
	Stroke in Inches	Present Reading	Previous Reading	Gallons Per 24 Hrs.	Stroke in Inches	Present Reading	Previous Reading	Gallons Per 24 Hrs.	Stroke in Inches	Present Reading	Previous Reading	Gallons Per 24 Hrs.
1	1.69	180220	173594	11,197	1.61	540680	534634	9,734	1.69	758879	755774	5,242
2		187109	180220	11,642		547087	540680	10,315		761637	758879	4,666
3		191926	187109	8,140		551305	547087	6,790		765158	761637	5,950
4		196780	191926	8,203		554353	551305	4907		767623	765158	4,165
5		200601	196780	6,457		557263	554353	4,685		770711	767623	5,219
6		204121	200601	5,949		560347	557263	4,965		773198	770711	4,203
7		207333	204121	5,428		563251	560347	4,625		776330	773198	5,293
8		210718	207333	5,120		566192	563251	4,235		779136	776330	4,242
9		214089	210718	5,656		569043	566192	4,590		782515	779136	5,310
10		217534	214089	5,822		571927	569043	4,643		785204	782515	4,544
11		220847	217534	5,598		574844	571927	4,696		788075	785204	4,851
12		224229	220847	5,315		577824	574844	4,797		790865	788075	4,715
13		228026	224229	6,416		581236	577824	5,493		794228	790865	5,683
14		232780	228026	8,034		585557	581236	6,556		796785	794228	4,321
15		237477	232780	7,937		590071	585557	7,267		796785	796785	9/5
16		242226	237477	8,025		594577	590071	7,254		800662	796785	6,552
17		247181	242226	8,373		599184	594577	7417		803722	800662	5,171
18		253965	247181	11,464		605341	599184	9912		806997	803722	5534
19		261520	253965	12,767		611333	605341	9,647		810648	806997	6,170
20		269504	261520	14,168		618487	611333	11,517		812697	810648	3,462
21		277970	269504	13,631		626254	618487	12,504		815024	812697	3,932
22		286032	277970	13,624		633712	626254	12,007		818340	815024	5,604
23		294145	286032	13,710		635558	633712	5,412		821705	818340	5,653
24		297968	294145	6,460		642671	635558	5,011		825054	821705	5,653
25		301413	297968	5,822		645387	642671	4,372		828744	825054	6,236
26		304809	301413	5,739		648065	645387	4,311		831723	828744	5,034
27		308141	304809	5,631		650686	648065	4,219		834074	831723	3,973
28		311783	308141	6,154		653662	650686	4,751		836543	834074	4,172
29		316700	311783	8,309		657941	653662	6,889		839452	836543	4,516
30		321503	316700	8,117		662152	657941	6,229		842538	839452	5,215
31		326323	321503	8,145		666366	662152	4,784		846193	842538	6,176

MONTH August YEAR 1983

FIGURE 14

DAILY SLUDGE PUMP LOG

sludge to primary digesters 1 and 2. The entire daily flow from a pump is assigned either to digester 1 or digester 2. Flow from a particular sludge pump is calculated by the equation:

EQ 2 flow = [present reading - previous reading] X stroke

where the present and previous readings are obtained daily from a pump and the stroke is a constant for a particular pump. The resulting value is expressed in gallons per twenty-four hours as shown in Figures 13 and 14. At this point it is necessary for the operator to indicate which digester has been assigned to each pump. The total daily flow to a digester is calculated as the sum of the flows from all sludge pumps assigned to the digester. Figure 12 shows that for August, 1983 all flows were assigned to primary digester 1 with no flow to primary digester 2. Also shown in Figure 12 is the total flow to the digesters. The total flow to digesters is the sum of the flows to primary digester 1 and 2.

Some items in the monthly operating report are generated for use in other reports. Figure 15 shows a portion of the monthly operating report with the heading Effluent Solids. The first column in Figure 15 is a BOD5 loading expressed in lbs/day. BOD5 loading is calculated by the following equation:

EQ 3 BOD5, lb/d = effluent BOD5, mg/1 X flow, MGD X 8.34

where effluent BOD5 and flow are obtained for the corresponding date in Figure 9 and 8.34 is a conversion factor. The seven day high in the second column of Figure 15 is a seven day running average of

EFFLUENT SOLIDS						
POUNDS/DAY						
B.O.D.	7 DAY HIGH	SUSPENDED	7 DAY HIGH	CL_2 RESIDUE MG/L		DATE
806		863		.96		1
989		557		.98		2
823		115		1.16		3
525		726		1.27		4
547		677		1.27		5
310		300		1.00		6
442	635	808	578	1.46		7
525	594	584	538	.96		8
688	551	304	502	1.15		9
691	533	403	543	1.25		10
588	542	1021	585	1.31		11
483	532	560	569	1.20		12
214	519	563	606	1.01		13
136	475	309	535	1.27		14
581	483	447	515	1.15		15
1005	528	852	594	1.00		16
753	537	992	678	1.16		17
893	581	992	674	1.11		18
507	584	640	685	.81		19
354	604	367	657	1.03		20
357	636	240	647	1.30		21
464	619	267	621	1.20		22
400	533	267	538	1.01		23
509	498	593	481	1.30		24
636	461	234	372	1.25		25
450	453	250	317	1.30		26
326	449	560	344	.91		27
318	440	572	392	1.48		28
340	423	128	372	1.18		29
556	445	1081	488	1.25		30
670	471	651	497	1.31		31
16,888	13,126	16,924	13,328	35.96		TOTAL
1005	636	1081	685	1.48		MAX
136	423	115	317	.81		MIN
545	525	546	532	1.16		AVG

FIGURE 15

MONTHLY OPERATING REPORT FOR SPRINGDALE PLANT

the BOD5 loading. The suspended solids loading shown in Figure 15 is calculated by substituting the value of effluent suspended solids in mg/l from Figure 9 into EQ 3. The seven day high for suspended solids is a seven day running average of the suspended solids loading.

Figure 16 is a copy of the NPDES Discharge Monitoring Report (DMR) for August, 1983 for the Springdale plant. The first row in Figure 16 is a report of BOD5. Values of BOD5 are reported as the BOD5 loading, lb/day obtained from Figure 15, the monthly average of effluent BOD5, mg/l from Figure 9, and the monthly maximum of the seven day running average of BOD5, mg/l from Figure 9. The remaining rows in Figure 16 were obtained from appropriate columns in the monthly report for August, 1983.

The Database Management System: The DBMS has been customized to perform the data management tasks required by the Springdale plant. The operator is guided through the system by a series of menus and prompts.

Figure 17 shows the main menu listing the program options which appears on the screen at the beginning of the program. When the operator chooses to add data by indicating option 1, the system responds as shown in Figure 18. After indicating the desired date, the data entry menu in Figure 19 is displayed. In Figure 19 the operator chose option 1, plant flow. An appropriate data entry form is displayed. In this case the FLOW DATA form in Figure 20

...TEE NAME/ADDRESS (Include Name/Location if different)

SPRI GDALE WSTE WTER DEPT
P O BOX 7[illegible]
SPRI GDALE [illegible] 72[illegible]

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES)
DISCHARGE MONITORING REPORT (DMR)

(2-16) PERMIT NUMBER: [illegible]22[illegible]63
(17-19) DISCHARGE NUMBER: [illegible]1

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~~July~~ August 1983

Form Approved OMB No. [illegible]

MONITORING PERIOD	YEAR	MO	DAY		YEAR	MO	DAY
FROM	83	08	01	TO	83	08	31
	(20-21)	(22-23)	(24-25)		(26-27)	(28-29)	(30-31)

NOTE: Read instructions before completing this form.

PARAMETER (32-37)		(3 Card Only) QUANTITY OR LOADING (46-53) AVERAGE	(54-61) MAXIMUM	UNITS	(4 Card Only) QUALITY OR CONCENTRATION (38-45) MINIMUM	(46-53) AVERAGE	(54-61) MAXIMUM	UNITS	NO. EX (62-63)	FREQUENCY OF ANALYSIS (64-68)	SAMPLE TYPE
	SAMPLE MEASUREMENT										
	PERMIT REQUIREMENT										
B.O.D.5	SAMPLE MEASUREMENT	546		LBS/DAY		10.3	11.9	MG/L	0	7/7	24HR Comp.
	PERMIT REQUIREMENT	2002				15	22				
P.H	SAMPLE MEASUREMENT							STD. UNITS	0	7/7	Grab
	PERMIT REQUIREMENT				6.0		9.0				
T.S.S.	SAMPLE MEASUREMENT	546				10.7	17	MG/L	0	7/7	24HR Comp.
	PERMIT REQUIREMENT	2002				15	22				
Flow	SAMPLE MEASUREMENT	6.2	7.8	M.G.D.				CONTINUOUS TOTALIZING METER			
	PERMIT REQUIREMENT										
FECAL COLIFORM	SAMPLE MEASUREMENT					1.23	2.06	N/100mL	0	7/7	Grab
	PERMIT REQUIREMENT					200	400				
	SAMPLE MEASUREMENT										
	PERMIT REQUIREMENT										

NAME/TITLE PRINCIPAL EXECUTIVE OFFICER: RENE LANGSTON EX. DIR.
TYPED OR PRINTED

I CERTIFY UNDER PENALTY OF LAW THAT I HAVE PERSONALLY EXAMINED AND AM FAMILIAR WITH THE INFORMATION SUBMITTED HEREIN AND BASED ON MY INQUIRY OF THOSE INDIVIDUALS IMMEDIATELY RESPONSIBLE FOR OBTAINING THE INFORMATION I BELIEVE THE SUBMITTED INFORMATION IS TRUE ACCURATE AND COMPLETE I AM AWARE THAT THERE ARE SIGNIFICANT PENALTIES FOR SUBMITTING FALSE INFORMATION INCLUDING THE POSSIBILITY OF FINE AND IMPRISONMENT SEE 18 USC § 1001 AND 33 USC § 1319 *(Penalties under these statutes may include fines up to $10,000 and/or maximum imprisonment of between 6 months and 5 years)*

SIGNATURE OF PRINCIPAL EXECUTIVE OFFICER OR AUTHORIZED AGENT

TELEPHONE AREA CODE	NUMBER	DATE YEAR	MO	DAY
501	751-5751	83	~~08~~ 10	15

COMMENT AND EXPLANATION OF ANY VIOLATIONS *(Reference all attachments here)*

W
6

EPA Form 3320-1 (Rev. 10-79) PREVIOUS EDITION TO BE USED UNTIL SUPPLY IS EXHAUSTED

(REPLACES EPA FORM T-40 WHICH MAY NOT BE USED.)

PAGE 1 OF 1

FIGURE 16

NPDES REPORT FOR THE SPRINGDALE PLANT

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

      MAIN MENU

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

   0--QUIT

   1--ENTER NEW DATA

   2--CHANGE OLD DATA

   3--GENERATE A REPORT

   4--USE PLOTTER




CHOOSE AN ITEM AND PRESS RETURN 1
```

FIGURE 17

MAIN MENU SCREEN

Press [ESC] when done with this data

WHAT DATE FOR THIS DATA? (MM/DD/YY): 08/01/83

FIGURE 18

DATE INPUT SCREEN

```
                         DATA ENTRY MENU
****************************************************************************
0---QUIT                 6---PLANT PH                      12---PRIMARY DIGESTER #2

1---PLANT FLOW           7---SETTLEABLE SOLIDS             13---SECONDARY DIGESTER

2---WEATHER              8---DISSOLVED OXYGEN AND TEMP     14---CHLORINE LOG

3---5 DAY BOD            9---FECAL COLIFORM                15---COMMENTS

4---SUSPENDED SOLIDS    10---SLUDGE PUMP RECORDS           16---ANOTHER DATE

5---TOTAL SOLIDS        11---PRIMARY DIGESTER #1

ALL ENTRIES FROM THIS MENU WILL BE FOR THE DATE---08/01/83

TO ENTER ANOTHER DATE CHOOSE 16



CHOOSE AN ITEM AND PRESS RETURN 1
```

FIGURE 19

DATA ENTRY MENU

is displayed with the date indicated by the operator in Figure 18. The operator fills in the blanks on the forms with data as shown in Figure 20 and selects the C(hange) option to add data to the database.

Figure 21 demonstrates the error checking capability of the system. The operator has input text values for the attribute containing values of maximum flow. Since this value has been predefined as a real number, only real numbers are accepted and the operator is informed of the error and asked to correct the entry. In addition to restricting data type, rules may be set restricting certain data values to a particular range of expected values.

Figure 22 shows the input form for option 3 on the data entry menu. The BOD5 form shown in Figure 22 corresponds with the first row on the daily log in Figure 11. At this point, the operator would have the option of inputting BOD5 data from the daily log or eliminating the daily log altogether and inputting data directly from the laboratory report in Figure 10.

Figure 23 shows the input form for sludge pump records data. Figure 23 corresponds to Figures 13 and 14. The input form provides a column to indicate flow assignment for each sludge pump.

Option 2 in Figure 19, the edit option, follows the same rules as the input routine and gives the same menu for editing as shown in the data entry menu. Option 0 sends the operator back to the main menu.

```
C(hange entry),A(dd entry),R(eset),S(kip),E(dit),D(elete),Q(uit):

******************************
* FLOW DATA    DATE: 08/01/83 *
******************************
* MAXIMUM, 1000 GPM: 7.80000  *
*                             *
* MINIMUM, 1000 GPM: 1.70000  *
*                             *
*       TOTAL, MGD: 6.90000   *
******************************
```

FIGURE 20

FLOW INPUT SCREEN

```
-ERROR- Attribute MAX:FLOW must be a valid REAL     - Press [ESC] when corrected

                *******************************
                * FLOW DATA     DATE: 08/01/83 *
                *******************************
                * MAXIMUM, 1000 GPM: flow      *
                *                              *
                * MINIMUM, 1000 GPM: 1.70000   *
                *                              *
                *         TOTAL, MGD: 6.90000  *
                *******************************
```

FIGURE 21

ERROR CHECKING CAPABILITY

```
C(hange entry),A(dd entry),R(eset),S(kip),E(dit),D(elete),Q(uit):


************************************
* BOD 5 DAY, MG/L    DATE: 08/01/83 *
* ***********************************
*                INFLUENT: 518.000  *
*                                   *
*             PRIMARY EFF: 207.000  *
*                                   *
*        INTERMEDIATE EFF: 28.0000  *
*                                   *
*                EFFLUENT: 14.0000  *
************************************
```

FIGURE 22

BOD5 INPUT SCREEN

```
C(hange entry),A(dd entry),R(eset),S(kip),E(dit),D(elete),Q(uit):
 ********************************************************************
 * SLUDGE PUMP RECORDS        DATE: 08/01/83                       *
 ********************************************************************
 *  SLUDGE    PRESENT     PREVIOUS     STROKE,   FLOW ASSIGNED TO: (1 OR 2) *
 *  PUMP #    READING     READING      IN.       1=PRIMARY DIGESTER #1      *
 *                                               2=PRIMARY DIGESTER #2      *
 ********************************************************************
 *   EAST:   47350.7     47186.4      82.00            1            *
 *           _________   _________    _____           ___           *
 *   WEST:   55600.5     55425.8      82.00            1            *
 *           _________   _________    _____           ___           *
 * #2 VAC:   34311.6     34174.1      82.00            1            *
 *           _________   _________    _____           ___           *
 *  NORTH:   180220.     173594.      1.690            1            *
 *           _________   _________    _____           ___           *
 *  SOUTH:   540680.     534634.      1.610            1            *
 *           _________   _________    _____           ___           *
 * #1 VAC:   758879.     755774.      1.690            1            *
 *           _________   _________    _____           ___           *
 ********************************************************************
```

FIGURE 23

SLUDGE PUMP RECORDS INPUT SCREEN

Option 3 in the main menu in Figure 17 prepares the system for report generation. Figure 24 requests the range of dates for the report and shows that the operator has chosen the entire month of August, 1983 for a report.

Figure 25 is the report menu. Items 1-16 correspond to items in the monthly operating report kept by the plant. Various other options select multiple reports and data for permits. All reports are available as printed copies.

Option 1 from the report menu gives the Flow Report shown in Figure 26. The Flow Report corresponds to the data under the heading Flow Data in Figure 9.

Option 3 gives the BOD5 Report shown in Figure 27. The BOD5 Report corresponds to data under the heading BOD5 in Figure 9. The items AVG:BOD and PR:BOD refer to seven day running average effluent BOD5 and Percent Reduction BOD5 respectively.

Option 10 produces the Sludge Movement Report shown in Figure 28. The Sludge Movement Report corresponds to the data under the heading Sludge Movement in Figure 12 and is composed of data from the input form in Figure 23 and others. The "-0-" seen in two columns of Figure 28 represent nulls - items for which no data has been entered.

Option 14 results in the Effluent Solids Report shown in Figure 29. The items in the Effluent Solids Report correspond to items in Figure 15 under the heading Effluent Solids.

```
Press [ESC] when done with this data

                 REPORT DATES
****************************************

ENTER STARTING DATE (MM/DD/YY): 08/01/83

  ENTER ENDING DATE (MM/DD/YY): 08/31/83
```

FIGURE 24

REPORT DATES INPUT SCREEN

----------------------------------REPORTS----------------------------------

100---GENERAL
****

1---Flow
2---Weather

200---CHEMICAL AND BIOLOGICAL ANALYSIS
****

3---Bod5
4---Suspended Solids
5---Total Solids
6---Plant pH
7---Settleable Solids
8---Dissolved Oxygen and Temp.
9---Fecal Coliform

300---GENERAL SOLIDS CONTROL
****

10---Sludge Movement
11---Primary Digesters 1 & 2
Flow, Vol. Acids, Alkalinity
12---Primary Digesters 1 & 2
Flow pH and Temp.
13---Secondary Digester

400---ADDITIONAL INFORMATION
****

14---Effluent Solids (Bod5, SS)
15---Chlorine Residue
16---Comments

500---PERMIT DATA 600---PRINT ALL TOPICS 700---USE DIFFERENT DATES

Items 100-600 are printed. Items 1-16 may be printed or viewed on the screen.

Choose an item listed or 0 and press return

FIGURE 25

REPORT MENU

FLOW REPORT

DATE	MAX:FLOW	MIN:FLOW	TOT:FLOW
08/01/83	7.80000	1.70000	6.90000
08/02/83	7.00000	2.30000	6.70000
08/03/83	7.30000	2.20000	6.90000
08/04/83	7.10000	2.20000	6.70000
08/05/83	6.20000	2.10000	5.80000
08/06/83	3.70000	1.90000	4.00000
08/07/83	7.60000	1.40000	5.70000
08/08/83	7.80000	2.00000	7.00000
08/09/83	7.60000	2.20000	7.30000
08/10/83	7.10000	2.40000	6.90000
08/11/83	7.60000	2.10000	7.20000
08/12/83	6.20000	2.50000	6.10000
08/13/83	4.60000	4.50000	4.50000
08/14/83	3.60000	1.50000	3.70000
08/15/83	7.50000	1.70000	6.70000
08/16/83	8.00000	2.00000	7.30000
08/17/83	7.20000	2.30000	7.00000
08/18/83	7.70000	2.00000	7.00000
08/19/83	6.10000	2.00000	5.90000
08/20/83	3.90000	1.90000	4.00000
08/21/83	3.60000	1.50000	3.60000
08/22/83	7.20000	1.80000	6.40000
08/23/83	6.80000	2.00000	6.40000
08/24/83	7.60000	2.00000	7.10000
08/25/83	7.10000	2.50000	7.00000
08/26/83	6.20000	2.30000	6.00000
08/27/83	4.30000	1.80000	4.20000
08/28/83	9.70000	1.50000	4.90000
08/29/83	8.20000	2.40000	7.70000
08/30/83	7.50000	2.20000	7.20000
08/31/83	8.50000	2.30000	7.80000
			191.600

SUMMARY	MAX:FLOW	MIN:FLOW	TOT:FLOW
MAXIMUM	9.70000	4.50000	7.80000
AVERAGE	6.71935	2.10323	6.18064
MINIMUM	3.60000	1.40000	3.60000

FIGURE 26

FLOW REPORT

BOD5 REPORT

DATE	INF:BOD	PRI:BOD	INT:BOD	EFF:BOD	AVG:BOD	PR:BOD
08/01/83	518.000	207.000	28.0000	14.0000	11.7857	97.2973
08/02/83	578.000	231.000	43.0000	17.7000	12.0571	96.9377
08/03/83	623.000	240.000	48.0000	14.3000	12.3714	97.7047
08/04/83	420.000	198.000	41.0000	9.40000	11.8857	97.7619
08/05/83	533.000	222.000	50.0000	11.3000	11.8714	97.8799
08/06/83	615.000	141.000	43.0000	9.30000	11.8143	98.4878
08/07/83	147.000	52.0000	16.0000	9.30000	12.1857	93.6735
08/08/83	428.000	165.000	26.0000	9.00000	11.4714	97.8972
08/09/83	488.000	258.000	33.0000	11.3000	10.5571	97.6844
08/10/83	548.000	246.000	49.0000	12.0000	10.2286	97.8102
08/11/83	443.000	234.000	45.0000	9.80000	10.2857	97.7878
08/12/83	480.000	255.000	49.0000	9.50000	10.0286	98.0208
08/13/83	758.000	177.000	52.0000	5.70000	9.51428	99.2480
08/14/83	204.000	78.0000	23.0000	4.40000	8.81429	97.8431
08/15/83	630.000	222.000	24.0000	10.4000	9.01428	98.3492
08/16/83	600.000	261.000	59.0000	16.5000	9.75714	97.2500
08/17/83	563.000	231.000	63.0000	12.9000	9.88571	97.7087
08/18/83	555.000	234.000	57.0000	15.3000	10.6714	97.2432
08/19/83	615.000	240.000	54.0000	10.3000	10.7857	98.3252
08/20/83	278.000	147.000	63.0000	10.6000	11.4857	96.1871
08/21/83	189.000	57.0000	20.0000	11.9000	12.5571	93.7037
08/22/83	413.000	147.000	17.0000	8.70000	12.3143	97.8935
08/23/83	420.000	186.000	23.0000	7.50000	11.0286	98.2143
08/24/83	435.000	177.000	23.0000	8.60000	10.4143	98.0230
08/25/83	435.000	192.000	36.0000	10.9000	9.78571	97.4943
08/26/83	623.000	213.000	43.0000	9.00000	9.60000	98.5554
08/27/83	315.000	132.000	38.0000	9.30000	9.41429	97.0476
08/28/83	186.000	63.0000	18.0000	7.30000	8.75714	96.0753
08/29/83	315.000	177.000	13.0000	5.30000	8.27143	98.3175
08/30/83	533.000	204.000	47.0000	9.30000	8.52857	98.2552
08/31/83	488.000	282.000	57.0000	10.6000	8.81429	97.8279

SUMMARY	INF:BOD	PRI:BOD	INT:BOD	EFF:BOD	AVG:BOD	PR:BOD
MAXIMUM	758.000	282.000	63.0000	17.7000	12.5571	99.2480
AVERAGE	463.742	189.323	38.7419	10.3677	10.5147	97.5002
MINIMUM	147.000	52.0000	13.0000	4.40000	8.27143	93.6735

FIGURE 27

BOD5 REPORT

SLUDGE MOVEMENT REPORT

DATE	GAL:PD1	GAL:PD2	S:TH:12	S:TH:34	V:TH:12	V:TH:34
08/01/83	65.2525	0.00000	2.70000	-0-	63.0000	-0-
08/02/83	69.1520	0.00000	2.00000	-0-	75.0000	-0-
08/03/83	58.7659	0.00000	3.00000	-0-	60.0000	-0-
08/04/83	57.9734	0.00000	3.10000	-0-	65.0000	-0-
08/05/83	55.6637	0.00000	4.00000	-0-	73.0000	-0-
08/06/83	55.3054	0.00000	4.00000	-0-	68.0000	-0-
08/07/83	56.5361	0.00000	3.00000	-0-	67.0000	-0-
08/08/83	49.9085	0.00000	4.50000	-0-	62.0000	-0-
08/09/83	45.7063	0.00000	4.50000	-0-	71.0000	-0-
08/10/83	45.2920	0.00000	4.20000	-0-	71.0000	-0-
08/11/83	44.8070	0.00000	3.20000	-0-	69.0000	-0-
08/12/83	45.6095	0.00000	3.20000	-0-	66.0000	-0-
08/13/83	48.9260	0.00000	3.00000	-0-	67.0000	-0-
08/14/83	55.0724	0.00000	3.00000	-0-	80.0000	-0-
08/15/83	57.9605	0.00000	2.70000	-0-	70.0000	-0-
08/16/83	58.4293	0.00000	3.20000	-0-	69.0000	-0-
08/17/83	58.0183	0.00000	3.40000	-0-	65.0000	-0-
08/18/83	68.1828	0.00000	3.10000	-0-	67.0000	-0-
08/19/83	67.0436	0.00000	2.60000	-0-	69.0000	-0-
08/20/83	71.8631	0.00000	3.00000	-0-	70.0000	-0-
08/21/83	82.1804	0.00000	2.50000	-0-	64.0000	-0-
08/22/83	84.1099	0.00000	2.60000	-0-	58.0000	-0-
08/23/83	84.2076	0.00000	5.90000	-0-	34.0000	-0-
08/24/83	69.0729	0.00000	3.00000	-0-	60.0000	-0-
08/25/83	56.8649	0.00000	3.40000	-0-	59.0000	-0-
08/26/83	58.5290	0.00000	3.10000	-0-	61.0000	-0-
08/27/83	52.1507	0.00000	3.00000	-0-	70.0000	-0-
08/28/83	52.5769	0.00000	2.00000	-0-	70.0000	-0-
08/29/83	54.8091	0.00000	4.40000	-0-	50.0000	-0-
08/30/83	52.9041	0.00000	3.60000	-0-	67.0000	-0-
08/31/83	52.6853	0.00000	3.90000	-0-	64.0000	-0-
	1835.56	0.00000				

SUMMARY	GAL:PD1	GAL:PD2	S:TH:12	S:TH:34	V:TH:12	V:TH:34
MAXIMUM	84.2076	0.00000	5.90000	0.00000	80.0000	0.00000
AVERAGE	59.2116	0.00000	3.31613	0.00000	65.2903	0.00000
MINIMUM	44.8070	0.00000	2.00000	0.00000	34.0000	0.00000

FIGURE 28

SLUDGE MOVEMENT REPORT

EFFLUENT SOLIDS REPORT

DATE	LB/D:BOD	A:LB:BOD	LB/D:SS	A:LB:SS
08/01/83	805.644	598.657	863.190	828.758
08/02/83	989.041	600.647	558.780	644.086
08/03/83	822.908	620.174	115.092	539.002
08/04/83	525.253	597.609	726.414	513.148
08/05/83	546.604	599.634	677.208	536.500
08/06/83	310.248	597.728	300.240	498.375
08/07/83	442.103	634.543	808.146	578.439
08/08/83	525.420	594.511	583.800	538.526
08/09/83	687.967	551.500	304.410	502.187
08/10/83	690.552	532.592	402.822	543.291
08/11/83	588.470	541.623	1020.82	585.349
08/12/83	483.303	532.580	559.614	568.550
08/13/83	213.921	518.819	562.950	606.080
08/14/83	135.775	475.058	308.580	534.713
08/15/83	581.131	483.017	447.024	515.174
08/16/83	1004.55	528.244	852.348	593.451
08/17/83	753.102	537.179	992.460	677.685
08/18/83	893.214	580.714	992.460	673.634
08/19/83	506.822	584.074	639.678	685.071
08/20/83	353.616	604.030	-0-	705.425
08/21/83	357.286	635.675	240.192	694.027
08/22/83	464.371	618.995	266.880	664.003
08/23/83	400.320	532.676	266.880	566.425
08/24/83	509.240	497.838	592.140	499.705
08/25/83	636.342	461.142	233.520	373.215
08/26/83	450.360	453.076	250.200	308.302
08/27/83	325.760	449.097	560.448	344.323
08/28/83	298.322	440.674	572.124	391.742
08/29/83	340.355	422.957	128.436	371.964
08/30/83	558.446	445.547	1080.86	488.247
08/31/83	689.551	471.305	650.520	496.587
	16890.0		16558.2	

SUMMARY	LB/D:BOD	A:LB:BOD	LB/D:SS	A:LB:SS
MAXIMUM	1004.55	635.675	1080.86	828.758
AVERAGE	544.839	540.062	551.941	550.516
MINIMUM	135.775	422.957	115.092	308.302

FIGURE 29

EFFLUENT SOLIDS REPORT

Figures 30, 31 and 32 together form the Permit Report available as option 500. Data in the Permit Report contains the permit data required to fill out the Springdale NPDES Report shown in Figure 16.

When the operator chooses to plot data, Option 4 in the main menu, the system requests a range of dates as in the report menu, and the plotting menus in Figures 33 and 34 are displayed. Every item on the monthly operating report except comments may be plotted versus any other item. Figure 33 asks for the Y-axis and Figure 34 asks for the X-axis. All plotting items may be displayed before selecting the axis.

After selection of the axes, the system unloads appropriate data and shifts program control to a BASIC program for plotting. The format of the BASIC program is menu-driven like that of the DBMS. Assuming the operator had requested TOT:FLOW (total flow) as the Y-axis and DATE as the X-axis, the program will give the operator an option to receive a printed copy and to name the axes. Figure 35 shows data values chosen by the operator and gives the names that were supplied. The operator has the option to delete any data points from the graph. Figure 36 shows the graph of the data items in Figure 35.

In Figure 37 the operator has chosen to plot influent suspended solids with influent BOD5 for the month of August, 1983. Suppose the operator chooses to delete data point Number 1 in

PERMIT REPORT

DATE	EFF:FC	AVG:FC
08/01/83	0	1.00000
08/02/83	0	1.00000
08/03/83	0	1.00000
08/04/83	0	1.00000
08/05/83	0	1.00000
08/06/83	0	1.00000
08/07/83	0	1.00000
08/08/83	4	1.30000
08/09/83	1	1.30000
08/10/83	0	1.30000
08/11/83	0	1.30000
08/12/83	0	1.30000
08/13/83	0	1.30000
08/14/83	0	1.30000
08/15/83	0	1.00000
08/16/83	0	1.00000
08/17/83	0	1.00000
08/18/83	78	14.0000
08/19/83	0	14.0000
08/20/83	0	14.0000
08/21/83	0	14.0000
08/22/83	0	14.0000
08/23/83	0	14.0000
08/24/83	2	2.10000
08/25/83	0	1.20000
08/26/83	0	1.20000
08/27/83	0	1.20000
08/28/83	0	1.20000
08/29/83	0	1.20000
08/30/83	0	1.20000
08/31/83	0	1.00000
SUMMARY	EFF:FC	AVG:FC
MAXIMUM	78	14.0000
AVERAGE	2	2.80000
MINIMUM	0	1.00000

FIGURE 30

PERMIT REPORT

PERMIT REPORT

DATE	LB/D:SS	EFF:SS	AVG:SS	TOT:FLOW
08/01/83	863.190	15.0000	16.2857	6.90000
08/02/83	558.780	10.0000	13.4286	6.70000
08/03/83	115.092	2.00000	11.5714	6.90000
08/04/83	726.414	13.0000	11.0000	6.70000
08/05/83	677.208	14.0000	11.4286	5.80000
08/06/83	300.240	9.00000	10.2857	4.00000
08/07/83	808.146	17.0000	11.4286	5.70000
08/08/83	583.800	10.0000	10.7143	7.00000
08/09/83	304.410	5.00000	10.0000	7.30000
08/10/83	402.822	7.00000	10.7143	6.90000
08/11/83	1020.82	17.0000	11.2857	7.20000
08/12/83	559.614	11.0000	10.8571	6.10000
08/13/83	562.950	15.0000	11.7143	4.50000
08/14/83	308.580	10.0000	10.7143	3.70000
08/15/83	447.024	8.00000	10.4286	6.70000
08/16/83	852.348	14.0000	11.7143	7.30000
08/17/83	992.460	17.0000	13.1429	7.00000
08/18/83	992.460	17.0000	13.1429	7.00000
08/19/83	639.678	13.0000	13.4286	5.90000
08/20/83	-0-	-0-	13.1667	4.00000
08/21/83	240.192	8.00000	12.8333	3.60000
08/22/83	266.880	5.00000	12.3333	6.40000
08/23/83	266.880	5.00000	10.8333	6.40000
08/24/83	592.140	10.0000	9.66667	7.10000
08/25/83	233.520	4.00000	7.50000	7.00000
08/26/83	250.200	5.00000	6.16667	6.00000
08/27/83	560.448	16.0000	7.57143	4.20000
08/28/83	572.124	14.0000	8.42857	4.90000
08/29/83	128.436	2.00000	8.00000	7.70000
08/30/83	1080.86	18.0000	9.85714	7.20000
08/31/83	650.520	10.0000	9.85714	7.80000

SUMMARY	LB/D:SS	EFF:SS	AVG:SS	TOT:FLOW
MAXIMUM	1080.86	18.0000	16.2857	7.80000
AVERAGE	551.941	10.7000	10.9516	6.18064
MINIMUM	115.092	2.00000	6.16667	3.60000

FIGURE 31

PERMIT REPORT

PERMIT REPORT

DATE	LB/D:BOD	EFF:BOD	AVG:BOD	EFF:PH
08/01/83	805.644	14.0000	11.7857	6.30000
08/02/83	989.041	17.7000	12.0571	6.30000
08/03/83	822.908	14.3000	12.3714	6.30000
08/04/83	525.253	9.40000	11.8857	6.10000
08/05/83	546.604	11.3000	11.8714	6.30000
08/06/83	310.248	9.30000	11.8143	6.10000
08/07/83	442.103	9.30000	12.1857	6.30000
08/08/83	525.420	9.00000	11.4714	6.30000
08/09/83	687.967	11.3000	10.5571	6.10000
08/10/83	690.552	12.0000	10.2286	6.20000
08/11/83	588.470	9.80000	10.2857	6.30000
08/12/83	483.303	9.50000	10.0286	6.30000
08/13/83	213.921	5.70000	9.51428	6.70000
08/14/83	135.775	4.40000	8.81429	6.30000
08/15/83	581.131	10.4000	9.01428	6.50000
08/16/83	1004.55	16.5000	9.75714	6.70000
08/17/83	753.102	12.9000	9.88571	6.50000
08/18/83	893.214	15.3000	10.6714	6.70000
08/19/83	506.822	10.3000	10.7857	6.50000
08/20/83	353.616	10.6000	11.4857	6.50000
08/21/83	357.286	11.9000	12.5571	6.50000
08/22/83	464.371	8.70000	12.3143	6.60000
08/23/83	400.320	7.50000	11.0286	6.40000
08/24/83	509.240	8.60000	10.4143	6.30000
08/25/83	636.342	10.9000	9.78571	6.40000
08/26/83	450.360	9.00000	9.60000	6.30000
08/27/83	325.760	9.30000	9.41429	6.20000
08/28/83	298.322	7.30000	8.75714	6.10000
08/29/83	340.355	5.30000	8.27143	6.30000
08/30/83	558.446	9.30000	8.52857	6.10000
08/31/83	689.551	10.6000	8.81429	6.40000

SUMMARY	LB/D:BOD	EFF:BOD	AVG:BOD	EFF:PH
MAXIMUM	1004.55	17.7000	12.5571	6.70000
AVERAGE	544.839	10.3677	10.5147	6.35161
MINIMUM	135.775	4.40000	8.27143	6.10000

FIGURE 32

PERMIT REPORT

```
***TERMS**                             PLOTTING MENU
------------------------------------------------------------
         Q ---QUIT
MAX:FLOW=D ---MAXIMUM FLOW
MIN:FLOW=D ---MINIMUM FLOW
TOT:FLOW=D ---TOTAL FLOW
 RAIN:IN=D ---RAINFALL
  HIGH:T=D ---HIGH TEMP.
   LOW:T=D ---LOW TEMP.
 INF:BOD=D ---INFLUENT BOD5
 PRI:BOD=D ---PRIMARY BOD5
 INT:BOD=D ---INTERMEDIATE BOD5
 EFF:BOD=D ---EFFLUENT BOD5
  PR:BOD=D ---PERCENT REDUCTION BOD5
 AVG:BOD=D ---7 DAY AVERAGE EFFLUENT BOD5
  INF:SS=D ---INFLUENT SS
  PRI:SS=D ---PRIMARY SS
  INT:SS=D ---INTERMEDIATE SS
  EFF:SS=D ---EFFLUENT SS
   PR:SS=D ---PERCENT REDUCTION SS
More output follows - press [ESC] to quit, any key to continue
EXAMPLE:  EFF:BOD=D
TYPE THE TERM YOU WANT AS THE Y-AXIS (Q TO QUIT) tot:flow=dEXAMPLE:  INF:BOD
TYPE IT AGAIN WITHOUT THE =D tot:flow
```

FIGURE 33

PLOTTING MENU FOR Y-AXIS

```
***TERMS**                              PLOTTING MENU
       Q  ---QUIT
    DATE  ---DATE
MAX:FLOW  ---MAXIMUM FLOW
MIN:FLOW  ---MINIMUM FLOW
TOT:FLOW  ---TOTAL FLOW
 RAIN:IN  ---RAINFALL
  HIGH:T  ---HIGH TEMP.
   LOW:T  ---LOW TEMP.
 INF:BOD  ---INFLUENT BOD5
 PRI:BOD  ---PRIMARY BOD5
 INT:BOD  ---INTERMEDIATE BOD5
 EFF:BOD  ---EFFLUENT BOD5
  PR:BOD  ---PERCENT REDUCTION BOD5
 AVG:BOD  ---7 DAY AVERAGE EFFLUENT BOD5
  INF:SS  ---INFLUENT SS
  PRI:SS  ---PRIMARY SS
  INT:SS  ---INTERMEDIATE SS
  EFF:SS  ---EFFLUENT SS
   PR:SS  ---PERCENT REDUCTION SS
More output follows - press [ESC] to quit, any key to continue
EXAMPLE:   INF:BOD

TYPE THE TERM YOU WANT AS THE X-AXIS (Q TO QUIT) date
```

FIGURE 34

PLOTTING MENU FOR X-AXIS

Y-AXIS	X-AXIS	Y-AXIS	X-AXIS
******************	******************	******************	******************
TOTAL FLOW, MGD	AUGUST 1983	TOTAL FLOW, MGD	AUGUST 1983
******************	******************	******************	******************
1-- 7.8	08-31-1983	16-- 6.7	08-04-1983
2-- 7.7	08-29-1983	17-- 6.7	08-15-1983
3-- 7.3	08-09-1983	18-- 6.4	08-22-1983
4-- 7.3	08-16-1983	19-- 6.4	08-23-1983
5-- 7.2	08-11-1983	20-- 6.1	08-12-1983
6-- 7.2	08-30-1983	21-- 6	08-26-1983
7-- 7.1	08-24-1983	22-- 5.9	08-19-1983
8-- 7	08-08-1983	23-- 5.8	08-05-1983
9-- 7	08-17-1983	24-- 5.7	08-07-1983
10-- 7	08-18-1983	25-- 4.9	08-28-1983
11-- 7	08-25-1983	26-- 4.5	08-13-1983
12-- 6.9	08-01-1983	27-- 4.2	08-27-1983
13-- 6.9	08-03-1983	28-- 4	08-06-1983
14-- 6.9	08-10-1983	29-- 4	08-20-1983
15-- 6.7	08-02-1983	30-- 3.7	08-14-1983
		31-- 3.6	08-21-1983

DELETE A VALUE? (Y/N) N

FIGURE 35
DATA FOR PLOTTING

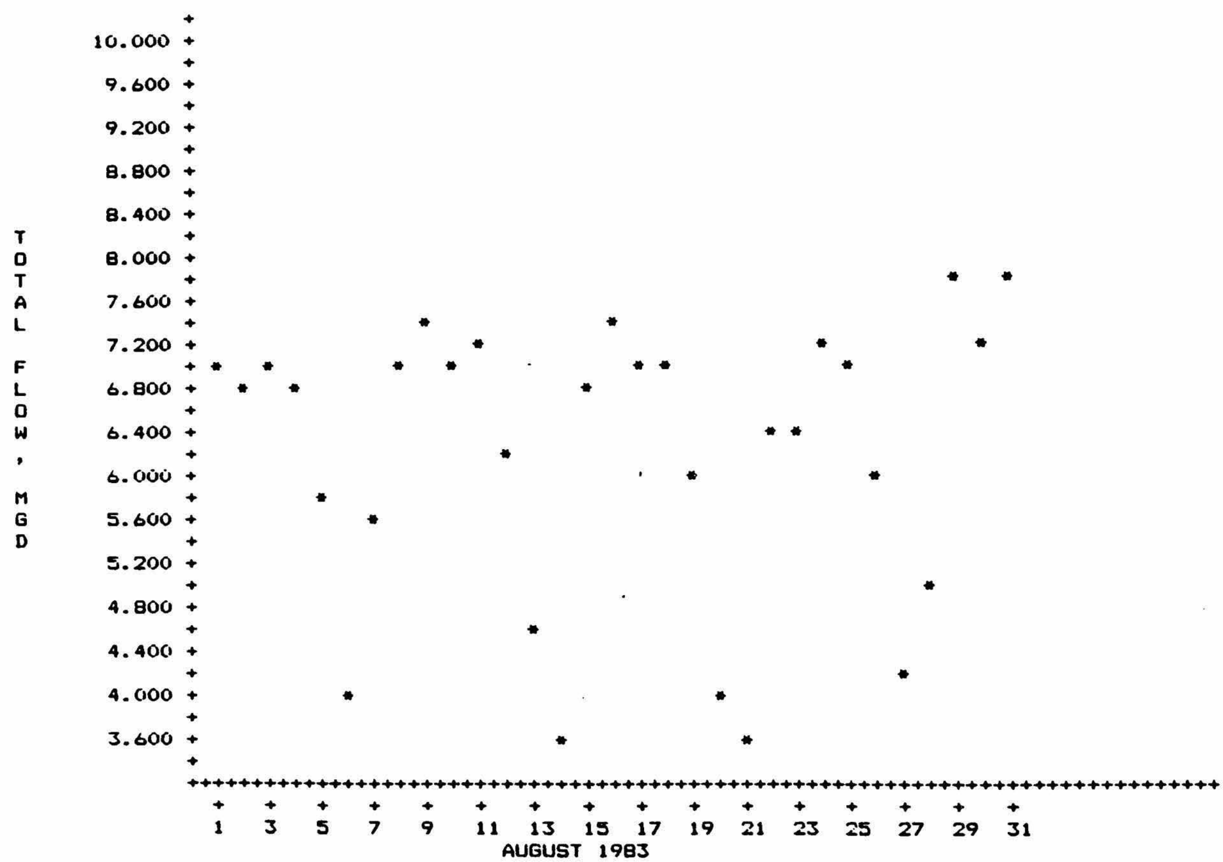

FIGURE 36

FLOW VS. TIME

Figure 38, the list of data items for Figure 37. The new data items to be plotted are shown in Figure 39. The new graph is shown in Figure 40. The deletion of the stray data point in Figure 40 enable the scaling feature of the plotting program to expand the Y-scale and changed the shape of the graph. Deletion of bad or questionable data may allow the operator to make a better interpretation of data.

Database Structure and Application Programs:

The preceding section described the capabilities of the DBMS tailored for the Springdale plant, demonstrated use of the DBMS with actual data, and compared results from the two systems. This section will consider the following items: Database Structure; Development of Application Programs to Perform Various Operations; Problems Encountered in the DBMS Design; Solutions to Problems in the DBMS Design, and Differences in Results of the Two Systems.

Database Structure: According tc Codd (5), a domain in a relation containing values that uniquely identify each element in the relation is called a primary key for that domain. The structure of the monthly operating reports for the Springdale plant shows that each row in a report is uniquely identified by a particular date. No rows exist where there is no value for date. Therefore, date may be identified as a primary key for all relations in a database for the Springdale plant.

Following rules of normalization, the database would be set up

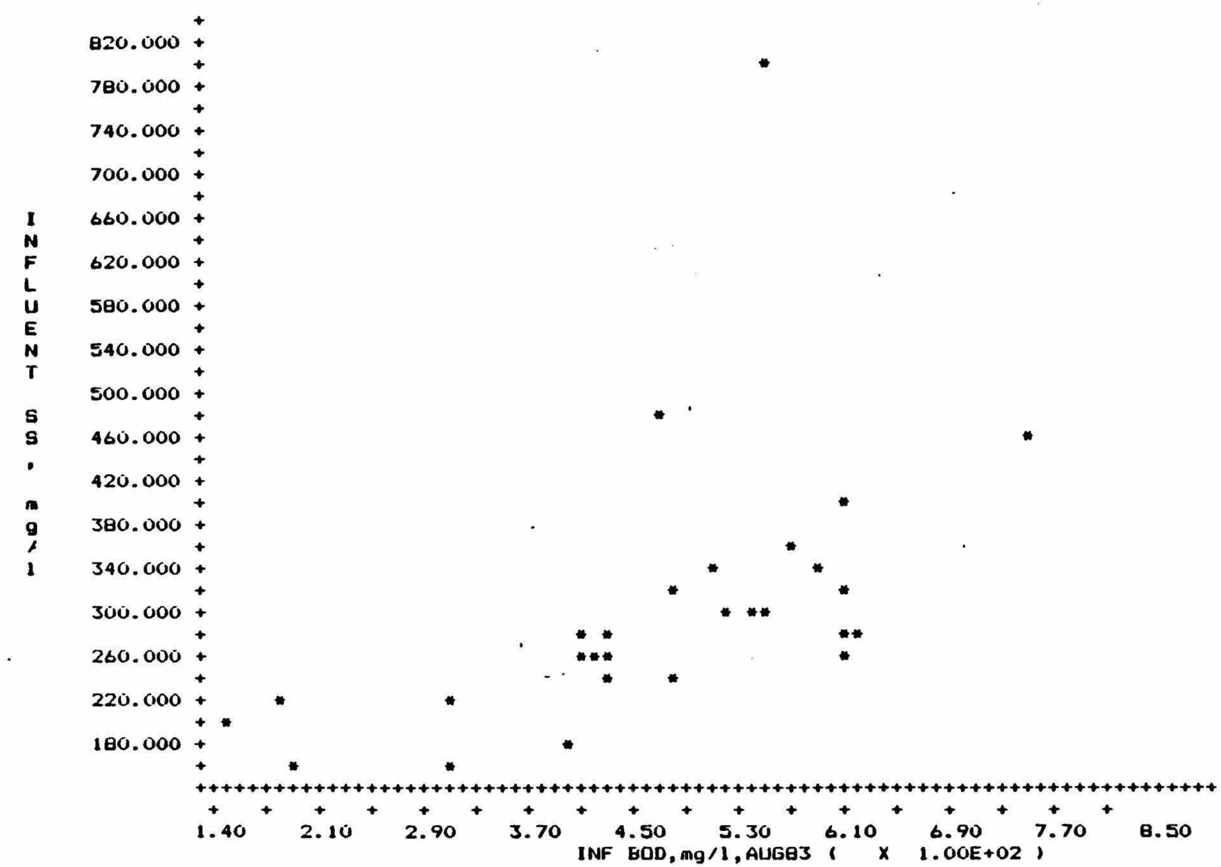

FIGURE 37

INFLUENT SUSPENDED SOLIDS VS. INFLUENT BOD5

Y-AXIS	X-AXIS	Y-AXIS	X-AXIS
******************	******************	******************	******************
INFLUENT SS, mg/l	INF BOD,mg/l,AUG83	INFLUENT SS, mg/l	INF BOD,mg/l,AUG83
******************	******************	******************	******************
1-- 790	563	16-- 275	443
2-- 480	480	17-- 270	420
3-- 460	758	18-- 265	435
4-- 395	615	19-- 260	615
5-- 360	578	20-- 255	428
6-- 340	600	21-- 250	420
7-- 330	518	22-- 245	435
8-- 315	488	23-- 240	488
9-- 315	623	24-- 225	186
10-- 305	548	25-- 220	189
11-- 300	533	26-- 220	315
12-- 300	533	27-- 195	147
13-- 290	555	28-- 185	413
14-- 285	630	29-- 165	204
15-- 280	623	30-- 160	315

DELETE A VALUE? (Y/N) Y
ROW TO DELETE? 1[[

FIGURE 38

DATA FOR PLOTTING

Y-AXIS	X-AXIS	Y-AXIS	X-AXIS
******************	******************	******************	******************
INFLUENT SS, mg/l	INF BOD,mg/l,AUG83	INFLUENT SS, mg/l	INF BOD,mg/l,AUG83
******************	******************	******************	******************
1-- 480	480	16-- 270	420
2-- 460	758	17-- 265	435
3-- 395	615	18-- 260	615
4-- 360	578	19-- 255	428
5-- 340	600	20-- 250	420
6-- 330	518	21-- 245	435
7-- 315	488	22-- 240	488
8-- 315	623	23-- 225	186
9-- 305	548	24-- 220	189
10-- 300	533	25-- 220	315
11-- 300	533	26-- 195	147
12-- 290	555	27-- 185	413
13-- 285	630	28-- 165	204
14-- 280	623	29-- 160	315
15-- 275	443		

DELETE A VALUE? (Y/N) N

FIGURE 39

DATA FOR PLOTTING

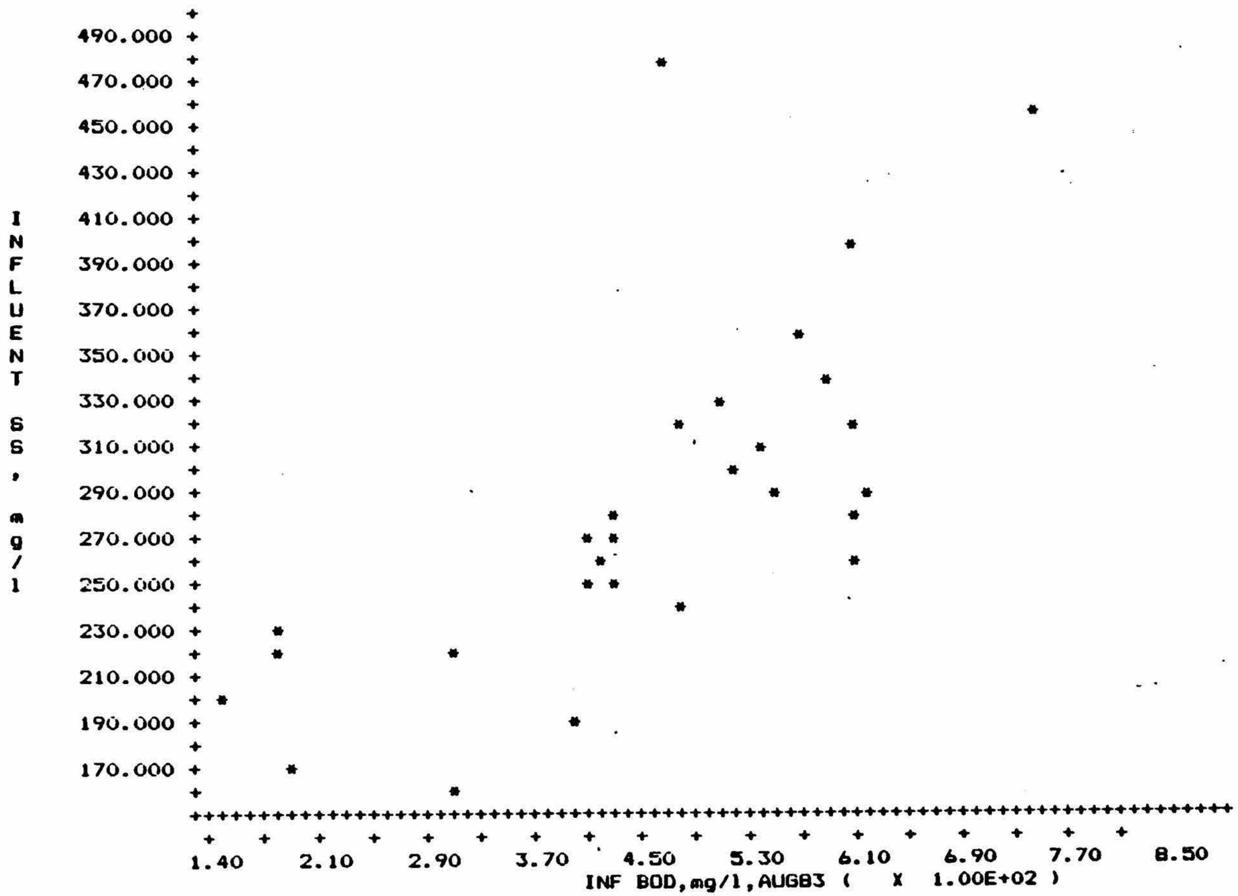

FIGURE 40

INFLUENT SUSPENDED SOLIDS VS. INFLUENT BOD5 as a number of relations each having the attribute date as a primary key. Three relations that would be set up may be taken from Figure 9:

FLOW (DATE, maximum, minimum, total)

WEATHER (DATE, rain, high, low)

BOD1 (DATE, influent, primary, intermediate, effluent)

These relations satisfy first, second, third, fourth, and fifth normal form. The attributes percent reduction BOD5 and seven day Avg BOD5 would not be included in any relation since both attributes may be calculated from other attributes and would, if included in any relation, violate fifth normal form. (12)

The preceding example illustrates the application of normalization rules in relational database theory. In practice, such a normalized system does not always result in the best performance. Relational operations performed with commercial DBMS used in this research showed that a fully normalized relation resulted in a significantly slower system and greater data storage requirements. It has been suggested (12) that complete normalization is not always practical when performance requirements are considered. For performance considerations, the entire database of the Springdale plant was placed in one very large relation.

A primary advantage of the relational system is the ease in which it may be visualized. The structure of the DBMS for the Springdale plant may be visualized as a large table identical in structure to the monthly operating reports. An effort was made to make the operation of the DBMS as similar as possible to the present data management system so that an operator could feel comfortable using the system in a short time. Input forms and reports were designed from the forms and reports already in use at the plant.

Application Programs: In addition to programs that guide the operator through the system with menus and prompts, programs were needed to control the relational DBMS in performing the relational commands. In the working model the commercial DBMS and the application programs used almost all the space on a double-sided, double-density floppy disk (320,512 bytes). The space requirements were high because the applications had to be stored as ASCII (American National Standard Code for Information Interchange) files. ASCII files seem to take up at least one byte per character.

Calculations such as percent reduction and loading may be performed quickly using the relational commands. The relational commands for calculating percent reduction in BOD5 are shown below:

```
ASSIGN PR:BOD TO INF:BOD - EFF:BOD IN OPERATE WHERE +
     DATE GE .SDATE AND DATE LE .EDATE
ASSIGN PR:BOD TO PR:BOD / INF:BOD IN OPERATE WHERE +
     DATE GE .SDATE AND DATE LE .EDATE
ASSIGN PR:BOD TO PR:BOD X 100 IN OPERATE WHERE +
     DATE GE .SDATE AND DATE LE .EDATE
```

OPERATE is the name of the relation containing the attributes PR:BOD, EFF:BOD, and INF:BOD. .SDATE and .EDATE are variables that specify a starting date and an ending date respectively.

Calculations such as seven day running averages and log-mean averages are more difficult to perform. The log-mean or geometric mean was a special problem for the system since the commercial DBMS used in this project lacked the ability to take logarithms or perform exponentiation.

Figure 41 and 42 show an application program written to calculate seven day running log-mean averages of fecal coliforms. The variable FEC1 is set equal to a newly entered value of EFF:FC (effluent fecal coliforms). The logarithm of FEC1 is taken the old-fashioned way. The program looks up the value in a table. After all, a relational database is really a table where row-ordering is not significant. First, characteristic of FEC1 is determined as stored as variable CHAR. Then the value of FEC1 is reduced by dividing FEC1 by 10 to the CHAR power. Dividing FEC1 by a large number truncates all but two significant figures in FEC1. FEC1 is then "looked up" from a relation named LOGS which contains the attributes ALOG, a number between 1.0 and 9.9 in increments of 0.1, and LOG. A row in LOGS contains a number under LOGS which is the base 10 logarithm of the number in the same row under ALOG. The column ALOG is searched for a value close to FEC1 and the value of LOG on the same row is assigned to FEC1. CHAR is added to FEC1

```
*(UPDATE.FEC)
SET RULES OFF
SET VARIABLE FEC1 TO EFF:FC IN OPERATE WHERE DATE EQ .EDATE
  IF FEC1 LT 10 THEN
     SET VAR CHAR TO 0
  ENDIF
   IF FEC1 GE 10 AND FEC1 LT 100 THEN
      SET VARIABLE CHAR TO 1
      SET VARIABLE FEC1 TO .FEC1 / 10
   ENDIF
   IF FEC1 GE 100 AND FEC1 LT 1000 THEN
      SET VARIABLE CHAR TO 2
      SET VARIABLE FEC1 TO .FEC1 / 1000000
      SET VARIABLE FEC1 TO .FEC1 X 10000
   ENDIF
   IF FEC1 GE 1000 THEN
      SET VARIABLE CHAR TO 3
      SET VARIABLE FEC1 TO .FEC1 / 1000000
      SET VARIABLE FEC1 TO .FEC1 / 10
      SET VARIABLE FEC1 TO .FEC1 X 10000
   ENDIF
SET VARIABLE FEC1 TO LOG IN LOGS WHERE ALOG GE .FEC1
SET VARIABLE FEC1 TO .FEC1 + .CHAR
CHANGE DUMB:1 TO .FEC1 IN OPERATE WHERE DATE EQ .EDATE
   SET VARIABLE SDATE TO .EDATE - 6
   SET VARIABLE COUNT TO 1
   SET VARIABLE DAYS TO .EDATE + 6
   SET VARIABLE DAYS TO .DAYS - .SDATE
      WHILE COUNT LE 7 THEN
         SET VARIABLE VDATE TO .SDATE + 6
         COMPUTE AVG AS AVE DUMB:1 IN OPERATE WHERE DATE GE .SDATE +
```

FIGURE 41

7-DAY RUNNING LOG-MEAN AVERAGES

```
          AND DATE LE .VDATE AND DUMB:1 EXISTS
            IF AVG LT 1 THEN
               SET VARIABLE ACHAR TO 1
            ENDIF
            IF AVG GE 1 AND AVG LT 2 THEN
               SET VARIABLE ACHAR TO 10
               SET VARIABLE AVG TO .AVG - 1
            ENDIF
            IF AVG GE 2 AND AVG LT 3 THEN
               SET VARIABLE ACHAR TO 100
               SET VARIABLE AVG TO .AVG - 2
            ENDIF
            IF AVG GE 3 THEN
               SET VARIABLE ACHAR TO 1000
               SET VARIABLE AVG TO .AVG - 3
            ENDIF
SET VARIABLE FEC1 TO ALOG IN LOGS WHERE LOG GE .AVG
SET VARIABLE FEC1 TO .FEC1 X .ACHAR
         CHANGE AVG:FC TO .FEC1 IN OPERATE WHERE DATE EQ .VDATE
         SET VARIABLE SDATE TO .SDATE + 1
         SET VARIABLE COUNT TO .COUNT + 1
      ENDWHILE
```

FIGURE 42

7-DAY RUNNING LOG-MEAN AVERAGES

and the logarithm of the original value of FEC1 is obtained. By using the characteristic of FEC1, the relation LOGS is able to function as a log table using only ninety rows. The resulting accuracy is considered sufficient for coliform data.

Figures 41 and 42 also demonstrate the calculations for seven day running averages. Using variables to represent the values of dates, a loop is set up between the WHILE and ENDWHILE statements to calculate a new value of AVG:FC (seven day running average of effluent fecal coliform) and store the new value in the database. The relation LOG is used in reverse to take an antilog.

Processing time was a major consideration in developing methods to update the database and performing calculations. Seven day running average calculations use more time for processing than any other operation in the DBMS. Note that if a new value of EFF:FC is added to the database, and the value added occurs on a date later than the date for any other fecal coliform, then only one seven day running average need be performed to update the database. This value would be the average of the last date added and the six preceding days and would be inserted on the same row as the last date added. However, editing a previously existing value of EFF:FC requires updating up to seven rows where dates are later than the date edited. The updating process can take considerable time. Calculation and update of a single seven day running average can take up to one minute for simple arithmetic averages and even longer for log-mean average update.

Performance requirements make it necessary to store redundant values such as seven day running averages. Time required to generate a monthly report calculating seven day running averages would be absurdly long, at least several hours.

The approach in this project has been to calculate all seven day running averages as the data is input. This results in a delay of about one minute when data is input sequentially by date and longer if an existing value requiring seven day averages is input. Updates of the database which are able to use the relational commands are much faster and take only a few seconds to update even two months' of data. Updates which can be done quickly are only performed at the time the information is requested. Updating the database as discussed seems to be the most reasonable approach in terms of performance.

Report generation was a problem due to the limited capability of the report writing feature included in the commercial DBMS. The report writing feature allowed reports to be generated using attributes from a single relation. Only ten variables are permitted for calculations within a report. Calculations of maximums and minimums using the report writing feature was virtually impossible.

An alternate method of producing reports with the desired calculations was developed using the SELECT command to select a subset containing the desired report items from the main relations OPERATE.

A second relation named SUMMARY was projected from the main relation. SUMMARY contained all the attributes from OPERATE that would be shown in the monthly operating reports. In place of the attribute DATE, SUMMARY contained the key attribute SUMMARY. The relation SUMMARY contained three rows. Under the attribute SUMMARY were three elements; maximum, minimum, and average, corresponding to the three rows. When a report was requested, maximum, minimum, and average values were obtained for the reported attributes in OPERATE and stored in SUMMARY under the identical attribute name and on the appropriate row. A report is then obtained by using two SELECT commands with the following syntax:

```
SELECT DATE att1 att2 att3 .... from OPERATE where DATE +
   GE starting date AND DATE LE ending date
SELECT SUMMARY att1 att2 att3 .... from SUMMARY where +
   DATE GE starting date AND DATE LE ending date
```

The DBMS could also be accessed directly using the relational commands. The ability to handle direct queries in a plain English language is a strong feature of the commercial DBMS used in this research, since it would be impossible to anticipate all future applications of the database when writing the application programs.

The BASIC plotting program was written to demonstrate the interface capabilities of the system. Data for plotting is written to a ASCII file named A:PLOT.DAT by the UNLOAD command.

The UNLOAD command allows optional sorting of data written to the file. The plotting program reads the file A:PLOT.DAT as a sequential data file and will work for any sequential data file that has the structure described in the documentation of the BASIC plotting program in the program listing found in the appendix.

PRINCIPLE FINDINGS AND SIGNIFICANCE

Data management has been shown to be important part of wastewater treatment plant operation. Treatment plants must record, process, and report data. Data management in treatment plants involves a significant amount of time and effort.

Computerized DBMS have demonstrated the capability of handling the data management needs of treatment plants. The recent development of microcomputers has made possible a low-cost system for computerized data management. DBMS using microcomputers have been demonstrated in treatment plants for data storage, report generation, and process control.

The relational database model has been shown to have a number of advantages over other DBMS. Relational databases have a simple structure which is easy to understand and use. Relational processing is a powerful tool for manipulation of data.

A general relational DBMS that may be tailored for use at a specific wastewater treatment plant was developed for use on a microcomputer. The general DBMS consists of a menu-driven format for entry, editing, processing and report of data. Error checking is provided on data entry. Operators require no special computer training to use the system.

The system was tailored for use at the Springdale, Arkansas wastewater treatment plant. The data management requirements of the Springdale plant are typical of the wastewater treatment plants that could benefit from a DBMS operating on a microcomputer. The present data management system at the Springdale plant consists of data logging sheets with calculations performed by hand and requiring a great deal of time. As with any manual data management system there is the possibility of errors in calculations, and errors in transposing data between the many forms.

The customized system was demonstrated with actual data from the Springdale plant. Reports corresponding to the regular monthly operating reports were generated with the DBMS. Permit calculations were performed by the DBMS. The interface of independent programs with the DBMS was demonstrated by a plotting program written in BASIC.

One of the disadvantages of the computer DBMS developed was the slowness in processing. This slowness was particularly evident during processing of nonrelational commands and modification of the database. The speed of the system seemed to be limited by the ability of the DBMS in reading command files and changing data files on the floppy disks. One possible alternative to improve performance would be to add a hard disk for additional storage and memory.

A hard disk would increase the total cost of the system hardware by roughly $1,500. Although the system may be called slow in terms of computer speed, it should be noted that the actual savings in time for the operator represents an improvement over the manual method of data management by a factor of some ten to twenty times.

Another strong point of the system is data independence. Data is stored independent of the various links, pointers, and indexes that describe the physical structure of the database. Data independence makes it possible to change the physical structure of the database by adding new rows and attributes without affecting the user's view of the data. In a normalized database, data independence allows the database to grow without forcing the application programs to be rewritten.

The DBMS was compared to the present system in use at the Springdale plant. Comparison of reports from the two systems proved the DBMS could handle the data management requirements of the Springdale plant while providing accuracy and less chance of error.

CONCLUSIONS

The following conclusions were drawn from this research:

1) A database management system operating on a microcomputer can be developed to meet the data management needs of a wastewater treatment plant.

2) The relational model database is well suited for use in

data management applications at wastewater treatment plants.

3) The speed and accuracy of a microcomputer-based data management system is superior to the typical manual data handling systems currently in use by most wastewater treatment plants.

LITERATURE CITED

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