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# LAND USE-WATER QUALITY RELATIONSHIP
# DOCUMENTATION REPORT OF MODELS

Environmental Protection Agency

Washington, D.C. 20460

November 1976

# EPA REVIEW NOTICE

Land Use/Water Quality Relationship:

Documentation Report of Models

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: DEC 3 1976

SUBJECT: Land Use-Water Quality Relationship: Documentation Report of Models

FROM: Walter S. Groszyk
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TO: All Regional Water Division Directors

ATTN: Regional 208 Coordinators

Technical Guidance Memorandum: TECH-25

## Purpose

This memorandum transmits the recently completed report, "Land Use-Water Quality Relationship: Documentation Report of Models."

## Background

In March 1976, the Water Planning Division published the report entitled "Land Use-Water Quality Relationship." A substantial part of that report dealt with the use of various computer models. The report, however, did not include the documentation of the models which were used.

This documentation report was prepared to aid water quality management and other agencies which might want to use the models which were utilized in the "Land Use-Water Quality Relationship" report. Since this documentation report will only be useful to those agencies utilizing the models included in the original report, it is not being sent directly to State and areawide water quality management agencies. Copies of the documentation report are available from the Water Planning Division library.

If you would like further information on the report, please contact Bill Lienesch of the Program Development Branch (426-2522).

Enclosure

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# Chapter 1

## Programming Changes to Link STORM and SWMM

### Introduction

This chapter describes in detail the programming changes necessary to link the rainfall-runoff model STORM* with the receiving water body module (RECEIV) of EPA's Storm Water Management Model** (See Figure 1-1).*** Additional changes were made in the models to simplify the preparation of input data and to expand several output formats. The user may refer to Meta Systems' revision of pages 26-26A and 82-104 of the STORM User's Manual for a description of the changes required in input data (see Revision of User's Manual pp. 1-9 ff.).

### Modifications of and Additions to STORM

#### Creation of Hydrograph and Pollutograph Files to Pass Results from STORM to SWMM

Each of these files is fixed-length with output formats coded in the program. The user may specify his own logical and physical record lengths for these files as long as the logical record length is a minimum of 30 bytes for each file. JCL must, of course, be specified for the creation of each file. Typical IBM JCL for a hydrograph file might be:

```
//FT18F001 DD DSN=HGPH.1974,UNIT=3330,DISP=(NEW,CATLG),

//DCB=(...),SPACE=(...)
```

The record formats are shown in Table 1-1.

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* Computer Program 723-S8-L2520, Urban Storm Water Runoff, The Hydrologic Engineering Center, Corps of Engineers, U.S. Department of the Army, Davis, California, October 1974.

** Storm Water Management Model, User's Manual Version II, EPA-670/2-79-017, Cincinnati, Ohio, March 1975.

*** Details of the linkage are described in "Land Use-Water Quality Relationship," Water Quality Management Guidance Document, WPD 3-76-02, March 1976.

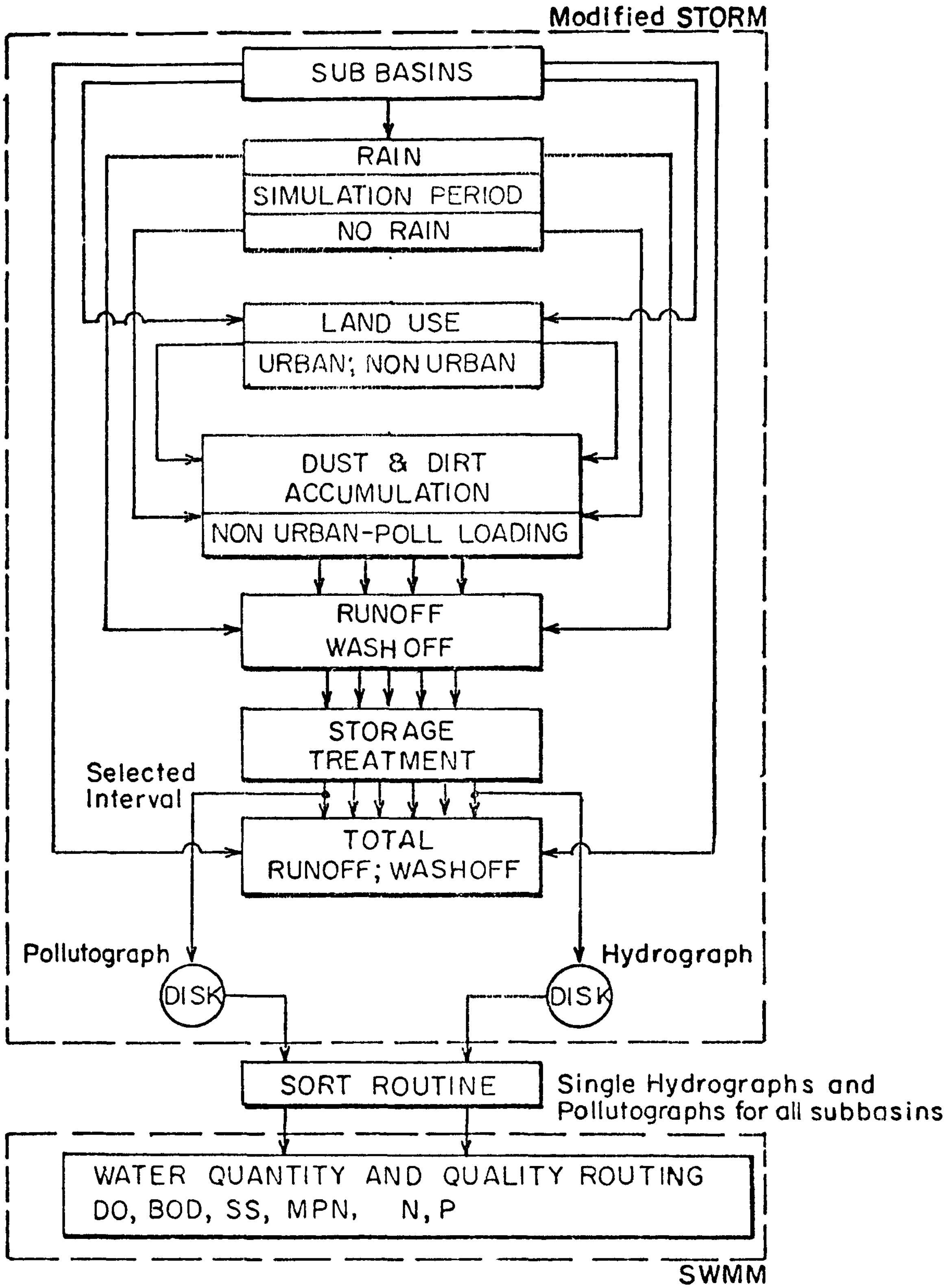


Figure 1-1 Analysis Framework for Storm Water Runoff

Table 1-1

Record Formats for Files Created by STORM

(a) Hydrograph file

| Position | Field Name | Field Length | Data Type | Description | Hierarchy* in SORT |
|---|---|---|---|---|---|
| 1 | NHOUR | 4 | integer | hour # within given interval | |
| 5 | NWS | 4 | integer | watershed # within program loop | |
| 9 | ITEEM | 4 | integer | time of day in hours | 2 |
| 13 | JSW | 4 | integer | watershed # (used externally) | 3 |
| 17 | INTNUM | 4 | integer | interval # | 1 |
| 21 | CFSOFF | 10 | real | flow in cfs | |

(b) Pollutograph file

| Position | Field Name | Field Length | Data Type | Description | Hierarchy* in SORT |
|---|---|---|---|---|---|
| 1 | JTEEM | 8 | integer | time of day in seconds | 2 |
| 9 | I | 4 | integer | pollutant # | 3 |
| 13 | JSW | 4 | integer | watershed # (external) | 4 |
| 17 | INTNUM | 4 | integer | interval # | 1 |
| 21 | PSPLRT(I) | 10 | real or scien-tific | pollution rate lbs/day or MPN/minute | |

* 1 = high-order.

One hydrograph record will be generated for each hour of each time interval modeled per watershed. The number of pollutograph records generated will be the product of the number of hydrograph records and the number of pollutants modeled (maximum of six). In our study we allowed for 125 and 750 records, respectively.

These files are sorted subsequent to execution of STORM in order to be processed by SWMM. The sort itself is described in Interfacing STORM and SWMM (see pp. 1-7 ff.).

### Use of Time Interval Instead of Rain Event for File Generation

STORM defines an "event" to occur when precipitation causes runoff, and performs no computations when runoff does not occur. The occurrence of runoff, however, is a function of several factors and is not easily predictable by the analyst. It is therefore impossible to assign by inspection an event number in advance of a run to a given time period. For this reason STORM was recoded to generate hydrograph and pollutograph information for "intervals" specified by starting and ending times -- hour, day, month, and year. Up to 20 such intervals may be so specified. SWMM will analyze one such interval per run.

### Calculation of Erosion on an Hourly Basis

The replacement of the "event" concept by that of the "interval" necessitated a complete recoding of the computation of storm erosion. In addition, SWMM was structured to accept input only in terms of a <u>rate</u>: pounds per day at each and every input time. It was therefore necessary to calculate the amount of soil eroded at each hour during a requested time interval and convert to the specified rate:

$$E = \sum_{i=1}^{MLU} T_i * SDR_i * (1-TEFF) * 48000 \qquad (1-1)$$

where E = erosion in pounds per day,
T = erosion in tons,
i = land use type,
MLU = number of different land use types,
SDR = sediment delivery ratio, and
TEFF = efficiency of sediment traps.

### Addition of Eroded Material to Suspended Solids

This was done straightforwardly on an hourly basis. The suspended solids, as all other pollutants, were expressed in pounds per hour and multiplied by 24 (except for coliforms, which were expressed in MPN per hours -- see below). This paralleled the handling of eroded soil in SWMM's runoff and washoff module.

## Introduction of Coliforms as a Sixth Pollutant

This was done to take advantage of SWMM's ability to handle coliforms. Note the change in the format of the input F-2 card on page 88 of the User's Manual. Default values for coliforms are those from the SWMM User's Manual, page 48:

| Land Use Type | MPN/gram DD |
|---|---|
| single | $1.3 \times 10^6$ |
| multiple | $2.7 \times 10^6$ |
| commercial | $1.7 \times 10^6$ |
| industrial | $1.0 \times 10^6$ |
| open | 0 |

These values are multiplied by $4.5 \times 10^4$ to convert to MPN/100 pounds DD. Then the procedures already in STORM were applied to coliforms. In developing equation (16f) to parallel equations (16a-c) found on pages 12-13 of the STORM User's Manual, however, it was noted that the coefficients of $MU_{sus}$ and $MU_{set}$ as programmed in SWMM's model RUNOFF were 0 (see statements QSHD194 and RNBD35-36) which reduced equation (16f) to

$$MU_{colif}(t) = P_{colif}(t)*EXPT \qquad (1\text{-}2)$$

## Accumulation of Erosion over the Rain Interval

Although erosion was now calculated on an hourly basis, the land surface erosion report already in existence was not abandoned. The calculated erosion was therefore summed in accumulators for each defined time interval and a report output identical to the original except for the use of an interval number rather than an event number.

## Change in Output Format for Pollutants

The quality analysis report illustrated on page 77 of the STORM User's Manual was broken up into two reports (which necessitated the allocation of another direct access device and, in general, different device allocation numbers for the generated reports (see pages 26-26A of the Revised User's Manual). The first report includes columns one through ten and two new columns described in the section following. The second report includes columns 11 through 23. The large magnitudes used in calculations involving coliforms necessitated considerable reprogramming for scaling (since STORM used integer variables for this particular report).

The pollutographs also had to be reformatted, although the changes made were not nearly as extensive as those above. Interval numbers were substituted for event numbers, and two lines were required to print one hour's worth of information. In other respects the formats were quite similar when not identical.

## Refinements of STORM

### Continuous Calculations of Dust and Dirt

The amount of accumulated dust and dirt at the start of each "event" and the amount left after washoff is printed for each "event" as part of the first of the two quality reports (see above). These amounts are calculated by taking the calculated suspended solids before and after each event, dividing by the ratio of SS/DD, and summing over land use; that is:

$$DD = \sum_{i}^{MSLG} (P_{sus,i}/F_{p,i}*100) \qquad (1-3)$$

where $P_{sus}$ and $F_p$ have been calculated as before (see pages 11-12 of the User's Manual).

### Input of Land Use Data Using Acres Instead of Percentages

It was found that the computation of percentages of area was quite tedious when multiple runs were made reflecing slightly different land use patterns. All land use areas are now input in terms of acres and the relevant percentages are calculated by the program. (See the revised input specifications).

### Adjustment of BOD Due to Falling Leaves During Autumn

At the user's option, the computed available BOD during the months of September, October and November will be multiplied by 1.1, 1.2, and 1.1, respectively.

## Corrections of Original Version of STORM

The following errors were noted during our testing procedures. Some were corrected; others were bypassed.

The Q-card was required by the program logic instead of being optional as stated in the manual. We found it easier to input a Q-card specifying sediment traps with an efficiency of 0 than to change the code: those who wish to correct the coding will find the task trivial.

Some default options stated in the manual did not in fact exist. These included those for the variables NWSHD, COEF, and RFU. The source code was not changed.

Precipitation records generated by a previous run will have been saved on FORTRAN logical unit 12 (as described on page 29 of the User's Manual) only if no snowmelt computations were made. If snowmelt computations were made, these records would be available on FORTRAN logic unit 11.

A coding error resulted in the reading of an incorrect number of D-2 cards when the year in references was an even non-leap year. (Example: 1974)

The argument of 80 used in the call to the subroutine CORE (which replaced the ENCODE-DECODE statements not compatible with IBM FORTRAN) was changed to 4. The original erroneous argument resulted in unpredictable results due to destruction of computer code.

## Interfacing STORM and SWMM

This part describes the routines required to sort the hydrograph and pollutograph files generated by STORM for input to RECEIV, the receiving water body module of SWMM. Since development and testing took place on an IBM 370, IBM's SORTD routines were used. Following are the required input cards:

1. //EXEC SORTD, REGION=72K[1+]
2. //S.SORTIN[2+] DD DSN=filename1[3+], DISP=SHR
3. //S.SORTOUT[2+] DD DSN=filename2[3+], DISP=(NEW,CATLG), DCB=(...), SPACE=(...)[4+]
4. //S.SYSIN DD *
5. SORT FIELDS=(17,4,A,9,4,A,13,4,A),FORMAT=FI,SIZE=E125[5+]
6. END
7. /*

---

\+ Numbers refer to explanatory comments.

8. same as 1.

9. same as 2 except DSN-filename3[3+]

10. same as 3 except DSN=filename4[3+]

11. same as 4.

12. SORT FIELDS=(17,4,A,1,8,A,9,4,A,13,4,A),FORMAT=FI,SIZE=E750[5+]

13. END

14. /*

Comments

1. Region size may be varied at the discretion of the user.
2. The procedure-name S (as in S.SORTIN) is installation-dependent. Check with the installation to ascertain the procedure-name of the sort-routine and substitute it for the S.
3. Filenamen (where n=1,2,3, or 4) is supplied by the user and may be any data set name that abides by IBM's conventions. The four files are hydrograph and pollutograph input and output. The first sort illustrated is that of the hydrograph file (cards 2-7); the second, the pollutograph file (cards 8-13): they may be executed in either order.
4. In Meta Systems' test runs, files containing approximately 60 hours' worth of data required about three tracks on a IBM 3330 for the hydrograph file and 17 for the pollutograph file.
5. Ennn is the estimated number of records in a file and may vary considerably. For hydrograph files, Ennn ≅ number of hours x number of watersheds; for pollutograph files, Ennn ≅ $Ennn_{hydrograph}$ x number of pollutants.

Changes may have to be made to these cards if the sort routine is to be run on a non-IBM system. The files and the sort hierarchy are described in Modifications and Additions to STORM above.

## Changes to RECEIV, the Receiving Water Body Module of SWMM

Meta Systems' revision of the receiving water body module allows it to accept hydrograph and pollutograph inputs generated by STORM (see above). This input may, at the user's option, be multiplied by arbitrary constants or delayed for an arbitrary number of hours, or both. The

---

+ Numbers refer to explanatory comments.

input files contain data for many different time intervals determined by the user when the files were created. Only one such time interval may be selected for analysis per run of SWMM.

The input hydrograph file is equated to FORTRAN logical unit 18 and the pollutograph file to unit 19. Changes in the directions for the preparation of input data are detailed below.

## Revisions of the User's Manuals

Following is a compilation of revisions to the User's Manuals for STORM and SWMM. Only those pages which incorporate changes to the instructions for data preparation have been included. The changes have been typed on blank pages at the position of the original statements in order to avoid any problem of identification. The number on the bottom of the page denotes the original page number of the respective User's Manual.

| FORTRAN Logical Unit | Option |
|---|---|
| IN (Input variable) (see C1 card, P. 84) | Input precipitation file if not read from cards |
| ITAPE (Input variable) (see D1 card, P. 84) | Input temperature file if not read from cards |
| 11 | Working storage -- snowmelt computation. May be used as permanent storage for input precipitation file iff ISNO = 1 (see B1 card, P. 82) |
| 12 | Working storage -- precipitation data. May be used as permanent storage for input precipitation file iff ISNO = Ø |

| | |
|---|---|
| 13 and 14 | Output files for Quality Report |
| 15 | Output file for Sediment Report |
| 16 | Output file for Pollutograph Report |
| 18 | Working storage -- hydrograph |
| 19 | Working storage -- pollutograph |

Files 18 and 19 are subsequently sorted and passed to SWMM (Storm Water Management Module) for later use.

It is only necessary to use a maximum of seven tape/disk units at one time. The rainfall/snowmelt computations need not be recomputed for each job. If no snowmelt computations were specified, the working-storage file on unit 12 may be saved and used for input on future jobs. If snowmelt computations were specified, the file on unit 11 may be saved. The input data would then specify such direct input on unit 11 or 12 and units IN, ITAPE, and 12 (or 11 -- they would then be mutually exclusive) would not be necessary. The Input Description, Exhibit 3, describes the variables necessary to accomplish these tape/disk options.

B1 Card (required)

| Field | Variable | Value | I/O Unit Required | Description |
|---|---|---|---|---|
| 0 | | B1 | | Card identification. |
| 1 | NWSHD | + | | Number of watersheds to be analyzed. Calls for NWSHD sequences of E through T cards as required. |
| 2 | ISNO | Ø | 12 | No snowmelt computations are desired. Omit D cards. |
| | | 1 | 11 | Snowmelt computations are to be made using D cards. |
| 3 | NONURB | 0 | | Nonurban watershed computations will not be made. Omit H, J, and K cards. |
| | | 1 | | Nonurban watershed computations will be performed using H, J, and K cards as required. |
| 4 | ISED | 0 | 15 | No land surface erosion computations will be made. Omit * through R cards. |
| | | 1 | | Land surface erosion computations will be made using * through R cards. |
| 5 | IQUAL | 0 | 13,14 | No water quality computations will be made. F2 cards are still required even though blank. |
| | | 1 | | Water quality computations will be made. |
| 6 | IEVNT | 0 | 16 | No detailed analysis (pollutograph) of selected events is desired. IPOLMX (T2-3) will be zero. |
| | | 1 | | Detailed event analysis will be required, IPOLMX (T2-3) may be greater than zero. |
| 7 | INTNUM | + | 18,19 | Number of intervals to be saved on hydro/pollutograph files (maximum = 2Ø). |

B3 Cards (required if INTNUM, B1-7, > Ø)

Intervals for which hydrographs and/or pollutographs will be stored on disk.

| Field | Variable | Value | Description |
|---|---|---|---|
| 3 | INTST | + | Date (yymmddhh) of start of interval. |
| 4 | INTEND | + | Date (yymmddhh) of end of interval. |

Supply n B3 cards where n = INTNUM (B1-7).

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| | |
|---|---|
| + | Unit number for precipitation data tape/ disk. No C2 cards are read. Format is same as on C2 card. |
| - | Previously generated unformatted binary tape/disk rainfall/snowmelt records will be used on FORTRAN logical unit 11 or 12. (See B1-2) Omit C2 and D cards. This is a time saving option in that the basic precipitation and temperature data need only be processed once. Upon generation of a satisfactory rainfall/snowmelt file, the tape/disk on logical unit 11 or 12 should be saved for future use under this option. |

| | | | |
|---|---|---|---|
| | | 1 | Max/Min temperatures are on D2 card. |
| 6 | COEF | + | Degree-day melt rate coefficient. |

| | | | |
|---|---|---|---|
| 3 | MXLG | + | Number of land use groups modeled (Maximum = default = 5). MXLG pairs of F1, F2 cards will be read for land uses as defined on F1 card. |
| 4 | EXPTE | + | Exponent for dust and dirt washoff, equation (15) in text: $M_P = P_c (1 - e^{-EXPTE*\Delta t})/\Delta t$ *Default = 4.6 |
| 5 | REFF | + | Street sweeping efficiency (ratio of material picked up to the total material on the street) as a decimal fraction (default = 0.70). |
| 6 | JSW | + | Watershed number. If > 1 watershed, their numbers must be in ascending sequence. |

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| | | | |
|---|---|---|---|
| 0 | | E2 | Card identification. |
| 1 | AREA | + | Total area, in acres, of the watershed. |
| 4 | RFU | + | Factor by which KRAIN, rainfall array, is multiplied to obtain average rainfall over urban area. |
| 5 | IQU | 0 | No hydrographs are to be input on G cards. |

| | | | |
|---|---|---|---|
| 2 | LAREA | + | Area, in acres, of this land group. Never enter a value of Ø if erosion is being modeled; rather, eliminate the pair of F1-F2 cards and reduce MXLG (E1-3) accordingly. |
| 5 | NCLEAN | + | Number of days between street sweeping in each land use group (see Note 1 for default value) |
| 6 | LEAFSW | 1 | Available BOD will be increased in September, October, and November by factors of 1.1, 1.2, and 1.1 respectively to account for falling leaves. |
| | | Ø | Available BOD will not be increased. |

| | | |
|---|---|---|
| 3-7 | FRACTN(L,2-6) + | Pounds of settleable solids, BOD, nitrogen, and orthophosphate, and MPN of coliforms respectively per 100 pounds of dust and dirt. See Note 1 for default values. |

| | | | |
|---|---|---|---|
| 0 | | H1 | Card identification |
| 2 | CN | + | Runoff coefficient for nonurban area; water excess will be multiplied by this factor in order to determine runoff. |

m. Q Card (required)

Sediment trap data

| Field | Variable | Value | Description |
|---|---|---|---|
| 0 | ICG | Q | Card identification. |
| 3 | TEFF | + | Trap efficiency desired for the sediment detention reservoirs. |

R. Card (cont.)

| Field | Variable | Value | Description |
|---|---|---|---|
| 3 | PALU | + | Area, in acres, of this land use category that has the soil and slope properties to be defined on this R card. PALU values are summed for all R cards specifying the same land use and if this summation is less than 100 percent R cards only sample land use in the basin and that sample will be expanded to include the entire basin by the program. |
| 4 | XLTH | + | The length of lot in the direction of the ground slope expressed in feet. This must be an average value for the percent of land use shown on this R card. (Default= 15Ø feet). |
| 5 | XS | + | The lot slope is entered in percent and for those lots sloping away from the street it should be a plus value. (Default= Ø). |
| 6 | GCOV | + | This is a cropping-management factor in % (see the universal soil loss equation). Its values are identified in that reference. As used here it is a ground cover factor to ratio erosion from land having vegetation or some other cover to the erosion plot values determined by the equation. (Default= 2). |

NOTE 1

Defaults* for quality data are as follows:

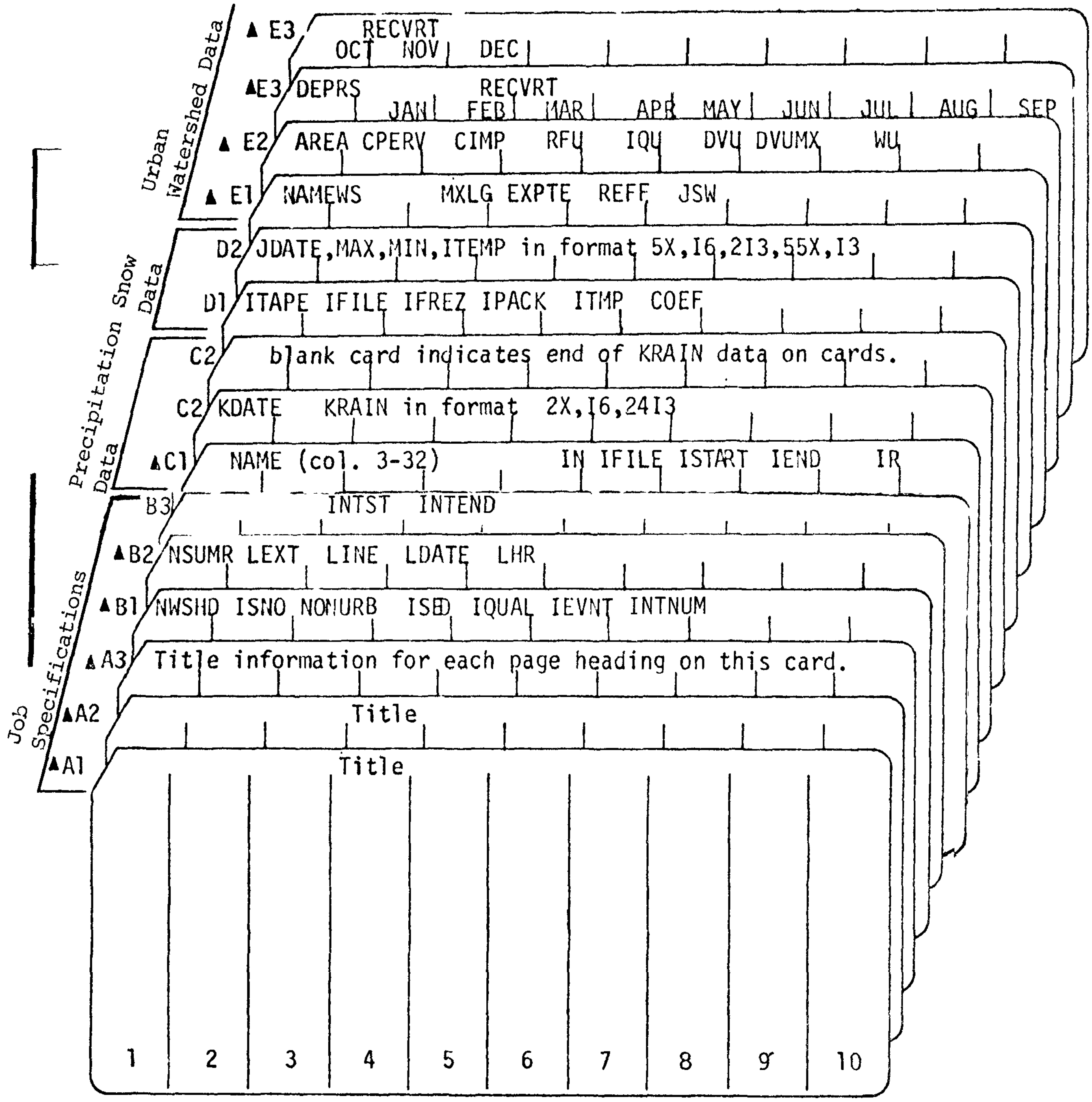
| Variable Name | NCLEAN (F1-5) | DD (F2-1)+ | FRACTN (F2-3, 7)* | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Sweeping | DD rate* | Lbs Pollutant/100 lbs DD | | | | | |
| Land Use | Interval, Days | lb/dy/100 ft | SUS | SET | BOD | NIT | $PO_4$ | Coliforms++ |
| Single Family Res. | 90.0 | .7 | 11.1 | 1.1 | .500 | .048 | .005 | $5.9 \times 10^{10}$ |
| Multiple Family Res. | 90.0 | 2.3 | 8.0 | .8 | .360 | .061 | .005 | $1.2 \times 10^{11}$ |
| Commercial | 90.0 | 3.3 | 17.0 | 1.7 | .770 | .041 | .007 | $7.7 \times 10^{10}$ |
| Industrial | 90.0 | 4.6 | 6.7 | .7 | .300 | .043 | .003 | $4.5 \times 10^{10}$ |
| Open or Park | 90.0 | 1.5 | 11.1 | 1.1 | .500 | .048 | .005 | 0 |

* Data obtained from American Public Works Association, "Water Pollution Aspects of Urban Runoff," Water Pollution Control Research Series, Federal Water Pollution Control Administation, Report No. WP-20-15, January 1969.

\+ DD = Dust and Dirt.

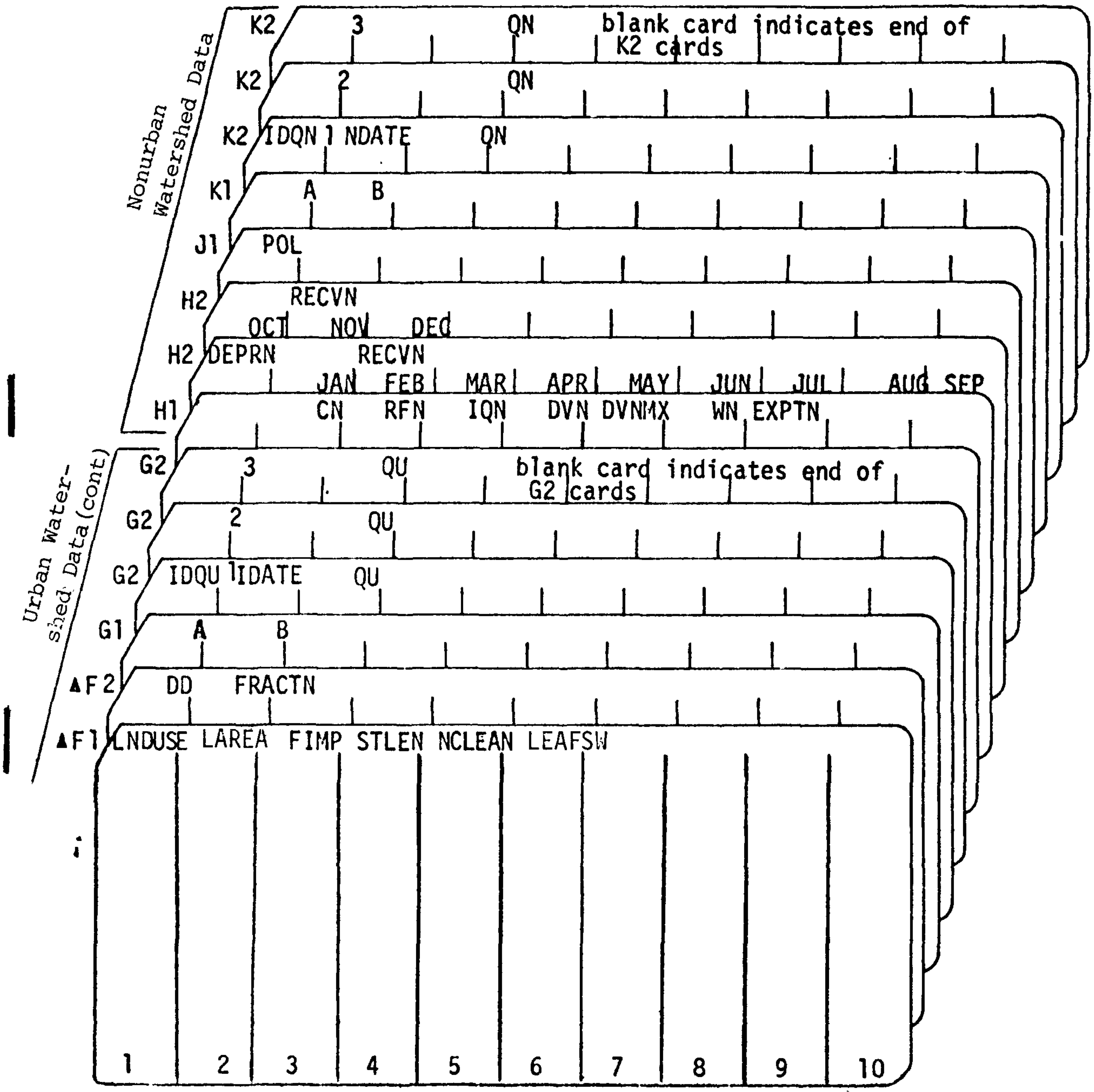
++ Default values, as presented in SWMM User's Manual, p. 48.

SUMMARY OF INPUT CARDS



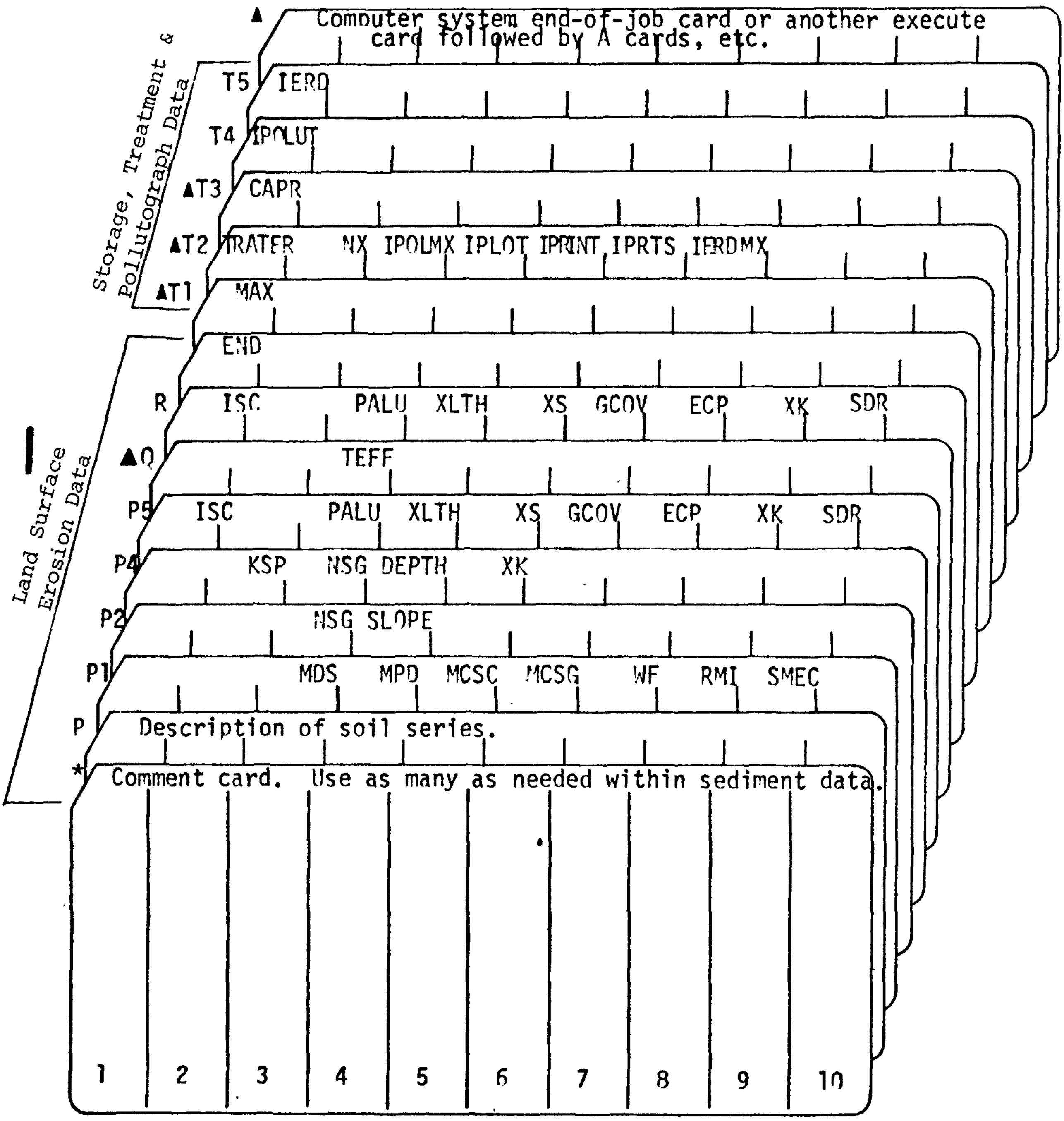

Note: Bars on left hand side of page indicate where revisions have been made.

▲ Required cards. Other cards are required depending upon input options.




Note: Bars on left hand side of page indicate where revisions have been made.

▲ Required cards. Other cards are required depending upon input options.




▲ Required cards. Other cards are required depending upon input options.

Note: Bars on left hand side of page indicate where revisions have been made.

If STORM-generated hydrograph/pollutograph input is used, a data set (input file) must be defined for each. See above for a detailed description of these files.

If STORM-generated hydrograph/pollutograph input is used, set ISWCH(8) = INTNUM, the number of the requested time interval.

Card Groups 22-28. Stormwater Input -- If STORM-generated hydrograph input is used, omit card groups 22, 24, 26, 28, and 29 (note that ISWCH(3) must be set to 1).

If STORM-generated pollutograph input is used, this card group is omitted.

| | | |
|---|---|---|
| 11-15 = 1, Spatially variable rainfall allowed. Junction inflows computed using card groups 23-27. Required if STORM-generated hydrograph input is used. | ISWCH(3) | 0 |

[a]If both QUANTITY and QUALITY are punched, the program first carries out quantity, then quality analysis.

| | | | |
|---|---|---|---|
| 36-40 | = | n, interval number requested from hydrograph input file. | ISWCH(8)/ INTREQ |

IF NJSW = 0 ON CARD 5, SKIP TO CARD GROUP 30.[a]

IF ISWCH(8) $\neq$ 0 ON CARD 5, SKIP TO CARD GROUP 23.

| Card Group | Format | columns | Description | Variable name | Default value |
|---|---|---|---|---|---|
| | | 16-20 | Multiplier for stormwater flow. | HFACT | 1 |
| | | 21-25 | Warm-up or delay factor in hours. | IWARM | 0 |

IF ISWCH(8) ≠ 0 ON CARD
GROUP 5, SKIP TO CARD
GROUP 25

---

IF ISWCH(8) ≠ 0 ON CARD
GROUP 5, SKIP TO CARD
GROUP 27.

IF ISWCH(8) $\neq$ 0 ON CARD GROUP 5, INPUT NTIMST+2 BLANK CARDS. (SEE CARD GROUP 23 for NTIMST).

| | | | |
|---|---|---|---|
| 21-25 | Weighting factor applied to STORM-generated pollutograph input. | PFACT | 1 |
| 26-30 | Delay factor in hours. | PWARM | 0 |

IF ISWCH(8) $\neq$ 0 ON CARD GROUP 5,
SKIP TO CARD GROUP 40.

Table 8-1 (continued). RECEIVING WATER BLOCK CARD DATA

| Card group | Format | Card columns | Description | Variable name | Default value |
|---|---|---|---|---|---|
| 40 | | | Selection of pollutants to be anlayzed from STORM-generated pollutograph input file. | | |
| | 8I10 | 1-10 | Pollutant number according to the following table:<br>1 suspended solids<br>2 settleable solids<br>3 BOD<br>4 Nitrogen<br>5 Phosphorus<br>6 Coliforms | KSELCT(1) | 0 |
| | | 11-20 | Second pollutant selected for analysis | KSELCT(2) | |
| | | . . . | . . . | . . . | |
| | | | $I^{th}$ (max. of 8) pollutant selected for analysis. | KSELCT(I) | |

# Chapter 2

## Sanitary Sewer-Wastewater Treatment Plant Capacity Evaluation Module

### General Description

#### Introduction

Much of the network coding used and discussed below is based on ideas developed in previous work by Meta Systems Inc.* The link network system is divided into a series of discrete links by defining the two end points of each -- to be called nodes -- according to a set of rules.

A node is defined where:

1. a link crosses a cell boundary;
2. a change in pipe diameter occurs;
3. a confluence of two links occurs; and
4. flows are to be monitored.

It is at these nodes that comparisons of actual flow and capacity will be made.

#### Assumptions

Before defining the link types and describing the network numbering scheme, a few of the assumptions of the model will be presented:

1. The flow capacity of each link is measured in cubic feet per second (CFS) and is calculated using Manning's equation:

$$V = (1.49/N)\ (H)^{2/3}(S)^{1/2} \qquad (2\text{-}1)$$

where:

V = velocity in feet per second (FPS),
N = coefficient of roughness,
H = hydraulic radius=(area/wetted perimeter); in our case:
H = link radius (in feet)/2, and
S = link slope in feet/feet.

---

* "A Program for Simulation of Acid Mine Drainage in a River Basin," prepared by Meta Systems for the Appalachian Regional Commission, 1969.

From this:

$$Q = V \times A \quad (2-2)$$

where:

Q = capacity flow in CFS,
V = velocity in FPS, and
A = cross-sectional link area in square feet.

2. It is assumed that the total wastewater generated within a cell is uniformly distributed throughout that cell.

3. Each link in the system is assigned a percentage of the flow generated in the cell in which the link is located. It may be found that no drainage links have been allocated to certain cells. In this case a link (or links) may be chosen or newly defined so as to receive the cells' flow.

4. This assigned flow drains into the link in a continuous, but not necessarily uniform, fashion for the length of the link.

5. On the basis of the above assumption, capacity checks will occur only at the downstream node of each link.

6. Nothing is suggested concerning detailed layout and hydraulic design of relief sewers. This omission is based on the multiplicity of technical factors, many external to the model, which would play an important role in any such statement. When an overcapacity flow occurs, the planner, among the many choices, may select an independent branch of links, or a relief interceptor. In either case the technical assistance of a sanitary wastewater engineer will be needed to help determine exact location, pipe diameters, minimal velocity requirements, and characteristics.

7. To account for the temporal variation of flows, we have used Babbitt's equation* to relate the ratio of peak average flow to tributary population equivalents:

$$r = 5/(p)^{.2} \text{ for } 1 \leq p \leq 410$$

$$\text{and } r = 5 \quad \text{for } p < 1 \quad (2-3)$$

$$\text{and } r = 1.5 \quad \text{for } p > 410$$

where p is population in 1,000's and r is the ratio.

---

* H.E. Babbitt, and E.R. Boumann, Sewerage and Sewage Treatment, 8th Edition, New York: John Wiley and Sons, 1958; see also Working Paper No. 3, p. 36.

8. A peak flow adjustment vector is required for the land uses to implement sensitivity analysis. By increasing or decreasing the average flow by land use, the sensitivity of capacity utilization to each land use can be explored.

The following types of links are recognized by the model:

1. Starting link -- a beginning link of a branch in the network;

2. Continuing link -- all links lacking the attributes of a starting, junction, terminal, diversion or pump main link;

3. Junction link -- the link formed by the confluence of two upstream links. The program handles confluences of only two links. In order to simulate the confluence of three (or more) links it is necessary to manipulate the model by introducing a series of confluences, each of two links, as shown in Figure 2-1. The linear distance of link number 3 can be made negligibly small so that the net effect is that of a triple confluence into link number 5.

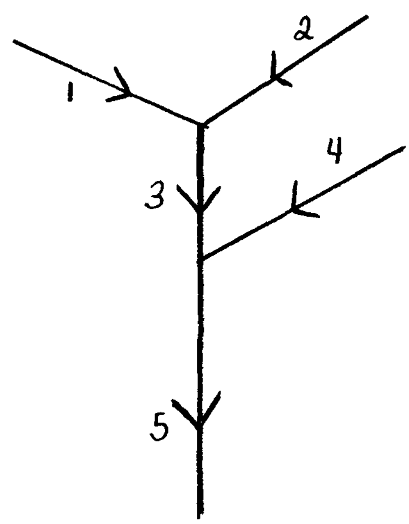
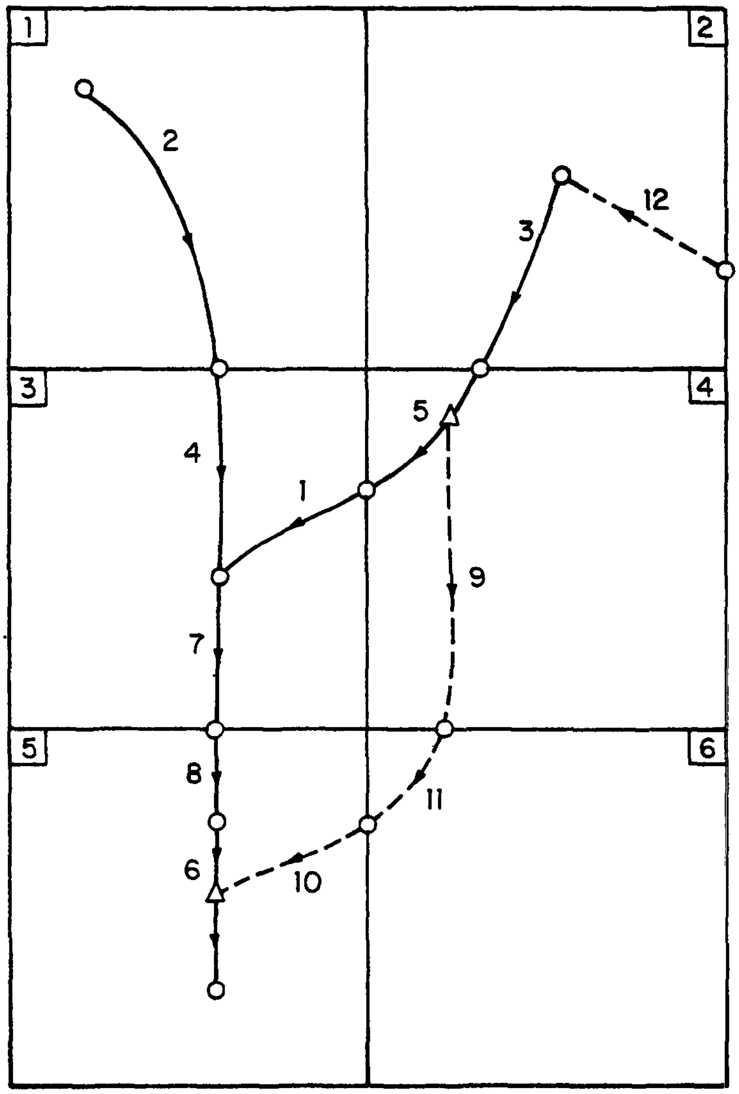



Figure 2-1 Manipulation of Confluences in a Tree Network

4. Terminal link -- final link of the system network, emptying into a treatment plant or pumping station. Each system must have exactly one terminal link. Unlike junction links, more than two upstream links may flow into the terminal link. However, in order to accomplish this a few restrictions govern:

   a. There can be only one discrete, fixed node of intersection between the terminal link and an upstream link. In general a system is best arranged with only one link entering the

Figure 2-2 Scheme of Sewer Network for Coding




LEGEND:

- [1] = Cell Identification number
- 4 → = Link identification and flow direction
- O = Denotes division of links
  - a) junction intersection
  - b) crossing cell lines
  - c) change in link diameter
  - d) test points
- Δ = Denotes a non-fixed point of link intersection
  - a) diversion links
  - b) relief links leading into terminal link

terminal link (as in Figure 2-2), considering only the original system of links 1-8), with additional links being used to represent relief sewers.

b. Any additional links draining into the terminal link must have non-fixed points of intersection; otherwise the terminal link would constantly have to be redefined as a series of junction links.

c. The numbering rule that applies to the incoming branches of junctions must be followed (explanation below).

5. Diversion links -- a relief sewer designed to carry the over-capacity flow and a fixed percentage of the full capacity link flow from the upstream link it intersects.* The percentage may be fixed such that minimum flow velocities are achieved. The decision to have non-fixed points of intersection between diversion links and the upstream link arises from the fact that the program measures only the end of link flows and thus has no way of knowing at exactly what point in the link the overflow occurs. However, this convention serves two functions. It enables the planner to freely place diversion links in the system and measure resulting flow without a detailed layout provided by the engineer (once the design to place a diversion link is made then the engineer may be consulted for details). In addition, as with terminal links, this convention eliminates the need to divide the upstream link.

6. Pump main link -- a link carrying into the system flows generated from an external source, for example from a pumping station.

## Network Numbering

Having been defined by type, the links are now numbered in a fashion similar to that used in the report cited above.** A NEXT vector, containing the identification number of the next downstream link, and an ITYPE vector, indicating the type of link, are used in the program logic for defining the network structure. This method allows for:

1. an arbitrary assignment of identification numbers to the links except for first links of branches leading into the terminal and junction links; and

2. an internal network ordering such that link flow capacities and actual flows can be calculated in one pass of the system each.

---

* Note: if a relief sewer consists of several links, only the first link would be designated as a "diversion" link.

** Meta Systems <u>op. cit.</u>

Links 1 through 8 in Figure 2-2 would have NEXT and ITYPE vectors as appear in Table 2-1:

Table 2-1 Numbering of Links

| Link ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| NEXT | 7 | 4 | 5 | 7 | 1 | 0 | 8 | 6 |
| ITYPE | 2 | 1 | 1 | 2 | 2 | 4 | 3 | 2 |

The rules for numbering links are as follows: If there are I links in the network, link identification numbers must run from i=1 to I. The numbering need not be consecutive except for the first link of the second branch that flows into a junction link. In the case of a terminal link with j inflowing branches, the first link of each consecutive branch from 2 to j must be the next higher integer from the immediate upstream link of the last branch flowing into the terminal link.

Consider the network system comprised of links 1-8 in Figure 2-2. Starting with link 3 the numbering proceeds to link 5, link 1, and then 7, which is a junction link. The numbering rule specifies that before link 7 is examined the next link to be considered must be that one with the next higher integral identification. In this case the program cannot route from link 1 to 7 until the left-hand branch is accounted for, whereupon the branch which starts at link 2 becomes the next link in the sequence. From link 2 the routines then moves to link 4, and then to link 7 where the junction is now satisfied because both incoming branches are completed. Link 7 then leads to link 8 and link 6, the terminal link of the system.

## Data Collection and Input

This section provides an overview of the data that will have to be collected.

1. For each link the following characteristics are required:

    a. link identification number
    b. next link -- identification of next downstream link
    c. type link -- identification of link type
    d. diameter in inches of the link
    e. length in feet of the link
    f. slope of the link (feet per 1,000 feet)
    g. Manning's roughness coefficient of the link -- a default value of .013 is assigned*

* G.M. Fair, J.C. Geyer, and D.A. Okun, Water and Wastewater Engineering, 1969.

h. infiltration coefficient of the link -- in gpd/inch diameter/mile -- a default value of 450 is assigned.*

2. For each cell and each of the four periods (T, T+10, T+25, T+50), the total population or population equivalents are required for six land use types.**

   a. single family -- low density
   b. single family -- high density
   c. multi-family
   d. commercial
   e. industrial
   f. open-space and recreational.

3. The expected wastewater generation in gallons per capita per day is required by land use.

4. Peak flow adjustment factors by land use for sensitivity analysis.

5. Percentage of cell wastewater allocated to each link.

6. The type of unit, treatment plant or pumping station and its capacity in CFS, receiving flows from the terminal link.

Output

Returning to our original system of links 1-8 (Figure 2-2) we may find that after running the program for various development projections an overcapacity flow constantly occurs at link 5, and that the planner decides to check what the impact would be if a relief sewer consisting of links 9, 10, and 11 is chosen to remedy the situation. At the same time a pump main, link 12, is added to help drain some external area now that the capacity of the system's right-hand branch has been increased by the addition of the relief sewer.

In addition to the necessary new data to be collected, the NEXT and ITYPE vectors would have to be changed to those as appear in Table 2-2.

---

* Design and Construction of Sanitary and Storm Sewers, ASCE-Manuals and Reports on Engineering Practice, No. 37, 1970.

** The population equivalents for commercial, industrial, and open-space, recreational land uses should be based upon the wastewater flow value (gpc/d) assigned to one of the land uses; for example, single family low density.

Table 2-2

Renumbering of Links After Addition of Relief Sewer

| LINK ID | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NEXT | 7 | 4 | 5 | 7 | 1 | 0 | 8 | 6 | 11 | 6 | 10 | 3 |
| ITYPE | 2 | 1 | 2 | 2 | 2 | 4 | 3 | 2 | 5 | 2 | 2 | 6 |

Adding these new links creates only a minimal change in the existing input data.

Results of Sample Run. Tables 2-3 to 2-7 illustrate checking and display of sample input (discussed above) for validity. Output for the resulting system in Table 2-8 displays minimum capacity of the sewer network and of the waste treatment plant, their actual utilization at various future points in time and overflow of network link as well as overutilization of the treatment plant.

## Detailed Program Description

This part consists of four sections. Immediately below is a summary of the hardware required to execute the program. This summary is followed by a generalized flow diagram of the entire module, to give an overview of its structure (Figure 2-3). Then come descriptions of the main program and each of the subroutines it calls, with (in one case) an accompanying flow chart. The final section is an input variable dictionary, which contains every variable input to the module from cards.

### Hardware Requirements

This program is written in IBM FORTRAN G. The catalogued procedure used at the Massachusetts Institute of Technology, (where development and testing were done) to invoke the FORTRAN compiler required 106K bytes; catalogued procedures at other installations may have different requirements. 48K bytes (exclusive of I/O buffers) are required for execution. It is recommended that a minimum of 4K bytes be added to I/O buffering, which could result in a requirement of 52K bytes for execution. Execution time of the IBM 370/168 in a multiprogramming environment for a typical test run was 32 seconds. One card reader and one line printer are required.

Table 2-3

LINK CHARACTERISTICS

| LINK ID | DIAMETER (INCHES) | LENGTH (FEET) | SLOPE (FT PER 1000. FT) | ROUGHNESS COEFFICIENT | INFILTRATION FACTOR (GPD/IN DIAM/MILE) |
|---|---|---|---|---|---|
| 1 | 10 | 400 | 0.00300 | 0.013 | 450 |
| 2 | 10 | 1500 | 0.00300 | 0.013 | 450 |
| 3 | 12 | 1000 | 0.00300 | 0.013 | 450 |
| 4 | 10 | 500 | 0.00300 | 0.013 | 450 |
| 5 | 10 | 450 | 0.00300 | 0.013 | 450 |
| 6 | 24 | 800 | 0.00500 | 0.013 | 450 |
| 7 | 18 | 600 | 0.00450 | 0.013 | 450 |
| 8 | 24 | 350 | 0.00450 | 0.013 | 450 |
| 9 | 10 | 1600 | 0.00300 | 0.013 | 450 |
| 10 | 18 | 650 | 0.00300 | 0.013 | 450 |
| 11 | 15 | 300 | 0.00400 | 0.013 | 450 |
| 12 | 12 | 400 | 0.00200 | 0.013 | 450 |

Table 2-4

## SANITARY WASTEWATER FLOW VALUES

| LAND USE | GPC/D |
|---|---|
| SINGLE FALMIY (LOW DENSITY)............. | 100.0 |
| SINGLE FAMILY (HIGH DENSITY)............ | 80.0 |
| MULTI-FAMILY.......................... | 60.0 |

## PEAK FLOW ADJUSTMENT FACTORS

| | |
|---|---|
| SINGLE FALMIY (LOW DENSITY)............. | 1.00 |
| SINGLE FAMILY (HIGH DENSITY)............ | 1.00 |
| MULTI-FAMILY.......................... | 1.00 |
| COMMERCIAL............................ | 1.00 |
| INDUSTRIAL............................ | 4.00 |
| OPEN SPACE - RECREATION................ | 1.00 |

Table 2-5

## CELL CHARACTERISTICS

CELL ID — PRESENT (TIME T) AND PROJECTED POPULATION OR POPULATION EQUIVALENTS

SINGLE FAMILY (LOW DENSITY)

| CELL ID | T | T+10 | T+25 | T+50 |
|---|---|---|---|---|
| 1 | 640 | 640 | 640 | 640 |
| 2 | 200 | 250 | 400 | 640 |
| 3 | 200 | 250 | 250 | 250 |
| 4 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 |

CELL ID — PRESENT (TIME T) AND PROJECTED POPULATION OR POPULATION EQUIVALENTS

SINGLE FAMILY (HIGH DENSITY)

| CELL ID | T | T+10 | T+25 | T+50 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 840 | 900 | 900 | 940 |
| 4 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 |

CELL ID — PRESENT (TIME T) AND PROJECTED POPULATION OR POPULATION EQUIVALENTS

MULTI-FAMILY

| CELL ID | T | T+10 | T+25 | T+50 |
|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3 | 1000 | 1100 | 1200 | 1300 |
| 4 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 |

Table 2-6

CELL WASTEWATER ALLOCATIONS

| LINK ID | ASSOCIATED CELL ID | PERCENT OF ASSOCIATED CELL FLOW INTO LINK |
|---|---|---|
| 1 | 3 | 40 |
| 2 | 1 | 100 |
| 3 | 2 | 100 |
| 4 | 3 | 40 |
| 5 | 4 | 50 |
| 6 | 5 | 80 |
| 7 | 3 | 20 |
| 8 | 5 | 20 |
| 9 | 4 | 50 |
| 10 | 5 | 0 |
| 11 | 6 | 50 |
| 12 | 2 | 0 |

Table 2-7

SYSTEM GEOMETRY

| LINK ID | LINK TYPE | NEXT LINK |
|---|---|---|
| 1 | CONTINUING | 7 |
| 2 | STARTING | 4 |
| 3 | CONTINUING | 5 |
| 4 | CONTINUING | 7 |
| 5 | CONTINUING | 1 |
| 6 | TERMINAL | 0 |
| 7 | JUNCTION | 8 |
| 8 | CONTINUING | 6 |
| 9 | DIVERSION | 11 |
| 10 | CONTINUING | 6 |
| 11 | CONTINUING | 10 |
| 12 | PUMP MAIN | 3 |

LIST OF STARTING LINKS

| NUMBER | IDENTIFICATION |
|---|---|
| 1 | 2 |

LIST OF CONTINUING LINKS

| NUMBER | IDENTIFICATION |
|---|---|
| 1 | 1 |
| 2 | 3 |
| 3 | 4 |
| 4 | 5 |
| 5 | 8 |
| 6 | 10 |
| 7 | 11 |

LIST OF JUNCTION LINKS

| NUMBER | IDENTIFICATION INTERSECTION LINKS | IDENTIFICATION RESULTING LINK |
|---|---|---|
| 1 | 1 AND 4 | 7 |

LIST OF DIVERSION LINKS

| NUMBER | IDENTIFICATION | PERCENT OF UPSTREAM LINK FLOW ENTERING LINK |
|---|---|---|
| 1 | 9 | .15 |

LIST OF PUMP MAIN LINKS

| NUMBER | IDENTIFICATION | FLOW IN LINK |
|---|---|---|
| 1 | 12 | 1.500 |

ROUTING OF FLOWS BEGINS AT LINK 12

TERMINAL LINK ID IS 6

Table 2-8

**LINK CAPACITIES AND FLOWS**

CHECKING SYSTEM CAPACITY FOR PROJECTED POPULATION 0 YEARS FROM PRESENT

FULL AND/OR OVERCAPACITY FLOWS

LINK 6 FLOW EXCEEDED THE MAXIMUM CAPACITY BY 12.69 PERCENT ( 1.577 CFS)

THERE WERE 1 FULL AND/OR OVERCAPACITY FLOWS

(FLOW VALUES IN CFS)

| LINK ID | MAXIMUM FLOW CAPACITY | ACTUAL FLOW | PERCENT UTILIZATION | CUMULATIVE OVER FLOWS |
|---|---|---|---|---|
| 1 | 1.203 | 1.114 | 92.61 | 0.0 |
| 2 | 1.203 | 0.101 | 8.39 | 0.0 |
| 3 | 1.957 | 1.533 | 78.35 | 0.0 |
| 4 | 1.203 | 0.193 | 16.02 | 0.0 |
| 5 | 1.203 | 1.023 | 85.00 | 0.0 |
| 6 | 12.424 | 12.424 | 100.00 | 1.577 |
| 7 | 5.769 | 1.354 | 23.47 | 0.0 |
| 8 | 12.424 | 3.731 | 30.03 | 0.0 |
| 9 | 1.203 | 0.514 | 42.73 | 0.0 |
| 10 | 5.769 | 0.762 | 13.21 | 0.0 |
| 11 | 3.548 | 0.761 | 21.44 | 0.0 |
| 12 | 1.957 | 1.501 | 76.69 | 0.0 |

TOTAL FLOW ENTERING TREATMENT PLANT (CFS) = 12.424

TREATMENT PLANT CAPACITY

| STAGE | MAXIMUM CAPACITY (CFS) | PERCENT UTILIZATION |
|---|---|---|
| PRIMARY | 30.00 | 41.41 |
| SECONDARY | 20.00 | 62.12 |
| TERTIARY | 10.00 | 124.24 |

Figure 2-3

**Flow Chart**

**Sewer Routing Module**

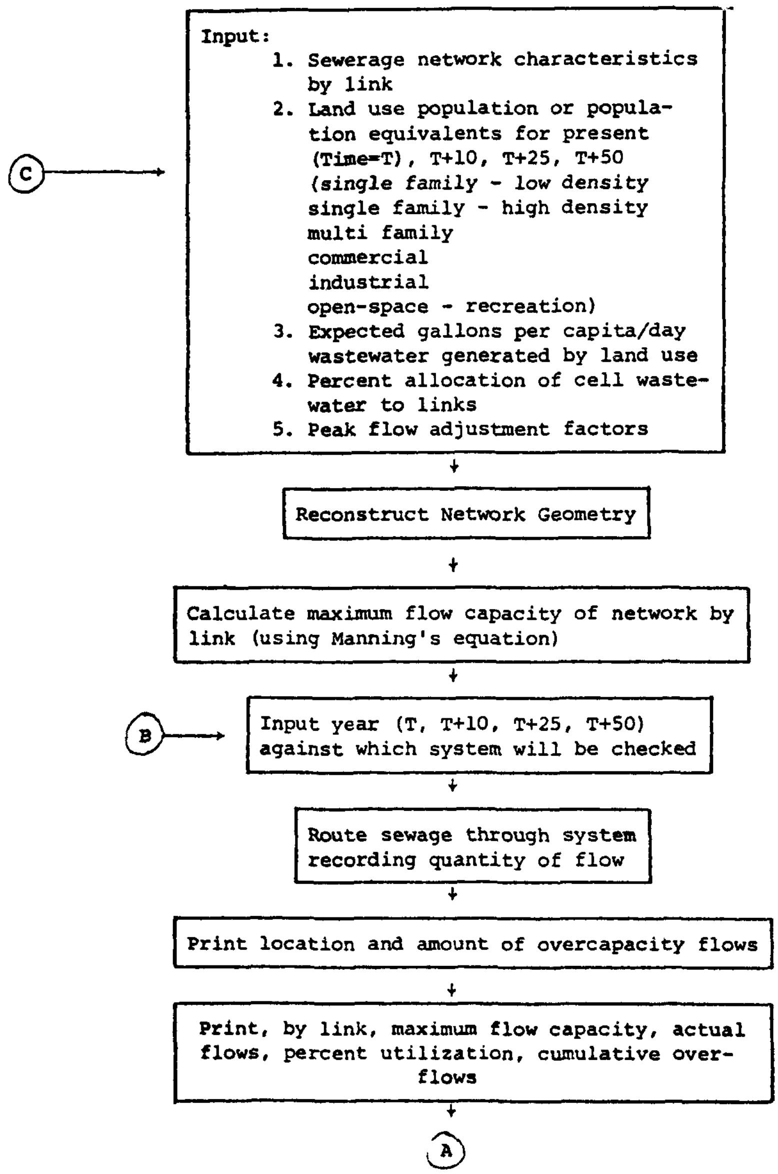
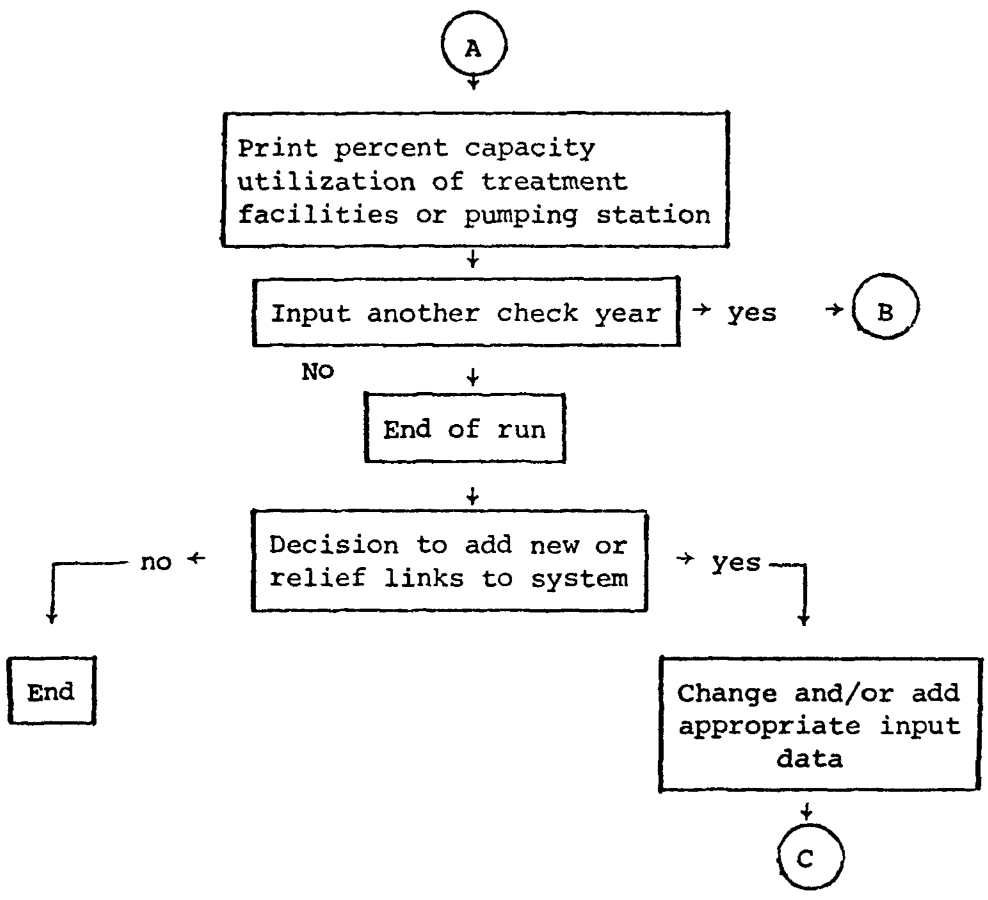


Figure 2-3 (continued)

**Flow Chart**

**Sewer Routing Module**



## Program Description

### Main Program. Functions:

a. Dimensions; and specifies the variables which will be in COMMON.

b. Assigns the logical unit numbers for the card reader and line printer -- the only two input/output devices used by the program.

c. Reads in the status desired for the debugging option. This option ON causes to be output intermediate variable values and would be of use to the professional programmer who is altering the logic of the program. Under normal circumstances the program would be run with this option OFF.

d. Initiates the execution of all other program segments through a series of CALL statements.

e. Reads in the planning horizon (scenario) against which the system is to be checked (card type 11).*

### Subroutine IDAPG. Functions:

Numbers pages and prints identification comments on the top of each output (card type 2).

### Subroutine INDATA. Functions:

a. Reads input data (card types 3-10).

b. Assigns appropriate variable default values.

c. Checks actual numbers of diversion and pump main links against maximum allowed. If there are too many, an error message is printed and execution terminated.

### Subroutine OUTDATA. Functions:

a. Prints the input data.

b. Converts, by link, the infiltration rate from gpd/inch diameter/mile to gpd/mile.

---

* These card types refer to the input data, as listed below.

Subroutine RECONS. Functions:

Attempts to reconstruct the network system geometry, as defined by the input data, by checking:

1. the actual number of starting, junction, continuing, and terminal links against the maximum number allowed for each; and

2. that the actual numbering scheme is consistent with the number rules.

Any violation of the above checks results in an error message and program termination.

Subroutine GEOPRT. Function:

Prints the system geometry in tabular form.

Subroutine ROUTE. Functions:

a. Calculates the flow capacity of each link (in CFS).

b. Given the scenario calculates the actual flow at each link's downstream node.

c. Calculates percent utilization by link.

d. Records overcapacity flows and cumulative overflows.

This subroutine, in which the routing of flows is modeled, is by far the most complex in the program. For each run of the program ROUTE is executed once to determine link capacity flows and then once for each scenario input, calculating the actual flows. A sizeable portion of the routine is devoted to the creation of an internal ordering of links, using the NEXT and ITYPE vectors, such that all links in the network system can be checked in one pass. The remainder of the routine consists of two sections -- one to calculate capacity flows and the other to calculate actual flows.

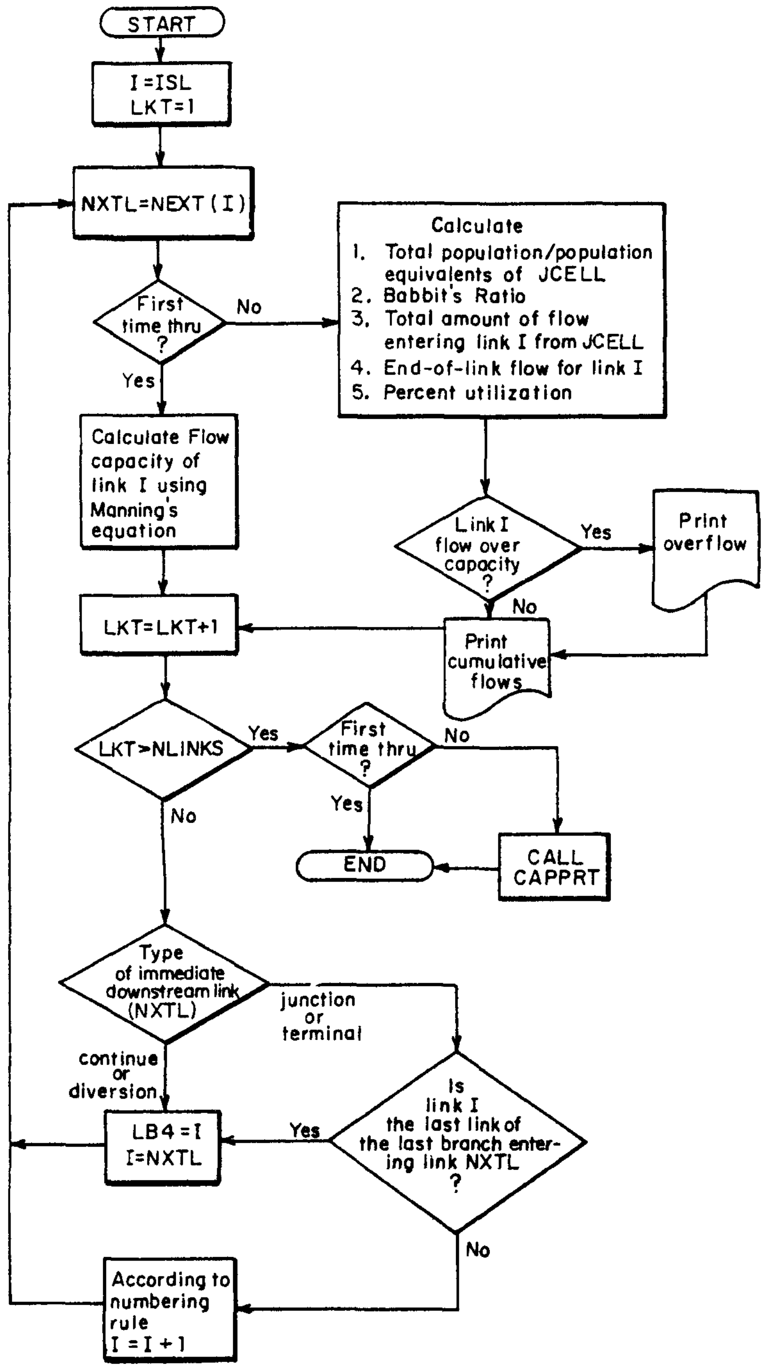
Figure 2-4, a flow chart of ROUTE, indicates important details. Following are definitions of variables referred to in the flow chart, while a complete list of input variables is presented at the end of the chapter.

ISL = identification number of the link at which the system routing begins

I = identification number of the present link in the system

Figure 2-4

Flow Chart of ROUTE



NXTL = the identification number of the link immediately downstream from link I

LB4 = the identification number of the link immediately upstream from link I

LKT = counter for the number of links thus far encountered

NLINKS = total number of links in the system

JCELL = identification number of the cell in which link I is located.

Subroutine CAPPRT. Functions:

a. Prints capacity utilization data.

b. Prints capacity utilization of treatment plant pumping station.

Input Variable Dictionary

| Card Type | Variable Name | Card Columns | FORMAT | Comments |
|---|---|---|---|---|
| 1 | IDEBUG | 1 | I1 | Debug option - (prints intermediate output)<br>= 0 - option off<br>= 1 - option on |
| 2 | IDCARD(I) | 1-80 | 80A1 | Identification card - up to 80 characters - to be printed on the top of each page |
| 3 | NLINKS | 1-3 | I3 | Number of links in the system (maximum of 20) |
| 3 | NCLS | 4-6 | I3 | Number of cells in grid (maximum of 10) |
| 3 | NITL | 7-9 | I3 | Number of links flowing into the terminal link |
| 4 | ISL | 1-3 | I3 | Identification number of link at which routing of flows will begin |
| 5 | ITYPT | 1 | I1 | End of terminal link collector<br>= 0 - pumping station<br>= 1 - treatment plant |
| 5 | TREAT(I) | 2-22 | 3F7.2 | If ITYPT = 0:<br>input into TREAT(1) the pumping station capacity in CFS<br><br>If ITYPT = 1:<br>input into TREAT(I) the following treatment plant capaci- |

| Card Type | Variable Name | Cards Columns | FORMAT | Comments |
|---|---|---|---|---|
| | | | | ties in CFS<br>TREAT(1) = primary<br>TREAT(2) = secondary<br>TREAT(3) = tertiary |

Input one card type 6 for each link in the system. Card type 6 must be input in ascending order as ID goes from 1 to NLINKS.

| | | | | |
|---|---|---|---|---|
| 6 | ID | 1-3 | I3 | Identification number of link |
| 6 | NEXT(I) | 4-6 | I3 | Identification number of the link immed- iately downstream from link ID |
| 6 | ITYPE(I) | 7 | I1 | Link type<br>= 1 - starting link (max # = 4)<br>= 2 - continuing link (max # = 15)<br>= 3 - junction link (max # = 6)<br>= 4 - terminal link (max # = 1)<br>= 5 - diversion link<br>= 6 - pump main link |
| 6 | LDIAM(I) | 8-9 | I2 | Link diameter in inches |
| 6 | LENGTH(I) | 10-14 | I5 | Length of link in feet |
| 6 | SLOPE(I) | 15-20 | F6.5 | Slope of link (feet per 1000 feet) |
| 6 | RUFCOF(I) | 21-24 | F4.3 | Roughness coefficient of link - if no value is input a default value of .013 is ass- igned |
| 6 | INFIL(I) | 25-28 | I4 | Infiltration factor of link in gpd/inch dia- meter/mile - if no value is input a def- ault value of 450 is assigned |

| Card Type | Variable Name | Cards Columns | FORMAT | Comments |
|---|---|---|---|---|
| 6 | LPCNT | 29-31 | I3 | For diversion links only - percentage of full capacity of up-stream link flow entering the diversion link |
| 6 | LINKUP | 32-34 | I3 | For diversion links only - ID of the up-stream intersected link |
| 6 | FMLF | 35-42 | F8.3 | For pump main links only - amount of flow in CFS entering link from some external source |
| 7 | WASTEF(LU) | 1-27 | 3F9.1 | Waste flows assigned to land uses (gpl/day)<br>WASTEF(1) = flow for low density single family<br>WASTEF(2) = flow for high density single family<br>WASTEF(3) = flow for multi-family housing |
| 7 | IPE | 28 | I1 | The land use type upon which population equivalents for commercial, industrial and open-space and recreation are based<br>= 1 - single family - low density<br>= 2 - single family - high density<br>= 3 - multi-family |
| 8 | PKADJF(LU) | 1-36 | 6F6.2 | Peak flow adjustment factors by land use for sensitivity analysis<br>PKADJF(1) = single family-low density |

| Card Type | Variable Name | Cards Columns | FORMAT | Comments |
|---|---|---|---|---|
| | | | | PKADJF(2) = single family-high density<br>PKADJF(3) = multi-family<br>PKADJF(4) = commercial<br>PKADJF(5) = industrial<br>PKADJF(6) = open-space --recreation |

There are six (one per land use) type 9 cards for each cell in the grid. Their ID's must be input in ascending order from 1 to NCLS.

| Card Type | Variable Name | Cards Columns | FORMAT | Comments |
|---|---|---|---|---|
| 9 | ID | 1-3 | I3 | Identification number of cell |
| 9 | NCELLS(I,J) | 4-40 | 4I9 | For cell I (I=ID) the population (or population equivalents) for the four time periods (present = time T)<br>NCELLS(I,1) = values for T<br>NCELLS(I,2) = values for T + 10<br>NCELLS(I,3) = values for T + 25<br>NCELLS(I,4) = values for T + 50 |

Input one type 10 card for each link in the system. Their ID's must be input in ascending order from 1 to NLINKS.

| Card Type | Variable Name | Cards Columns | FORMAT | Comments |
|---|---|---|---|---|
| 10 | ID | 1-3 | I3 | Identification number of link |
| 10 | IALOCT(I,1) | 4-6 | I3 | ID of cell in which link I (I=ID) is located |
| 10 | IALOCT(I,2) | 7-9 | I3 | Percentage of cell ID's wastewaters that drains into link I (I=ID) |

There may be up to four type 11 cards in a single run.

| Card Type | Variable Name | Cards Columns | FORMAT | Comments |
|---|---|---|---|---|
| 11 | IPHOR | 1 | I1 | Planning horizon or scenario against which system capacity is checked<br>= 0 - present (time T)<br>= 1 - T + 10<br>= 2 - T + 25<br>= 3 - T + 50 |

A sentinel card such as the IBM /* indicating end of data is required by the program.

Chapter 3

# Cost Evaluation Module*

## General Description

The cost evaluation module is designed to estimate costs incurred by added development within a community and to provide an allocation of capital and operation and maintenance costs to those groups sharing the project's costs. By varying the cost allocation schemes, a planner is able to generate a range of financial impacts over time on the community. The current version of the model has provision for calculating the impact of the following environmental infrastructure cost types (index = j):

1. on-site wastewater disposal;
2. sanitary sewer laterals;
3. sanitary sewer building connections;
4. sanitary sewer trunks/mains;
5. storm sewer laterals;
6. stormwater detention ponds;
7. storm sewer trunks/mains;
8. sewage treatment plant(s).

A general logic diagram of the module is presented in Figure 3-1.

Regardless of the infrastructural cost types j to be estimated, a set of community and development characteristics is required as input:**

a. Projected population/population equivalents of the community for six land uses, for four time periods -- the present (time T) and 10, 25 and 50 years into the future:

    1. single family -- low density;
    2. single family -- high density;
    3. multi-family;
    4. commercial;

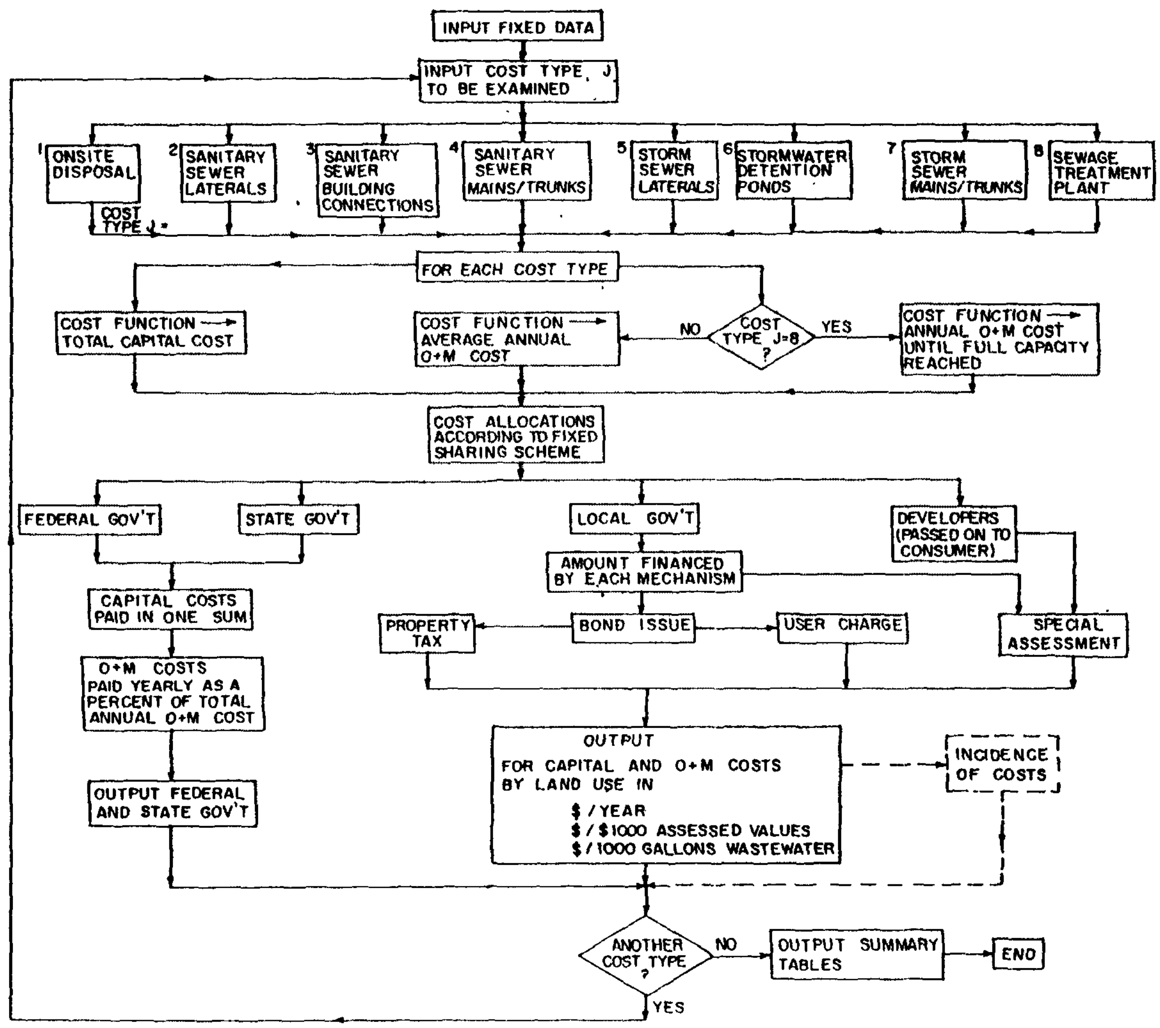
---

* Detailed description of the module is given in Chapter 6 of <u>Land Use-Water Quality Relationship</u>, Report prepared by Meta Systems Inc for U.S. EPA under contract #68-01-2622; published by EPA's Water Planning Division WPD 3-76-02, March 1976.

** It should be noted that some of the data is deliberately in formats compatible to the sewer capacity evaluation module (Meta Systems Inc, <u>ibid.</u>), because this module complements that module by analyzing the associated financial impacts.

Figure 3-1

Logic of Cost Evaluation Module



5. industrial;
6. open space -- recreational;

b. the expected gallons per capita per day of wastewater generated, by land use;

c. present and projected assessed property values of the community by land use for the four time periods T, T+10, T+25, T+50;

d. projected assessed property values of the proposed development by land use for the four time periods T, T+10, T+25, T+50;

e. the numbers and kinds of residential structures to be constructed in the proposed development;

f. expected number of persons per household for the various residential dwellings within the proposed development;

g. interest and discount rates to be used in calculating the cost streams.

In addition to this data, development characteristics will be required by the individual cost types j to satisfy the cost functions. The details of such input are included in the Input Variable Dictionary (see last section of this chapter).

For each cost type j there will be a maximum of up to four groups $\ell$ sharing the costs:

$\ell$ = 1 -- developer;
$\ell$ = 2 -- local government;
$\ell$ = 3 -- state government;
$\ell$ = 4 -- federal government.

Having defined the cost types to be studied, the planner decides on a cost allocation scheme based upon local practices, and state and federal cost sharing programs. Thus, for each cost type j, input vectors will be required indicating the percent share of the capital costs (k=1) and the operation and maintenance costs (k=2) to be allocated to each group $\ell$.

From this point $\alpha_{jk\ell}$, the share of cost in dollars of cost component k, for cost type j, to be allocated to group $\ell$, is calculated. The assumptions made concerning the cost calculations and allocations are:

1. all operation and maintenance costs are in average annual cost except for sewage treatment plants (j=8), for which annual operation and maintenance costs vary in accordance with the capacity utilization of the plant and so are calculated on a yearly basis until full capacity is reached;

2. any financing of capital costs by the federal or state governments will be realized in one payment at the beginning of the construction period;

3. any financing of operation and maintenance costs from the federal or state government will be realized as an annual fixed percentage of the costs;

4. within the local government costs may be further broken down by the method in which funds are raised to finance the project:

   a. special assessment -- a one-time charge is assessed against the property owners of the development in dollars per $1,000 assessed value;*

   b. bond issue -- the community may decide to float a bond issue in order to finance the cost type. The revenues required to then pay off the bond issue will be raised in two ways:

   (1) property taxes -- the additional tax per $1,000 assessed property values that will be paid by each land use over the bond issue payback period;

   (2) user charge -- given the total amount of revenues to be raised by user charges, the equivalent dollars per capita and dollars per 100 gallons of wastewater generated are computed by land use.

   Required input for the bond issue mechanism includes the payback period, the percentage of the bond issue to be financed by property taxes and user charges, the percentage of each to be paid by the six land uses and, for the capital costs financed with this mechanism, the annual rate of increase in the amount paid back each year;**

5. costs borne by the developers will generally be passed on to the consumers within the development in the same fashion as a special assessment by the local government.***

---

* Note: assessed values are obtained from straight line interpolation between time periods.

** If the annual rate of increase in the amount to be paid back is zero, the annual payback is constant.

*** If the housing market is highly competitive, or developers in nearby locations do not have to pay as much, the developer may absorb part of the costs to remain competitive.

Description of the Program and its Subroutines

Each subroutine of the current version is listed and explained below:

Main Program

Functions:

a. defines, through a series of COMMENT cards, the variables and arrays of COMMON;

b. reads in the infrastructure cost type j's to be estimated;

c. reads in the associated percent allocations to each group $\ell$;

d. serves as a calling program for nearly all subroutines (see Figure 3-2).

Subroutine FIXDATA

Function:

Reads in data that is required by the program regardless of the cost types to be estimated.

Subroutine FIXOUT

Function:

Prints portions of the data read in FIXDATA.

Subroutine PAVPYR

Function:

Calculates the population and assessed property values by land use for each year. A method of linear interpolation is employed between the four input points: present; +10 years; +25 years; +50 years.

The following subroutines are those used to compute capital costs and operation and maintenance costs of each (infrastructure) cost type j.* Each of the subroutines reads in data required for the cost

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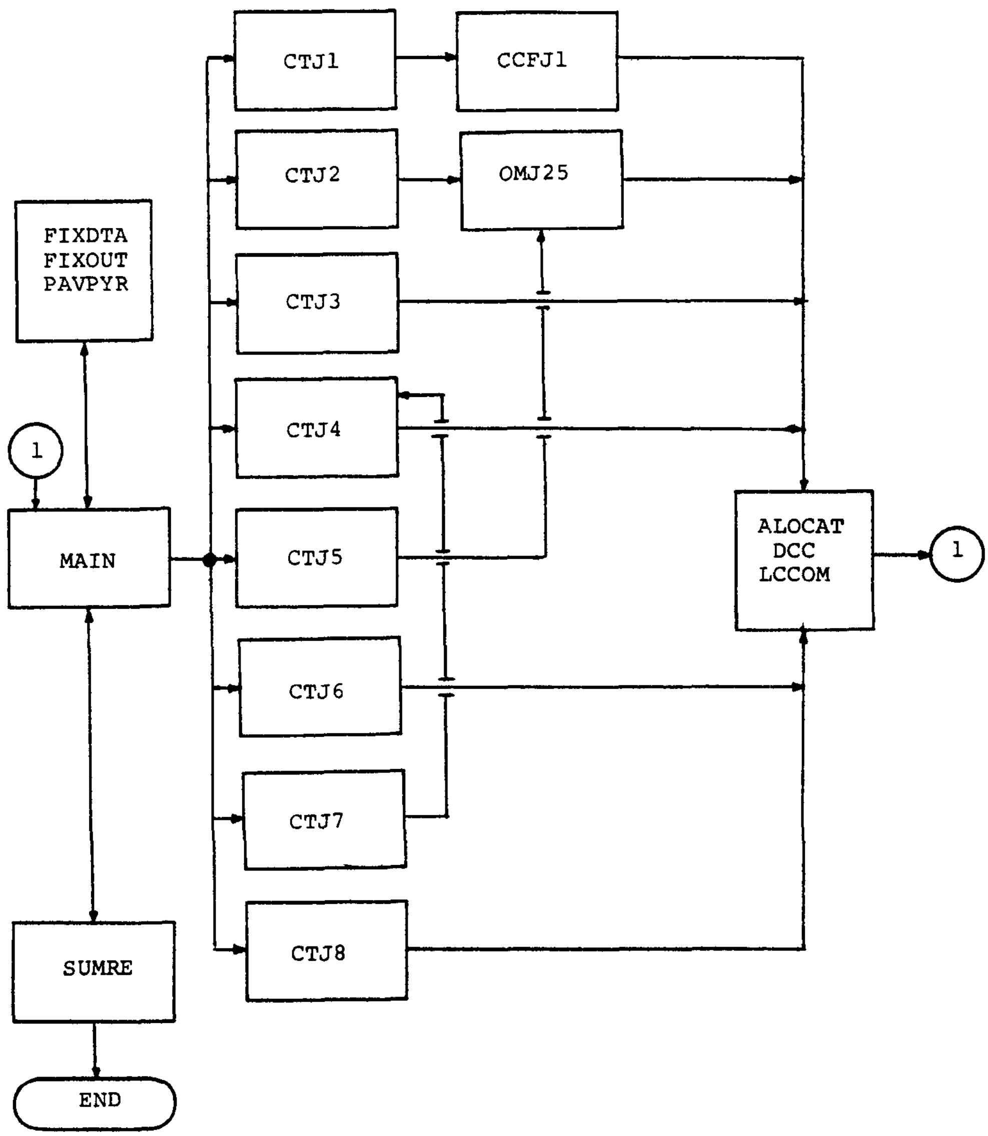
* The equations presently used in each subroutine are fully derived and referenced in Meta Systems' report (ibid.).

Figure 3-2

Calling Sequence Program



estimation functions, computes the costs and places them in COMMON for use by the allocation, finance mechanisms, and output routines. Liberal use of COMMENT statements provides easy correspondence between variables defined in the report and the associated variable names in the program.

Subroutine CTJ1

On-site disposal.

Subroutine CTJ2

Sanitary sewer laterals.

Subroutine CTJ3

Sanitary sewer building connections.

Subroutine CTJ4

Sanitary sewer trunks/mains.

Subroutine CTJ5

Storm sewer laterals.

Subroutine CTJ6

Stormwater detention ponds.

Subroutine CTJ7

Storm sewer trunks/mains.

Subroutine CTJ8

Sewage treatment plant.

Subroutine CCFJ1

Used by CTJ1 for capital cost estimate calculations.

Subroutine OMJ25

Used by CTJ2 and CTJ5 for operations and maintenance cost estimate calculations.

Subroutine ALOCAT

Function:

Calculates and prints the financial impact to consumers of property in the development due to costs borne by the developer (using the financing mechanism in the report).

Subroutine LCCOM

Function:

Calculates and prints the financial impact to the community and developer due to costs borne by the local government (using the financing mechanism defined in the report).

Subroutine SUMRE

Function:

Prints summary tables of the cost types examined and the total costs allocated to each group $\ell$.

## Hardware Requirements

The Cost Estimate Module is written in IBM FORTRAN G. Execution requires a minimum of 144K bytes of storage; if large physical block sizes are desired for buffering of reader/printer I/O, more core may be necessary. One card reader and one line printer are required, they are assigned to FORTRAN logical units 5 and 6 respectively.

## Additions to the Program

At present the term CLF (cost of associated leaching field) referred to in the report* is not in the program. The following changes would be required to introduce this variable:

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* Meta Systems, ibid., p. 6-34.

in subroutine CTJ1 change statement #11 ...PMF, CLF

in subroutine CTJ1 change statement #12 ...(3F5.2, F8.0)

in subroutine CCFJ1 change statement #15 C=C+275.+CLF

Subroutine CTJ6 contains at present no capital cost function or estimate. The planner should provide some variable or function to compute the capital cost of stormwater detention ponds if they are to be modeled. Its value should be stored in the variable TCC(J) where J is the index of the cost type being modeled (in this case equal to 6). Minimal coding required would be

```
      READ (NR,1) relevant variable(s)
1     FORMAT (as required)
      coding to compute the value of TCC(J)
      CALL ALOCAT
```

These statements would be inserted between existing statement numbers 12 and 13.

In general, each cost function is in the form TCC(J) = $F(A_1, A_2, . . ., A_n)$, where J is the index of the cost types being modeled. The programmer wishing to change a given cost function need only refer to the expression(s) involving TCC(J) in the relevant subroutine.

## Sample Run

A new residential development is hypothesized to contain 890 dwelling units made up of 590 townhouse units and 10 garden apartments with 30 dwelling units each. The development requires sanitary and stormwater lateral interceptor sewers. Capital and operating and maintenance costs for each infrastructure component are allocated hypothetically to different financing methods.* Costs are assigned to developers and local, state and federal governments. Within the local government category expenditures are further classified by revenue source. Table 3-1 represents a sample of the output which can be generated by this module.

The program also produces more detailed tables indicating the temporal allocation of costs, effects upon property taxes, and the

---

* Note: This allocation scheme does not necessarily correspond to existing practices.

Table 3-1

RESIDENTIAL DEVELOPMENT - TEST DATA - JULY 29, 1975

SUMMARY TABLE I

TOTAL COSTS (+)

| COST TYPE (++) | DEVELOPER | SPECIAL ASSESSMENT | LOCAL GOVERNMENT USER CHARGE | LOCAL GOVERNMENT PROPERTY TAX | STATE GOVERNMENT | FEDERAL GOVERNMENT |
|---|---|---|---|---|---|---|
| SANITARY SEWER LATERALS | | | | | | |
| CAPITAL | 303714.81 | 0.0 | 60742.97 | 182228.88 | 60742.95 | 0.0 |
| O+M | | | 1474.75 | 0.0 | 368.69 | 0.0 |
| SANITARY SEWER INTERCEPTORS | | | | | | |
| CAPITAL | 278044.31 | 222435.44 | 0.0 | 0.0 | 55608.85 | 0.0 |
| O+M | | | 162.00 | 648.00 | 202.50 | 0.0 |
| STORM SEWER LATERALS | | | | | | |
| CAPITAL | 26480.98 | 13240.49 | 0.0 | 0.0 | 10592.39 | 2648.10 |
| O+M | | | 0.0 | 800.76 | 228.79 | 114.39 |
| STORM SEWER INTERCEPTORS | | | | | | |
| CAPITAL | 290222.56 | 0.0 | 90694.56 | 272083.75 | 72555.63 | 0.0 |
| O+M | | | 0.0 | 810.00 | 202.50 | 0.0 |

(+) ALL VALUES ARE IN BASE YEAR DOLLARS
A BLANK ENTRY INDICATES THE GROUP OR MECHANISM IS NOT USED FOR FINANCING THE COST TYPE
AN ENTRY OF ZERO INDICATES THE GROUP OR MECHANISM WAS NOT CHOOSEN FOR FINANCING THE COST TYPE

(++) CAPITAL COSTS ARE IN DOLLARS PER GROUP OR MECHANISM
O+M COSTS ARE IN DOLLARS PER YEAR PER GROUP OR MECHANISM

required user charges of each cost type among the various land uses. (See Table 3-2.) After examination of the costs, the planner may choose to rerun the program with a different local government financing mechanism.

Table 3-2

Sample Output: Cost Module

RESIDENTIAL DEVELOPMENT - TEST DATA - JULY 29, 1975

COST TYPE J= 2 — SANITARY SEWER LATERALS

COST TYPE INPUT DATA

| | |
|---|---|
| NUMBER OF TOWN HOUSE UNITS | 590. |
| NUMBER OF GARDEN APARTMENT BUILDINGS (30 DU/BLDG) | 10. |
| NUMBER OF MEDIUM RISE APARTMENT BUILDINGS (100 DU/BLDG) | 0. |
| SLOPE CHARACTERISTIC | STEEP |
| TOTAL POPULATION OF DEVELOPMENT - EXPECTED | 4300. |

PERCENTAGE AND AMOUNT (IN DOLLARS) OF COST TYPE TO BE PAID BY -

| | CAPITAL COSTS | | OPERATING AND MAINTENANCE COSTS | |
|---|---|---|---|---|
| | PERCENT | AMOUNT | PERCENT | AMOUNT |
| DEVELOPER | 50.00 | 303714.88 | 0.0 | 0.0 |
| LOCAL GOVT | 40.00 | 242971.88 | 80.00 | 1474.75 |
| STATE GOVT | 10.00 | 60742.95 | 20.00 | 368.69 |
| FEDERAL GOVT | 0.0 | 0.0 | 0.0 | 0.0 |
| TOTALS - | | 607429.75 | | 1843.44 |

DEVELOPERS CAPITAL COSTS

COST PASSED ON TO CONSUMERS (IN $/$1000 ASSESSED VALUE)= 9.89

LOCAL GOVERNMENT CAPITAL COSTS FINANCING

BOND ISSUE --

TOTAL AMOUNT (DOLLARS) 242971.88

| | |
|---|---|
| PAYBACK PERIOD OF BOND ISSUE (YEARS) | 20 |
| PERCENT OF BOND ISSUE TO BE REPAID BY REVENUES RAISED FROM AN INCREASE IN PROPERTY TAXES | 75.00 |
| PERCENT OF BOND ISSUE TO BE REPAID BY REVENUES RAISED FROM AN INCREASE IN USER CHARGES | 25.00 |
| INTEREST RATE USED IN CALCULATING COST STREAMS (PERCENT) | 7.00 |
| ANNUAL PERCENT INCREASE IN AMOUNT OF BOND ISSUE TO BE REPAID EACH YEAR | 1.50 |

## Table 3-2 (continued)

PROPERTY TAX --

TOTAL AMOUNT (DOLLARS) 182228.88

AMOUNT BY LAND USE (IN CURRENT DOLLARS)

| | |
|---|---|
| SINGLE FAMILY LOW DENSITY | 54668.65 |
| SINGLE FAMILY HIGH DENSITY | 36445.77 |
| MULTI-FAMILY | 36445.77 |
| COMMERCIAL | 18222.88 |
| INDUSTRIAL | 36445.77 |
| OPEN SPACE - RECREATION | 0.0 |

$/$1000 INCREASE IN PROPERTY TAX

| YEAR | SINGLE FAMILY LOW DENSITY | SINGLE FAMILY HIGH DENSITY | MULTI-FAMILY | COMMERCIAL | INDUSTRIAL | OPEN SPACE RECREATION | ALL |
|---|---|---|---|---|---|---|---|
| 1 | 0.05 | 0.08 | 0.21 | 0.03 | 0.02 | 0.0 | 0.04 |
| 2 | 0.05 | 0.08 | 0.22 | 0.03 | 0.02 | 0.0 | 0.04 |
| 3 | 0.05 | 0.08 | 0.23 | 0.04 | 0.02 | 0.0 | 0.05 |
| 4 | 0.05 | 0.08 | 0.24 | 0.04 | 0.02 | 0.0 | 0.05 |
| 5 | 0.06 | 0.09 | 0.25 | 0.04 | 0.02 | 0.0 | 0.05 |
| 6 | 0.06 | 0.09 | 0.26 | 0.04 | 0.02 | 0.0 | 0.05 |
| 7 | 0.06 | 0.10 | 0.27 | 0.05 | 0.02 | 0.0 | 0.06 |
| 8 | 0.06 | 0.10 | 0.29 | 0.05 | 0.03 | 0.0 | 0.06 |
| 9 | 0.07 | 0.10 | 0.30 | 0.06 | 0.03 | 0.0 | 0.06 |
| 10 | 0.07 | 0.11 | 0.31 | 0.06 | 0.03 | 0.0 | 0.06 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 20 | 0.11 | 0.20 | 0.60 | 0.06 | 0.05 | 0.0 | 0.10 |

USER CHARGES --

TOTAL AMOUNT (DOLLARS) 60742.97

AMOUNT BY LAND USE (IN CURRENT DOLLARS)

| | |
|---|---|
| SINGLE FAMILY LOW DENSITY | 6074.29 |
| SINGLE FAMILY HIGH DENSITY | 6074.29 |
| MULTI-FAMILY | 6074.29 |
| COMMERCIAL | 12148.59 |
| INDUSTRIAL | 30371.48 |
| OPEN SPACE - RECREATION | 0.0 |

$/CAPITA

| YEAR | SINGLE FAMILY LOW DENSITY | SINGLE FAMILY HIGH DENSITY | MULTI-FAMILY | COMMERCIAL | INDUSTRIAL | OPEN SPACE RECREATION | ALL |
|---|---|---|---|---|---|---|---|
| 1 | 0.06 | 0.11 | 0.08 | 12.63 | 1.58 | 0.0 | 0.24 |
| 2 | 0.07 | 0.11 | 0.08 | 12.32 | 0.81 | 0.0 | 0.23 |
| 3 | 0.07 | 0.11 | 0.09 | 12.12 | 0.57 | 0.0 | 0.23 |
| 4 | 0.07 | 0.12 | 0.09 | 12.01 | 0.45 | 0.0 | 0.22 |
| 5 | 0.07 | 0.12 | 0.10 | 11.97 | 0.39 | 0.0 | 0.22 |
| 6 | 0.07 | 0.13 | 0.10 | 11.99 | 0.35 | 0.0 | 0.22 |
| 7 | 0.08 | 0.13 | 0.10 | 12.06 | 0.32 | 0.0 | 0.22 |
| 8 | 0.08 | 0.14 | 0.11 | 12.19 | 0.30 | 0.0 | 0.22 |
| 9 | 0.08 | 0.15 | 0.12 | 12.35 | 0.28 | 0.0 | 0.22 |
| 10 | 0.09 | 0.15 | 0.12 | 11.53 | 0.25 | 0.0 | 0.21 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 20 | 0.13 | 0.28 | 0.23 | 24.18 | 0.43 | 0.0 | 0.37 |

Table 3-2 (continued)

$/1000 GALLONS WASTEWATER

| YEAR | SINGLE FAMILY LOW DENSITY | SINGLE FAMILY HIGH DENSITY | MULTI-FAMILY | COMMERCIAL | INDUSTRIAL | OPEN SPACE RECREATION | ALL |
|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.35 | 0.04 | 0.0 | 0.01 |
| 2 | 0.00 | 0.00 | 0.00 | 0.34 | 0.02 | 0.0 | 0.01 |
| 3 | 0.00 | 0.00 | 0.00 | 0.33 | 0.02 | 0.0 | 0.01 |
| 4 | 0.00 | 0.00 | 0.00 | 0.33 | 0.01 | 0.0 | 0.01 |
| 5 | 0.00 | 0.00 | 0.00 | 0.33 | 0.01 | 0.0 | 0.01 |
| 6 | 0.00 | 0.00 | 0.00 | 0.33 | 0.01 | 0.0 | 0.01 |
| 7 | 0.00 | 0.00 | 0.00 | 0.33 | 0.01 | 0.0 | 0.01 |
| 8 | 0.00 | 0.00 | 0.01 | 0.33 | 0.01 | 0.0 | 0.01 |
| 9 | 0.00 | 0.01 | 0.01 | 0.34 | 0.01 | 0.0 | 0.01 |
| 10 | 0.00 | 0.01 | 0.01 | 0.33 | 0.01 | 0.0 | 0.01 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 20 | 0.00 | 0.01 | 0.01 | 0.66 | 0.01 | 0.0 | 0.01 |

LOCAL GOVERNMENT OPERATION AND MAINTENANCE COSTS FINANCING

YEARLY COST (DOLLARS) 1474.75

USER CHARGES --

TOTAL AMOUNT (DOLLARS) 1474.75

AMOUNT BY LAND USE (IN CURRENT DOLLARS)

| | |
|---|---|
| SINGLE FAMILY LOW DENSITY | 147.48 |
| SINGLE FAMILY HIGH DENSITY | 147.48 |
| MULTI-FAMILY | 147.48 |
| COMMERCIAL | 294.95 |
| INDUSTRIAL | 737.38 |
| OPEN SPACE - RECREATION | 0.0 |

$/CAPITA

| YEAR | SINGLE FAMILY LOW DENSITY | SINGLE FAMILY HIGH DENSITY | MULTI-FAMILY | COMMERCIAL | INDUSTRIAL | OPEN SPACE RECREATION | ALL |
|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.25 | 0.03 | 0.0 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.25 | 0.02 | 0.0 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.24 | 0.01 | 0.0 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.24 | 0.01 | 0.0 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 0.24 | 0.01 | 0.0 | 0.00 |
| 6 | 0.00 | 0.00 | 0.00 | 0.24 | 0.01 | 0.0 | 0.00 |
| 7 | 0.00 | 0.00 | 0.00 | 0.24 | 0.01 | 0.0 | 0.00 |
| 8 | 0.00 | 0.00 | 0.00 | 0.24 | 0.01 | 0.0 | 0.00 |
| 9 | 0.00 | 0.00 | 0.00 | 0.24 | 0.01 | 0.0 | 0.00 |
| 10 | 0.00 | 0.00 | 0.00 | 0.23 | 0.00 | 0.0 | 0.00 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 20 | 0.00 | 0.01 | 0.00 | 0.46 | 0.01 | 0.0 | 0.01 |

Table 3-2 (continued)

$/1000 GALLONS WASTEWATER

| YEAR | SINGLE FAMILY LOW DENSITY | SINGLE FAMILY HIGH DENSITY | MULTI-FAMILY | COMMERCIAL | INDUSTRIAL | OPEN SPACE RECREATION | ALL |
|---|---|---|---|---|---|---|---|
| 1 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |
| 2 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |
| 3 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |
| 4 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |
| 5 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |
| 6 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |
| 7 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |
| 8 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |
| 9 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |
| 10 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 20 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.0 | 0.00 |

Input Variable Dictionary

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|
| 1 | IDEBUG | I1 | 1 | Debug option - <br> = 0 - option off <br> = 1 - option on |
| 2 | IDCARD(I) | 80A1 | 1-80 | Identification card - up to 80 characters to be printed on the top of each new page |
| 3 | ICT(I) | 8I1 | 1-8 | Punch in column J a 1 for each cost type to be studied: <br> J=1 - septic tanks <br> J=2 - sanitary sewer laterals <br> J=3 - sewer building connections <br> J=4 - sanitary sewer trunk/main <br> J=5 - storm sewer laterals <br> J=6 - stormwater detention ponds <br> J=7 - storm sewer trunk/main <br> J=8 - sewage treatment plant |
| 4 | DR | F5.2 | 1-5 | Discount rate in percent |
| 5 | AIR | F5.2 | 1-5 | Interest rate in percent |
| 6 | NACRES | I5 | 1-5 | Number of acres in development |
| 7 | IPOP(LU, ITIME) | 4I9 | 1-36 | For each of six land uses (LU) the projected population/ |

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|
| | | | | population equivalents for the community at four points in time (ITIME):<br>LU=1 - single family (low density)<br>LU=2 - single family (high density)<br>LU=3 - multi-family<br>LU=4 - commercial<br>LU=5 - industrial<br>LU=6 - open space - recreation<br>ITIME=1 - present (T)<br>ITIME=2 - T + 10 yrs.<br>ITIME=3 - T + 25 yrs.<br>ITIME=4 - T + 50 yrs.<br>(six cards) |
| 8 | APVOT(LU, ITIME) | 4F10.2 | 1-40 | For each of the six land uses (LU) the projected assessed values of the community at four points in time (ITIME) in $1000 (6 cards) |
| 9 | APVOD(LU, ITIME) | 4F10.2 | 1-40 | For each of the six land uses (LU) the projected assessed values of the development at four points in time (ITIME) in $1000 (6 cards) |
| 10 | WASTEF(LU) | 3F9.1 | 1-27 | Expected wastewater flows generated by the three residential land uses:<br>WASTEF(1) - single family (low density)<br>WASTEF(2) - single family (high density)<br>WASTEF(3) - multi-family |
| 10 | IPE | I1 | 28 | Land use against which |

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|
| | | | | population equivalents will be based for commercial, industrial and open space - recreational land uses:<br>= 1 - single family (low density)<br>= 2 - single family (high density)<br>= 3 - multi-family |
| 11 | NSFLDU | I6 | 1-6 | Number of single family (low density) housing units in the development |
| 11 | PPULD | F5.2 | 7-11 | Number of persons per unit for single family (low density) housing |
| 12 | NSFHDU | I6 | 1-6 | Number of single family (high density) housing units in the development |
| 12 | PPUHD | F5.2 | 7-11 | Number of persons per unit for single family (high density) housing |
| 13 | NMFB | I6 | 1-6 | Number of multi-family buildings in the development |
| 13 | NUBMF | I6 | 7-12 | Number of units per multi-family building |
| 13 | PPUMF | F5.2 | 13-17 | Number of persons per unit of multi-family housing |

The remaining card types refer to data required for the individual cost types. As many cost types as desired may be examined in a single run. The data deck must be prepared as J=1,8 for the cost types to be run.

Card types 14 and 15 are required as the first two data cards of each cost type J.

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|
| 14 | PSOC(J,1,L) | 4F5.2 | 1-20 | Percentage of the capital cost of cost type J to be financed by group L:<br>L=1 - developer<br>L=2 - local gov't<br>L=3 - state gov't<br>L=4 - federal gov't |
| 15 | PSOC(J,2,L) | 4F5.2 | 1-20 | Percentage of the operation and maintenance cost of cost type J to be financed by group L |
| 16 | ADJUST(J) | 8F5.0 | 1-20 | Multipliers for cost type J (1-8) adjusting for local conditions (Default= 1). |

COST TYPE J=1 - SEPTIC TANKS

| | | | | |
|---|---|---|---|---|
| 1 | PSFL | F5.2 | 1-5 | Percentage of single family (low density) homes in the development to have septic tanks |
| 1 | PSFH | F5.2 | 6-10 | Percentage of single family (high density) homes in the development to have septic tanks |
| 1 | PMF | F5.2 | 11-15 | Percentage of multi-family housing in the development to have septic tanks |
| 1 | CLF | F8.0 | 16-23 | Cost in dollars of the associated leaching field (see section Addition to Program). |

COST TYPE J=2 - SANITARY SEWER LATERALS

| | | | | |
|---|---|---|---|---|
| 1 | TH | F6.0 | 1-6 | Number of townhouse units in the development |

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|
| 1 | GA | F6.0 | 7-12 | Number of garden apartment buildings in the development |
| 1 | AMRA | F6.0 | 13-18 | Number of medium rise apartment buildings in the development |
| 1 | IALPHA | I1 | 19 | Slope characteristic of development:<br>=1 - flat<br>=2 - moderate<br>=3 - steep |
| 1 | IBETA | I1 | 20 | Soil type of development:<br>=1 - hard clay and shales<br>=2 - loose mud, loam, gravel, compacted gravel, till |
| 2 | SIZEP | F10.0 | 1-10 | Population size of development |

COST TYPE J=3 - SEWER BUILDING CONNECTIONS

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|
| 1 | TH | F6.0 | 1-6 | Number of townhouse units in the development |
| 1 | GA | F6.0 | 7-12 | Number of garden apartment buildings in the development |
| 1 | AMRA | F6.0 | 13-18 | Number of medium rise apartment buildings in the development |
| 2 | AL | F6.2 | 1-6 | Average length of building connection to single family and townhouses (in feet) |

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|
| 2 | IALPHA | I1 | 7 | Slope characteristic of development:<br>=1 - flat<br>=2 - moderate<br>=3 - steep |
| 2 | IBETA | I1 | 8 | Soil type of development:<br>=1 - hard clay and shales<br>=2 - loose mud, loam, gravel, compacted gravel, till |
| 3 | AL | F6.2 | 1-6 | Average length of building connection to garden and medium rise apartments (in feet) |

COST TYPE J=4 - SANITARY SEWER INTERCEPTORS

| | | | | |
|---|---|---|---|---|
| 1 | Z | F10.2 | 1-10 | Average depth of trench in feet |
| 1 | D | F10.2 | 11-20 | Diameter of sewer pipe in inches |
| 1 | FT | F10.2 | 21-30 | Length of pipe in feet |

COST TYPE J=5 - STORM SEWER LATERALS

| | | | | |
|---|---|---|---|---|
| 1 | F | F10.4 | 1-10 | Recurrence interval |
| 1 | SG | F10.4 | 11-20 | Average ground slope (feet per 100 feet) |
| 1 | R | F10.4 | 21-30 | Runoff coefficient, C from rational method |
| 1 | DB | F10.4 | 31-40 | Smallest pipe diameter in inches |
| 1 | Q | F10.4 | 41-50 | Total capacity of system in cubic feet per second (CFS) |
| 2 | SIZEP | F10.0 | 1-10 | Population size of |

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|
| | | | | development |

COST TYPE J=6 - STORMWATER DETENTION PONDS

no input(at this time)

COST TYPE J=7 - STORM SEWER INTERCEPTORS

| | | | | |
|---|---|---|---|---|
| 1 | Z | F10.2 | 1-10 | Average depth of trench in feet |
| 1 | D | F10.2 | 11-20 | Diameter of sewer pipe in inches |
| 1 | FT | F10.2 | 21-30 | Length of pipe in feet |

COST TYPE J=8 - SEWAGE TREATMENT PLANT

| | | | | |
|---|---|---|---|---|
| 1 | IRP | I1 | 1 | Community served by regional or community treatment plant; =0 - community; =1 - regional |

Card type 2 is required if IRP=1, i.e., regional plant (card type 1)

| | | | | |
|---|---|---|---|---|
| 2 | PCS | F5.2 | 1-5 | Percentage of the total capital cost to be shared by the community (regional cost sharing agreement) |
| 2 | FC | F10.0 | 6-15 | Fixed annual charge (in dollars) to community (annual share of capital costs) |
| 3 | IPCCF(I) | 17I1 | 1-17 | Treatment plant characterastics - a 1 in the associated column indicates the characteristic is included - a blank indicates not included:<br>Biological Treatment -<br>column characteristic<br>1 activated sludge<br>2 filtration<br>3 sludge pump |

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|
| | | | | 4 sludge digestion<br>5 holding tank<br>6 vacuum filtration<br>7 incineration<br>Physical/Chemical Treatment<br>8 coagulation & sedimentation<br>9 filtration<br>10 carbon adsorption (X2.LE.10 MGD)<br>11 carbon adsorption (X2.GT.10 MGD)<br>(X2 from card type 4)<br>12 chlorination<br>13 sludge pump<br>14 sludge digester<br>15 sludge holding tank<br>16 vacuum filtration<br>17 incineration |
| 4 | X2 | F10.3 | 1-10 | Design flow (MGD) |
| 4 | F | F5.3 | 11-15 | Ancillary works factor |
| 4 | C | F10.3 | 16-25 | $BOD_5$ of wastewater (in mg/l) |

After each set of cost type J data the following card types are required - exceptions are noted.

Card types 1-4 refer to input required for capital costs:

| | | | | |
|---|---|---|---|---|
| 1 | IFM | I1 | 1 | Financing mechanism for local government capital costs:<br>=1 - bond issue<br>=2 - special assessment |

If IFM=1 (card type 1) card types 2,3,4 are necessary; if

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|

IFM=2 they are not included in the data deck.

| | | | | |
|---|---|---|---|---|
| 2 | IPP | I2 | 1-2 | Payback period for bond issue in years (max = 50) |
| 2 | PPT | F5.2 | 3-7 | Percent of bond issue to be repaid from property taxes |
| 2 | PUC | F5.2 | 8-12 | Percent of bond issue to be repaid from user charges |
| 3 | PBUC(LU, K) | 6F5.2 | 1-30 | Percent allocation, by land use, of total revenues to be raised from user charges |
| 4 | PBPT(LU, K) | 6F5.2 | 1-30 | Percent allocation, by land use, of total revenues to be raised from property taxes |

For cost type J=8 only the following card type is necessary:

| | | | | |
|---|---|---|---|---|
| 5 | IFCP | I2 | 1-2 | Number of years until full capacity of treatment plant is reached (max=50) |

Cost types J=1 and J=8 require no further data.

Card types 6-8 refer to input required for the remaining cost types for operation and maintenance costs.

| | | | | |
|---|---|---|---|---|
| 6 | IPP | I2 | 1-2 | Payback period for operation and maintenance costs (max=50) |
| 6 | PPT | F5.2 | 3-7 | Percent of operation and maintenance costs to be repaid from property taxes |
| 6 | PUC | F5.2 | 8-12 | Percent of operation |

| Card Type | Variable Name | FORMAT | Card Columns | Comments |
|---|---|---|---|---|
| | | | | and maintenance costs to be repaid from user charges |
| 7 | PBUC(LU, K) | 6F5.2 | 1-30 | Percent allocation, by land use, of total revenues to be raised from user charges |
| 8 | PBPT(LU, K) | 6F5.2 | 1-30 | Percent allocation, by land use, of total revenues to be raised from property taxes |