

URBAN HIGHWAY STORM DRAINAGE MODEL

Research, Development,
and Technology

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VOL. 7 COST ESTIMATION MODULE

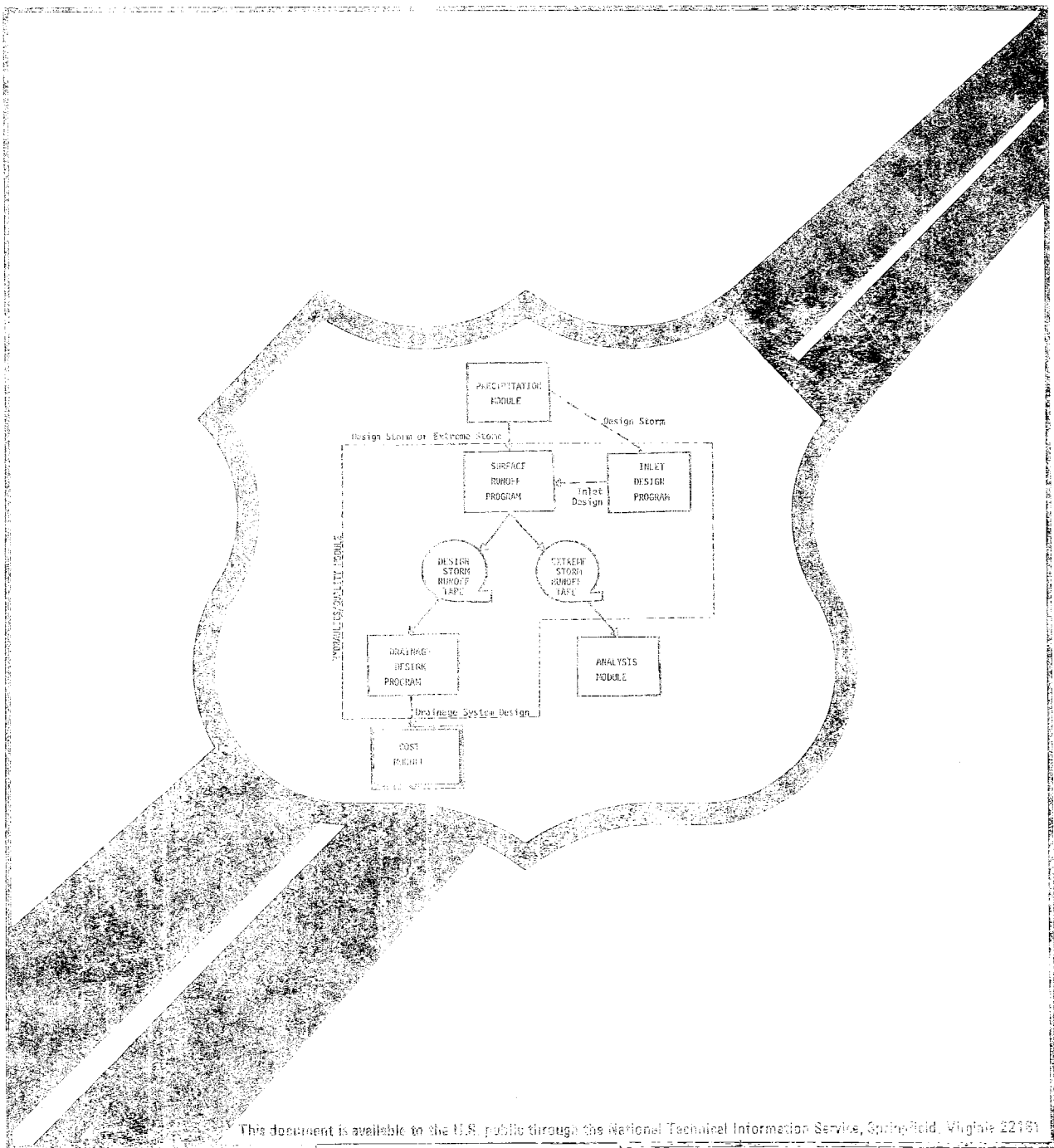
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FOREWORD

This report documents the development and presents the user's manual for the Cost Estimation Module of this computer model. This program estimates, from specified unit cost data, construction, operation and maintenance costs of a drainage system. It is most useful in the relative cost comparison for alternative drainage system designs.

Research and development in urban and rural highway storm drainage is included in the Federally Coordinated Program of Highway Research, Development, and Technology Project 5H "Highway Drainage and Flood Protection." Dr. Roy E. Trent is the Project Manager and Dr. D. C. Woo is the Contracting Officer's Technical Representative for this study.

This report is being distributed on request only due to the specialized nature of the contents.



Richard E. Hay, Director
Office of Engineering
and Highway Operations
Research and Development
Federal Highway Administration

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| 16. Abstract A package of six user-oriented computer programs has been developed and tested for the analysis and design of urban highway drainage systems and related non-point source pollution problems. These programs are organized into four related but independent Modules. This report consists of the documentation and user's manual for the Cost Estimation Module. Construction, operation, and maintenance costs associated with the drainage system can be estimated using this Module. This report is the seventh in a series. The others in the series are: | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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CHAPTER I
OVERVIEW OF THE URBAN HIGHWAY STORM DRAINAGE MODEL

The Urban Highway Storm Drainage Model consists of four modules in six computer programs, developed for the Federal Highway Administration, U.S. Department of Transportation by the Water Resources Division of Camp Dresser & McKee Inc. The basic purpose of this package of programs is to provide the engineer with computational tools to assist in the analysis and design of highway drainage systems. Due to the nature of the problem, this model is not intended to fully automate the design process. Each module or program can be used separately to suit the designer's purpose.

The programs of the model are organized into four related but independent modules, as follows:

- Precipitation Module
- Hydraulics/Quality Module
 - Surface Runoff Program
 - Inlet Design Program
 - Drainage Design Program
- Analysis Module
- Cost Module

The Precipitation Module can perform a variety of statistical analyses on long-term hourly precipitation data and generate design storm hyetographs. The Hydraulics/Quality Module is the basic design tool in the package. This module simulates time-varying runoff quantity and quality, locates stormwater inlets and sizes the conduits of the major drainage system. The Analysis Module simulates unsteady gradually-varied flow in the drainage system and can be used to analyze complex hydraulic conditions,

such as surcharge and backwater, that may be encountered during extreme storm events. The Cost Module can be used to estimate construction, operation and maintenance, and total annual costs associated with the drainage system.

The interrelationships among the computer programs are illustrated by Figure I-1. As can be seen from this figure, there are a variety of ways in which these programs can be used independently or in conjunction with each other. This flexibility should allow the engineer to apply one or more of these programs to a wide variety of common stormwater-related problems. The major features of each of the programs are summarized in Tables I-1 through I-4.

This chapter is intended only to give the reader a broad overview of the Urban Highway Storm Drainage Model. To gain an understanding of the potential applications, the capabilities and the limitations of a particular program in the package, the engineer will need to study the appropriate User's Manual and Documentation Report.

This report is the User's Manual and Documentation Report for the Cost Module. Chapter II of the report is an introduction to this program, describing the general approach used in the program and how the program fits into the drainage design process. The technical approach employed in the program is presented in some detail in Chapter III. Finally, Chapter IV is a complete user's manual for the program including input requirements, a Fortran listing of the program, and an example problem.

The total cost of a drainage system consists of the capital cost and the operation and maintenance cost. The capital cost includes items such as material, labor, insurance, replacement of property, and required fees; the operation and maintenance cost includes cost incurred for energy, repair, cleaning, and replacement of materials.

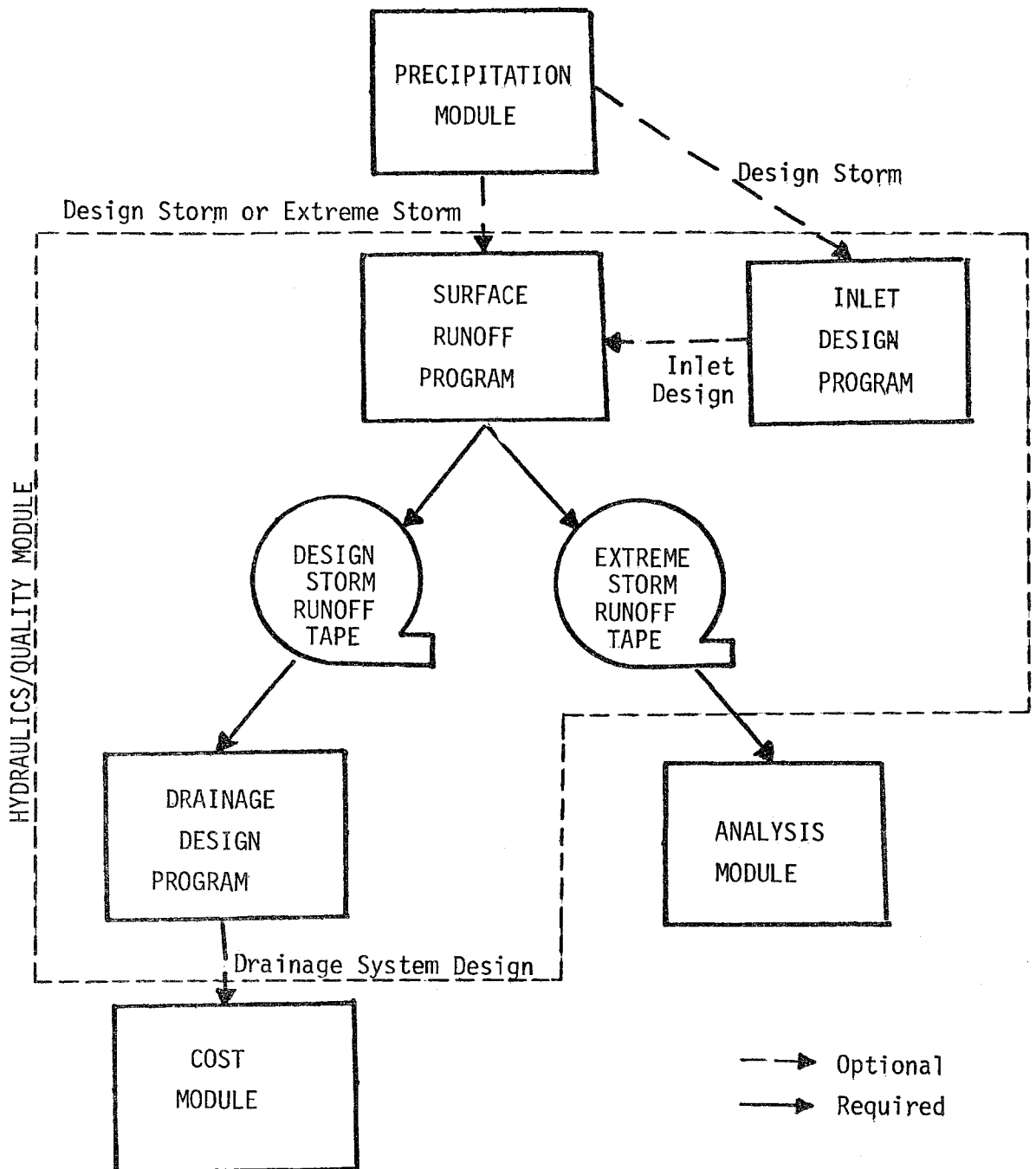


FIGURE 1-1. Urban Highway Storm Drainage Model

TABLE I-1
MAJOR FEATURES OF THE PRECIPITATION MODULE

-
- Derivation of Hyetographs of Selected Return Frequency, Duration, and Skew
 - Statistical Analysis of Hourly Rainfall Records to Generate Intensity-Duration-Frequency Curves
 - Frequency of Occurrence Analysis of Hourly Rainfall Records for Peak Rainfall Intensity, Storm Duration, and Dry Period Duration
 - Statistical Analysis of Hourly Rainfall Records for Storm Skew
-

TABLE I-2
MAJOR FEATURES OF HYDRAULICS/QUALITY MODULE PROGRAMS

INLET DESIGN PROGRAM (INLET)

- Simulation of Time-Varying Runoff and Gutter/Channel Flow
- Spacing of Fixed-Size Inlets in Gutters or Channels
- Prespecification of Inlet Locations if Required
- Simulation of Six Basic Inlet Types

SURFACE RUNOFF PROGRAM (SRO)

- Simulation of Time-Varying Runoff and Gutter/Channel Flow
- Simulation of Accumulation and Washoff of Suspended Solids and Associated Pollutants
- Simulation of All Inlet Types Considered in Inlet Design Program
- Simulation of Four Types of Gutters/Channels
- Generation of Runoff Tape (Inlet Hydrographs and Pollutographs)

DRAINAGE DESIGN PROGRAM (DRAIN)

- Standard Pipe Sizing
 - Sizing of Trapezoidal Open Channels
 - Routing of Pollutants Through Drainage System
 - Simulation of Treatment at Outfalls (Suspended Solids Removal)
-

TABLE I-3
MAJOR FEATURES OF THE ANALYSIS MODULE

-
- Analysis of Extreme Storm Event Hydraulic Conditions in the Major Drainage System Such as Surge, Backwater, and Surface Flooding
 - Simulation of Unsteady Gradually-Varied Flow in the Major Drainage System
 - Simulation of Channels and Pipes of Five Different Cross-Sections
 - Simulation of Pumping Station Operation
-

TABLE I-4
MAJOR FEATURES OF THE COST ESTIMATION MODULE

-
- Calculation of Capital Costs for Construction of Major Drainage Systems
 - Calculation of Operation and Maintenance Costs and Total Annual Costs for Major Drainage Systems
 - Estimation of Excavation and Backfill Volumes Associated with Construction of Major Drainage Systems
-

However, since the highway storm drainage system is a part of the highway system, many items of the cost module are interrelated with other items of a highway system. Therefore, this module cannot be used to calculate the real cost of a highway storm drainage system as such, but it should be used to compare the relative costs of alternate systems for the development of a most cost-effective system.

CHAPTER II

INTRODUCTION TO THE COST ESTIMATION MODULE

In designing the drainage system for an urban highway, the engineer is limited by design criteria, topography, and a host of other physical conditions. In addition to these constraints, the engineer needs to be aware of the financial impact the drainage system will have. Therefore, the cost of constructing and maintaining the drainage system should be an integral part in the selection of the final drainage design.

The initial cost of construction, termed capital cost, includes a wide variety of items such as materials, labor, insurance, replacement of property, and required fees. The monies required to operate and maintain, termed operation and maintenance (O&M) costs, consist of the costs incurred for energy, repair, cleaning, and replacement of materials.

Using available unit cost data for each drainage structure associated with a highway drainage system, the engineer can calculate the capital costs and the O&M costs for his highway drainage project. However, since most drainage projects consist of numerous drainage structures, the engineer needs a helpful tool in determining these costs. The Cost Estimation Module developed for the Federal Highway Administration provides that tool.

GENERAL APPROACH

The Cost Estimation Module, as explained earlier, is one of four modules of the Urban Highway Storm Drainage Design Model developed by CDM for the Federal Highway Administration. The Cost Estimation Module is applied after the Hydraulics/Quality Module, typically.

The Hydraulics/Quality Module allows the engineer to examine and modify, if necessary, the highway drainage system to within specified hydraulic and design criteria. The Cost Estimation Module is then used to evaluate the total cost of the drainage system. It is quite possible that after an estimation of the total cost of the drainage system, further use of the Hydraulics/Quality Module may be warranted to develop a more cost-effective alternative.

Information is supplied to the Cost Estimation Module by the user and by the Hydraulics/Quality Module. User-supplied information includes unit cost data for each cost item in the drainage system. The Hydraulics/Quality Module supplies information about the drainage system layout, pipe sizes, inlets, and manholes. Alternately, the user may apply the Cost Estimation Module to an existing drainage system or to a drainage system design produced by means other than the Hydraulics/Quality Module. All input for the Module is supplied on cards by the user. Figure II-1 shows the input/output structure of the module.

Using the drainage system data and the unit cost information, the Cost Estimation Module calculates the capital and O&M costs of the drainage system. Costs are calculated for each pipe and open channel, termed hereafter as conduits, and each inlet, manhole, and special appurtenance, hereafter termed junctions. The Module also calculates the volume of excavation and backfill associated with each junction and conduit. If unit cost data are available for excavation and backfill, these costs are also calculated and included in the capital cost of each structure. Calculations can be done in either British or metric units.

The capital costs calculated for each junction and conduit are amortized, and a capital recovery cost for each junction and conduit is calculated. The O&M costs and the capital recovery costs are combined to determine the total annual costs for each conduit and junction.

DRAINAGE SYSTEM DATA

UNIT COST DATA

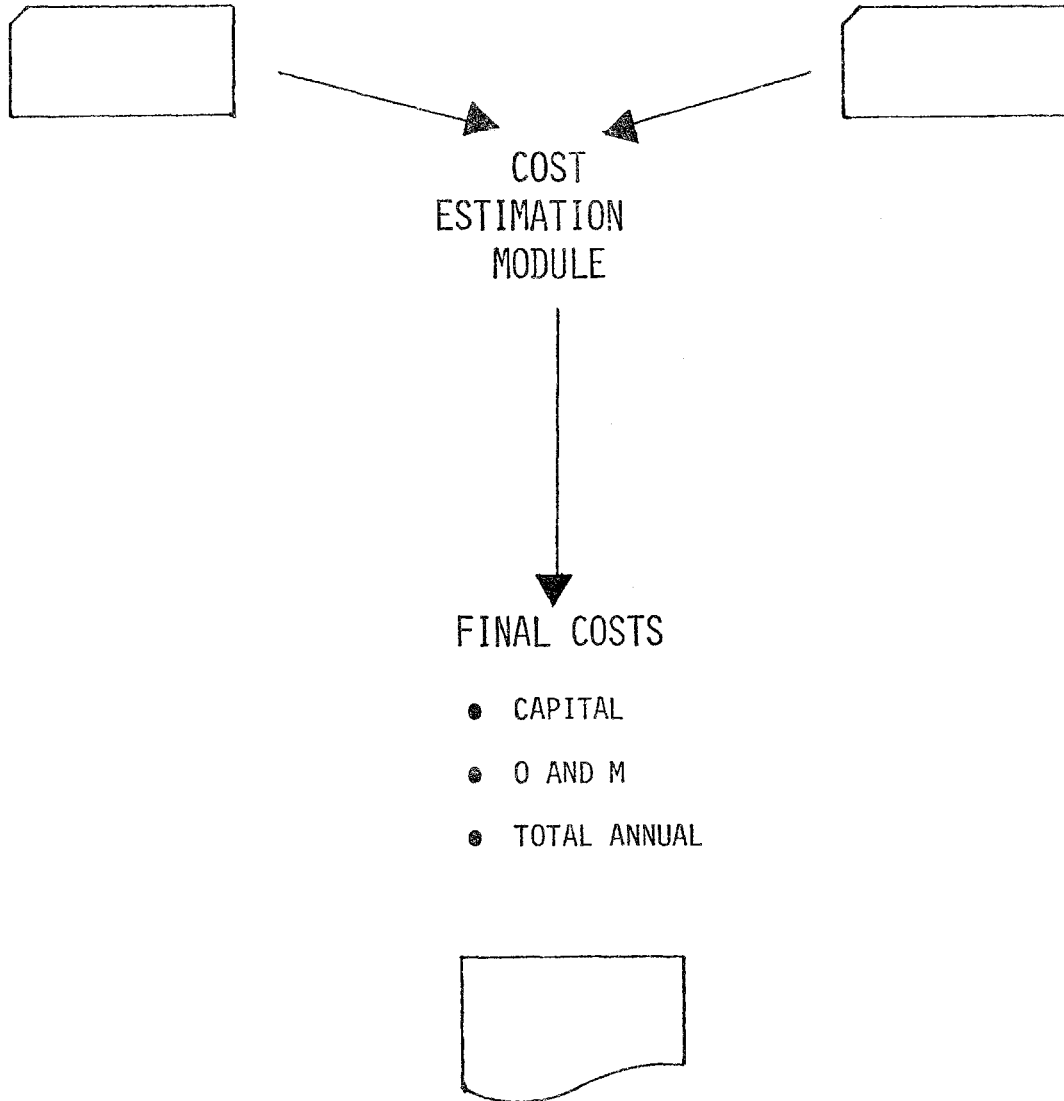


FIGURE II-1. Cost Estimation Module
Input/Output Structure

CAPABILITIES AND LIMITATIONS

The Cost Estimation Module has the capability of calculating for each junction and conduit the following information:

- the volume and cost of excavation,
- the volume and cost of backfill,
- the capital cost including installation costs,
- the O&M costs, and
- the total annual costs.

Inherent in the development of the procedures used to determine the above mentioned items are the following assumptions:

- unit costs are up-to-date and do not need time or geographical adjustments,
- installation costs, if available, are a percentage of of the unit costs,
- O&M costs are a percentage of the unit costs,
- labor and materials are combined in the O&M costs,
- excavation and backfill volumes are based on the highway grade line, and
- no bedrock is encountered during excavation.

In addition to the assumptions made in the development of the Module, there are several limitations imposed on the Module. These limitations are:

- only 100 junctions and 100 conduits can be simulated at once,
- unit costs for conduits must be in dollars per linear foot or meter, and
- unit costs for junctions must be in dollars per vertical foot or meter or dollars per structure.

COMPUTER REQUIREMENTS

The Cost Estimation Module was developed and run on a CDC 6600/6700 shared system at the Naval Ship Research and Development Center in Carderock, Maryland. The program requires approximately 64000₈ words of core for storage. Execution on the CDC 6600/6700 system requires approximately 2.5 seconds for each set of 10 junctions and 10 conduits. Execution time for 10 junctions and 10 conduits is reduced to a minimum of 1.5 seconds if specific options are not selected.

CHAPTER III

TECHNICAL APPROACH

This chapter of the Cost Estimation Module User's Manual describes the technical approach used in calculating for each junction and conduit the following information:

- the volume and cost of excavation
- the volume and cost of backfill
- the capital cost including installation costs
- the O&M costs
- the total annual costs.

Inherent in the development of the procedures used to determine the above mentioned items are the following assumptions:

- unit costs are up-to-date and do not need time or geographical adjustments;
- installation costs, if available, are a percentage of the unit costs;
- O&M costs are a percentage of the unit costs;
- labor and materials are combined in the O&M costs;
- excavation and backfill volumes are based on the highway grade line;
- no bedrock or special subsurface conditions are encountered during excavation;
- all excavation is done in trenches with vertical walls.

In addition to the assumptions made in the development of the Module, there are several limitations imposed on the Module. These limitations are:

- only 100 junctions and 100 conduits can be simulated at once;
- unit costs for conduits must be in dollars per linear foot or dollars per linear meter;
- unit costs for junctions must be in dollars per vertical foot, dollars per vertical meter, or dollars per structure.

The remainder of this chapter presents the technical approach in some detail. In discussing the approach, the equations presented contain constants where appropriate in the British system of units. Equivalent equations for calculations in metric units are contained in the program, but are not presented herein for the sake of simplicity.

GENERAL APPROACH

As stated earlier, the Cost Estimation Module reads user-supplied cards containing the drainage system configuration. This information describes each junction and conduit with respect to the size of each structure. To identify each junction and conduit in the drainage system, a code number must be established for each drainage structure by the user. These code numbers are described below.

The Cost Estimation Module calculates for each junction and conduit an excavation volume, a backfill volume, a capital cost, an O&M cost, an installation cost, and an annual cost. These parameters are presented for each junction and conduit and are also summed by similar code numbers. This gives the engineer an estimate of the total quantities and costs for specific types of drainage structures.

CONDUITS

Each conduit must be assigned a five-digit code number. For conduits the first digit must be 3; the second digit denotes the type of conduit. The required code numbers are as follows:

- 31000-31999 Pipe
- 32000-32999 Open channel

The last three digits of the conduit code number state the pipe diameter or the channel width. For example, a 48-inch pipe will have a code number of 31048, while a 3-foot-wide open channel will have a code number of 32036.

The engineer must determine which code numbers will be used in identifying the drainage system. For each different conduit code number, the engineer supplies the appropriate cost information, which will vary depending on the detail of costing desired. In addition to the cost information supplied for each separate cost code number, the engineer may also input cost information relating to excavation and backfill procedures if these costs are known.

The Cost Estimation Module calculates for each conduit an excavation volume, a backfill volume, a capital cost, an O&M cost, an installation cost, and an annual cost. These parameters are presented for each conduit and are also summed by similar code numbers. This gives the engineer an estimate of the total quantities for a specific type of drainage structure.

For each cost code number used by the engineer, the Cost Estimation Module calculates the total quantity, the total capital cost, the total installation cost, the total annual cost, and the total O&M costs. Also given are the total volume and cost of excavation and backfill associated with the drainage structures of the particular code number. If the unit costs given for the cost code number include excavation and backfill costs, then only the volume of excavation and backfill are calculated, and the costs are zero.

JUNCTIONS

Each junction is assigned a four-digit code number which describes the junction type and the junction opening length. At this time, the

Module can handle four general types of junctions. These four types of junctions are a curb opening inlet (TYPE 1), a grate inlet (TYPE 2), a combination curb opening and grate inlet (TYPE 3), and a standard manhole or appurtenance (TYPE 4). To identify the type of junction, the following code numbers must be used:

- 4100 - 4199 Curb Opening Inlet (TYPE 1)
- 4200 - 4299 Grate Inlet (TYPE 2)
- 4300 - 4399 Combination Inlet (TYPE 3)
- 4400 - 4999 Manhole or Special Appurtenance (TYPE 4)

As can be seen by the code numbers, the second digit of the code identifies the type of junction.

If the junction has been identified as an inlet (i.e., code numbers 4100 to 4399), further information is needed to describe each junction. Each inlet has an opening length which may vary according to design criteria. The last two digits of the junction code number are used to identify the inlet opening length in feet or meters. For example, code number 4112 signifies a junction which is a Type 1 inlet with an opening length of 12 feet.

If the junction is a manhole, the code number is 4400. (There is of course no opening length associated with manholes.) If the drainage system has any special appurtenances, they are treated as junctions with the code number greater than 4400. For example, if the outlet of the drainage system includes an 84-inch endwall, a code number of 4500 may be used for the endwall.

Analogous input is required and output produced for junctions as described above for conduits.

EXCAVATION

In a highway drainage project, the amount of excavation required to install the drainage structures varies tremendously from one point in

the system to another. In situations where large volumes of excavation are required to establish the highway grade (i.e., a cut), the excavation associated with the drainage system is an easily identifiable entity. However, in situations where extra material is needed to establish the highway grade (i.e., a fill), there is no excavation attributable to the highway drainage system.

In the Cost Estimation Module all excavation is calculated based on the final highway grade line and the bottom elevation of the junctions and assumes no bedrock is encountered. This allows for the separation of highway excavation and subsurface drainage excavation, especially in cut situations. During fill situations, all excavation is assumed to be zero.

The calculation of the excavation required for each junction is based on the input values of the highway grade elevation, the junction bottom elevation, and the junction opening length. If a junction is a manhole, the opening length is assumed to be four feet which is the standard length of a manhole.

The volume of excavation for each junction is calculated by adding the volume of the junction to an additional clearance volume required for construction. The excavation volume is calculated by:

$$EXJNC = VOLJ + BKFLJN \quad (III-1)$$

where

$$EXJNC = \text{volume of junction excavation, yd}^3$$

$$VOLJ = \text{volume of junction, yd}^3$$

$$BKFLJN = \text{volume of backfill, yd}^3$$

The volume of the junction is calculated by:

$$VOLJ = (ELGD-ELINV)*(OPEN + 1.33)*(LGSTP + 1.33)/27.0 \quad (III-2)$$

where

ELGD = highway grade elevation, feet
ELINV = junction bottom elevation, feet
OPEN = junction opening length, feet
LGSTP = diameter of downstream conduit, feet

The number 1.33 accounts for 8-inch walls of the junction (1.33 feet). If a junction is a manhole, OPEN is assumed to be four feet. The calculation for the backfill BKFLJN is described below.

The excavation required to place each conduit is calculated using the following equation:

$$\text{EXPIPE} = \frac{(\text{DEPTH1} * \text{LEN} + (\text{DEPTH2} - \text{DEPTH1}) * \text{LEN}/2.0) * (\text{DIA} + 2.0)}{27.0} \quad (\text{III-3})$$

where

EXPIPE = volume of conduit excavation, yd³,
DEPTH1 = depth of the upstream junction calculated from ELGD1 - ELINV1 where ELGD1 and ELINV1 are the highway grade elevation and the junction bottom elevation, respectively, of the upstream junction in feet,
LEN = length of the conduit, feet
DEPTH2 = the depth of the downstream junction calculated similar to DEPTH1, feet, and
DIA = conduit diameter or channel width, feet.

The number 2.0 added to the conduit diameter or width accounts for the 1-foot clearance on each side of the conduit needed for construction.

It was assumed that the excavation required for each junction ends where the conduit begins. This allows for specific volumes of excavation to be attributed to each junction and each conduit. Figure III-1 shows a typical junction/conduit combination and the excavation associated with each.

If either end of the conduit is connected to a junction which is in a fill situation, the conduit excavation is reduced to half the amount calculated. If both ends of the conduit are attached to junctions in fill situations, then the conduit excavation is assumed to be zero.

Once the volume of excavation has been determined for each junction and conduit, the cost of that excavation can be calculated if so desired. If the unit costs supplied by the engineer for the junctions and conduits include excavation and installation of the structure, then the cost of excavation will not be calculated as a separate item.

If excavation costs are included in one structure's unit cost, then the excavation costs must be included in all the unit costs provided. In other words, if one unit cost includes excavation, then the excavating costs for all structures will be zero.

BACKFILL

After a drainage structure has been placed in the ground, the excavated material is usually used to cover (i.e., backfill) the structure. In some cases, however, state highway drainage requirements demand a special type of backfill for various reasons. The Cost Estimation Module calculates the volume of backfill required for each junction and conduit, and if special backfill material is required, that volume is also calculated.

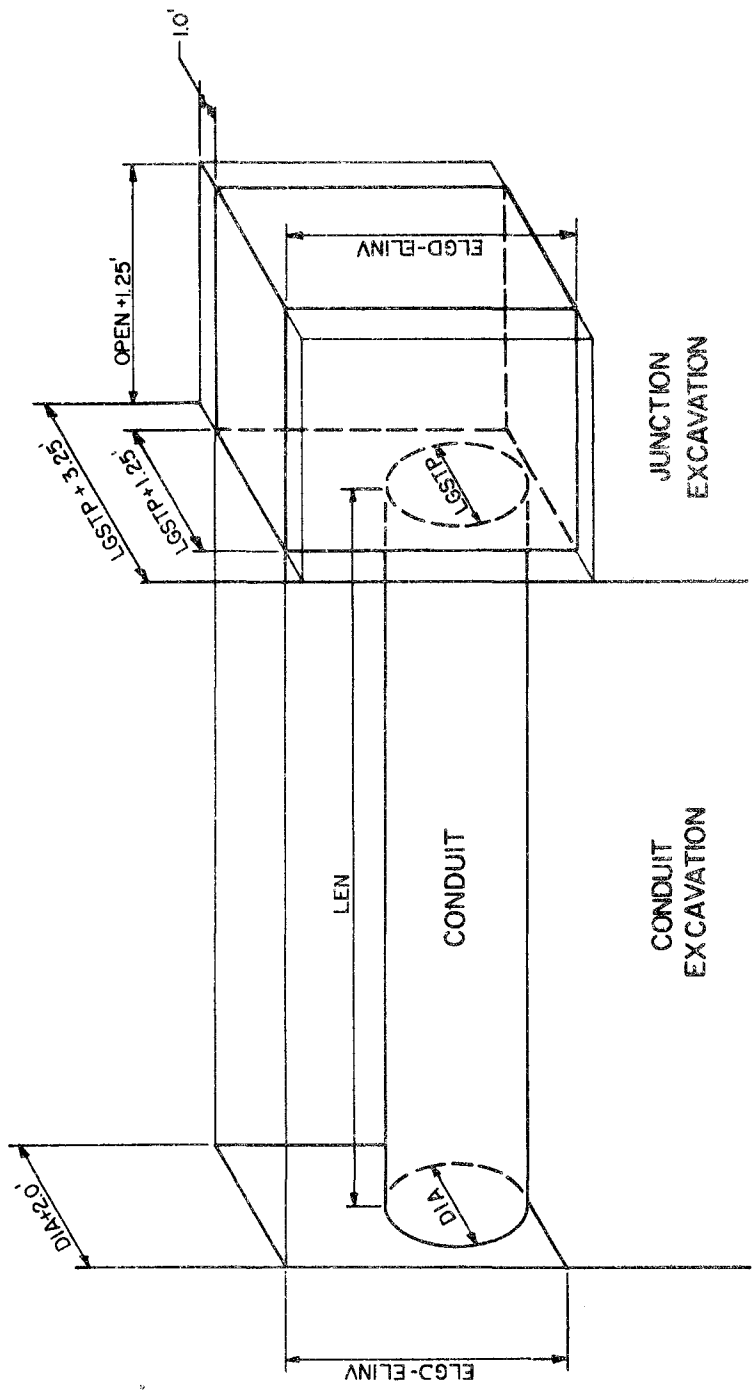


FIGURE III-1. Typical Junction/Conduit Excavation

The volume of backfill required for each junction is the additional clearance volume necessary for excavation. The backfill is calculated by using the following equation:

$$\text{BKFLJN} = 2.0 * \text{OPEN} * (\text{ELGD} - \text{ELINV}) / 27.0 \quad (\text{III-4})$$

The number 2.0 accounts for one foot of extra clearance on each side of the junction. The assumption that all excavation is done in trenches with vertical walls is implicit in this equation and the other equations for excavation and backfill given in this chapter.

The backfill of the conduits is calculated in a manner similar to the junctions. The volume of a placed concrete conduit is subtracted from the conduit excavation calculated in Equation III-2. The volume of the conduit is:

$$\text{VOLP} = (3.14159 * \text{LEN} * (\text{DIA}^2 / 4.0)) / 27.0 \quad (\text{III-5})$$

where

$$\text{VOLP} = \text{conduit volume, yd}^3.$$

The thickness of the conduit is considered negligible in these calculations.

If the conduit is an open channel, the backfill for the conduit is assumed to be zero. Since there is no channel volume which will be occupying part of the excavated trench, the backfill cannot be calculated. The trench excavated for an open channel is assumed to be the open channel.

If special backfill is required, the volume needed is calculated for conduits only. The engineer inputs to the Module a percentage of the conduit diameter requiring special backfill. For example, if state

drainage requirements demand that all conduits placed in a certain type of soil are required to be covered by gravel, then the design engineer notes those conduits requiring the backfill and inputs a percentage of 100. The special backfill is calculated using the following equation:

$$\text{SPBKFLP} = \frac{((\text{TEMP} * \text{DIA}) * (\text{DIA} + 2.0) * \text{LEN}/27.0)}{(\text{VOLP} * \text{TEMP})} \quad (\text{III-6})$$

where

SPBKFLP = special backfill volume, yd³,
TEMP = percentage of diameter covered by special backfill,
DIA = pipe diameter, feet,
VOLP = pipe volume, yd³, and
LEN = pipe length, feet.

Once the backfill for each junction and conduit has been calculated, the costs of placing the backfill can be determined. If special backfill is required for one or more conduits, the user must supply a unit cost for the special backfill. Then for every conduit which requires special backfill, a total cost of the special backfill will be calculated.

If the cost of normal backfill is included in the unit cost of the junction or conduit, or if normal backfill is not considered to be a separate pay item, then the cost of normal backfill will not be presented as a separate cost item. The volume of normal backfill for each structure will still be calculated and listed for each structure, but the costs will be zero.

CAPITAL COSTS

Capital costs, as stated earlier, represent the initial costs of construction. These construction costs include the cost of materials, the cost of installation, the cost of excavation, and the cost of normal and/or special backfill.

The Cost Estimation Module requires a unit cost for each distinct code number used in identifying the drainage system. All separate conduit code numbers require a unit cost in dollars per unit length. Each separate junction code number must have a unit cost expressed in dollars per unit of depth or dollars per structure. These units costs, however, can consist of various construction costs which affect the other cost data required by the Module.

The unit costs provided by the engineer may consist of several combinations of the four construction costs mentioned earlier. These combinations of costs are:

- materials only,
- materials plus installation,
- materials plus excavation,
- materials plus backfill,
- materials, installation, and excavation,
- materials, installation, and backfill, and
- materials, installation, excavation, and backfill.

When the unit cost available to the engineer consists of only the price of materials, then the engineer needs the costs for installation, excavation, and backfill if an accurate estimate of capital costs is desired. If these costs are not available and cannot be input to the Module, the program assumes that whichever costs are input as zero are included in the given unit cost.

When the unit costs supplied by the engineer include excavation and/or backfill, costs for these two items are not required. Again, if the cost of excavation and/or backfill are input as zero, they are assumed to be included in the unit cost. It must be noted again that special backfill costs are never included in the unit costs.

If the unit costs given for each distinct code number include the cost of materials and the cost of installing that particular structure, separate installation costs are not required. If the unit costs do not contain installation, then the installation costs assigned to each code number are given as a percentage of the unit costs. For example, if the unit cost of code number 31012 (i.e., a 12-inch concrete conduit) is given as \$48.00 per linear foot (l.f.) and does not include placing the conduit in the ground, and the known installation cost is \$12/l.f., then the installation cost must be input to the Module as 25 percent.

By using installation costs as a percentage of unit costs, the option of estimating the installation costs is available. If an actual installation cost is unknown, and the unit cost for the item does not include installation, then an estimate of the installation percentage can be made. This allows the engineer to obtain a more representative capital cost for each junction and conduit if his unit cost includes only materials.

The total capital cost of each drainage structure is calculated by the Module as the sum of the given unit cost, installation cost, excavation cost, and backfill cost. Using total capital costs allows the engineer to compare several design alternatives using different types of conduits and/or junctions.

OPERATION AND MAINTENANCE COSTS

After a highway drainage system has been built, there is an annual appropriation of monies required to operate and maintain the system. When designing the initial drainage system, the engineer needs to examine the effects of capital costs versus O&M costs and determine the most cost-effective system while still meeting design requirements.

Usually, the operation and maintenance of the highway drainage system is distributed among several political jurisdictions. This decentralization of responsibilities inhibits the collection of adequate O&M cost data. The design engineer does not have readily available O&M cost data for the separate drainage structures he is including in the designed system. Therefore, if the engineer desires an analysis of the drainage system's O&M costs and he has some knowledge of these costs, the Cost Estimation Module will calculate O&M costs for each junction and conduit and provide a summary by each distinct cost code number.

The Cost Estimation Module calculates the O&M cost based on a percentage of the unit cost supplied for each separate code number. If the engineer desires the O&M cost analysis, he must supply as input a percentage of each given unit cost which he estimates will represent the O&M cost of that particular drainage item. For example, given a unit cost of \$500 for a four-foot long grate inlet junction, code number 4204, and an estimated annual maintenance cost of \$50., the user would input a value of 10 percent for the annual O&M cost for this item.

Calculating O&M costs as a percentage of known unit costs allows the engineer to use actual O&M data if he has the information available or to estimate the expected O&M costs. Since the costs generated will be used primarily for comparative purposes in examining alternative drainage design, the percentage of unit cost method will allow that comparison with the minimal amount of O&M cost data that is available to most design engineers.

ANNUAL COSTS

The final set of cost calculations performed by the Cost Estimation Module are the total annual costs. The total annual cost for each junc-

tion and conduit are calculated based on the design life for each structure and a single interest rate.

If the engineer desires an annual cost analysis, he provides as input to the Module a design life or amortization period for each cost code number and an interest percentage rate. A capital recovery cost is calculated for each structure using the given interest rate, the appropriate amortization period, and the calculated total capital cost of each drainage structure.

The capital recovery cost is the annual payment required to repay the capital investment needed to construct the drainage system. The capital recovery cost for each junction and conduit is calculated from the following equation:

$$\text{ANCST} = \frac{\text{TCAP} * (\text{RATE} * (1.0 + \text{RATE})^{\text{DSGN}})}{((\text{RATE} + 1.0)^{\text{DSGN}} - 1.0)} \quad (\text{III-7})$$

where,

- ANCST = capital recovery cost, \$/yr,
- TCAP = total capital cost of the structure, \$,
- RATE = interest rate,
- DSGN = amortization period or design life, years.

The capital recovery cost equals the annual expenditures required for capital investment repayment. The total annual cost, however, is the sum of the capital recovery cost plus the calculated O&M cost. If O&M costs are not calculated and the annual cost analysis is desired, the total annual cost equals the calculated capital recovery cost determined for each junction and conduit. As with the other costs calculated, the total annual costs are summed by each distinct cost code number.

CHAPTER IV
USER'S MANUAL

The Cost Estimation Module requires input data describing the drainage system and relevant unit cost and annual cost information. This chapter provides detailed input data requirements and gives guidance for the preparation of the required data. The second section of the chapter is a detailed description of the program itself, including a Fortran listing and flowcharts. Finally, the input and output from an example problem are presented.

INPUT DATA REQUIREMENTS

The total data input requirements for the Cost Estimation Module are illustrated in Figure IV-1 and given in Table IV-1. Table IV-1 is organized into eight card groups which are as follows:

- Card Group 1: Title
- Card Group 2: Run Options
- Card Group 3: Materials Cost Information
- Card Group 4: Excavation Cost Information
- Card Group 5: Backfill Cost Information
- Card Group 6: System Junction Data
- Card Group 7: System Conduit Data
- Card Group 8: Annual Cost Data

Table IV-1 shows for each card group the keypunch format, the card columns where the variable is located, a variable description, the variable name, and the default value, if any. Each card group is explained in more detail below.

Card Group One: Title

Card Group One consists of one card containing an alphanumeric descriptor of the run being made. The title is printed at the upper left hand corner of each page of output. This allows the user to identify each run.

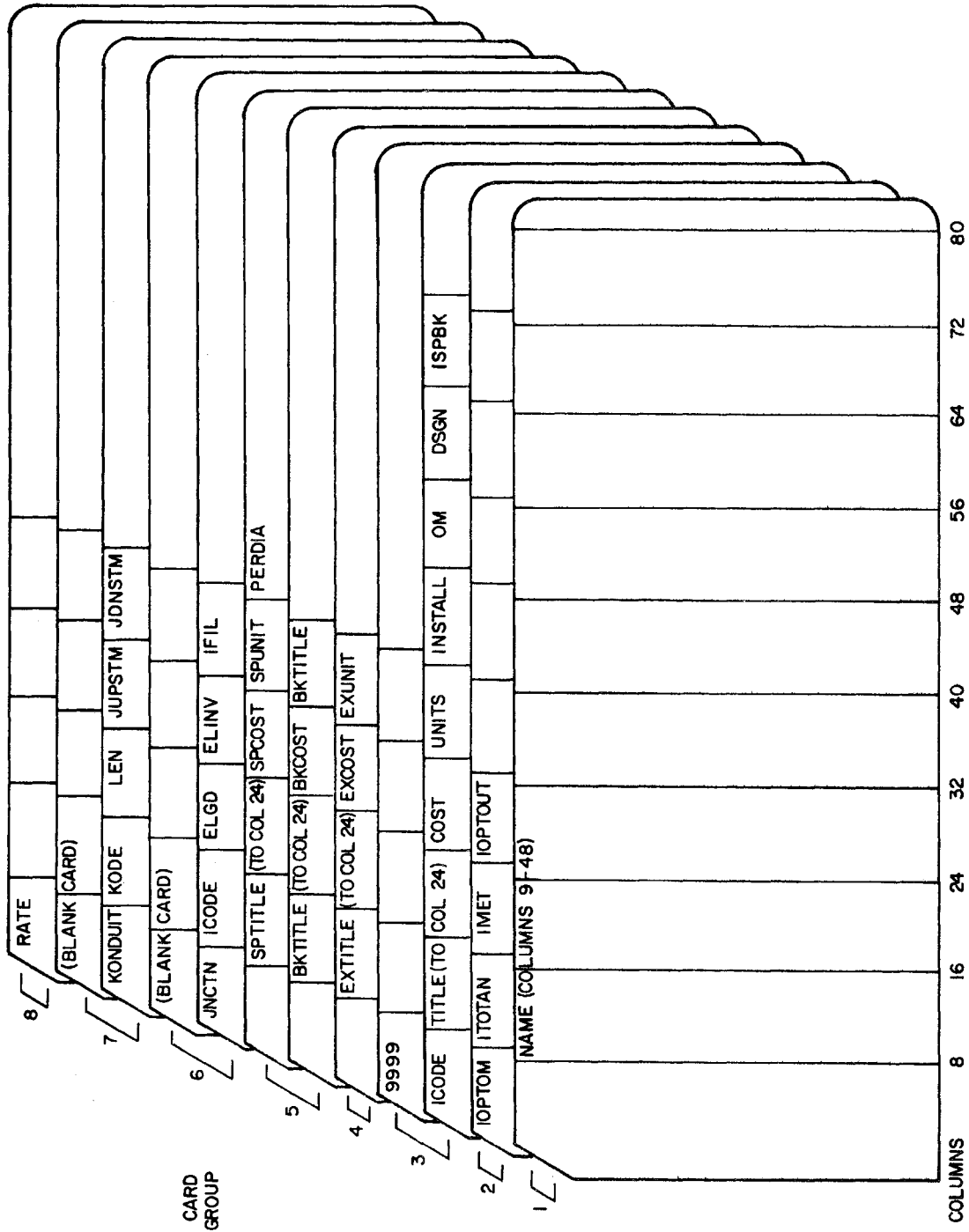


FIGURE IV-1. Sample Card Input System

TABLE IV-1
COST MODULE INPUT DATA REQUIREMENTS

| Card Group | Format | Card Column | Description | Variable Name | Default Value |
|------------|--------|-------------|---|---------------|---------------|
| | | | TITLE CARD - 1 card | | |
| 1 | 10A4 | 9-48 | Title (printed with heading at the top of every page) | NAME | None |
| | | | OPTION CARD - 1 card | | |
| | | | Except where noted, 0 = No and 1 = Yes. | | |
| 2 | 5I8 | 1-8 | O&M Cost Analysis Option | IOPTOM | 0 |
| | | 9-15 | Annual Cost Analysis Option | ITOTAN | 0 |
| | | 16-24 | Units Option (IMET =0 - British Units) (IMET =1 - Metric Units) | IMET | 0 |
| | | 25-32 | Short Output Option | IOPTOUT | 0 |
| 3 | | | MATERIALS CARD - 1 card | | |
| | I8 | 1-8 | Code Number | ICODE | None |
| | 4A4 | 9-24 | Title of Material (left-justified) | TITLE | None |
| | F8.0 | 25-32 | Unit Cost of Material (\$/unit) | COST | None |
| | 2A4 | 33-40 | Title of Units (left-justified) | UNITS | None |
| | F8.0 | 41-48 | Installation Percentage | INSTALL | None |
| | F8.0 | 49-56 | Annual O&M Percentage | OM | None |
| | F8.0 | 57-64 | Design Life (years) | DSGN | None |

TABLE IV-1 (Continued)
COST MODULE INPUT DATA REQUIREMENTS

| Card Group | Format | Card Column | Description | Variable Name | Default Value |
|------------|--------|-------------|---|---------------|-----------------------------------|
| | I8 | 65-72 | Special Backfill Indicator (0=no) (1=yes) | ISPBK | 0 |
| | | | Repeat Card Group 3 for each distinct code number. End Card Group 3 with single card with ICODE=9999. | | |
| 4 | | | EXCAVATION CARD - 1 card | | |
| | 4A4 | 9-24 | Title of Excavation (left-justified) | EXTITLE | None |
| | F8.0 | 25-32 | Unit Cost of Excavation (\$/yd ³ or \$/m ³) | EXCOST | None |
| | 2A4 | 33-40 | Title of Units (left-justified) | EXUNIT | yd ³ or m ³ |
| | | | BACKFILL CARDS - 2 cards | | |
| 5A | 4A4 | 9-24 | Title of Backfill (left-justified) | BKTITLE | None |
| | F8.0 | 25-32 | Unit Cost of Backfill (\$/yd ³ or \$/m ³) | BKCOST | None |
| | 2A4 | 33-40 | Title of Units (left-justified) | BKUNIT | yd ³ or m ³ |
| | | | Omit Card 5B when ISPBK equals zero on all cards of Card Group 3. | | |

TABLE IV-1 (Continued)
COST MODULE INPUT DATA REQUIREMENTS

| Card Group | Format | Card Column | Description | Variable Name | Default Value |
|------------|--------|-------------|--|---------------|-----------------------------------|
| 5B | 4A4 | 9-24 | Title of Special Backfill (left-justified) | SPTITLE | None |
| | F8.0 | 25-32 | Unit Cost of Special Backfill (\$/yd ³ or \$/m ³) | SPCOST | None |
| | 2A4 | 33-40 | Title of Units (left-justified) | SPUNIT | yd ³ or m ³ |
| | F8.0 | 41-48 | Diameter Percentage Covered by Special Backfill | PERDIA | None |
| 6 | | | SYSTEM JUNCTION CARD - 1 card | | |
| | I8 | 1-8 | Junction Number | JNCTN | None |
| | I8 | 9-16 | Junction Code Number | JCODE | None |
| | F8.0 | 17-24 | Highway Grade Elevation (feet or meters) | ELGD | None |
| | F8.0 | 25-32 | Junction Bottom Elevation (feet or meters) | ELINV | None |
| | I8 | 33-40 | Fill Situation Indicator (0=no (1=yes)) | IFIL | 0 |
| | | | Repeat Card Group 6 for every junction in the system. End Card Group 6 with a single blank card. | | |

TABLE IV-1 (Continued)
COST MODULE INPUT DATA REQUIREMENTS

| Card Group | Format | Card Column | Description | Variable Name | Default Value |
|------------|--------|-------------|--|---------------|---------------|
| 7 | | | SYSTEM CONDUIT CARD - 1 card | | |
| | I8 | 1-8 | Conduit Number | KONDUIT | None |
| | I8 | 9-16 | Conduit Code Number | KODE | None |
| | F8.0 | 17-24 | Conduit Length (feet or meters) | LEN | None |
| | I8 | 25-32 | Upstream Junction | JUPSTM | None |
| | I8 | 33-40 | Downstream Junction | JDNSTM | None |
| | | | Repeat Card Group 7 for every conduit in the system. End Card Group 7 with a single blank card. | | |
| | | | Omit Card Group 8 if variable ITOTAN in Card Group 2 is zero. | | |
| 8 | | | ANNUAL COST DATA CARD - 1 card | | |
| | F8.0 | 1-8 | Interest Rate | RATE | None |

Card Group Two: Run Options

Card Group Two is a single card defining four options available to the user. The first option is the operation and maintenance cost analysis option. If the user wants this analysis, IOPTOM should be set equal to one on this card and O&M data should be supplied in Card Group Three, described below. If the user does not want this analysis, IOPTOM should be set equal to zero.

The second option is the annual cost analysis option. If the user wants this option, ITOTAN should be set equal to one and the necessary data supplied in Card Groups Three and Eight, described below. ITOTAN should be set equal to zero if the user does not want this analysis.

The third option is the units option. If IMET is set equal to zero, all input and output will be in British units. If IMET is set equal to one, all input and output will be in metric units.

The fourth option is the short output option. If IOPTOUT is set equal to one, a short output consisting of only the total project costs is printed. If IOPTOUT is set equal to zero, detailed output is provided. Chapter IV shows an example of the detailed output.

Card Group Three: Materials Cost Information

Card Group Three describes the cost information required by the Module. One card is required for each different cost code number (i.e., for each different type and size drainage structure).

The standard cost code numbers required were described in Chapter II of this manual. To reiterate, each conduit type and size requires a five-digit code number, as follows:

- 31000-31999 Pipe
- 32000-32999 Open Channel

The last three digits of the conduit code number give the pipe diameter or the channel width in inches or centimeters. For example, a 48-inch pipe would have a code number of 31048, while a one-meter wide open channel would have a code number of 32100. Each junction type and size requires a four-digit code number as follows:

- 4100-4199 Curb Opening Inlet (Type 1)
- 4200-4299 Grate Inlet (Type 2)
- 4300-4399 Combination Inlet (Type 3)
- 4400-4999 Manhole or Special Appurtenance (Type 4)

For inlets, the last two digits give the inlet opening length in feet or meters. For example, code number 4204 describes a grate inlet four feet in length.

Unit costs for conduits should be supplied in dollars per linear foot or linear meter. Costs for junctions should be supplied in dollars per structure, dollars per vertical foot, or dollars per vertical meter. If the cost of installation is included in the unit cost, then the installation percentage INSTALL need not be supplied.

If the O&M cost analysis option has been selected, then OM, the O&M cost as a percentage of unit cost, must be input. The design life DSGN should be supplied if the annual cost option has been selected. The special backfill indicator ISPBK should be set equal to one if a special backfill is required for some or all of the conduits. It should be noted that the special backfill option is available only for conduits, not for junctions.

Card Group Four: Excavation Cost Information

Card Group Four consists of one card describing the excavation cost information. If the unit costs provided in Card Group 3 include excavations, then the unit cost EXCOST here should be set equal to zero. Otherwise, a unit cost for excavation in dollars per cubic yard or cubic meter should be given.

Note that if a unit cost for excavation is supplied here, then this cost will be applied to the excavation required for all conduits and junctions. If, on the other hand, the excavation cost is to be included in the materials unit costs, then it must be included for all the cost code numbers of Card Group Three.

Card Group Five: Backfill Cost Information

Card Group Five consists of one card if no special backfill is required and two cards if special backfill is required. The first card, which must always be supplied, is analogous to the excavation cost card described above. BKCOST, a unit cost for backfill in dollars per cubic yard or cubic meter, must be supplied unless the cost of backfill is included in the materials unit costs of Card Group Three.

If the special backfill indicator ISPBK is used for even one conduit type in Card Group Three, then the second card of this card group must be inserted. The unit cost of the special backfill must be given in dollars per cubic yard or cubic meter. The final variable in this card, PERDIA, allows the user to specify how much of the excavation must be backfilled with the special backfill. PERDIA is the depth of special backfill as a percentage of the conduit diameter. If the entire trench must be backfilled with special backfill, then PERDIA should be set equal to 100. If half the depth of the trench needs special backfill, then PERDIA should be set equal to 50. Note that a non-zero value must be supplied for PERDIA if special backfill is used.

Card Group Six: System Junction Data

A single card must be supplied for each junction in the system. The user should first identify the junctions in his system with a consecutive numbering scheme that he finds convenient. The number he has assigned to each junction should then be given as JNCTN on this card.

The junction code number JCODE describing the type and size of junction must also be given. It should be pointed out that each junction

code number given in Card Group Six must have a corresponding card in Card Group Three with the same code number and the associated unit cost information. If there is no cost information input for a particular junction code number, then the program will print an error message and stop.

Also required on this card are the highway grade elevation, the junction bottom elevation, and an indicator for whether the junction is in a fill situation or not. The fill indicator IFIL should be set equal to one if it is a fill situation and equal to zero if it is not.

Card Group Seven: System Conduit Data

For every conduit in the drainage system, a single card must be supplied. The conduits of the user's system should be numbered consecutively, as were the junctions, and the number of each conduit given here as KONDUIT.

As with the junctions, the code number KODE describing the type and size of conduit must be given for each conduit. Again, there must be a corresponding card in Card Group Three with the same code number and the associated cost information or the program will not run.

Additional data required here are the conduit length, the upstream junction number, and the downstream junction number.

Card Group Eight: Annual Cost Data

Card Group Eight consists of a single card containing the interest rate at which the capital costs will be amortized. The amortization period or design life of the drainage structure was input on Card Group Three. Card Group Eight is only included in the input stream if the variable ITOTAN in Card Group Two is set equal to one (i.e., the annual cost option is selected).

PROGRAM DESCRIPTION

The Cost Estimation Module consists of a main program and five subroutines as shown in Figure IV-2. The main program, COSTEST, controls the flow of execution and calls each subroutine for its particular function. The primary function of each subroutine is as follows:

- INDATA - reads cost data;
- SYSTEM - reads drainage system configuration;
- CALCUL - calculates the capital and O&M costs;
- AMORT - calculates the total annual costs; and
- TABLES - summarizes and prints total costs by cost code number.

The remainder of this section presents the subroutines called, the common blocks used, a flowchart, the key variables not in common, and a program listing for the main program and each of the five subroutines. Presented at the end of this chapter are the key variables in each of the common blocks used in the Module.

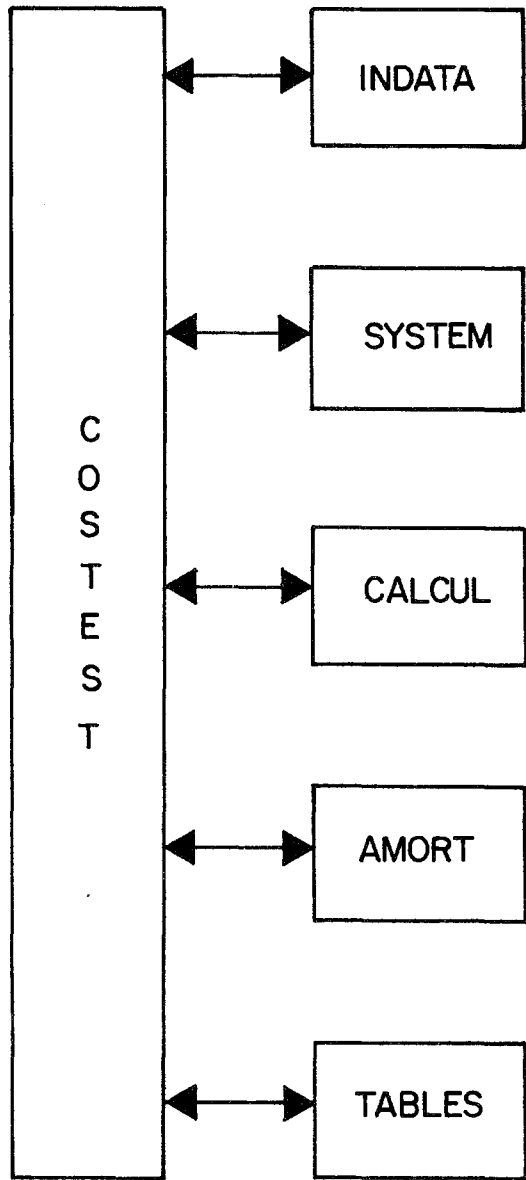


FIGURE IV-2. Cost Estimation Module Flowchart

Main Program COSTEST

- Common blocks used

- /CNTRL/
 - /DOLLARS/
 - /EXCAV/
 - /BKFILL/
 - /DRAIN/
 - /DIRT/
 - /CAPITAL/
 - /COUNT/
 - /OANDM/
 - /ANNUAL/

- Subroutines called

- INDATA
 - SYSTEM
 - CALCUL
 - AMORT
 - TABLES

The mainprogram, COSTEST, reads some preliminary input data and calls five subroutines to control the flow of execution. Figure IV-3 shows the flowchart for this program.

COSTEST reads two input cards, the first containing the title of the simulation run and the second containing the option selections available to the engineer. The title card is an alphanumeric descriptor which describes the run for future reference. If multiple runs are made on one designed drainage system, this title card helps keep the computer runs separate. The title is printed at the top of each page of the output.

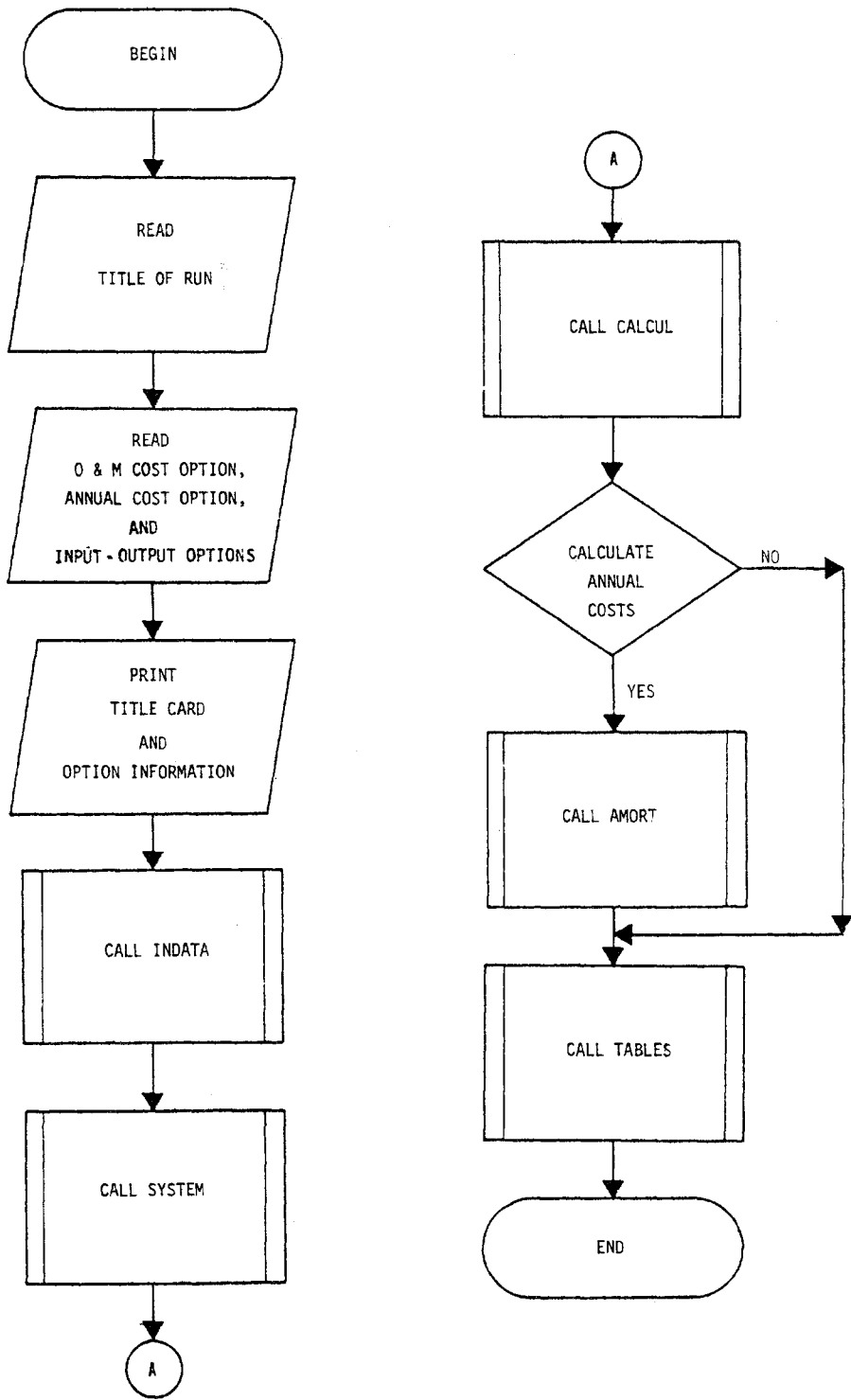


FIGURE IV-3. Flowchart for Main Program COSTEST

The option card contains four variables which, when selected, determine the input required and the output received. The card contains the following options:

- O&M cost option,
- annual cost option,
- metric units option, and
- short output option.

If the engineer desires any of these options, he must indicate with the number 1. Any option set to zero or left blank will not be selected.

COSTEST proceeds to call subroutines INDATA, SYSTEM, and CALCUL to read the cost data, to read the drainage system configuration, and to calculate the capital and O&M costs, respectively. Subroutine AMORT is then called by COSTEST if the engineer selected the annual cost analysis option on the input option card. The final subroutine called by COSTEST is subroutine TABLES which summarizes and prints the calculated cost information.

There are no key variables used in COSTEST which are not contained in the common blocks. The program listing for COSTEST follows.

Subroutine INDATA

- Called from
COSTEST


```

C
C***** READ TITLE OF RUN
C
      READ(N5,1010) NAME
      1010 FORMAT(8X,10A4)
C
C***** READ OPTION CARD
C
      READ(N5,1000) IOPTOM,ITOTAN,IMET,IOPTOUT
      1000 FORMAT(5I8)
C
C***** ECHO TITLE CARD AND OPTION CARD
C
      WRITE(N6,2000) NAME
      2000 FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
      2** URBAN HIGHWAY DRAINAGE MODEL ****,8X,*WATER RESOURCES ENGINEE
      3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
      4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, U.C.*,28X,4H
      5****,5X,*COST ESTIMATION MODULE*,5X,4H****,8X,*SPRINGFIELD, VIRGIN
      6IA*//,1X,*RUN: *,10A4)
      WRITE(N6,2010) N5,N6,OPT(IOPTOM+1),OPT(ITOTAN+1),OPT(IOPTOT+1),
      1 OPT(IMET+1)
      2010 FORMAT(//////////,1X,27(2H**),* OPTION INFORMATION *,27(2H**)
      1 ,///,53X,*D AND M*,10X,*ANNUAL*,9X,* SHORT*,11X,
      2 *METRIC*/20X,*CARD READER*,6X,*PRINTER*,11X,*COST*,12X,*COST*,
      3 11X,*OUTPUT*,11X,*UNIT*/21X,*UNIT NO.*,8X,*UNIT NO.*,9X,
      4 4(*OPTION*,10X)/23X,*(N5)*,12X,*(N6)*,10X,*(IOPTOM)*,8X,
      5 *(ITOTAN)*,8X,*(IOPTOT)*,9X,*(IMET)*/20X,6(11(*-*)
      6 ,5X)//24X,12,14X,12,13X,4(A4,12X))
C
C***** CALL INPUT DATA ROUTINE
C
      CALL INDATA
C
C***** CALL ROUTINE TO READ DRAINAGE SYSTEM CONFIGURATION
C
      CALL SYSTEM
C
C***** CALL ROUTINE TO CALCULATE COSTS
C
      CALL CALCUL
C
C***** CALL ROUTINE TO DETERMINE TOTAL ANNUAL COSTS
C
      IF(ITOTAN.EQ.1) CALL AMORT
C
C***** CALL ROUTINE FOR TABULAR OUTPUT
C
      CALL TABLES
      STOP
      END

```

- Common blocks used

- /CNTRL/
 - /DOLLARS/
 - /EXCAV/
 - /BKFILL/
 - /COUNT/

The cost data required by the Module is read in subroutine INDATA and contained on three sets of cards--materials cards, an excavation card, and backfill cards. The contents of these input cards are printed after they are read.

One materials card is requested for each distinct cost code number identifying the drainage system. The materials card contains cost information describing the distinct types of junctions and conduits. For each cost code number an alphanumeric title, a unit cost, an installation cost, and a special backfill indicator are given as input. If an O&M analysis is requested, then an O&M cost percentage is provided for each cost code number. Similarly, when an annual cost analysis is desired, a design life for each code number is given.

The excavation card is required for every simulation run and contains an alphanumeric title and a unit cost. If the cost of excavation is included in each materials unit cost, then the excavation unit cost is entered as zero.

The backfill cards are two cards describing the normal and special backfills. If the materials unit cost for each junction and conduit includes backfill, then the first backfill card only contains an alphanumeric descriptor and the unit cost is left blank. When special backfill is required, as indicated on the materials card, then the second backfill card must be included, otherwise the card is omitted. The special backfill card, when included, contains an alphanumeric descriptor, a unit

cost, and the percent of all conduits which must be covered by the special backfill.

After all the cost data have been read, the subroutine INDATA echoes the input data and then returns to the main program. Figure IV-4 shows the flowchart for subroutine INDATA.

The only key variable used in subroutine INDATA, which is not located in a common block, is ITEMP. This variable is an indicator for zero installation costs and contains no units. The program listing for INDATA follows.

Subroutine SYSTEM

- Called from
COSTEST
- Common blocks used
/CNTRL/
/BKFILL/
/DRAIN/
/DIRT/
/DOLLARS/
/COUNT/

Subroutine SYSTEM reads the drainage system configuration either from user-supplied cards or from a magnetic tape created by the Hydraulics/Design Module. The subroutine also calculates the excavation and backfill required for each structure.

Figure IV-5 presents the flowchart for subroutine SYSTEM. SYSTEM reads the required data for each junction and then for each conduit. The volume of excavation and total backfill is calculated for each

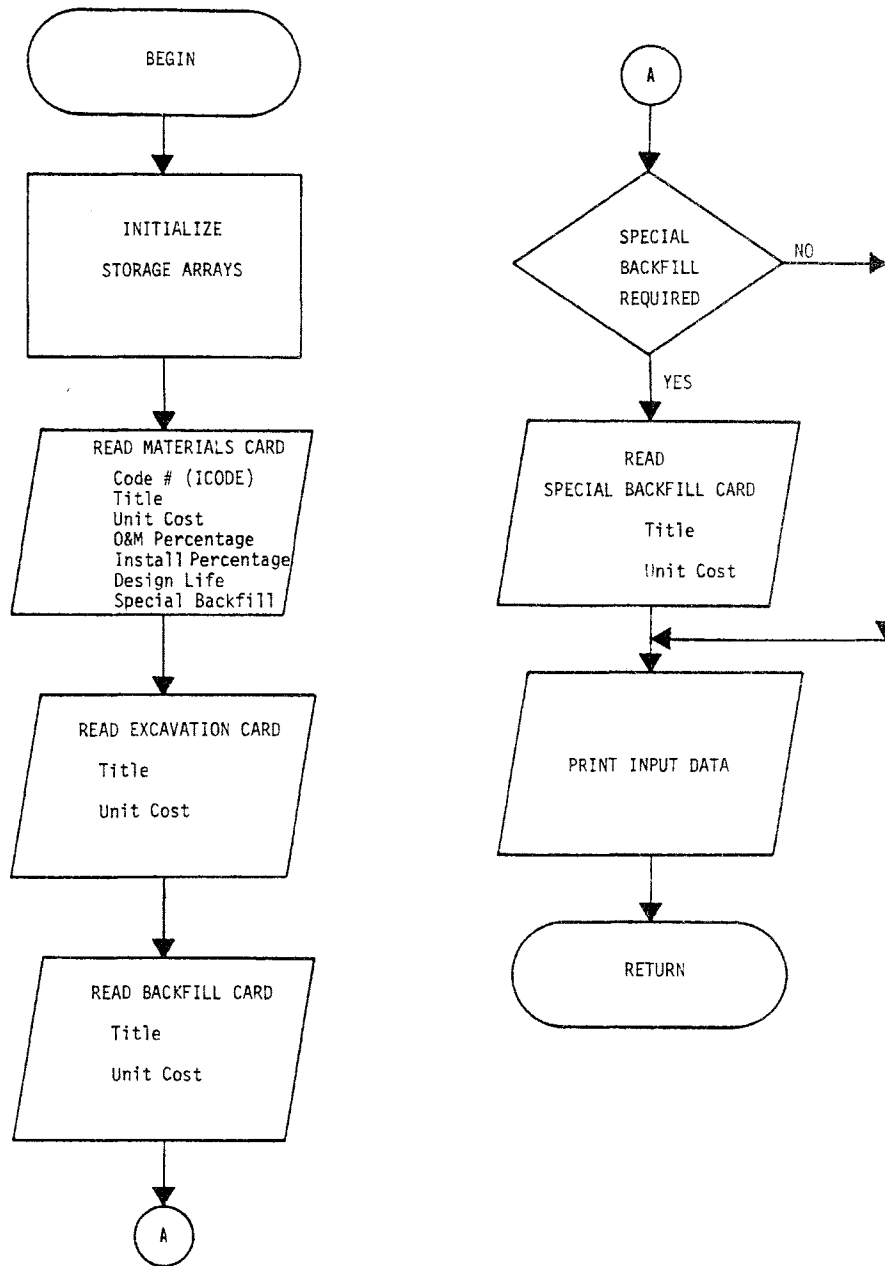


FIGURE IV-4. Flowchart for Subroutine INDATA


```

C
C**** READ EXCAVATION CARD
 110 READ(N5,1020) EXTITL,EXCOST,EXUNIT
 1020 FORMAT(8X,4A4,F8.0,2A4)
      IF(EXUNIT(1).EQ.BKF(1)) EXUNIT(1)=BKF(3)
      IF(IMET.EQ.1) EXUNIT(1)=BKF(4)
C
C***** READ BACKFILL CARDS
C
      READ(N5,1020) BKTITL,BK COST,BKUNIT
      IF(BKUNIT(1).EQ.BKF(1)) BKUNIT(1)=BKF(3)
      IF(IMET.EQ.1) BKUNIT(1)=BKF(4)
      ICNT=0
C
C**** CHECK FOR SPECIAL BACKFILL CARD
      DO 120 N=1,ICOUNT
      IF(ISPBK(N)) 120,120,130
 130 ICNT=ICNT+1
 120 CONTINUE
      IF(ICNT.GT.0) READ(N5,1050) SPTITL,SPCOST,SPUNIT,PERDIA
 1050 FORMAT(8X,4A4,F8.0,2A4,F8.0)
      IF(SPUNIT(1).EQ.BKF(1)) SPUNIT(1)=BKF(3)
      IF(IMET.EQ.1) SPUNIT(1)=BKF(4)
      IF(ICNT.GT.0.AND.SPCOST.EQ.0) WRITE(N6,1060)
 1060 FORMAT(///,1X,13H*** ERROR ***,* SPECIAL BACKFILL IS REQUIRED AND
      1ND COST DATA IS PROVIDED*)
C
C***** ECHO INPUT DATA
C
      DO 150 N=1,ICOUNT
      IF(COST(N).GT.0.0) GO TO 150
      WRITE(N6,1070) (TITLE(N,J),J=1,4),ICODE(N)
 1070 FORMAT(///,1X,13H*** ERROR ***,* NO COST DATA PROVIDED FOR *,4A4,
      1 * CODE NUMBER = *,I8)
      STOP 200
 150 CONTINUE
      WRITE(N6,2000) NAME
 2000 FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
      2** URBAN HIGHWAY DRAINAGE MODEL ****,8X,*WATER RESOURCES ENGINEE
      3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
      4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
      5****,5X,*COST ESTIMATION MODULE*,5X,4H****,8X,*SPRINGFIELD, VIRGIN
      6IA*,//,1X,*RUN: *,10A4)
      WRITE(N6,1110)
 1110 FORMAT(////////////////////,1X,26(2H**),* INPUT COST INFORMAT
      ION *,26(2H**))
      WRITE(N6,2000) NAME
      WRITE(N6,1090)

```

```

1090 FORMAT(////,62X,*INSTALLATION*,8X,*D AND M*,9X,*DESIGN*/,
1 4X,*CODE*,30X,*UNIT*,23X,*COST*,14X,*COST*,12X,*LIFE*,10X,
2 *SPECIAL*/,3X,*NUMBER*,7X,*DESCRIPTION*,11X,*CUST*,11X,
3 *UNITS*,6X,*(PERCENT)*,8X,*(PERCENT)*, 9X,*(YRS)*,8X,
4 *BACKFILL*/,
5 2X,9H-----,3X,8(2H--),6X,8H-----,8X,4(2H--),3X,5(2H--),
6 8X,4(2H--),8X,4(2H--),7X,4(2H--))
I=0
DO 140 N=1,ICDUNT
WRITE(N6,1100) ICODE(N),(TITLE(N,J),J=1,4),COST(N),(UNIT(N,J),J=1,
12), INSTAL(N),OM(N),DSGN(N),BKF(ISPBK(N)+1)
1100 FORMAT(/,2X,I8,6X,4A4,4X,F8.2,9X,2A4,3X,F8.2,8X,F8.2,8X,F8.2,7X,
2 3X,A4)
I=I+1
IF(I.NE.17) GO TO 140
WRITE(N6,2000) NAME
WRITE(N6,1090)
I=0
140 CONTINUE
IF(EXCDST.EQ.0.0) GO TO 170
WRITE(N6,2010) EXTITL,EXCOST,EXUNIT
2010 FORMAT(/,10X,6X,4A4,4X,F8.2,9X,2A4)
GO TO 180
170 WRITE(N6,1030)
1030 FORMAT(///,1X,45X,*UNIT COSTS INCLUDE EXCAVATION COSTS*)
180 IF(BKCDST.EQ.0.0) GO TO 190
WRITE(N6,2010) BKTITL,BKCDST,BKUNIT
GO TO 200
190 WRITE(N6,1040)
1040 FORMAT(///,47X,*UNIT COSTS INCLUDE BACKFILL COSTS*)
200 IF(ICNT.EQ.0) GO TO 210
WRITE(N6,2010) SPTITL,SPCOST,SPUNIT
WRITE(N6,2020) PERDIA
2020 FORMAT(/,38X,*SPECIAL BACKFILL REQUIRED FOR *,F6.2,* PERCENT OF PI
1 PE DIAMETER*)
210 IF(ITEMP.EQ.1) WRITE(N6,2030)
2030 FORMAT(/,35X,*IF INSTALLATION COSTS ARE ZERO THEY ARE INCLUDED IN
1 THE UNIT COSTS*)
IF(IMET.LT.1) GO TO 215
WRITE(N6,2035)
2035 FORMAT(///,55X,25H* * * UNIT NOTATION * * */59X,19HL.M. - LINEAR
1 METER/59X,21HV.M. - VERTICAL METER/59X,18HC.M. - CUBIC METER)
GO TO 2050
215 WRITE(N6,2040)
2040 FORMAT(///,55X,25H* * * UNIT NOTATION * * */59X,18HL.F. - LINEAR
1 FOOT/59X,20HV.F. - VERTICAL FOOT/59X,17HC.F. - CUBIC FOOT)
2050 RETURN
END

```

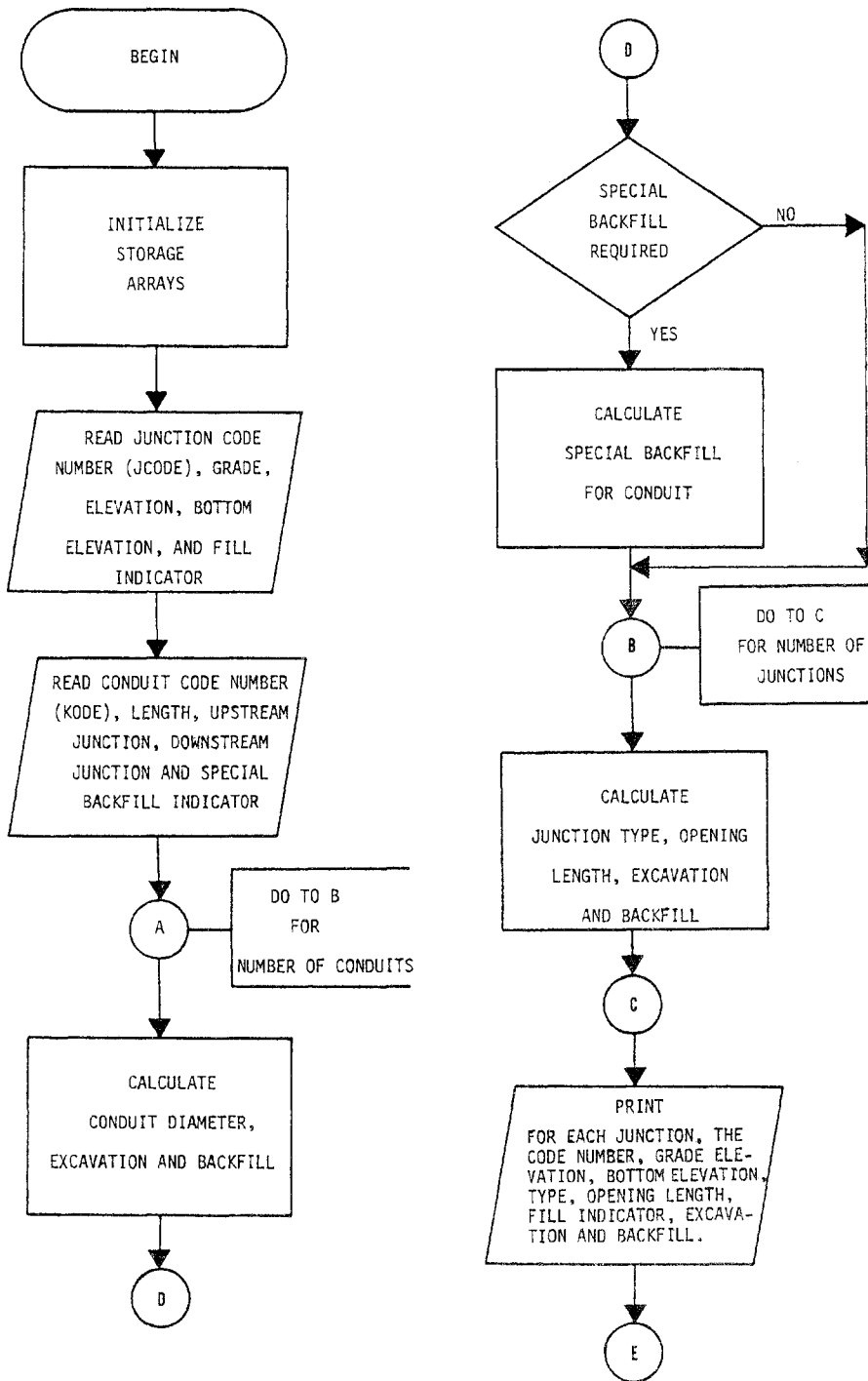


FIGURE IV-5. Flowchart for Subroutine SYSTEM

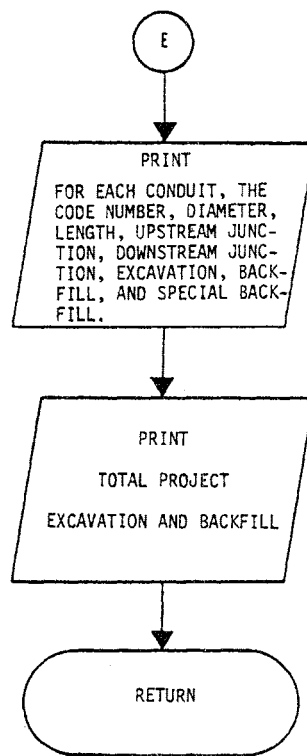


Figure IV-5
(Continued)

conduit and, if required, the volume of special backfill is also calculated. SYSTEM then calculates the excavation volume and backfill volume required for each junction. If the junction has a positive fill indicator, the excavation is assumed to be zero.

The input data read by SYSTEM and the calculated values for excavation and backfill are then printed for each junction and conduit. A total excavation and backfill for the entire drainage system is also printed before the subroutine returns to the mainprogram.

The key variables used in subroutine SYSTEM which are not held in COMMON are given in Table IV-2. A program listing of subroutine SYSTEM follows.

Subroutine CALCUL

- Called from
COSTEST
- Common blocks used
/CNTRL/
/DOLLARS/
/EXCAV/
/BKFILL/
/DRAIN/
/DIRT/
/CAPITAL/
/COUNT/
/OANDM/

The capital and O&M costs for each junction and conduit are calculated by subroutine CALCUL. Figure IV-6 shows the flowchart for subroutine CALCUL.

TABLE IV-2. KEY VARIABLES IN
SUBROUTINE SYSTEM AND NOT IN COMMON

| FORTRAN VARIABLE | DESCRIPTION | UNITS |
|---------------------|--|-----------------------------------|
| TTLEXP | Total conduit excavation for project | yd ³ or m ³ |
| TTLBKP | Total conduit backfill for project | yd ³ or m ³ |
| TTLSPBK | Total conduit special backfill for project | yd ³ or m ³ |
| TTLEXJ | Total junction excavation for project | yd ³ or m ³ |
| TTLBKJ | Total junction backfill for project | yd ³ or m ³ |
| DEPTH1 | Vertical height of upstream junction | ft or m |
| DEPTH2 | Vertical height of downstream junction | ft or m |
| LGSTP | Diameter of downstream conduit | ft or m |
| OPEN(100) | Opening length of junction | ft or m |
| VOLJ | Volume of junction | yd ³ or m ³ |
| VOLP | Volume of conduit | yd ³ or m ³ |

SUBROUTINE SYSTEM

C
C
C
C
C
C
C
C
C
C
C
C

```
*****  
*  
* SYSTEM READS THE DRAINAGE SYSTEM CONFIGURATION FROM CARDS *  
* INPUT BY THE USER. THE SUBROUTINE CALCULATES THE AMOUNT OF *  
* EXCAVATION AND BACKFILL FOR EACH DRAINAGE ITEM. *  
*  
*****
```

```
COMMON/CNTRL/ N5,N6,IOPTOM,ITOTAN, IOPTDT,NAME(10),IMET  
COMMON/BKFILL/ BKTITL(4),BK COST,BKUNIT(2),  
1 SPTITL(4),SPCOST,PERDIA,SPUNIT(2)  
COMMON/DRAIN/ JNCTN(100),KODE(100),ELGD(100),ELINV(100),  
1 ITYPE(100),KONOUT(100),JUPSTM(100),DIA(100),LEN(100),  
2 JDNSTM(100),JCODE(100),IFIL(100)  
COMMON/DIRT/ EXPIPE(100),BKFLP(100), SBKFLP(100),EXJNC(100),  
1 BKFLJN(100)  
COMMON/ DOLLAR/ ICODE(100),TITLE(100,4),COST(100), INSTAL(100),  
1 OM(100),UNIT(100,2),DSGN(100),ISPBK(100)  
COMMON/CDUNT/ ICOUNT,JNC,KON  
DIMENSION OPEN(100),FILL(2)  
REAL LEN,LGSTP  
DATA FILL/4H ,4H YES/  
IPIPE=31000  
ICHNL=32000  
20 CONTINUE  
IJNC1=4100  
IJNC2=4200  
IJNC3=4300  
IJNC4=4400
```

C
C***** INITIALIZE STORAGE ARRAYS
C

```
DO 50 N=1,100
```

```

JNCTN(N)=0.0
JCODE(N)=0.0
ELGD(N)=0.0
ELINV(N)=0.0
ITYPE(N)=0.0
KONDUT(N)=0.0
KODE(N)=0.0
JUPSTM(N)=0.0
DIA(N)=0.0
LEN(N)=0.0
JDNSTM(N)=0.0
EXPIPE(N)=0.0
BKFLP(N)=0.0
SBKFLP(N)=0.0
BKFLJN(N)=0.0
EXJNC(N)=0.0
50 CONTINUE
C
C***** READ JUNCTIONS FOR DRAINAGE SYSTEM
C
      JNC=0
      KON=0
      DO 100 N=1,100
      READ(N5,1000) JNCTN(N),JCODE(N),ELGD(N),ELINV(N),IFIL(N)
1000  FORMAT(2I8,2F8.0,I8)
      IF(JNCTN(N).EQ.0) GO TO 105
C
C**** CHECK CODE IDENTIFIER
      IF(JCODE(N).EQ.0) WRITE(N6,1060) N
1060  FORMAT(////,1X,13H*** ERROR ***,* CODE IDENTIFIER NOT SUPPLIED FOR
      1 JUNCTION *,I3)
      JNC=JNC+1
100  CONTINUE
C
C***** READ CONDUITS FOR DRAINAGE SYSTEM
C
105  DO 115 N=1,100
      READ(N5,1010) KONDUT(N),KODE(N),LEN(N),JUPSTM(N),JDNSTM(N)
1010  FORMAT(2I8,F8.0,2I8)
      IF( KONDUT(N).EQ.0) GO TO 110
C
C**** CHECK CODE IDENTIFIER
      IF(KODE(N).EQ.0) WRITE(N6,1070) N
1070  FORMAT(////,1X,13H*** ERROR ***,* CODE IDENTIFIER NOT SUPPLIED FOR
      1 CONDUIT *,I3)
      KON=KON+1
115  CONTINUE
C
C***** INITIALIZE TOTAL VARIABLES
C
110  EX=0.0

```



```

EXTRA=0.0
TTLEXP=0.0
TTLBKP=0.0
TTLSBK=0.0
TTLJEX=0.0
TTLBKJ=0.0
C
C***** CALCULATE CONDUIT EXCAVATION AND BACKFILL
C
DO 200 N=1,KON
J=JUPSTM(N)
K=JDNSTM(N)
IF(KODE(N).LT.ICHNL) GO TO 120
DIA(N)=KODE(N)-ICHNL
GO TO 130
120 DIA(N)=KODE(N)-IPIPE
130 DIA(N)=DIA(N)/12.0
IF(IMET.EQ.1) DIA(N)=DIA(N)*12./100.
DEPTH1=ELGD(J)-ELINV(J)
IF(DEPTH1.LE.0.0) DEPTH1=0.0
EX=DEPTH1*LEN(N)
DEPTH2=ELGD(K)-ELINV(K)
IF(DEPTH2.LE.0.0) DEPTH2=0.0
EXTRA=(DEPTH2-DEPTH1)*LEN(N)/2.0
C
C**** EXCAVATION
EXPIPE(N)=(EX+EXTRA)*(DIA(N)+2.0)/27.0
IF(IMET.EQ.1) EXPIPE(N)=(EX+EXTRA)*(DIA(N)+2.0/3.281)
IF(IFIL(J).EQ.1.OR.IFIL(K).EQ.1) EXPIPE(N)=EXPIPE(N)/2.0
IF(IFIL(J).EQ.1.AND.IFIL(K).EQ.1) EXPIPE(N)=0.0
IF(EXPIPE(N).LE.0.0) EXPIPE(N)=0.0
TTLEXP=TTLEXP+EXPIPE(N)
C
C**** BACKFILL
VOLP=((3.14159*(DIA(N)**2.0/4.0)*LEN(N))/27.0)
IF(IMET.EQ.1) VOLP=3.14159*(DIA(N)**2.0/4.0)*LEN(N)
IF(IFIL(J).EQ.1.AND.IFIL(K).EQ.1) VOLP=0.
IF(IFIL(J).EQ.1.OR.IFIL(K).EQ.1) VOLP=VOLP/2.
BKFLP(N)=EXPIPE(N)-VOLP
IF(KODE(N).GE.ICHNL) BKFLP(N)=0.0
IF(BKFLP(N).LE.0.0) BKFLP(N)=0.0
TTLBKP=TTLBKP+BKFLP(N)
C
C**** CHECK FOR SPECIAL BACKFILL
DO 220 L=1,ICOUNT
IF(KODE(N).EQ.ICODE(L)) GO TO 230
220 CONTINUE
230 IF(ISPBK(L).EQ.0) GO TO 200
TEMP=PERDIA/100.0
TEMP2=(TEMP*DIA(N)*(DIA(N)+2.)*LEN(N))/27.0
IF(IMET.EQ.1) TEMP2=(TEMP*DIA(N)*(DIA(N)+2./3.281)*LEN(N))

```

```

IF(IFIL(J).EQ.1.OR. IFIL(K).EQ.1) TEMP2=TEMP2/2.
IF(IFIL(J).EQ.1.AND. IFIL(K).EQ.1) TEMP2=0.
SBKFLP(N)=TEMP2-(VOLP*TEMP)
BKFLP(N)=BKFLP(N)- SBKFLP(N)
IF(BKFLP(N).LE.0.0) BKFLP(N)=0.0
TTLSBK= TTLSBK+ SBKFLP(N)
IF(BKFLP(N).EQ.0.0.AND. SBKFLP(N).GT.0.0) GO TO 200
TTLBKP=TTLBKP- SBKFLP(N)
200 CONTINUE
C
C***** CALCULATE JUNCTION EXCAVATION AND BACKFILL
C
DO 250 N=1,JNC
DO 255 J=1,KON
IF(N.EQ.JUPSTM(J)) GO TO 265
255 CONTINUE
265 IF(J.GT.KON) J=KON
LGSTP=DIA(J)
IF(JCODE(N).GT.IJNC2) GO TO 260
OPEN(N)=JCODE(N)-IJNC1
ITYPE(N)=1
GO TO 410
260 IF(JCODE(N).GT.IJNC3) GO TO 270
OPEN(N)=JCODE(N)-IJNC2
ITYPE(N)=2
GO TO 410
270 IF(JCODE(N).GE.IJNC4) GO TO 280
OPEN(N)=JCODE(N)-IJNC3
ITYPE(N)=3
GO TO 410
280 ITYPE(N)=4
OPEN(N)=4.0
IF(IMET.EQ.1) OPEN(N)=4.0/3.281
410 CONTINUE
IF(IMET.LT.1) GO TO 420
IF(OPEN(N).LT.4.0/3.281) OPEN(N)=4.0/3.281
VOLJ=(ELGD(N)-ELINV(N))*(OPEN(N)+1.333/3.281)*(LGSTP+1.333/3.281)
IF(IMET.EQ.1) BKFLJN(N)=2.0/3.281*OPEN(N)*(ELGD(N)-ELINV(N))
GO TO 430
420 IF(OPEN(N).LT.4.0) OPEN(N)=4.0
VOLJ=(ELGD(N)-ELINV(N))*(OPEN(N)+1.333)*(LGSTP+1.333)/27.0
C
C**** BACKFILL
BKFLJN(N)=2.0*OPEN(N)*(ELGD(N)-ELINV(N))/27.0
430 CONTINUE
IF(IFIL(N).EQ.1) BKFLJN(N)=0.0
IF( BKFLJN(N).LE.0.0) BKFLJN(N)=0.0
TTLBKJ=TTLBKJ+ BKFLJN(N)
C
C**** EXCAVATION
EXJNC(N)=VOLJ+ BKFLJN(N)

```

```

IF(IFIL(N).EQ.1) EXJNC(N)=0.0
IF(EXJNC(N).LE.0.0) EXJNC(N)=0.0
TTLJEX=TTLJEX+EXJNC(N)

```

```
250 CONTINUE
```

C

```
C***** PRINT DRAINAGE SYSTEM INFORMATION
```

C

```
WRITE(N6,2000) NAME
```

```
2000 FORMAT(*1*,64(2H--)/# *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
2** URBAN HIGHWAY DRAINAGE MODEL ****,8X,*WATER RESOURCES ENGINEE
3R5*/# *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
4 DIVISION OF CAMP DRESSER AND MCKEE*/# *,*WASHINGTON, D.C.*,28X,4H
5****,5X,*COST ESTIMATION MODULE*,5X,4H****,8X,*SPRINGFIELD, VIRGIN
61A*,//,1X,*RUN: *,10A4)

```

```
WRITE(N6,1080)
```

```
1080 FORMAT(////////////////////,23(2H**),* DRAINAGE SYSTEM DESIGN
1 INFORMATION *,24(2H**))
```

C

```
C.... PROPER METRIC UNITS IN TITLE
```

```
IF(IMET.EQ.1) GO TO 440
```

```
K1=4H(IN)
```

```
K2=4H(FT)
```

```
K3=5H(YD3)
```

```
GO TO 450
```

```
440 K1=4H(CM)
```

```
K2=3H(M)
```

```
K3=4H(M3)
```

```
450 CONTINUE
```

C

```
C*** JUNCTION INFORMATION
```

```
WRITE(N6,2000) NAME
```

```
WRITE(N6,1085)
```

```
1085 FORMAT(////,2B(2H**),* JUNCTION DATA *,29(2H**))
```

```
WRITE(N6,1090) K2,K3,K3
```

```
1090 FORMAT(////,32X,*HIGHWAY*,6X,*JUNCTION*,34X,*OPENING*,/,3X,
1 *JUNCTION*, 8X,*CODE*,10X,*GRADE *, 7X,*BOTTOM*,7X,*JUNCTION*,
2 8X,*FILL*,9X,*LENGTH*,6X,*EXCAVATION*,5X,*BACKFILL*,/,4X,
3 *NUMBER*,10X,*ID*,9X,*ELEVATION*,5X,*ELEVATION*,7X,*TYPE*,
4 8X,*SITUATION*,7X,A4,9X,A5,9X,A5,/,2X,
5 9(5(2H--),4X))

```

```
I=0
```

```
DO 500 N=1,JNC
```

```
WRITE(N6,1030) JNCTN(N),JCODE(N),ELGD(N),ELINV(N),ITYPE(N),
```

```
1 FILL(IFIL(N)+1),OPEN(N),EXJNC(N), BKFLJN(N)
```

```
1030 FORMAT(/,6X,I2,11X,I4,8X,F8.2,6X,F8.2,9X,I2,11X,A4,8X,F8.2,6X,
```

```
1 F8.2,6X,F8.2)
```

```
IF(IFIL(N).EQ.1) ITEMP=1
```

```
I=I+1
```

```
IF(I.NE.19) GO TO 500
```

```
WRITE(N6,2000) NAME
```

```
WRITE(N6,1085)
```

```

WRITE(N6,1090) K2,K3,K3
I=0
500 CONTINUE
IF(ITEMP.EQ.1) WRITE(N6,1020)
1020 FORMAT(/,34X,*IN FILL SITUATIONS EXCAVATION AND BACKFILL ARE NOT P
1AY ITEMS*)
C
C**** CONDUIT INFORMATION
WRITE(N6,2000) NAME
WRITE(N6,2010)
2010 FORMAT(////,28(2H**),* CONDUIT DATA *,29(2H**))
WRITE(N6,2020) K1,K2,K3,K3,K3
2020 FORMAT(////,117X,*SPECIAL*,/,5X,*CONDUIT*,8X,*CODE*,8X,*DIAMETER*,
1 7X,*LENGTH*,7X,*UPSTREAM*,5X,*DOWNSTREAM*,4X,*EXCAVATION*,5X,
2 *BACKFILL*,6X,*BACKFILL*,/,5X,*NUMBER*,10X,*ID*,11X,A4,
3 10X, A4 ,8X,*JUNCTION*,6X,*JUNCTION*,8X, A5 ,9X, A5 ,
4 9X, A5 ,/,3X,9(5(2H--),4X))
I=0
DO 600 N=1,KON
DIA(N)=DIA(N)*12.0
IF(IMET.EQ.1) DIA(N)=DIA(N)*100./12.
WRITE(N6,1040) KONDUIT(N),KODE(N),DIA(N),LEN(N),JUPSTM(N),
1 JONSTM(N),EXPIPE(N),BKFLP(N), SBKFLP(N)
1040 FORMAT(/,7X,12,10X,15,8X,F8.2,6X,F8.2,9X,12,12X,12,9X,F8.2,6X,
1 F8.2,6X,F8.2)
IF(KODE(N).GT.ICHNL) ITEMP2=1
I=I+1
IF(I.NE.19) GO TO 600
WRITE(N6,2000) NAME
WRITE(N6,2010)
WRITE(N6,2020) K1,K2,K3,K3,K3
I=0
600 CONTINUE
IF(ITEMP.EQ.1) WRITE(N6,2060)
2060 FORMAT(/,25X,*IF JUNCTION IS IN A FILL SITUATION CONDUIT EXCAVATIO
IN AND BACKFILL ARE ADJUSTED*)
IF(ITEMP2.EQ.1) WRITE(N6,2050)
2050 FORMAT(/,41X,*BACKFILL FOR OPEN CHANNELS ARE ASSUMED TO BE ZERO*)
C
C**** PRINT TOTAL SYSTEM EXCAVATION AND BACKFILL
WRITE(N6,2000) NAME
WRITE(N6,2030)
2030 FORMAT(////////////////////,24(2H**),* TOTAL EXCAVATION AND BACKFI
ILL *,25(2H**))
WRITE(N6,2040) K3,K3,K3,K3,K3
2040 FORMAT(////,14X,*T O T A L E X C A V A T I O N *,25X,
1 *T O T A L B A C K F I L L *,//,12X,
1 *JUNCTION*,17X,*CONDUIT*,15X,*JUNCTION*,17X,*CONDUIT*,17X,
3 *SPECIAL*,/,14X, A5 ,18X, A5 ,19X, A5 ,20X, A5
4 18X, A5 ,/,11X,5(5(2H--),14X))
WRITE(N6,1050) TTLJEX,TTLXP,TTLBKJ,TTLBKP, TTLSBK
1050 FORMAT(/,10X,5(F10.2,14X))
RETURN
END

```

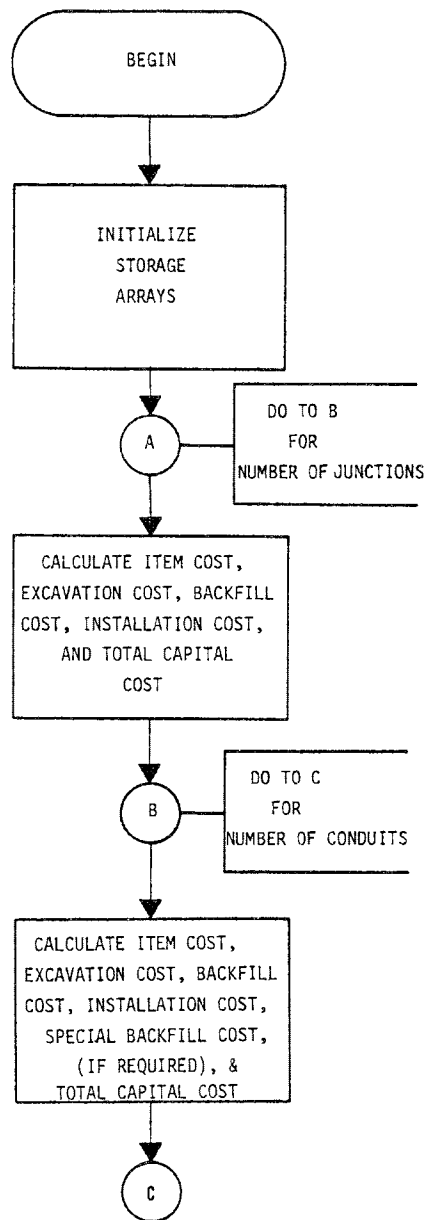


FIGURE IV-6. Flowchart for Subroutine CALCUL

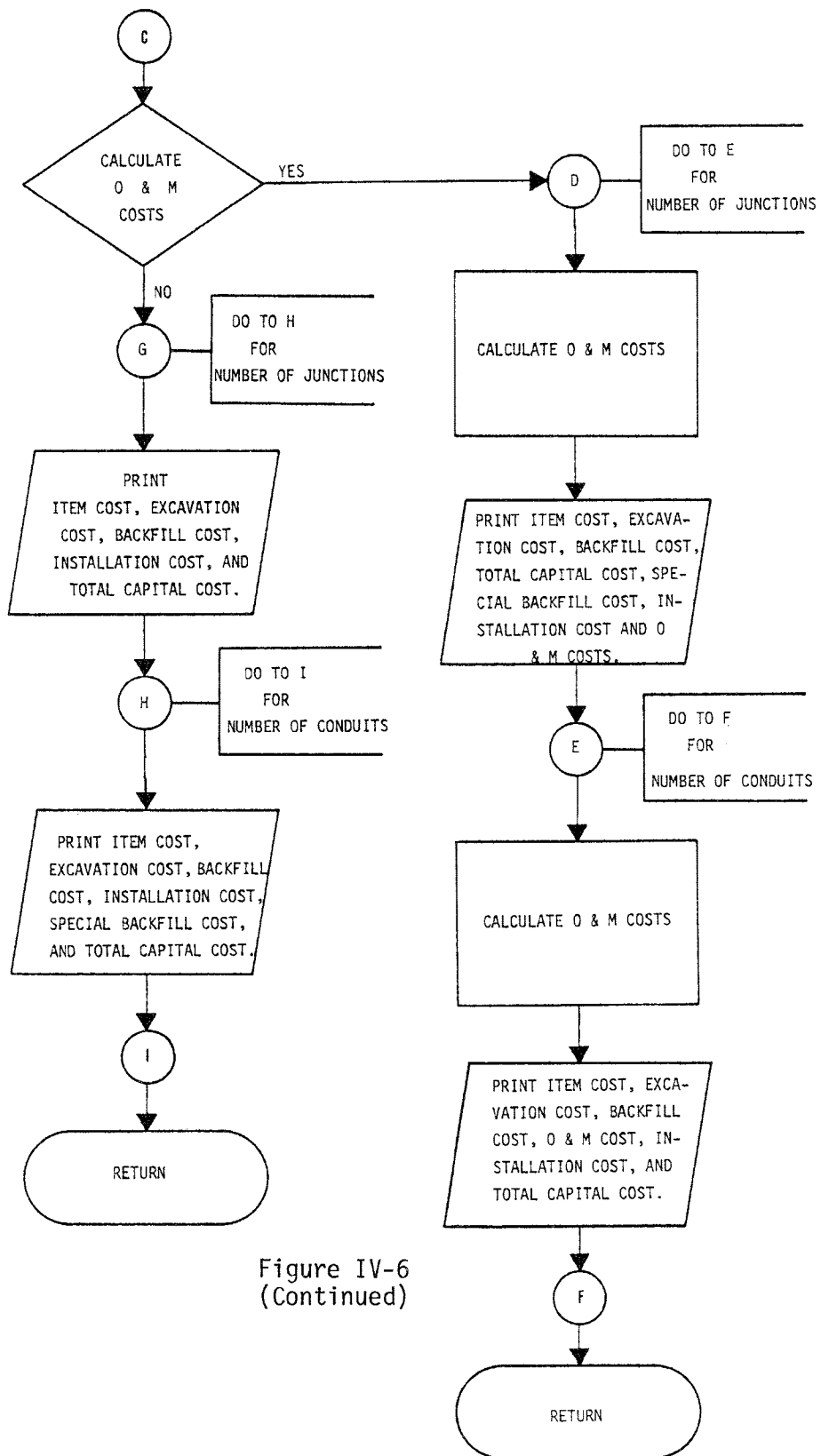


Figure IV-6
(Continued)

CALCUL first calculates the item cost, excavation cost, backfill cost, installation cost, and total capital cost for each junction and then for each conduit. If the unit costs given in INDATA include excavation, backfill, or installation, then the latter costs are not calculated and the item cost for each drainage structure is assumed to include these costs. The total capital cost calculated is the sum of the item cost, excavation cost, backfill cost, and installation cost. Special backfill costs are calculated for each conduit if required, and are never assumed to be part of the item costs.

If an O&M cost analysis has not been requested, the subroutine CALCUL prints the item, excavation, backfill, installation, and total capital costs for each junction and then for each conduit. When O&M costs are required, CALCUL calculates the O&M cost for each junction and conduit before printing all the costs calculated.

The only key variable used in subroutine CALCUL which is not held in common blocks is ITEMP, which is a temporary indicator of zero installation costs. A program listing of subroutine CALCUL follows.

Subroutine AMORT

- Called from
COSTEST

SUBROUTINE CALCUL

C
C
C
C
C
C
C
C
C
C
C
C

```
*****
*
*   CALCUL CALCULATES THE CAPITAL AND O&M COSTS FOR EACH COMP-
*   ONENT OF THE DRAINAGE SYSTEM BASED ON UNIT COST INFORMATION
*   SUPPLIED BY THE USER. O&M COSTS ARE CALCULATED WHEN IOPTOM
*   IS EQUAL TO ONE.
*
*****
```

```
COMMON/CNTRL/ N5,N6,IOPTOM,ITOTAN, IOPTOT,NAME(10),IMET
COMMON/ DOLLAR/ ICODE(100),TITLE(100,4),COST(100), INSTAL(100),
1  DM(100),UNIT(100,2),DSGN(100),ISPBK(100)
COMMON/EXCAV/  EXTITL(4),EXCOST,EXUNIT(2)
COMMON/BKFILL/ BKTITL(4),BK COST,BKUNIT(2),
1  SPTITL(4),SPCOST,PERDIA,SPUNIT(2)
COMMON/DRAIN/  JNCTN(100),KODE(100),ELGD(100),ELINV(100),
1  ITYPE(100), KONDU(100),JUPSTM(100),DIA(100),LEN(100),
2  JDNSTM(100),JCODE(100),IFIL(100)
COMMON/DIRT/  EXPIPE(100),BKFLP(100), SBKFLP(100),EXJNC(100),
1  BKFLJN(100)
COMMON/ CAPITA/ CSTJNC(100),CSTEXJ(100),CSTBKJ(100),PCST(100),
1  PEXCST(100),PBKCST(100), PSPBKC(100),TCAPJ(100),TCAPP(100),
2  CSTINJ(100),PINCST(100)
COMMON/COUNT/ ICOUNT,JNC,KON
COMMON/DANDM/  CSTOMJ(100),CSTOMP(100)
REAL  INSTAL,LEN
DATA  CSTJ/4HEACH/
```

C
C
C

***** INITIALIZE STORAGE ARRAYS

```
DO 50 N=1,100
CSTJNC(N)=0.0
CSTEXJ(N)=0.0
CSTBKJ(N)=0.0
CSTINJ(N)=0.0
TCAPJ(N)=0.0
PCST(N)=0.0
PEXCST(N)=0.0
PBKCST(N)=0.0
PSPBKC(N)=0.0
PINCST(N)=0.0
TCAPP(N)=0.0
CSTOMJ(N)=0.0
CSTOMP(N)=0.0
```



```

50 CONTINUE
C
C***** CALCULATE COST OF JUNCTIONS, EXCAVATION AND BACKFILL
C
      DO 100 N=1,JNC
      DO 200 J=1,ICOUNT
      IF(JCODE(N).EQ.ICODE(J)) GO TO 110
200 CONTINUE
      WRITE(N6,2000) NAME
2000 FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
2** URBAN HIGHWAY DRAINAGE MODEL ****,8X,*WATER RESOURCES ENGINEE
3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
5****,5X,*COST ESTIMATION MODULE*,5X,4H****,8X,*SPRINGFIELD, VIRGIN
6IA*,//,1X,*RUN: *,10A4)
      WRITE(N6,1000) JCODE(N)
1000 FORMAT(////,1X,13H*** ERROR ***,* NO UNIT COST DATA FOUND FOR CODE
1 NO.= *,I8)
      STOP 400
C
C**** COST OF JUNCTION
110 IF(JCODE(N).GE.4500) GO TO 120
      IF(UNIT(J,1).EQ.CSTJ) GO TO 120
      CSTJNC(N)=COST(J)*(ELGD(N)-ELINV(N))
      GO TO 130
120 CSTJNC(N)=COST(J)
C
C**** COST OF EXCAVATION
130 CSTEMJ(N)=EXCOST*EXJNC(N)
C
C**** COST OF BACKFILL
      CSTBKJ(N)=BKCDST* BKFLJN(N)
C
C**** TOTAL CAPITAL COST OF JUNCTIONS
      CSTINJ(N)=CSTJNC(N)* INSTAL(J)/100.
      TCAPJ(N)=CSTJNC(N)+CSTEMJ(N)+CSTBKJ(N)+CSTINJ(N)
100 CONTINUE
C
C***** CALCULATE COST OF CONDUITS, EXCAVATION AND BACKFILL
C
      DO 300 N=1,KON
      DO 400 J=1,ICOUNT
      IF(KODE(N).EQ.ICODE(J)) GO TO 310
400 CONTINUE
      WRITE(N6,2000)
      WRITE(N6,1000) KODE(N)
      STOP 401
C
C**** COST OF CONDUITS
310 PCST(N)=COST(J)*LEN(N)
C

```

```

C**** COST OF EXCAVATION
      PEXCST(N)=EXPIPE(N)*EXCOST
C
C**** COST OF BACKFILL
      PBKST(N)=BKFLP(N)*BKST
      IF(SPCST.EQ.0.) GO TO 340
C
C**** COST OF SPECIAL BACKFILL IF REQUIRED
      PSPBKC(N)= SBKFLP(N)*SPCST
C
C**** TOTAL CAPITAL COST OF CONDUITS
      340 PINCST(N)=PCST(N)* INSTAL(J)/100.0
          TCAPP(N)=PCST(N)+PEXCST(N)+PBKST(N)+ PSPBKC(N)+PINCST(N)
      300 CONTINUE
C
C***** CALCULATE OPERATION AND MAINTENANCE COSTS
C
      IF(IOPTOM.EQ.0) GO TO 900
C
C***** PRINT COSTS OF JUNCTIONS AND CONDUITS WITH O&M COSTS ADDED
C
      IF( IOPTOT.EQ.1) GO TO 410
      WRITE(N6,2000) NAME
      WRITE(N6,2090)
2090 FORMAT(///,28(2H**),* JUNCTION COSTS *,29(2H**),/,60X,*(DOLLARS)*
1)
      WRITE(N6,3010)
3010 FORMAT(/,55X,*(O+M IN DOLLARS/YR)*
      WRITE(N6,2050)
2050 FORMAT(/,96X,*TOTAL*,/,5X,*JUNCTION*,10X,*JUNCTION*,9X,
1  *EXCAVATION*,9X,*BACKFILL*,8X,*INSTALLATION*,
2  9X,*CAPITAL*,10X,*O AND M*,/,8X,*NO*,15X,6(*COST*,14X),/,4X,
3  7(5(2H--),8X))
410 I=0
C
C**** JUNCTIONS
      DO 500 N=1,JNC
      DO 525 J=1,ICDUNT
      IF(JCODE(N).EQ.ICODE(J)) GO TO 510
525 CONTINUE
510 CSTOMJ(N)=CSTJNC(N)*(OM(J)/100.0)
      IF(CSTINJ(N).EQ.0.0) ITEMP=1
      IF( IOPTOT.EQ.1) GO TO 500
      WRITE(N6,2060) JNCTN(N),CSTJNC(N),CSTEXJ(N),CSTBKJ(N),CSTINJ(N),
1  TCAPJ(N),CSTOMJ(N)
2060 FORMAT(/,6X,14,12X,6(2PE10.3,8X))
      I=I+1
      IF(I.NE.19) GO TO 500
      WRITE(N6,2000) NAME
      WRITE(N6,2090)
      WRITE(N6,3010)

```

```

WRITE(N6,2050)
I=0
500 CONTINUE
IF( IOPTDT.EQ.1) GO TO 420
IF(EXCOST.EQ.0.0) WRITE(N6,3030)
3030 FORMAT(///,46X,*ITEM COSTS INCLUDE EXCAVATION COSTS*)
IF(BK COST.EQ.0.0) WRITE(N6,3020)
3020 FORMAT(///,47X,*ITEM COSTS INCLUDE BACKFILL COSTS*)
IF(ITEMP.EQ.1) WRITE(N6,3040)
3040 FORMAT(//,31X,*IF INSTALLATION COSTS ARE ZERO THEY ARE INCLUDED IN
1 THE JUNCTION COSTS*)
WRITE(N6,2000) NAME
WRITE(N6,3000)
3000 FORMAT(////,28(2H**),* CONDUIT COSTS *,29(2H**),/,60X,* (DOLLARS)*
WRITE(N6,3010)
WRITE(N6,2070)
2070 FORMAT(//,70X,*SPECIAL*,26X,*TOTAL*,/,5X,*CONDUIT*,9X,*CONDUIT*,
1 8X,*EXCAVATION*,7X,*BACKFILL*,8X,*BACKFILL*,6X,*INSTALLATION*
2 7X,*CAPITAL*,9X,*0 AND M*,/,8X,*NO*,1X,7(12X,*COST*),/,4X,
3 8(5(2H--),6X))
420 I=0
C
C**** CONDUITS
DO 550 N=1,KON
DO 575 J=1,ICOUNT
IF(KODE(N).EQ.JCODE(J)) GO TO 580
575 CONTINUE
580 CSTOMP(N)=PCST(N)*(DM(J)/100.0)
IF(PINCST(N).EQ.0.0) ITEMP=1
IF( IOPTDT.EQ.1) GO TO 550
WRITE(N6,2080) KONDUIT(N),PCST(N),PEXCST(N),PBKCSI(N), PSPBKC(N),
1 PINCST(N),TCAPP(N),CSTOMP(N)
2080 FORMAT(/,7X,14,3X,7(6X,2PE10.3))
I=I+1
IF(I.NE.19) GO TO 550
WRITE(N6,2000) NAME
WRITE(N6,3000)
WRITE(N6,3010)
WRITE(N6,2070)
I=0
550 CONTINUE
IF( IOPTDT.EQ.1) GO TO 950
IF(EXCOST.EQ.0.) WRITE(N6,3030)
IF(BK COST.EQ.0.) WRITE(N6,3020)
IF(ITEMP.EQ.1) WRITE(N6,3050)
3050 FORMAT(//,31X,*IF INSTALLATION COSTS ARE ZERO THEY ARE INCLUDED IN
1 THE CONDUIT COSTS*)
GO TO 950
C
C***** PRINT COST FOR JUNCTIONS AND CONDUITS
C

```

```

900 IF( IDPTOT.EQ.1) GO TO 950
    WRITE(N6,2000) NAME
    WRITE(N6,2090)
    WRITE(N6,2010)
2010 FORMAT(//,110X,*TOTAL*,/,11X,*JUNCTION*,12X,*JUNCTION*,11X,
1    *EXCAVATION*,11X,*BACKFILL*,10X,*INSTALLATION*,10X,*CAPITAL*,
2/,14X,*NO*,1X,5(16X,*COST*),/,6(10X,5(2H--)))
    I=0
C
C**** JUNCTIONS
DO 600 N=1,JNC
    WRITE(N6,2020) JNCTN(N),CSTJNC(N),CSTEXJ(N),CSTBKJ(N),CSTINJ(N),
1    TCAPJ(N)
2020 FORMAT(/,12X,I4,14X,5(2PE10.3,10X))
    IF(CSTINJ(N).EQ.0.0) ITEMP=1
    I=I+1
    IF(I.NE.19) GO TO 600
    WRITE(N6,2000) NAME
    WRITE(N6,2090)
    WRITE(N6,2010)
    I=0
600 CONTINUE
    IF(EXCDST.EQ.0.0) WRITE(N6,3030)
    IF(BKCDST.EQ.0.0) WRITE(N6,3020)
    IF(ITEMP.EQ.1) WRITE(N6,3040)
    WRITE(N6,2000) NAME
    WRITE(N6,3000)
    WRITE(N6,2030)
2030 FORMAT(/////79X,*SPECIAL*,28X,*TOTAL*,/,8X,*CONDUIT*,11X,
1    *CONDUIT*,9X,*EXCAVATION*,9X,*BACKFILL*,10X,*BACKFILL*,8X,
2    *INSTALLATION*,9X,*CAPITAL*,/,10X,*NO*,1X,6(14X,*COST*),/,
3    6X,7(5(2H--),8X))
    I=0
C
C**** CONDUITS
DO 650 N=1,KON
    WRITE(N6,2040) KONDUIT(N),PCST(N),PEXCST(N),PBKCDST(N), PSPBKC(N),
1    PINCST(N),TCAPP(N)
2040 FORMAT(/,8X,I4,12X,6(2PE10.3,8X))
    IF(PINCST(N).EQ.0.0) ITEMP=1
    I=I+1
    IF(I.NE.19) GO TO 650
    WRITE(N6,2000) NAME
    WRITE(N6,3000)
    WRITE(N6,2030)
    WRITE(N6,2030)
    I=0
650 CONTINUE
    IF(BKCDST.EQ.0.0) WRITE(N6,3020)
    IF(EXCDST.EQ.0.0) WRITE(N6,3030)
    IF(ITEMP.EQ.1) WRITE(N6,3050)

```

- Common blocks used

- /CNTRL/
 - /DOLLARS/
 - /CAPITAL/
 - /DRAIN/
 - /OANDM/
 - /ANNUAL/
 - /COUNT/

When an annual cost analysis has been requested, subroutine AMORT is called by the mainprogram. AMORT reads the interest rate at which the drainage structures will be amortized. Figure IV-7 shows the flowchart for subroutine AMORT.

After reading the interest rate, AMORT calculates the capital recovery cost and total annual cost using the design life given for each junction. If O&M costs have already been determined for each junction, they are added to the capital recovery costs to determine the total annual costs. Total annual equals capital recovery when O&M costs are zero.

The subroutine then prints the calculated costs for each junction and proceeds to repeat the same procedure for each conduit. After printing the calculated costs for each conduit, AMORT returns to the mainprogram.

The key variables used in subroutine AMORT, which are not in COMMON, are given in Table IV-3. A program listing of the subroutine follows.

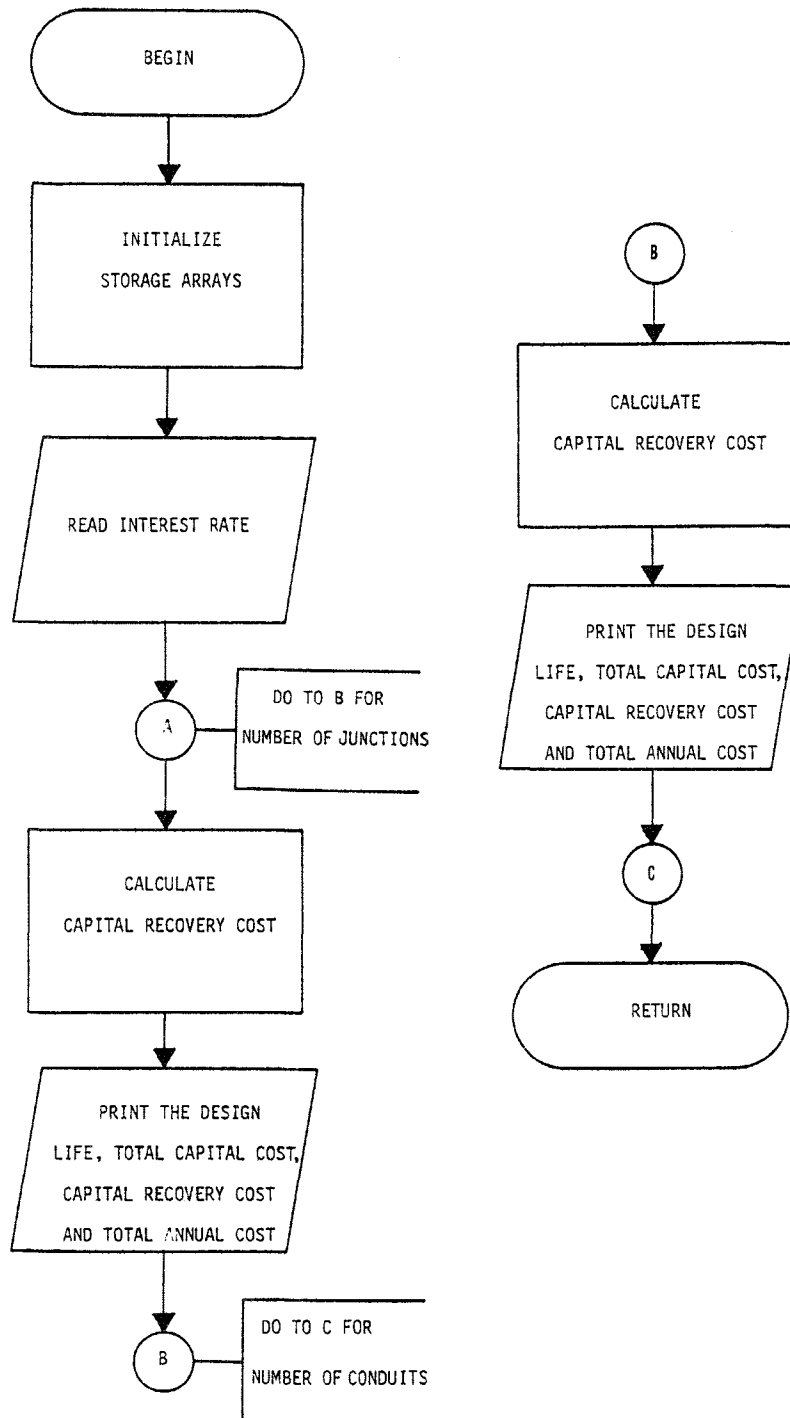


FIGURE IV-7. Flowchart for Subroutine AMORT

TABLE IV-3. KEY VARIABLES
IN SUBROUTINE AMORT AND NOT IN COMMON

| FORTRAN VARIABLE | DESCRIPTION | UNITS |
|---------------------|--|--------------|
| FACTR | Capital cost recover factor | None |
| ANJ | Capital recovery cost plus O&M cost for each junction | Dollars/year |
| ANP | Capital recovery cost plus O&M cost for each conduit | Dollars/year |


```

      STOP 500
300  TEMP=0.0
      FACTR=0.0
C
C***** CALCULATE ANNUAL COST FOR EACH JUNCTION
C
      IF( IOPTOT.EQ.1) GO TO 105
      WRITE(N6,2000) NAME
      WRITE(N6,1050) RATE
1050  FORMAT(////,28(2H**),* ANNUAL COSTS *,28(2H**),/,57X,*(DOLLARS/YR)
1 *,//,50X,*INTEREST RATE= *,F6.2,* PERCENT*)
      WRITE(N6,1060)
1060  FORMAT(////,42X,*DESIGN*,14X,*TOTAL*,14X,*CAPITAL*,15X,*TOTAL*,
1  /,21X,*JUNCTION*,14X,*LIFE*,14X,*CAPITAL*,12X,*RECOVERY*,14X,
2  *ANNUAL*,/,24X,*ND*,16X,*(YRS)*,15X,*COST*,16X,*COST*,17X,
3  *COST*,/,20X,5(5(2H--),10X))
105  I=0
      DO 100 N=1,JNC
      DO 110 J=1,ICOUNT
      IF(DSGN(J).NE.0.0) GO TO 130
      WRITE(N6,2000) NAME
      WRITE(N6,1030) N
1030  FORMAT(////,1X,13H*** ERROR ***,* DESIGN LIFE FOR JUNCTION*,14,
1  * IS ZERO*)
      STOP 500
130  IF(JCODE(N).EQ.ICODE(J)) GO TO 120
110  CONTINUE
120  TEMP=DSGN(J)
      TEMP2=RATE/100.0
      FACTR=(TEMP2*(1.0+TEMP2)**TEMP)/((TEMP2+1.0)**TEMP-1.0)
      ANCSTJ(N)=TCAPJ(N)*FACTR
      TEMP=0.0
      FACTR=0.0
      ANJ=ANCSTJ(N)+CSTOMJ(N)
      IF( IOPTOT.EQ.1) GO TO 100
C
C**** PRINT ANNUAL COST FOR EACH JUNCTION
      WRITE(N6,1070) JNCTN(N),DSGN(J),TCAPJ(N),ANCSTJ(N),ANJ
1070  FORMAT(/,22X,14,14X,F8.2,2X,3(10X,2PE10.3))
      I=I+1
      IF(I.NE.19) GO TO 100
      WRITE(N6,2000) NAME
      WRITE(N6,1050) RATE
      WRITE(N6,1060)
      I=0
100  CONTINUE
      IF( IOPTOT.EQ.1) GO TO 205
      IF(IOPTOM.EQ.1) WRITE(N6,3000)
3000  FORMAT(///,35X,*TOTAL ANNUAL COST INCLUDES OPERATION AND MAINTENAN
1CE COSTS*)
C

```

C***** CALCULATE ANNUAL COST FOR EACH CONDUIT

C

```
      WRITE(N6,2000) NAME
      WRITE(N6,1050) RATE
      WRITE(N6,1080)
1080  FORMAT(////,42X,*DESIGN*,15X,*TOTAL*,14X,*CAPITAL*,14X,*TOTAL*,/,
1     22X,*CONDUIT*,14X,*LIFE*,15X,*CAPITAL*,12X,*RECOVERY*,13X,
2     *ANNUAL*,/,24X,*NO*,16X,*(YRS)*,16X,*COST*,16X,*COST*,16X,
3     *COST*,/,20X,5(5(2H--),10X))
205  I=0
      DO 200 N=1,KDN
      DO 210 J=1,ICDUNT
      IF(DSGN(J).NE.0.0) GO TO 230
      WRITE(N6,2000) NAME
      WRITE(N6,1040) N
1040  FORMAT(////,1X,13H*** ERROR ***,* DESIGN LIFE FOR CONDUIT*,14,
1     * IS ZERO*)
      STOP 501
230  IF(KODE(N).EQ.ICODE(J)) GO TO 220
210  CONTINUE
220  TEMP=DSGN(J)
      TEMP2=RATE/100.0
      FACTR=(TEMP*(1.0+TEMP2)**TEMP)/((TEMP2+1.0)**TEMP-1.0)
      PANCST(N)=TCAPP(N)*FACTR
      TEMP=0.0
      FACTR=0.0
      ANP=PANCST(N)+CSTOMP(N)
      IF( IOPTOT.EQ.1) GO TO 200
```

C

C**** PRINT ANNUAL COST FOR CONDUITS

```
      WRITE(N6,1070) KONDUT(N),DSGN(J),TCAPP(N),PANCST(N),ANP
      I=I+1
      IF(I.NE.19) GO TO 200
      WRITE(N6,2000) NAME
      WRITE(N6,1050) RATE
      WRITE(N6,1080)
      I=0
200  CONTINUE
      IF( IOPTOT.EQ.1) RETURN
      IF( IOPTOM.EQ.1) WRITE(N6,3000)
      RETURN
      END
```

Subroutine TABLES

- Called from
COSTEST
- Common blocks used
 - /CNTRL/
 - /CAPITAL/
 - /ANNUAL/
 - /DIRT/
 - /DRAIN/
 - /DOLLARS/
 - /EXCAV/
 - /BKFILL/
 - /TOTAL/
 - /COUNT/
 - /OANDM/

Up until this point in the program, all the costs have been calculated and presented on either a junction-by-junction- or a conduit-by-conduit basis. Subroutine TABLES organizes all the calculated costs into a cost-code-number format. Each drainage structure having similar code numbers are summarized until every cost code number given in subroutine INDATA has been accounted for.

Subroutine TABLES summarizes the following information by distinct cost code number:

- code number total cost,
- total item quantity,
- total excavation,
- total backfill,
- total excavation cost,

- total backfill cost,
- total special backfill (if required),
- total special backfill cost (if required),
- total installation cost,
- total capital cost,
- total annual cost, and
- total O&M cost.

TABLES then prints out the summarized quantities with capital costs first, then O&M costs, and finally total annual costs. The subroutine also summarizes and prints all capital, O&M, and annual costs for the entire drainage system.

If an O&M cost analysis, or a total annual cost analysis, was omitted from the simulation run, those costs are not summarized and not printed. If the engineer selects the short output option, all the output is omitted except for the total project costs. Figure IV-8 presents the flowchart for subroutine TABLES.

The key variables used in subroutine TABLES, which are not held in COMMON are given in Table IV-4. A program listing of subroutine TABLES follows.

Key Variables in Common

Throughout the description of each subroutine and the main program, only the variables which were not held in COMMON were defined. The Cost Estimation Module has a total of 11 common blocks. Tables IV-5 through IV-15 present the key variables found in the 11 COMMON blocks used in the Module.

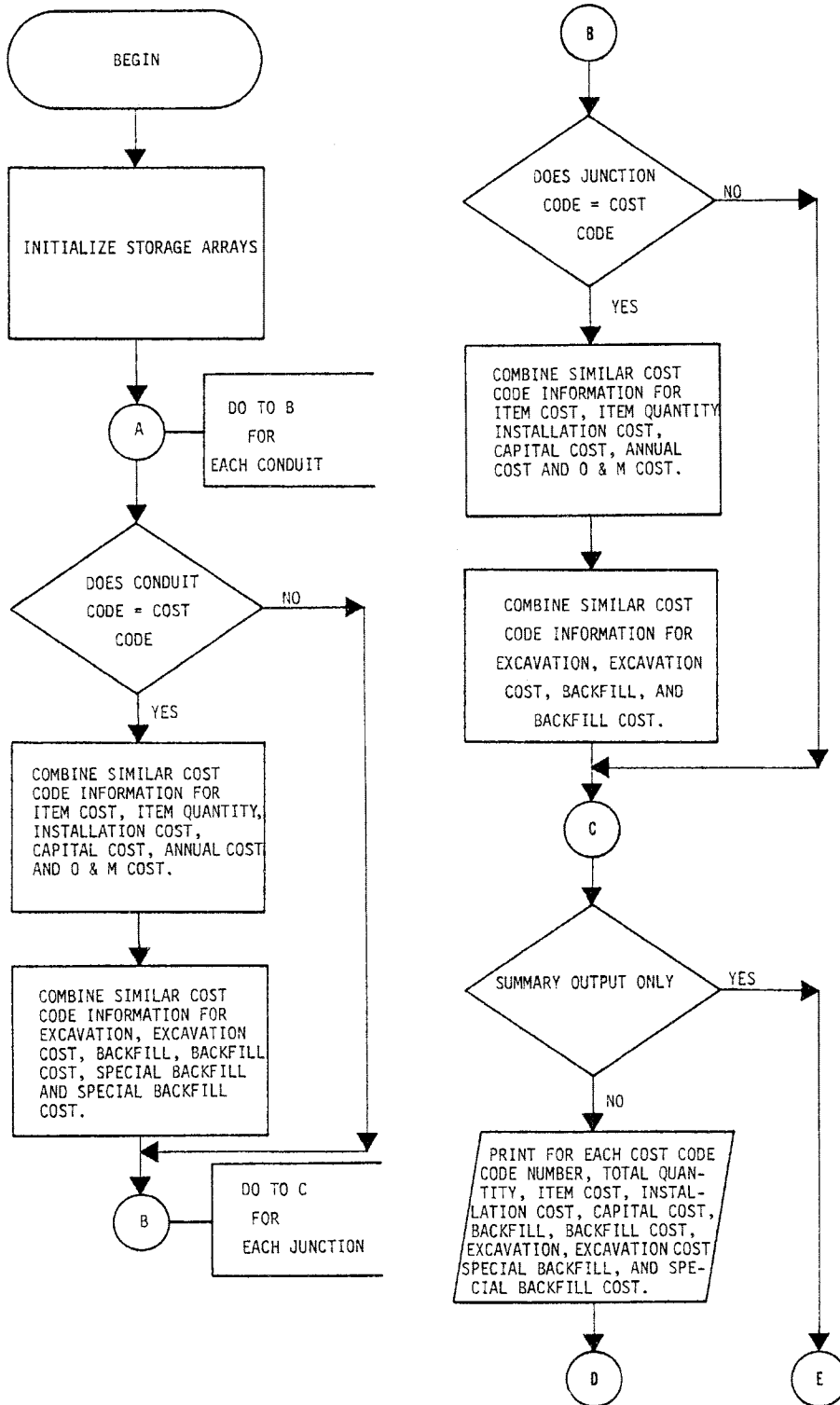


FIGURE IV-8. Flowchart for Subroutine TABLES

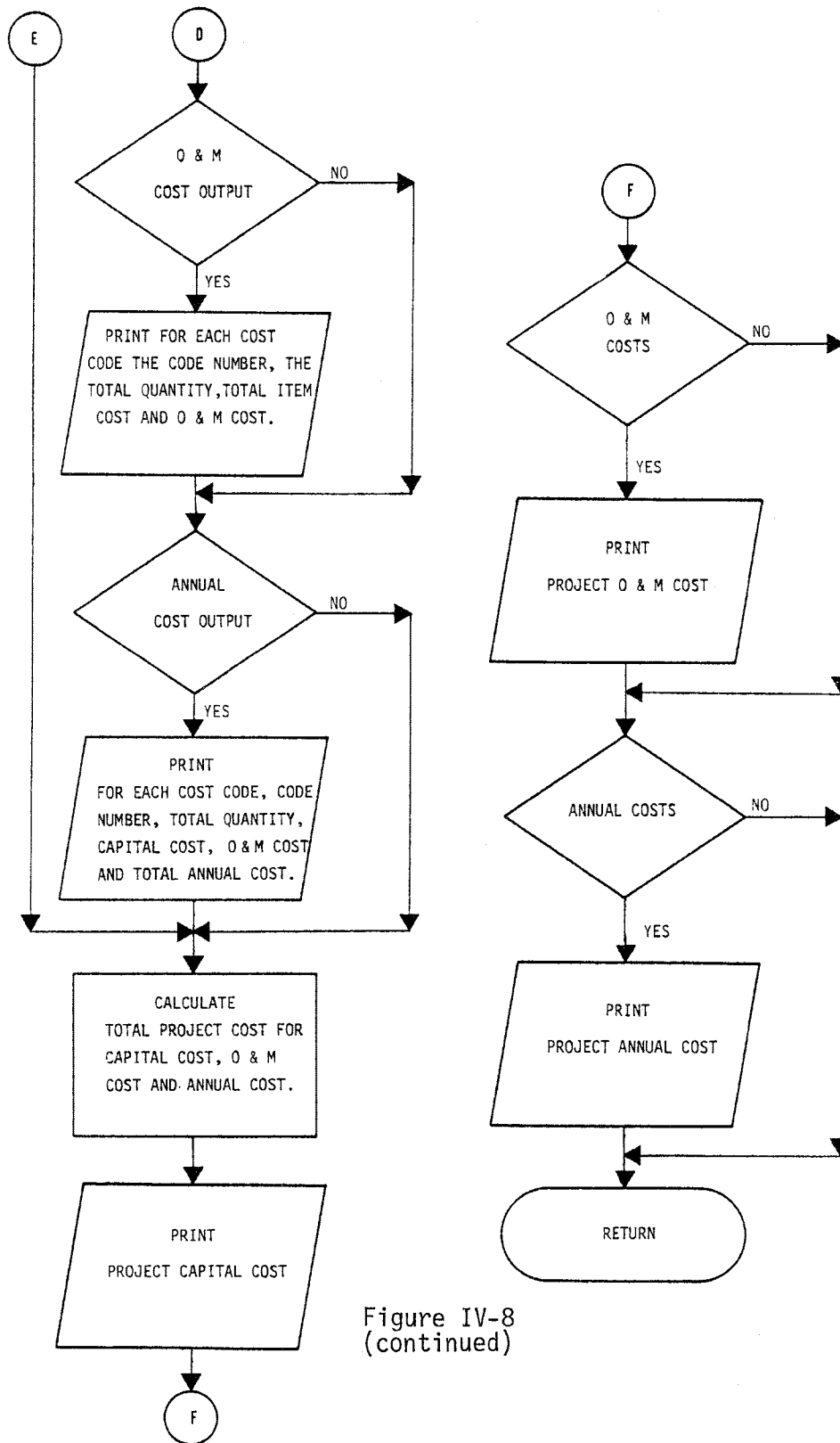


Figure IV-8
(continued)

TABLE IV-4. KEY VARIABLES IN
SUBROUTINE TABLES AND NOT IN COMMON

| FORTRAN VARIABLE | DESCRIPTION | UNITS |
|---------------------|---|--------------|
| ITEMP | Temporary indicator for zero installation costs | None |
| PROJAN | Total project annual cost | Dollars/year |
| PROJCAP | Total project capital cost | Dollars |
| PROJOM | Total project O&M cost | Dollars/year |

SUBROUTINE TABLES

C
C
C
C
C
C
C
C
C
C
C
C

```
*****
*
* TABLES PRINTS THE CAPITAL, O&M, AND TOTAL ANNUAL COSTS FOR
* EACH COMPONENT OF THE DRAINAGE SYSTEM IN TABULAR FORM. WHEN
* IOPTOT = 1 A SUMMARY TABLE ONLY OF TOTAL CAPITAL,
* O AND M, AND ANNUAL COSTS IS PRINTED
*
*****
```

```
COMMON/CNTRL/ N5,N6,IOPTOM,ITOTAN, IOPTOT,NAME(10),IMET
COMMON/ CAPITA/ CSTJNC(100),CSTEXJ(100),CSTBKJ(100),PCST(100),
1 PEXCST(100),PRKCST(100), PSPRKC(100),TCAPJ(100),TCAPP(100),
2 CSTINJ(100),PINCST(100)
COMMON/ANNUAL/ ANCSTJ(100),PANCST(100),RATE
COMMON/DIRT/ EXPIPE(100),BKFLP(100), SBKFLP(100),EXJNC(100),
1 BKFLJN(100)
COMMON/DRAIN/ JNCTN(100),KODE(100),ELGD(100),ELINV(100),
1 ITYPE(100), KONDUT(100),JUPSTM(100),DIA(100),LEN(100),
2 JDNSTM(100),JCODE(100),IFIL(100)
COMMON/ DOLLAR/ JCODE(100),TITLE(100,4),COST(100), INSTAL(100),
1 OM(100),UNIT(100,2),DSGN(100),ISPBK(100)
COMMON/EXCAV/ EXTITL(4),EXCOST,EXUNIT(2)
COMMON/BKFILL/ BKTITL(4),BKFCST,BKUNIT(2),
1 SPTITL(4),SPCOST,PERDIA,SPUNIT(2)
COMMON/TOTAL/ TCSTJ(100),TEXJ(100),TBKJ(100),TQJ(100),TINJ(100),
1 TEXCSJ(100), TBKCSJ(100),TTLCJ(100),TCSTP(100),TEXP(100),
2 TBKP(100),TSPBKP(100),TQP(100),TINP(100), TEXCSP(100),
3 TBKCSP(100),TSBCP(100),TTLCP(100),TANCJ(100),TANCP(100),
4 TOMCJ(100),TOMCP(100)
COMMON/COUNT/ ICOUNT,JNC,KON
COMMON/DANDM/ CSTMJ(100),CSTOMP(100)
REAL INSTAL,LEN
DATA QTY/4HEACH/
```

C
C
C

***** INITIALIZATION

```
DO 50 N=1,100
TCSTJ(N)=0.0
TEXJ(N)=0.0
TBKJ(N)=0.0
TQJ(N)=0.0
TINJ(N)=0.0
TEXCSJ(N)=0.0
TBKCSJ(N)=0.0
TTLCJ(N)=0.0
TANCJ(N)=0.0
TOMCJ(N)=0.0
TCSTP(N)=0.0
TEXP(N)=0.0
TBKP(N)=0.0
TSPBKP(N)=0.0
TQP(N)=0.0
TINP(N)=0.0
TEXCSP(N)=0.0
TBKCSP(N)=0.0
TSBCP(N)=0.0
```



```

      TTLCP(N)=0.0
      TANCP(N)=0.0
      TOMCP(N)=0.0
50  CONTINUE
C
C***** CALCULATE OUTPUT INFORMATION FOR JUNCTIONS
C
      DO 100 N=1,ICOUNT
      DO 110 J=1,JNC
      IF(ICODE(N).NE.JCODE(J)) GO TO 110
C
C**** CAPITAL COSTS
      TCSTJ(N)=TCSTJ(N)+CSTJNC(J)
      IF(UNIT(N,1).EQ.QTY) GO TO 130
      TQJ(N)=TQJ(N)+(ELGD(J)-ELINV(J))
      GO TO 140
130  TQJ(N)=TQJ(N)+1
140  TEXJ(N)=TEXJ(N)+EXJNC(J)
      TEXCSJ(N)=TEXCSJ(N)+CSTEXJ(J)
      TBKJ(N)=TBKJ(N)+RKFLJN(J)
      TBKCSJ(N)=TBKCSJ(N)+CSTBKJ(J)
      TINJ(N)=TINJ(N)+CSTINJ(J)
      TTLCJ(N)=TCSTJ(N)+TEXCSJ(N)+TBKCSJ(N)+TINJ(N)
C
C**** ANNUAL COSTS
      IF(ITOTAN.EQ.0) GO TO 120
      TANCJ(N)=TANCJ(N)+ANCSTJ(J)
C
C**** OPERATION AND MAINTENANCE COSTS
120  IF(IDPTOM.EQ.0) GO TO 110
      TOMCJ(N)=TOMCJ(N)+CSTOMJ(J)
      TANCJ(N)=TANCJ(N)+TOMCJ(N)
110  CONTINUE
100  CONTINUE
C
C***** CALCULATE OUTPUT INFORMATION FOR CONDUITS
C
      DO 200 N=1,ICOUNT
      DO 210 J=1,KON
      IF(ICODE(N).NE.KODE(J)) GO TO 210
C
C**** CAPITA COSTS
      TCSTP(N)=TCSTP(N)+PCST(J)
      TOP(N)=TOP(N)+LEN(J)
      TINP(N)=TINP(N)+PINCST(J)
      TEXP(N)=TEXP(N)+EXPIPE(J)
      TEXCSP(N)=TEXCSP(N)+PEXCST(J)
      TBKP(N)=TBKP(N)+RKFLP(J)
      TBKCSP(N)=TBKCSP(N)+PBKCSST(J)
      TSPBKP(N)=TSPBKP(N)+SBKFLP(J)
      TSBCP(N)=TSBCP(N)+PSPBKC(J)

```

```

      TTLCP(N)=TCSTP(N)+TINP(N)+ TEXCSP(N)+ TBKCSNP(N)+TSBCP(N)
C
C**** ANNUAL COSTS
      IF(ITOTAN.EQ.0) GO TO 220
      TANCP(N)=TANCP(N)+PANCST(J)
C
C**** OPERATION AND MAINTENANCE COSTS
      220 IF(IDOPTOM.EQ.0) GO TO 210
          TOMCP(N)=TOMCP(N)+CSTOMP(J)
          TANCP(N)=TANCP(N)+TOMCP(N)
      210 CONTINUE
      200 CONTINUE
          IF( IDPTOT.EQ.1) GO TO 800
C
C***** PRINT CAPITAL COSTS FOR JUNCTIONS
C
      WRITE(N6,2000) NAME
      2000 FORMAT(*1*,64(2H--)/* *,*FEDERAL HIGHWAY ADMINISTRATION*,14X,40H**
          2** URBAN HIGHWAY DRAINAGE MODEL ****,8X,*WATER RESOURCES ENGINEE
          3RS*/* *,*DEPARTMENT OF TRANSPORTATION*,16X,4H****,32X,4H****,8X,*A
          4 DIVISION OF CAMP DRESSER AND MCKEE*/* *,*WASHINGTON, D.C.*,28X,4H
          5****,5X,*COST ESTIMATION MODULE*,5X,4H****,8X,*SPRINGFIELD, VIRGIN
          6IA*,//,1X,*RUN: *,10A4)
          WRITE(N6,1000)
      1000 FORMAT(////,1X,28(2H**),* CAPITAL COSTS *,28(2H**),/,60X,
          1 *(DOLLARS)*)
          WRITE(N6,2040)
      2040 FORMAT(//,60X,*JUNCTIONS*)
          WRITE(N6,1010)
      1010 FORMAT(//,101X,*TOTAL*,/,17X,*CODE*,29X,*TOTAL*,12X,*ITEM*,8X,
          1 *INSTALLATION*,9X,*CAPITAL*,/,18X,*ID*,9X,*DESCRIPTION*,8X,
          2 *QUANTITY*,11X,*COST*,12X,*COST*,15X,*COST*,/,15X,4(2H--),4X,
          3 7(2H--),3X,9(2H--),2X,5(2H--),5X,6(2H--),8X,5(2H--))
          I=0
          DO 300 N=1,ICOUNT
          DO 310 J=1,JNC
          IF(JCODE(J).NE.ICDDE(N)) GO TO 310
          WRITE(N6,1020) ICDDE(N),(TITLE(N,K),K=1,4),TQJ(N),(UNIT(N,K),K=1,2
          1),ICSTJ(N),TINJ(N),TTLCJ(N)
      1020 FORMAT(/,16X,15,5X,4A4,2X,2PE10.3,1X,2A4,1X,2PE10.3,6X,2PE10.3,
          1 8X,2PE10.3)
          IF(TINJ(N).EQ.0.0) ITEMP=1
C
C**** JUNCTION EXCAVATION
      IF(EXCOST.EQ.0.0) GO TO 330
      WRITE(N6,1040) EXTITL,TEXJ(N),EXUNIT,TEXCSJ(N)
      1040 FORMAT(/,27X,4A4,1X,2PE10.3,1X,2A4,1X,2PE10.3)
          GO TO 340
      330 WRITE(N6,1030) EXTITL,TEXJ(N),EXUNIT
      1030 FORMAT(/,27X,4A4,1X,2PE10.3,1X,2A4)
C

```

```

C**** JUNCTION BACKFILL
340 IF(BKCDST.EQ.0.0) GO TO 350
    WRITE(N6,1040) BKTITL,TBKJ(N),BKUNIT, TBKCSJ(N)
    GO TO 320
350 WRITE(N6,1030) BKTITL,TBKJ(N),BKUNIT
320 I=I+1
    IF(I.NE.6) GO TO 300
    WRITE(N6,2000) NAME
    WRITE(N6,1000)
    WRITE(N6,2040)
    WRITE(N6,1010)
    I=0
310 CONTINUE
300 CONTINUE
    IF(EXCDST.EQ.0.0) WRITE(N6,3040)
3040 FORMAT(///,46X,*ITEM COSTS INCLUDE EXCAVATION COSTS*)
    IF(BKCDST.EQ.0.0) WRITE(N6,3050)
3050 FORMAT(///,47X,*ITEM COSTS INCLUDE BACKFILL COSTS*)
    IF(ITEMP.EQ.1) WRITE(N6,2060)
2060 FORMAT(//,35X,*IF INSTALLATION COSTS ARE ZERO THEY ARE INCLUDED IN
1 THE ITEM COSTS*)

```

C

```

C***** PRINT CAPITAL COSTS FOR CONDUITS

```

C

```

    WRITE(N6,2000) NAME
    WRITE(N6,1000)
    WRITE(N6,2050)
2050 FORMAT(//,60X,*CONDUITS*)
    WRITE(N6,1010)
    I=0
    DO 400 N=1,ICOUNT
    DO 410 J=1,KDN
    IF(KODE(J).NE.ICODE(N)) GO TO 410
    WRITE(N6,1020)ICODE(N),(TITLE(N,K),K=1,4),TQP(N),(UNIT(N,K),K=1,2)
1,TCSTP(N),TINP(N),TTLCP(N)
    IF(TINP(N).EQ.0.0) ITEMP=1

```

C

```

C**** CONDUIT EXCAVATION
    IF(EXCDST.EQ.0.0) GO TO 430
    WRITE(N6,1040) EXTITL,TEXP(N),EXUNIT, TEXCSP(N)
    GO TO 435
430 WRITE(N6,1030) EXTITL,TEXP(N),EXUNIT

```

C

```

C**** CONDUIT BACKFILL
435 IF(BKCDST.EQ.0.0) GO TO 440
    WRITE(N6,1040) BKTITL,TBKP(N),BKUNIT, TBKCSJ(N)
    GO TO 445
440 WRITE(N6,1030) BKTITL,TBKP(N),BKUNIT

```

C

```

C**** CONDUIT SPECIAL BACKFILL
445 IF(SPCDST.EQ.0.0) GO TO 450

```

```

WRITE(N6,1040) SPTITL,TSBPBK(N),SPUNIT,TSBCP(N)
450 I=I+1
IF(I.NE.5) GO TO 400
WRITE(N6,2000) NAME
WRITE(N6,1000)
WRITE(N6,2050)
WRITE(N6,1010)
I=0
410 CONTINUE
400 CONTINUE
IF(EXCOST.EQ.0.0) WRITE(N6,3040)
IF(BK COST.EQ.0.0) WRITE(N6,3050)
IF(ITEMP.EQ.1) WRITE(N6,2060)
C
C***** PRINT OPERATION AND MAINTENANCE COSTS
C
IF(IDPTOM.EQ.0) GO TO 500
WRITE(N6,2000) NAME
WRITE(N6,1050)
1050 FORMAT(////,1X,24(2H**),* OPERATION AND MAINTENANCE COSTS *,
1 24(2H**),/,59X,*(DOLLARS/YR)*
WRITE(N6,2040)
WRITE(N6,1060)
1060 FORMAT(/,18X,*CODE*,75X,*O AND M*,/,19X,*ID*,17X,*DESCRIPTION*,
1 23X,*QUANTITY*,18X,*COSTS*,/,16X,4(2H--),11X,9(2H--),14X,
2 9(2H--),10X,5(2H--))
C
C**** JUNCTIONS
I=0
DO 510 N=1,ICOUNT
DO 520 J=1,JNC
IF(JCODE(J).NE.ICODE(N)) GO TO 520
WRITE(N6,1070) ICODE(N),(TITLE(N,K),K=1,4),TQJ(N),(UNIT(N,K),K=1,2
1),IDMCJ(N)
1070 FORMAT(/,16X,I5,15X,4A4,16X,2PE10.3,1X,2A4,8X,2PE10.3)
I=I+1
IF(I.NE.19) GO TO 510
WRITE(N6,2000) NAME
WRITE(N6,1050)
WRITE(N6,2040)
WRITE(N6,1060)
520 CONTINUE
510 CONTINUE
WRITE(N6,1080)
1080 FORMAT(/,41X,* O AND M COSTS ARE A PERCENTAGE OF CAPITAL COSTS*)
I=0
C
C**** CONDUITS
WRITE(N6,2000) NAME
WRITE(N6,1050)
WRITE(N6,2050)

```

```

WRITE(N6,1060)
I=0
DO 600 N=1,ICOUNT
DO 620 J=1,KON
IF(KDDE(J).NE.ICCODE(N)) GO TO 620
WRITE(N6,1070)ICCODE(N),(TITLE(N,K),K=1,4),TOP(N),(UNIT(N,K),K=1,2)
1,TOMCP(N)
I=I+1
IF(I.NE.19) GO TO 600
WRITE(N6,2000) NAME
WRITE(N6,1050)
WRITE(N6,2050)
WRITE(N6,1060)
I=0
620 CONTINUE
600 CONTINUE
WRITE(N6,1080)

```

```

C
C***** PRINT ANNUAL COSTS
C
500 IF(ITOTAN.EQ.0) GO TO 800
WRITE(N6,2000) NAME
WRITE(N6,2010) RATE
2010 FORMAT(///,1X,28(2H**),* ANNUAL COSTS *,28(2H**),/,58X,*(DOLLARS/
1YR)*,/,57X,*INTEREST RATE = *,F6.2)
WRITE(N6,2020)
2020 FORMAT(///,8X,*CODE*,62X,*CAPITAL*,8X,*Q AND M*,10X,
1 *ANNUAL*,/,9X,*ID*,14X,*DESCRIPTION*,18X,*QUANTITY*,13X,*COST*,
2 12X,*COST*,12X,*COST*, /,6X,4(2H--),9X,8(2H--),10X,
3 9(2H--),5X,3(5(2H--),6X))

```

```

C
C**** JUNCTIONS
I=0
DO 700 N=1,ICOUNT
DO 710 J=1,JNC
IF(JCODE(J).NE.ICCODE(N)) GO TO 710
WRITE(N6,2030) ICODE(N),(TITLE(N,K),K=1,4),TOJ(N),(UNIT(N,K),K=1,2)
1),TTLCJ(N),TOMCJ(N),TANCJ(N)
2030 FORMAT(/,7X,15,11X,4A4,9X,2PE10.3,1X,2A4,5X,3(2PE10.3,6X))
I=I+1
IF(I.NE.19) GO TO 700
WRITE(N6,2000) NAME
WRITE(N6,2010)
WRITE(N6,2020)
I=0
710 CONTINUE
700 CONTINUE

```

```

C
C**** CONDUITS
I=0
WRITE(N6,2000) NAME

```

```

WRITE(N6,2010) RATE
WRITE(N6,2020)
DO 750 N=1,ICOUNT
DO 760 J=1,KON
IF(KODE(J).NE.ICODE(N)) GO TO 760
WRITE(N6,2030)ICODE(N),(TITLE(N,K),K=1,4),TOP(N),(UNIT(N,K),K=1,2)
1,TTLCP(N),TOMCP(N),TANCP(N)
I=I+1
IF(I.NE.19) GO TO 750
WRITE(N6,2000) NAME
WRITE(N6,2010)
WRITE(N6,2020)
I=0
760 CONTINUE
750 CONTINUE
C
C***** IF IOPTOT = 1 SUMMARY OUTPUT ONLY
C
800 PRJCAP=0.0
PROJDM=0.0
PROJAN=0.0
C
C***** CALCULATE TOTAL PROJECT COSTS
C
DO 810 N=1,ICOUNT
PRJCAP=PRJCAP+TTLCP(N)
PROJDM=PROJDM+TOMCP(N)
PROJAN=PROJAN+TANCP(N)
810 CONTINUE
C
C***** PRINT SUMMARY OUTPUT
C
WRITE(N6,2000) NAME
WRITE(N6,3000) PRJCAP
3000 FORMAT(//////////,1X,27(2H**),* TOTAL PROJECT COSTS *,
1 27(2H**),/,55X,10(2H--),1H-,//,46X,* CAPITAL COST (DOLLARS)= *,
2 2PE12.3)
IF(IOPTOM.EQ.0) GO TO 830
WRITE(N6,3010) PROJDM
3010 FORMAT(//,43X,*O AND M COSTS (DOLLARS/YEAR)= *,2PE12.3)
830 IF(IITOTAN.EQ.0) GO TO 840
WRITE(N6,3020) PROJAN
3020 FORMAT(//,43X,*ANNUAL COSTS (DOLLARS/YEAR)= *,2PE12.3)
IF( IOPTOT.EQ.1.AND.IOPTOM.EQ.1) WRITE(N6,3030)
3030 FORMAT(//,38X,* (TOTAL ANNUAL COSTS INCLUDE OPERATION AND MAINTENAN
ICE COSTS)*)
840 CONTINUE
RETURN
END

```

TABLE IV-5. KEY VARIABLES IN
COMMON BLOCK CNTRL

| FORTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|---------------------|------------------------------|-------|---------------|
| N5 | Card reader identifier | None | No |
| N6 | Line printer identifier | None | No |
| IOPTOM | O&M costs option | None | Yes |
| ITOTAN | Annual costs option | None | Yes |
| IOPTOUT | Output type option | None | Yes |
| INOPT | Drainage system input option | None | Yes |
| NAME(10) | Current simulation title | None | Yes |

TABLE IV-6. KEY VARIABLES IN
COMMON BLOCK COUNT

| FORTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|---------------------|---|-------|---------------|
| ICOUNT | Number of materials cards read in INDATA | None | No |
| JNC | Number of junctions read in SYSTEM | None | No |
| KON | Number of pipes read in SYSTEM | None | No |

TABLE IV-7. KEY VARIABLES IN
COMMON BLOCK EXCAV

| FORTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|---------------------|-------------------------------|-----------------------------------|---------------|
| EXTITLE(4) | Title of excavation | None | Yes |
| EXCOST | Unit cost of excavation | Dollars | Yes |
| EXUNIT(2) | Units of Excavation unit cost | yd ³ or m ³ | Yes |

TABLE IV-8. KEY VARIABLES IN
COMMON BLOCK BKFILL

| FORTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|---------------------|--|-----------------------------------|---------------|
| BKTITLE(4) | Title of backfill | None | Yes |
| BKCOST | Unit cost of backfill | Dollars | Yes |
| BKUNIT(2) | Units of backfill unit cost | yd ³ or m ³ | Yes |
| SPTITLE(4) | Title of special backfill | None | Yes |
| SPCOST | Special backfill unit cost | Dollars | Yes |
| PERDIA | Percent of pipe diameter for special backfill | Percent | Yes |
| SPUNIT(2) | Units of special backfill unit cost | yd ³ or m ³ | Yes |

TABLE IV-9. KEY VARIABLES IN
COMMON BLOCK DRAIN

| FORTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|---------------------|--------------------------------------|----------|---------------|
| JNCTN(100) | Number of junction | None | Yes |
| KODE(100) | Conduit code number | None | Yes |
| ELGD(100) | Junction grade elevation | ft or m | Yes |
| ELINV(100) | Junction bottom elevation | ft or m | Yes |
| ITYPE(100) | Junction type | None | No |
| KONDUIT(100) | Number of conduit | None | Yes |
| JUPSTM(100) | Upstream junction of conduit | None | Yes |
| DIA(100) | Conduit diameter | in or cm | No |
| LEN(100) | Conduit length | ft or m | Yes |
| JDNSTM(100) | Downstream junction of conduit | None | Yes |
| JCODE(100) | Junction code number | None | Yes |
| IFIL(100) | Junction fill situation indicator | None | Yes |

TABLE IV-10. KEY VARIABLES IN
COMMON BLOCK DIRT

| FORTTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|----------------------|--------------------------|-----------------------------------|---------------|
| EXPIPE(100) | Conduit excavation | yd ³ or m ³ | No |
| BKFLP(100) | Conduit backfill | yd ³ or m ³ | No |
| SPBKFLP(100) | Conduit special backfill | yd ³ or m ³ | No |
| EXJNC(100) | Junction excavation | yd ³ or m ³ | No |
| BKFLJNC(100) | Junction backfill | yd ³ or m ³ | No |

TABLE IV-11. KEY VARIABLES IN
COMMON BLOCK DOLLARS

| FORTTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|----------------------|----------------------------|--------------|---------------|
| ICODE(100) | Cost code number | None | Yes |
| TITLE(100,4) | Title of cost item | None | Yes |
| COST(100) | Unit cost of item | Dollars/unit | Yes |
| INSTALL(100) | Installation cost of item | Percent | Yes |
| OM(100) | O&M cost of item | Percent | Yes |
| UNIT(100,2) | Units for cost item | None | Yes |
| DSGN(100) | Design life of cost item | Years | Yes |
| ISPBK(100) | Special backfill indicator | None | Yes |

TABLE IV-12. KEY VARIABLES IN
COMMON BLOCK CAPITAL

| FORTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|---------------------|-------------------------------------|---------|---------------|
| CSTJNC(100) | Cost of junction | Dollars | No |
| CSTEXJ(100) | Cost of junction excavation | Dollars | No |
| CSTBKJ(100) | Cost of junction backfill | Dollars | No |
| PCST(100) | Cost of conduit | Dollars | No |
| PEXCST(100) | Cost of conduit excavation | Dollars | No |
| PBKCS(100) | Cost of conduit backfill | Dollars | No |
| PSPBKCS(100) | Cost of special conduit backfill | Dollars | No |
| TCAPJ(100) | Total capital cost of junction | Dollars | No |
| TCAPP(100) | Total capital cost of conduit | Dollars | No |
| CSTINJ(100) | Cost of junction installation | Dollars | No |
| CSTINP(100) | Cost of conduit installation | Dollars | No |

TABLE IV-13. KEY VARIABLES IN
COMMON BLOCK OANDM

| FORTTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|----------------------|--------------------|--------------|---------------|
| CSTOMJ(100) | Junction O&M costs | Dollars/year | No |
| CSTOMP(100) | Conduit O&M costs | Dollars/year | No |

TABLE IV-14. KEY VARIABLES IN
COMMON BLOCK ANNUAL

| FORTTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|----------------------|-----------------------|--------------|---------------|
| ANCSTJ(100) | Junction annual costs | Dollars/year | No |
| PANCST(100) | Conduit annual costs | Dollars/year | No |
| RATE | Interest Rate | Percent | Yes |

TABLE IV-15. KEY VARIABLES IN
COMMON BLOCK TOTAL

| FORTTRAN VARIABLE | DESCRIPTION | UNITS | INPUT DATA |
|----------------------|---|-----------------------------------|---------------|
| TCSTJ(100) | Total item cost of like junctions | Dollars | No |
| TEXJ(100) | Total excavation of like junctions | yd ³ or m ³ | No |
| TBJK(100) | Total backfill of like junctions | yd ³ or m ³ | No |
| TQJ(100) | Total quantity of like junctions | (Variable) | No |
| TINJ(100) | Total installation cost of like junctions | Dollars | No |
| TEXCSTS(100) | Total excavation cost of like junctions | Dollars | No |
| TBKCSTS(100) | Total backfill cost of like junctions | Dollars | No |
| TTLCJ(100) | Total capital cost of like junctions | Dollars | No |
| TCSTP(100) | Total item cost of like conduits | Dollars | No |
| TEXP(100) | Total excavation of like conduits | yd ³ or m ³ | No |
| TBKP(100) | Total backfill of like conduits | yd ³ or m ³ | No |
| TSPBKP(100) | Total special backfill of like conduits | yd ³ or m ³ | No |
| TQP(100) | Total quantity of like conduits | ft or m | No |
| TINP(100) | Total installation costs of like conduits | Dollars | No |
| TEXCSTP(100) | Total excavation costs of like conduits | Dollars | No |
| TBKCSTP(100) | Total backfill costs of like conduits | Dollars | No |
| TSBCP(100) | Total special backfill costs of like conduits | Dollars | No |
| TTLCP(100) | Total capital cost of like conduits | Dollars | No |
| TANCJ(100) | Total annual costs of like junctions | Dollars/year | No |
| TANCP(100) | Total annual costs of like conduits | Dollars/year | No |
| TOMCP(100) | Total O&M costs of like conduits | Dollars/year | No |
| TOMCJ(100) | Total O&M costs of like junctions | Dollars/year | No |

EXAMPLE PROBLEM

This section of the User's Manual presents the input and output from an example problem. Both the operation and maintenance cost option and the annual cost option are run.

The drainage system analyzed here consists of nine kinds of conduits and eight kinds of junctions. There are a total of 23 junctions and 22 conduits involved. Special backfill is required for most of the conduits. Part of the drainage system is in a fill situation.

A listing of the input card deck used to run this problem is given below, followed by a copy of the output for this problem. Note that if the short output option had been selected, only the last page of the output would have been printed. Exhibit IV-1 shows the input deck; Exhibit IV-2 shows the program output.

| EXAMPLE PROBLEM | | | | | | | | | |
|-----------------|-------|------------------|-------|------|-------|------|------|---|----|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | 1 | 1 | 0 | 0 | | | | | |
| | 31008 | PIPE EIGHT INCH | 1.00 | L.F. | 5.0 | 7.0 | 10.0 | | |
| | 31012 | PIPE TWELVE INCH | 2.00 | L.F. | 5.0 | 7.0 | 10.0 | | 1 |
| | 31024 | PIPE 24 INCH DIA | 4.00 | L.F. | 5.0 | 7.0 | 10.0 | | 1 |
| | 32024 | GRASS CHANNEL | 25.0 | L.F. | 5.0 | 7.0 | 10.0 | | |
| | 31030 | PIPE 30 INCH DIA | 3.00 | L.F. | 5.0 | 7.0 | 10.0 | | 1 |
| | 31036 | PIPE 36 INCH DIA | 6.00 | L.F. | 5.0 | 7.0 | 10.0 | | 1 |
| | 31048 | PIPE 48 INCH DIA | 8.00 | L.F. | 5.0 | 7.0 | 10.0 | | 1 |
| | 31054 | PIPE 54 INCH DIA | 10.0 | L.F. | 5.0 | 7.0 | 10.0 | | 1 |
| | 31060 | PIPE 60 INCH DIA | 20.0 | L.F. | 5.0 | 7.0 | 10.0 | | 1 |
| | 4104 | STD. DROP INLET | 55.0 | V.F. | 5.0 | 10.0 | 25.0 | | |
| | 4114 | STD. DROP INLET | 55.0 | V.F. | 5.0 | 10.0 | 25.0 | | |
| | 4124 | STD. DROP INLET | 55.0 | V.F. | 5.0 | 10.0 | 25.0 | | |
| | 4204 | GATED INLET STD | 55.0 | V.F. | 5.0 | 10.0 | 25.0 | | |
| | 4214 | STD GRATE INLET | 55.0 | V.F. | 5.0 | 10.0 | 25.0 | | |
| | 4224 | STD GRATE INLET | 200.0 | EACH | 5.0 | 10.0 | 25.0 | | |
| | 4304 | COMBINATN INLET | 55.0 | V.F. | 5.0 | 10.0 | 25.0 | | |
| | 4314 | COMBINATN INLET | 55.0 | V.F. | 5.0 | 10.0 | 25.0 | | |
| | 4324 | COMBINATN INLET | 55.0 | V.F. | 5.0 | 10.0 | 25.0 | | |
| | 4400 | STANDARD MANHOLE | 100.0 | V.F. | 0.0 | 0.0 | 50.0 | | |
| | 4500 | 60 IN. ENDWALL | 500.0 | EACH | 0.0 | 0.0 | 50.0 | | |
| | 9999 | | | | | | | | |
| | | EXCAVATION | 10.0 | C.Y. | | | | | |
| | | REG. BACKFILL | 5.0 | C.Y. | | | | | |
| | | GRAVEL BACKFILL | 100.0 | C.Y. | 100.0 | | | | |
| | 1 | 4114 | 100. | 95.0 | | | | | |
| | 2 | 4104 | 100. | 94.0 | | | | | |
| | 3 | 4114 | 100. | 93.0 | | | | | |
| | 4 | 4124 | 100. | 92.0 | | | | | |
| | 5 | 4104 | 100. | 91.0 | | | | | |
| | 6 | 4204 | 100. | 90.0 | | | | | |
| | 7 | 4214 | 100. | 89.0 | | | | | |
| | 8 | 4204 | 100. | 88.5 | | | | | |
| | 9 | 4224 | 100. | 87.0 | | | | | |
| | 10 | 4214 | 90.0 | 86.0 | | | | 1 | |
| | 11 | 4204 | 90.0 | 85.0 | | | | 1 | |
| | 12 | 4304 | 90.0 | 84.0 | | | | 1 | |
| | 13 | 4314 | 100. | 93.0 | | | | | |
| | 14 | 4114 | 120. | 82.0 | | | | | |
| | 15 | 4204 | 130. | 81.5 | | | | | |
| | 16 | 4314 | 135. | 81.5 | | | | | |
| | 17 | 4204 | 130. | 81.0 | | | | | |
| | 18 | 4114 | 120. | 90.0 | | | | | |
| | 19 | 4214 | 110. | 90.0 | | | | | |
| | 20 | 4124 | 100. | 90.0 | | | | | |
| | 21 | 4114 | 90.0 | 85.0 | | | | | |
| | 22 | 4400 | 100. | 85.0 | | | | | |
| | 23 | 4500 | 90.0 | 88.0 | | | | | |
| | 1 | 31012 | 100. | 1 | 2 | | | | |
| | 2 | 31012 | 100. | 2 | 3 | | | | |
| | 3 | 31024 | 100. | 3 | 4 | | | | |
| | 4 | 32024 | 100. | 4 | 5 | | | | |
| | 5 | 31036 | 100. | 5 | 6 | | | | |
| | 6 | 31036 | 100. | 6 | 7 | | | | |
| | 7 | 31048 | 125. | 7 | 8 | | | | |
| | 8 | 31048 | 200. | 8 | 9 | | | | |
| | 9 | 31048 | 200. | 9 | 10 | | | | |
| | 10 | 31048 | 150. | 10 | 11 | | | | |
| | 11 | 31048 | 30.0 | 11 | 13 | | | | |
| | 12 | 31008 | 50.0 | 12 | 13 | | | | |
| | 13 | 31048 | 50.0 | 13 | 14 | | | | |
| | 14 | 31054 | 100. | 14 | 15 | | | | |
| | 15 | 31008 | 50.0 | 15 | 17 | | | | |
| | 16 | 31054 | 100. | 16 | 17 | | | | |
| | 17 | 31054 | 75.0 | 17 | 18 | | | | |
| | 18 | 31060 | 50.0 | 18 | 19 | | | | |
| | 19 | 31060 | 300. | 19 | 20 | | | | |
| | 20 | 31060 | 50.0 | 20 | 21 | | | | |
| | 21 | 31008 | 50.0 | 21 | 23 | | | | |
| | 22 | 31060 | 25.0 | 22 | 23 | | | | |

EXHIBIT IV-1. EXAMPLE PROBLEM INPUT DECK

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FEDERAL HIGHWAY ADMINISTRATION
DEPARTMENT OF TRANSPORTATION
WASHINGTON, D.C.

***** URBAN HIGHWAY DRAINAGE MODEL ***** WATER RESOURCES ENGINEERS
***** A DIVISION OF CAMP DRESSER AND MCKEE
***** COST ESTIMATION MODULE ***** SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

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***** OPTION INFORMATION *****
*****

CARD READER UNIT NO. (N5) 5
PRINTER UNIT NO. (N6) 6
O AND M COST OPTION (IOPTOM) YES
ANNUAL COST OPTION (IOTAN) YES
SHORT OUTPUT OPTION (IOPTOT) NO
METRIC UNIT OPTION (IMET) NO

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EXHIBIT IV-2. EXAMPLE PROBLEM OUTPUT

 FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

 URBAN HIGHWAY DRAINAGE MODEL *****
 COST ESTIMATION MODULE *****
 WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

***** INPUT COST INFORMATION *****

| CODE NUMBER | DESCRIPTION | UNIT COST | UNITS | INSTALLATION COST (PERCENT) | O AND M COST (PERCENT) | DESIGN LIFE (YRS) | SPECIAL BACKFILL |
|-------------|------------------|-----------|-------|-----------------------------|------------------------|-------------------|------------------|
| 31008 | PIPE EIGHT INCH | 1.00 | L.F. | 5.00 | 7.00 | 10.00 | |
| 31012 | PIPE TWELVE INCH | 2.00 | L.F. | 5.00 | 7.00 | 10.00 | YES |
| 31024 | PIPE 24 INCH DIA | 4.00 | L.F. | 5.00 | 7.00 | 10.00 | YES |
| 32024 | GRASS CHANNEL | 25.00 | L.F. | 5.00 | 7.00 | 10.00 | |
| 31030 | PIPE 30 INCH DIA | 3.00 | L.F. | 5.00 | 7.00 | 10.00 | YES |
| 31036 | PIPE 36 INCH DIA | 6.00 | L.F. | 5.00 | 7.00 | 10.00 | YES |
| 31048 | PIPE 48 INCH DIA | 8.00 | L.F. | 5.00 | 7.00 | 10.00 | YES |
| 31054 | PIPE 54 INCH DIA | 10.00 | L.F. | 5.00 | 7.00 | 10.00 | YES |
| 31060 | PIPE 60 INCH DIA | 20.00 | L.F. | 5.00 | 7.00 | 10.00 | YES |
| 4104 | STD. DROP INLET | 55.00 | V.F. | 5.00 | 10.00 | 25.00 | |
| 4114 | STD. DROP INLET | 55.00 | V.F. | 5.00 | 10.00 | 25.00 | |
| 4124 | STD. DROP INLET | 55.00 | V.F. | 5.00 | 10.00 | 25.00 | |
| 4204 | GRADED INLET STD | 55.00 | V.F. | 5.00 | 10.00 | 25.00 | |
| 4214 | STD GRATE INLET | 55.00 | V.F. | 5.00 | 10.00 | 25.00 | |
| 4224 | STD GRATE INLET | 200.00 | EACH | 5.00 | 10.00 | 25.00 | |
| 4304 | COMBINATN INLET | 55.00 | V.F. | 5.00 | 10.00 | 25.00 | |
| 4314 | COMBINATN INLET | 55.00 | V.F. | 5.00 | 10.00 | 25.00 | |

EXHIBIT IV-2. (Continued)

 FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.
 ***** URBAN HIGHWAY DRAINAGE MODEL ***** WATER RESOURCES ENGINEERS
 ***** COST ESTIMATION MODULE ***** A DIVISION OF CAMP DRESSER AND MCKEE
 ***** SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

| CODE NUMBER | DESCRIPTION | UNIT COST | UNITS | INSTALLATION COST (PERCENT) | O AND M COST (PERCENT) | DESIGN LIFE (YRS) | SPECIAL BACKFILL |
|----------------|------------------|--------------|-------|-----------------------------------|------------------------------|-------------------------|---------------------|
| 4324 | COMBINATN INLET | 55.00 | V.F. | 5.00 | 10.00 | 25.00 | |
| 4400 | STANDARD MANHOLE | 100.00 | V.F. | 0.00 | 0.00 | 50.00 | |
| 4500 | 60 IN. ENDWALL | 500.00 | EACH | 0.00 | 0.00 | 50.00 | |
| | EXCAVATION | 10.00 | C.Y. | | | | |
| | REG. BACKFILL | 5.00 | C.Y. | | | | |
| | GRAVEL BACKFILL | 100.00 | C.Y. | | | | |

SPECIAL BACKFILL REQUIRED FOR 100.00 PERCENT OF PIPE DIAMETER

IF INSTALLATION COSTS ARE ZERO THEY ARE INCLUDED IN THE UNIT COSTS

* * * UNIT NOTATION * * *

L.F. - LINEAR FOOT
 V.F. - VERTICAL FOOT
 C.F. - CUBIC FOOT

EXHIBIT IV-2. (Continued)

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

URBAN HIGHWAY DRAINAGE MODEL
 COST ESTIMATION MODULE

WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

***** DRAINAGE SYSTEM DESIGN INFORMATION *****

***** JUNCTION DATA *****

| JUNCTION NUMBER | CODE ID | HIGHWAY GRADE ELEVATION | JUNCTION BOTTOM ELEVATION | JUNCTION TYPE | FILL SITUATION | OPENING LENGTH (FT) | EXCAVATION (YD3) | BACKFILL (YD3) |
|-----------------|---------|-------------------------|---------------------------|---------------|----------------|---------------------|------------------|----------------|
| 1 | 4114 | 100.00 | 95.00 | 1 | | 14.00 | 11.81 | 5.19 |
| 2 | 4104 | 100.00 | 94.00 | 1 | | 4.00 | 4.54 | 1.78 |
| 3 | 4114 | 100.00 | 93.00 | 1 | | 14.00 | 20.51 | 7.26 |
| 4 | 4124 | 100.00 | 92.00 | 1 | | 24.00 | 39.24 | 14.22 |
| 5 | 4104 | 100.00 | 91.00 | 1 | | 4.00 | 10.37 | 2.67 |
| 6 | 4204 | 100.00 | 90.00 | 2 | | 4.00 | 11.52 | 2.96 |
| 7 | 4214 | 100.00 | 89.00 | 2 | | 14.00 | 44.72 | 11.41 |
| 8 | 4204 | 100.00 | 88.50 | 2 | | 4.00 | 15.52 | 3.41 |
| 9 | 4224 | 100.00 | 87.00 | 2 | | 24.00 | 88.16 | 23.11 |
| 10 | 4214 | 90.00 | 86.00 | 2 | YES | 14.00 | 0.00 | 0.00 |
| 11 | 4204 | 90.00 | 85.00 | 2 | YES | 4.00 | 0.00 | 0.00 |
| 12 | 4304 | 90.00 | 84.00 | 3 | YES | 4.00 | 0.00 | 0.00 |
| 13 | 4314 | 100.00 | 93.00 | 3 | | 14.00 | 28.46 | 7.26 |
| 14 | 4114 | 120.00 | 82.00 | 1 | | 14.00 | 165.28 | 39.41 |
| 15 | 4204 | 130.00 | 81.50 | 2 | | 4.00 | 33.53 | 14.37 |
| 16 | 4314 | 135.00 | 81.50 | 3 | | 14.00 | 232.70 | 55.48 |
| 17 | 4204 | 130.00 | 81.00 | 2 | | 4.00 | 70.97 | 14.52 |
| 18 | 4114 | 120.00 | 90.00 | 1 | | 14.00 | 139.00 | 31.11 |
| 19 | 4214 | 110.00 | 90.00 | 2 | | 14.00 | 92.67 | 20.74 |

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

RUN: EXAMPLE PROBLEM

URBAN HIGHWAY DRAINAGE MODEL
 COST ESTIMATION MODULE

WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

***** JUNCTION DATA *****

| JUNCTION NUMBER | CODE ID | HIGHWAY GRADE ELEVATION | JUNCTION BOTTOM ELEVATION | JUNCTION TYPE | FILL SITUATION | OPENING LENGTH (FT) | EXCAVATION (YD3) | BACKFILL (YD3) |
|-----------------|---------|-------------------------|---------------------------|---------------|----------------|---------------------|------------------|----------------|
| 20 | 4124 | 100.00 | 90.00 | 1 | | 24.00 | 77.20 | 17.78 |
| 21 | 4114 | 90.00 | 85.00 | 1 | | 14.00 | 10.86 | 5.19 |
| 22 | 4400 | 100.00 | 85.00 | 4 | | 4.00 | 23.21 | 4.44 |
| 23 | 4500 | 90.00 | 88.00 | 4 | | 4.00 | 3.09 | .59 |

IN FILL SITUATIONS EXCAVATION AND BACKFILL ARE NOT PAY ITEMS

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

URBAN HIGHWAY DRAINAGE MODEL
 COST ESTIMATION MODULE

WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

***** CONDUIT DATA *****

| CONDUIT NUMBER | CODE ID | DIAMETER (IN) | LENGTH (FT) | UPSTREAM JUNCTION | DOWNSTREAM JUNCTION | EXCAVATION (YD3) | BACKFILL (YD3) | SPECIAL BACKFILL (YD3) |
|----------------|---------|---------------|-------------|-------------------|---------------------|------------------|----------------|------------------------|
| 1 | 31012 | 12.00 | 100.00 | 1 | 2 | 61.11 | 50.00 | 8.20 |
| 2 | 31012 | 12.00 | 100.00 | 2 | 3 | 72.22 | 61.11 | 8.20 |
| 3 | 31024 | 24.00 | 100.00 | 3 | 4 | 111.11 | 81.48 | 17.99 |
| 4 | 32024 | 24.00 | 100.00 | 4 | 5 | 125.93 | 0.00 | 0.00 |
| 5 | 31036 | 36.00 | 100.00 | 5 | 6 | 175.93 | 120.37 | 29.38 |
| 6 | 31036 | 36.00 | 100.00 | 6 | 7 | 194.44 | 138.89 | 29.38 |
| 7 | 31048 | 48.00 | 125.00 | 7 | 8 | 312.50 | 201.39 | 52.93 |
| 8 | 31048 | 48.00 | 200.00 | 8 | 9 | 544.44 | 366.67 | 84.69 |
| 9 | 31048 | 48.00 | 200.00 | 9 | 10 | 188.89 | 100.00 | 42.35 |
| 10 | 31048 | 48.00 | 150.00 | 10 | 11 | 0.00 | 0.00 | 0.00 |
| 11 | 31048 | 48.00 | 30.00 | 11 | 13 | 20.00 | 6.67 | 6.35 |
| 12 | 31008 | 8.00 | 50.00 | 12 | 13 | 16.05 | 15.73 | 0.00 |
| 13 | 31048 | 48.00 | 50.00 | 13 | 14 | 250.00 | 205.56 | 21.17 |
| 14 | 31054 | 54.00 | 100.00 | 14 | 15 | 1041.20 | 932.87 | 49.43 |
| 15 | 31008 | 8.00 | 50.00 | 15 | 17 | 240.74 | 240.09 | 0.00 |
| 16 | 31054 | 54.00 | 100.00 | 16 | 17 | 1233.80 | 1125.46 | 49.43 |
| 17 | 31054 | 54.00 | 75.00 | 17 | 18 | 713.19 | 631.94 | 37.07 |
| 18 | 31060 | 60.00 | 50.00 | 18 | 19 | 324.07 | 259.26 | 28.45 |
| 19 | 31060 | 60.00 | 300.00 | 19 | 20 | 1166.67 | 777.78 | 170.72 |

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

RUN: EXAMPLE PROBLEM

***** URBAN HIGHWAY DRAINAGE MODEL *****
 ***** COST ESTIMATION MODULE *****

***** WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA *****

***** JUNCTION COSTS *****
 (DOLLARS)

(COM IN DOLLARS/YR)

| JUNCTION NO | JUNCTION COST | EXCAVATION COST | BACKFILL COST | INSTALLATION COST | TOTAL CAPITAL COST | C AND M COST |
|-------------|---------------|-----------------|---------------|-------------------|--------------------|--------------|
| 1 | 27.50E+01 | 11.81E+01 | 25.93E+00 | 13.75E+00 | 43.28E+01 | 27.50E+00 |
| 2 | 33.00E+01 | 45.43E+00 | 88.89E-01 | 16.50E+00 | 40.08E+01 | 33.00E+00 |
| 3 | 38.50E+01 | 20.51E+01 | 36.30E+00 | 19.25E+00 | 64.56E+01 | 38.50E+00 |
| 4 | 44.00E+01 | 39.24E+01 | 71.11E+00 | 22.00E+00 | 92.55E+01 | 44.00E+00 |
| 5 | 49.50E+01 | 10.37E+01 | 13.33E+00 | 24.75E+00 | 63.68E+01 | 49.50E+00 |
| 6 | 55.00E+01 | 11.52E+01 | 14.81E+00 | 27.50E+00 | 70.75E+01 | 55.00E+00 |
| 7 | 60.50E+01 | 44.72E+01 | 57.04E+00 | 30.25E+00 | 11.40E+02 | 60.50E+00 |
| 8 | 63.25E+01 | 15.52E+01 | 17.04E+00 | 31.63E+00 | 83.64E+01 | 63.25E+00 |
| 9 | 20.00E+01 | 88.16E+01 | 11.56E+01 | 10.00E+00 | 12.07E+02 | 20.00E+00 |
| 10 | 22.00E+01 | 0. | 0. | 11.00E+00 | 23.10E+01 | 22.00E+00 |
| 11 | 27.50E+01 | 0. | 0. | 13.75E+00 | 28.88E+01 | 27.50E+00 |
| 12 | 33.00E+01 | 0. | 0. | 16.50E+00 | 34.65E+01 | 33.00E+00 |
| 13 | 38.50E+01 | 28.46E+01 | 36.30E+00 | 19.25E+00 | 72.51E+01 | 38.50E+00 |
| 14 | 20.90E+02 | 16.53E+02 | 19.70E+01 | 10.45E+01 | 40.44E+02 | 20.90E+01 |
| 15 | 26.68E+02 | 33.53E+01 | 71.85E+00 | 13.34E+01 | 32.08E+02 | 26.68E+01 |
| 16 | 29.43E+02 | 23.27E+02 | 27.74E+01 | 14.71E+01 | 56.94E+02 | 29.43E+01 |
| 17 | 26.95E+02 | 70.97E+01 | 72.59E+00 | 13.48E+01 | 36.12E+02 | 26.95E+01 |
| 18 | 16.50E+02 | 13.90E+02 | 15.56E+01 | 82.50E+00 | 32.78E+02 | 16.50E+01 |
| 19 | 11.00E+02 | 92.67E+01 | 10.37E+01 | 55.00E+00 | 21.85E+02 | 11.00E+01 |

EXHIBIT IV-2. (Continued)

 FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

 *** URBAN HIGHWAY DRAINAGE MODEL *** WATER RESOURCES ENGINEERS
 *** COST ESTIMATION MODULE *** A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

***** JUNCTION COSTS ***** (DOLLARS) *****

(0+M IN DOLLARS/YR)

| JUNCTION NO | JUNCTION COST | EXCAVATION COST | BACKFILL COST | INSTALLATION COST | TOTAL CAPITAL COST | O AND M COST |
|-------------|---------------|-----------------|---------------|-------------------|--------------------|--------------|
| 20 | 55.00E+01 | 77.20E+01 | 88.89E+00 | 27.50E+00 | 14.38E+02 | 55.00E+00 |
| 21 | 27.50E+01 | 10.86E+01 | 25.93E+00 | 13.75E+00 | 42.33E+01 | 27.50E+00 |
| 22 | 15.00E+02 | 23.21E+01 | 22.22E+00 | 0. | 17.54E+02 | 0. |
| 23 | 50.00E+01 | 30.94E+00 | 29.63E-01 | 0. | 53.39E+01 | 0. |

IF INSTALLATION COSTS ARE ZERO THEY ARE INCLUDED IN THE JUNCTION COSTS

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

***** URBAN HIGHWAY DRAINAGE MODEL ***** WATER RESOURCES ENGINEERS
 ***** COST ESTIMATION MODULE ***** A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

***** CONDUIT COSTS ***** (DOLLARS)

(0+M IN DOLLARS/YR)

| CONDUIT NO | CONDUIT COST | EXCAVATION COST | BACKFILL COST | SPECIAL BACKFILL COST | INSTALLATION COST | TOTAL CAPITAL COST | O. AND M COST |
|------------|--------------|-----------------|---------------|-----------------------|-------------------|--------------------|---------------|
| 1 | 20.00E+01 | 61.11E+01 | 25.00E+01 | 82.02E+01 | 10.00E+00 | 18.91E+02 | 14.00E+00 |
| 2 | 20.00E+01 | 72.22E+01 | 30.56E+01 | 82.02E+01 | 10.00E+00 | 20.58E+02 | 14.00E+00 |
| 3 | 40.00E+01 | 11.11E+02 | 40.74E+01 | 17.99E+02 | 20.00E+00 | 37.38E+02 | 28.00E+00 |
| 4 | 25.00E+02 | 12.59E+02 | 0. | 0. | 12.50E+01 | 38.84E+02 | 17.50E+01 |
| 5 | 60.00E+01 | 17.59E+02 | 60.19E+01 | 29.38E+02 | 30.00E+00 | 59.29E+02 | 42.00E+00 |
| 6 | 60.00E+01 | 19.44E+02 | 69.44E+01 | 29.38E+02 | 30.00E+00 | 62.06E+02 | 42.00E+00 |
| 7 | 10.00E+02 | 31.25E+02 | 10.07E+02 | 52.93E+02 | 50.00E+00 | 10.48E+03 | 70.00E+00 |
| 8 | 16.00E+02 | 54.44E+02 | 18.33E+02 | 84.69E+02 | 80.00E+00 | 17.43E+03 | 11.20E+01 |
| 9 | 16.00E+02 | 18.89E+02 | 50.00E+01 | 42.35E+02 | 80.00E+00 | 83.04E+02 | 11.20E+01 |
| 10 | 12.00E+02 | 0. | 0. | 0. | 60.00E+00 | 12.60E+02 | 84.00E+00 |
| 11 | 24.00E+01 | 20.00E+01 | 33.33E+00 | 63.52E+01 | 12.00E+00 | 11.21E+02 | 16.80E+00 |
| 12 | 50.00E+00 | 16.05E+01 | 78.63E+00 | 0. | 25.00E-01 | 29.16E+01 | 35.00E-01 |
| 13 | 40.00E+01 | 25.00E+02 | 10.28E+02 | 21.17E+02 | 20.00E+00 | 60.65E+02 | 28.00E+00 |
| 14 | 10.00E+02 | 10.41E+03 | 46.64E+02 | 49.43E+02 | 50.00E+00 | 21.07E+03 | 70.00E+00 |
| 15 | 50.00E+00 | 24.07E+02 | 12.00E+02 | 0. | 25.00E-01 | 36.60E+02 | 35.00E-01 |
| 16 | 10.00E+02 | 12.34E+03 | 56.27E+02 | 49.43E+02 | 50.00E+00 | 23.96E+03 | 70.00E+00 |
| 17 | 75.00E+01 | 71.32E+02 | 51.60E+02 | 37.07E+02 | 37.50E+00 | 14.79E+03 | 52.50E+00 |
| 18 | 10.00E+02 | 32.41E+02 | 12.96E+02 | 28.45E+02 | 50.00E+00 | 84.32E+02 | 70.00E+00 |
| 19 | 60.00E+02 | 11.67E+03 | 38.89E+02 | 17.07E+03 | 30.00E+01 | 38.93E+03 | 42.00E+01 |

EXHIBIT IV-2. (Continued)

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

RUN: EXAMPLE PROBLEM

URBAN HIGHWAY DRAINAGE MODEL
 COST ESTIMATION MODULE

WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

***** CONDUIT COSTS *****
 (DOLLARS)
 (0*M IN DOLLARS/YR)

| CONDUIT NO | CONDUIT COST | EXCAVATION COST | BACKFILL COST | SPECIAL BACKFILL COST | INSTALLATION COST | TOTAL CAPITAL COST | O AND M COST |
|------------|--------------|-----------------|---------------|-----------------------|-------------------|--------------------|--------------|
| 20 | 10.00E+02 | 97.23E+01 | 16.20E+01 | 28.45E+02 | 50.00E+00 | 50.30E+02 | 70.00E+00 |
| 21 | 50.00E+00 | 17.28E+01 | 83.19E+00 | 0. | 25.00E-01 | 30.85E+01 | 35.00E-01 |
| 22 | 50.00E+01 | 55.09E+01 | 11.34E+01 | 14.23E+02 | 25.00E+00 | 26.12E+02 | 35.00E+00 |

IF INSTALLATION COSTS ARE ZERO THEY ARE INCLUDED IN THE CONDUIT COSTS

EXHIBIT IV-2. (Continued)

 FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

 URBAN HIGHWAY DRAINAGE MODEL
 COST ESTIMATION MODULE

 WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

***** ANNUAL COSTS (DOLLARS/YR) *****

INTEREST RATE= 7.00 PERCENT

| JUNCTION NO | DESIGN LIFE (YRS) | TOTAL CAPITAL COST | CAPITAL RECOVERY COST | TOTAL ANNUAL COST |
|-------------|-------------------|--------------------|-----------------------|-------------------|
| 1 | 25.00 | 43.28E+01 | 37.14E+00 | 64.64E+00 |
| 2 | 25.00 | 40.08E+01 | 34.39E+00 | 67.39E+00 |
| 3 | 25.00 | 64.56E+01 | 55.40E+00 | 93.90E+00 |
| 4 | 25.00 | 92.55E+01 | 79.42E+00 | 12.34E+01 |
| 5 | 25.00 | 63.68E+01 | 54.64E+00 | 10.41E+01 |
| 6 | 25.00 | 70.75E+01 | 60.71E+00 | 11.57E+01 |
| 7 | 25.00 | 11.40E+02 | 97.78E+00 | 15.83E+01 |
| 8 | 25.00 | 83.64E+01 | 71.77E+00 | 13.50E+01 |
| 9 | 25.00 | 12.07E+02 | 10.36E+01 | 12.36E+01 |
| 10 | 25.00 | 23.10E+01 | 19.82E+00 | 41.82E+00 |
| 11 | 25.00 | 28.88E+01 | 24.78E+00 | 52.28E+00 |
| 12 | 25.00 | 34.65E+01 | 29.73E+00 | 62.73E+00 |
| 13 | 25.00 | 72.51E+01 | 62.22E+00 | 10.07E+01 |
| 14 | 25.00 | 40.44E+02 | 34.70E+01 | 55.60E+01 |
| 15 | 25.00 | 32.08E+02 | 27.53E+01 | 54.20E+01 |
| 16 | 25.00 | 56.94E+02 | 48.86E+01 | 78.29E+01 |
| 17 | 25.00 | 36.12E+02 | 31.00E+01 | 57.95E+01 |
| 18 | 25.00 | 32.78E+02 | 28.13E+01 | 44.63E+01 |
| 19 | 25.00 | 21.85E+02 | 18.75E+01 | 29.75E+01 |

EXHIBIT IV-2. (Continued)

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

URBAN HIGHWAY DRAINAGE MODEL
 COST ESTIMATION MODULE

WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

***** ANNUAL COSTS ***** ANNUAL COSTS ***** ANNUAL COSTS ***** ANNUAL COSTS ***** ANNUAL COSTS *****
 (DOLLARS/YR)

INTEREST RATE= 7.00 PERCENT

| JUNCTION NO | DESIGN LIFE (YRS) | TOTAL CAPITAL COST | CAPITAL RECOVERY COST | TOTAL ANNUAL COST |
|----------------|-------------------------|--------------------------|-----------------------------|-------------------------|
| 20 | 25.00 | 14.38E+02 | 12.34E+01 | 17.84E+01 |
| 21 | 25.00 | 42.33E+01 | 36.32E+00 | 63.82E+00 |
| 22 | 50.00 | 17.54E+02 | 12.71E+01 | 12.71E+01 |
| 23 | 50.00 | 53.39E+01 | 38.69E+00 | 38.69E+00 |

TOTAL ANNUAL COST INCLUDES OPERATION AND MAINTENANCE COSTS

EXHIBIT IV-2. (Continued)

 FEDERAL HIGHWAY ADMINISTRATION ***** URBAN HIGHWAY DRAINAGE MODEL ***** WATER RESOURCES ENGINEERS
 DEPARTMENT OF TRANSPORTATION ***** COST ESTIMATION MODULE ***** A DIVISION OF CAMP DRESSER AND MCKEE
 WASHINGTON, D.C. *****

RUN: EXAMPLE PROBLEM

***** ANNUAL COSTS (DOLLARS/YR) *****

INTEREST RATE= 7.00 PERCENT

| CONDUIT NO | DESIGN LIFE (YRS) | TOTAL CAPITAL COST | CAPITAL RECOVERY COST | TOTAL ANNUAL COST |
|------------|-------------------|--------------------|-----------------------|-------------------|
| 1 | 10.00 | 18.91E+02 | 26.93E+01 | 28.33E+01 |
| 2 | 10.00 | 20.58E+02 | 29.30E+01 | 30.70E+01 |
| 3 | 10.00 | 37.38E+02 | 53.22E+01 | 56.02E+01 |
| 4 | 10.00 | 38.84E+02 | 55.30E+01 | 72.80E+01 |
| 5 | 10.00 | 59.29E+02 | 84.41E+01 | 88.61E+01 |
| 6 | 10.00 | 62.06E+02 | 88.37E+01 | 92.57E+01 |
| 7 | 10.00 | 10.48E+03 | 14.91E+02 | 15.61E+02 |
| 8 | 10.00 | 17.43E+03 | 24.81E+02 | 25.93E+02 |
| 9 | 10.00 | 83.04E+02 | 11.82E+02 | 12.94E+02 |
| 10 | 10.00 | 12.60E+02 | 17.94E+01 | 26.34E+01 |
| 11 | 10.00 | 11.21E+02 | 15.95E+01 | 17.63E+01 |
| 12 | 10.00 | 29.16E+01 | 41.52E+00 | 45.02E+00 |
| 13 | 10.00 | 60.65E+02 | 86.35E+01 | 89.15E+01 |
| 14 | 10.00 | 21.07E+03 | 30.00E+02 | 30.70E+02 |
| 15 | 10.00 | 36.60E+02 | 52.12E+01 | 52.47E+01 |
| 16 | 10.00 | 23.96E+03 | 34.11E+02 | 34.81E+02 |
| 17 | 10.00 | 14.79E+03 | 21.05E+02 | 21.58E+02 |
| 18 | 10.00 | 84.32E+02 | 12.01E+02 | 12.71E+02 |
| 19 | 10.00 | 38.93E+03 | 55.42E+02 | 59.62E+02 |

EXHIBIT IV-2. (Continued)

 FEDERAL HIGHWAY ADMINISTRATION ***** URBAN HIGHWAY DRAINAGE MODEL ***** WATER RESOURCES ENGINEERS
 DEPARTMENT OF TRANSPORTATION ***** COST ESTIMATION MODULE ***** A DIVISION OF CAMP DRESSER AND MCKEE
 WASHINGTON, D.C. *****

RUN: EXAMPLE PROBLEM

 ***** ANNUAL COSTS *****
 (DOLLARS/YR)

INTEREST RATE= 7.00 PERCENT

| CONDUIT NO | DESIGN LIFE (YRS) | TOTAL CAPITAL COST | CAPITAL RECOVERY COST | TOTAL ANNUAL COST |
|------------|-------------------|--------------------|-----------------------|-------------------|
| 20 | 10.00 | 50.30E+02 | 71.61E+01 | 78.61E+01 |
| 21 | 10.00 | 30.85E+01 | 43.93E+00 | 47.43E+00 |
| 22 | 10.00 | 26.12E+02 | 37.19E+01 | 40.69E+01 |

TOTAL ANNUAL COST INCLUDES OPERATION AND MAINTENANCE COSTS

EXHIBIT IV-2. (Continued)

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

***** URBAN HIGHWAY DRAINAGE MODEL *****

 ***** COST ESTIMATION MODULE *****

***** WATER RESOURCES ENGINEERS *****
 ***** A DIVISION OF CAMP DRESSER AND MCKEE *****
 ***** SPRINGFIELD, VIRGINIA *****

RUN: EXAMPLE PROBLEM

***** CAPITAL COSTS ***** (DOLLARS)

JUNCTIONS

| CODE ID | DESCRIPTION | TOTAL QUANTITY | ITEM COST | INSTALLATION COST | TOTAL CAPITAL COST |
|---------|------------------|----------------|-----------|-------------------|--------------------|
| 4104 | STD. DROP INLET | 15.00E+00 V.F. | 82.50E+01 | 41.25E+00 | 10.38E+02 |
| | EXCAVATION | 14.91E+00 C.Y. | 14.91E+01 | | |
| | REG. BACKFILL | 44.44E-01 C.Y. | 22.22E+00 | | |
| 4114 | STD. DROP INLET | 85.00E+00 V.F. | 46.75E+02 | 23.38E+01 | 88.24E+02 |
| | EXCAVATION | 34.75E+01 C.Y. | 34.75E+02 | | |
| | REG. BACKFILL | 88.15E+00 C.Y. | 44.07E+01 | | |
| 4124 | STD. DROP INLET | 18.00E+00 V.F. | 99.00E+01 | 49.50E+00 | 23.64E+02 |
| | EXCAVATION | 11.64E+01 C.Y. | 11.64E+02 | | |
| | REG. BACKFILL | 32.00E+00 C.Y. | 16.00E+01 | | |
| 4204 | GRADED INLET STD | 12.40E+01 V.F. | 68.20E+02 | 34.10E+01 | 86.53E+02 |
| | EXCAVATION | 13.15E+01 C.Y. | 13.15E+02 | | |
| | REG. BACKFILL | 35.26E+00 C.Y. | 17.63E+01 | | |
| 4214 | STD GRATE INLET | 35.00E+00 V.F. | 19.25E+02 | 96.25E+00 | 35.56E+02 |
| | EXCAVATION | 13.74E+01 C.Y. | 13.74E+02 | | |
| | REG. BACKFILL | 32.15E+00 C.Y. | 16.07E+01 | | |
| 4224 | STD GRATE INLET | 10.00E-01 EACH | 20.00E+01 | 10.00E+00 | 12.07E+02 |
| | EXCAVATION | 88.16E+00 C.Y. | 88.16E+01 | | |
| | REG. BACKFILL | 23.11E+00 C.Y. | 11.56E+01 | | |

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

***** URBAN HIGHWAY DRAINAGE MODEL ***** WATER RESOURCES ENGINEERS
 ***** COST ESTIMATION MODULE ***** A DIVISION OF CAMP DRESSER AND MCKEE
 ***** SPRINGFIELD, VIRGINIA *****

RUN: EXAMPLE PROBLEM

***** CAPITAL COSTS ***** (DOLLARS) *****

JUNCTIONS

| CODE ID | DESCRIPTION | TOTAL QUANTITY | ITEM COST | INSTALLATION COST | TOTAL CAPITAL COST |
|---------|------------------|----------------|-----------|-------------------|--------------------|
| 4304 | COMBINATN INLET | 60.00E-01 V.F. | 33.00E+01 | 16.50E+00 | 34.65E+01 |
| | EXCAVATION | 0. C.Y. | 0. | | |
| | REG. BACKFILL | 0. C.Y. | 0. | | |
| 4314 | COMBINATN INLET | 60.50E+00 V.F. | 33.28E+02 | 16.64E+01 | 64.19E+02 |
| | EXCAVATION | 26.12E+01 C.Y. | 26.12E+02 | | |
| | REG. BACKFILL | 62.74E+00 C.Y. | 31.37E+01 | | |
| 4400 | STANDARD MANHOLE | 15.00E+00 V.F. | 15.00E+02 | 0. | 17.54E+02 |
| | EXCAVATION | 23.21E+00 C.Y. | 23.21E+01 | | |
| | REG. BACKFILL | 44.44E-01 C.Y. | 22.22E+00 | | |
| 4500 | 60 IN. ENDWALL | 10.00E-01 EACH | 50.00E+01 | 0. | 53.39E+01 |
| | EXCAVATION | 30.94E-01 C.Y. | 30.94E+00 | | |
| | REG. BACKFILL | 59.26E-02 C.Y. | 29.63E-01 | | |

IF INSTALLATION COSTS ARE ZERO THEY ARE INCLUDED IN THE ITEM COSTS

EXHIBIT IV-2. (Continued)

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

***** URBAN HIGHWAY DRAINAGE MODEL ***** WATER RESOURCES ENGINEERS

 ***** COST ESTIMATION MODULE ***** A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

***** CAPITAL COSTS ***** (DOLLARS)

| CODE ID | DESCRIPTION | TOTAL QUANTITY | ITEM COST | INSTALLATION COST | TOTAL CAPITAL COST |
|---------|------------------|----------------|-----------|-------------------|--------------------|
| 31008 | PIPE EIGHT INCH | 15.00E+01 L.F. | 15.00E+01 | 75.00E-01 | 42.61E+02 |
| | EXCAVATION | 27.41E+01 C.Y. | 27.41E+02 | | |
| | REG. BACKFILL | 27.25E+01 C.Y. | 13.62E+02 | | |
| | GRAVEL BACKFILL | 0. C.Y. | 0. | | |
| 31012 | PIPE TWELVE INCH | 20.00E+01 L.F. | 40.00E+01 | 20.00E+00 | 39.49E+02 |
| | EXCAVATION | 13.33E+01 C.Y. | 13.33E+02 | | |
| | REG. BACKFILL | 11.11E+01 C.Y. | 55.56E+01 | | |
| | GRAVEL BACKFILL | 16.40E+00 C.Y. | 16.40E+02 | | |
| 31024 | PIPE 24 INCH DIA | 10.00E+01 L.F. | 40.00E+01 | 20.00E+00 | 37.38E+02 |
| | EXCAVATION | 11.11E+01 C.Y. | 11.11E+02 | | |
| | REG. BACKFILL | 81.48E+00 C.Y. | 40.74E+01 | | |
| | GRAVEL BACKFILL | 17.99E+00 C.Y. | 17.99E+02 | | |
| 32024 | GRASS CHANNEL | 10.00E+01 L.F. | 25.00E+02 | 12.50E+01 | 38.84E+02 |
| | EXCAVATION | 12.59E+01 C.Y. | 12.59E+02 | | |
| | REG. BACKFILL | 0. C.Y. | 0. | | |
| | GRAVEL BACKFILL | 0. C.Y. | 0. | | |
| 31036 | PIPE 36 INCH DIA | 20.00E+01 L.F. | 12.00E+02 | 60.00E+00 | 12.14E+03 |
| | EXCAVATION | 37.04E+01 C.Y. | 37.04E+02 | | |
| | REG. BACKFILL | 25.93E+01 C.Y. | 12.96E+02 | | |
| | GRAVEL BACKFILL | 58.75E+00 C.Y. | 58.75E+02 | | |

CONDUITS

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

RUN: EXAMPLE PROBLEM

*** URBAN HIGHWAY DRAINAGE MODEL ***
 *** COST ESTIMATION MODULE ***

WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

***** CAPITAL COSTS (DOLLARS) *****

CONDUITS

| CODE ID | DESCRIPTION | TOTAL QUANTITY | ITEM COST | INSTALLATION COST | TOTAL CAPITAL COST |
|---------|------------------|----------------|-----------|-------------------|--------------------|
| 31036 | PIPE 36 INCH DIA | 20.00E+01 L.F. | 12.00E+02 | 60.00E+00 | 12.14E+03 |
| | EXCAVATION | 37.04E+01 C.Y. | 37.04E+02 | | |
| | REG. BACKFILL | 25.93E+01 C.Y. | 12.96E+02 | | |
| | GRAVEL BACKFILL | 58.75E+00 C.Y. | 58.75E+02 | | |
| 31048 | PIPE 48 INCH DIA | 75.50E+01 L.F. | 60.40E+02 | 30.20E+01 | 44.65E+03 |
| | EXCAVATION | 13.16E+02 C.Y. | 13.16E+03 | | |
| | REG. BACKFILL | 88.03E+01 C.Y. | 44.01E+02 | | |
| | GRAVEL BACKFILL | 20.75E+01 C.Y. | 20.75E+03 | | |
| 31054 | PIPE 54 INCH DIA | 27.50E+01 L.F. | 27.50E+02 | 13.75E+01 | 59.81E+03 |
| | EXCAVATION | 29.88E+02 C.Y. | 29.88E+03 | | |
| | REG. BACKFILL | 26.90E+02 C.Y. | 13.45E+03 | | |
| | GRAVEL BACKFILL | 13.59E+01 C.Y. | 13.59E+03 | | |
| 31060 | PIPE 60 INCH DIA | 42.50E+01 L.F. | 85.00E+02 | 42.50E+01 | 55.00E+03 |
| | EXCAVATION | 16.43E+02 C.Y. | 16.43E+03 | | |
| | REG. BACKFILL | 10.92E+02 C.Y. | 54.61E+02 | | |
| | GRAVEL BACKFILL | 24.19E+01 C.Y. | 24.19E+03 | | |

IF INSTALLATION COSTS ARE ZERO THEY ARE INCLUDED IN THE ITEM COSTS

EXHIBIT IV-2. (Continued)

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

**** URBAN HIGHWAY DRAINAGE MODEL ****
 **** COST ESTIMATION MODULE ****

WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

***** OPERATION AND MAINTENANCE COSTS (DOLLARS/YR) *****

JUNCTIONS

| CODE ID | DESCRIPTION | QUANTITY | O AND M COSTS |
|---------|------------------|----------------|---------------|
| 4104 | STD. DROP INLET | 15.00E+00 V.F. | 82.50E+00 |
| 4114 | STD. DROP INLET | 85.00E+00 V.F. | 46.75E+01 |
| 4124 | STD. DROP INLET | 10.00E+00 V.F. | 99.00E+00 |
| 4204 | GRATED INLET STD | 12.40E+01 V.F. | 68.20E+01 |
| 4214 | STD GRATE INLET | 35.00E+00 V.F. | 19.25E+01 |
| 4224 | STD GRATE INLET | 10.00E-01 EACH | 20.00E+00 |
| 4304 | COMBINATN INLET | 60.00E-01 V.F. | 33.00E+00 |
| 4314 | COMBINATN INLET | 60.50E+00 V.F. | 33.28E+01 |
| 4400 | STANDARD MANHOLE | 15.00E+00 V.F. | 0. |
| 4500 | 60 IN. ENDWALL | 10.00E-01 EACH | 0. |

O AND M COSTS ARE A PERCENTAGE OF CAPITAL COSTS

EXHIBIT IV-2. (Continued)

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

URBAN HIGHWAY DRAINAGE MODEL
 COST ESTIMATION MODULE

WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

RUN: EXAMPLE PROBLEM

***** OPERATION AND MAINTENANCE COSTS (DOLLARS/YR) *****

CONDUITS

| CODE ID | DESCRIPTION | QUANTITY | O AND M COSTS |
|---------|------------------|----------------|---------------|
| 31008 | PIPE EIGHT INCH | 15.00E+01 L.F. | 10.50E+00 |
| 31012 | PIPE TWELVE INCH | 20.00E+01 L.F. | 28.00E+00 |
| 31024 | PIPE 24 INCH DIA | 10.00E+01 L.F. | 28.00E+00 |
| 32024 | GRASS CHANNEL | 10.00E+01 L.F. | 17.50E+01 |
| 31036 | PIPE 36 INCH DIA | 20.00E+01 L.F. | 84.00E+00 |
| 31048 | PIPE 48 INCH DIA | 75.50E+01 L.F. | 42.28E+01 |
| 31054 | PIPE 54 INCH DIA | 27.50E+01 L.F. | 19.25E+01 |
| 31060 | PIPE 60 INCH DIA | 42.50E+01 L.F. | 59.50E+01 |

O AND M COSTS ARE A PERCENTAGE OF CAPITAL COSTS

EXHIBIT IV-2. (Continued)

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

***** URBAN HIGHWAY DRAINAGE MODEL ***** WATER RESOURCES ENGINEERS
 ***** COST ESTIMATION MODULE ***** A DIVISION OF CAMP DRESSER AND MCKEE
 ***** SPRINGFIELD, VIRGINIA *****

RUN: EXAMPLE PROBLEM

***** ANNUAL COSTS ***** ANNUAL COSTS ***** ANNUAL COSTS *****
 (DOLLARS/YR)

INTEREST RATE= 7.00

| CODE ID | DESCRIPTION | QUANTITY | CAPITAL COST | O AND M COST | ANNUAL COST |
|---------|------------------|----------------|--------------|--------------|-------------|
| 4104 | STD. DROP INLET | 15.00E+00 V.F. | 10.38E+02 | 82.50E+00 | 20.45E+01 |
| 4114 | STD. DROP INLET | 85.00E+00 V.F. | 88.24E+02 | 46.75E+01 | 20.33E+02 |
| 4124 | STD. DROP INLET | 18.00E+00 V.F. | 23.64E+02 | 99.00E+00 | 34.58E+01 |
| 4204 | GRATED INLET STD | 12.40E+01 V.F. | 86.53E+02 | 68.20E+01 | 21.56E+02 |
| 4214 | STD GRATE INLET | 35.00E+00 V.F. | 35.56E+02 | 19.25E+01 | 64.06E+01 |
| 4224 | STD GRATE INLET | 10.00E-01 EACH | 12.07E+02 | 20.00E+00 | 12.36E+01 |
| 4304 | COMBINATN INLET | 60.00E-01 V.F. | 34.65E+01 | 33.00E+00 | 62.73E+00 |
| 4314 | COMBINATN INLET | 60.50E+00 V.F. | 64.19E+02 | 33.28E+01 | 92.21E+01 |
| 4400 | STANDARD MANHOLE | 15.00E+00 V.F. | 17.54E+02 | 0. | 12.71E+01 |
| 4500 | 60 IN. ENDWALL | 10.00E-01 EACH | 53.39E+01 | 0. | 38.69E+00 |

FEDERAL HIGHWAY ADMINISTRATION
 DEPARTMENT OF TRANSPORTATION
 WASHINGTON, D.C.

RUN: EXAMPLE PROBLEM

 URBAN HIGHWAY DRAINAGE MODEL *****

 COST ESTIMATION MODULE *****

WATER RESOURCES ENGINEERS
 A DIVISION OF CAMP DRESSER AND MCKEE
 SPRINGFIELD, VIRGINIA

***** TOTAL PROJECT COSTS *****

CAPITAL COST (DOLLARS)= 22.21E+04

O AND M COSTS (DOLLARS/YEAR)= 34.45E+02

ANNUAL COSTS (DOLLARS/YEAR)= 37.59E+03



FEDERALLY COORDINATED PROGRAM (FCP) OF HIGHWAY RESEARCH AND DEVELOPMENT

The Offices of Research and Development (R&D) of the Federal Highway Administration (FHWA) are responsible for a broad program of staff and contract research and development and a Federal-aid program, conducted by or through the State highway transportation agencies, that includes the Highway Planning and Research (HP&R) program and the National Cooperative Highway Research Program (NCHRP) managed by the Transportation Research Board. The FCP is a carefully selected group of projects that uses research and development resources to obtain timely solutions to urgent national highway engineering problems.*

The diagonal double stripe on the cover of this report represents a highway and is color-coded to identify the FCP category that the report falls under. A red stripe is used for category 1, dark blue for category 2, light blue for category 3, brown for category 4, gray for category 5, green for categories 6 and 7, and an orange stripe identifies category 0.

FCP Category Descriptions

1. Improved Highway Design and Operation for Safety

Safety R&D addresses problems associated with the responsibilities of the FHWA under the Highway Safety Act and includes investigation of appropriate design standards, roadside hardware, signing, and physical and scientific data for the formulation of improved safety regulations.

2. Reduction of Traffic Congestion, and Improved Operational Efficiency

Traffic R&D is concerned with increasing the operational efficiency of existing highways by advancing technology, by improving designs for existing as well as new facilities, and by balancing the demand-capacity relationship through traffic management techniques such as bus and carpool preferential treatment, motorist information, and rerouting of traffic.

3. Environmental Considerations in Highway Design, Location, Construction, and Operation

Environmental R&D is directed toward identifying and evaluating highway elements that affect

the quality of the human environment. The goals are reduction of adverse highway and traffic impacts, and protection and enhancement of the environment.

4. Improved Materials Utilization and Durability

Materials R&D is concerned with expanding the knowledge and technology of materials properties, using available natural materials, improving structural foundation materials, recycling highway materials, converting industrial wastes into useful highway products, developing extender or substitute materials for those in short supply, and developing more rapid and reliable testing procedures. The goals are lower highway construction costs and extended maintenance-free operation.

5. Improved Design to Reduce Costs, Extend Life Expectancy, and Insure Structural Safety

Structural R&D is concerned with furthering the latest technological advances in structural and hydraulic designs, fabrication processes, and construction techniques to provide safe, efficient highways at reasonable costs.

6. Improved Technology for Highway Construction

This category is concerned with the research, development, and implementation of highway construction technology to increase productivity, reduce energy consumption, conserve dwindling resources, and reduce costs while improving the quality and methods of construction.

7. Improved Technology for Highway Maintenance

This category addresses problems in preserving the Nation's highways and includes activities in physical maintenance, traffic services, management, and equipment. The goal is to maximize operational efficiency and safety to the traveling public while conserving resources.

0. Other New Studies

This category, not included in the seven-volume official statement of the FCP, is concerned with HP&R and NCHRP studies not specifically related to FCP projects. These studies involve R&D support of other FHWA program office research.

* The complete seven-volume official statement of the FCP is available from the National Technical Information Service, Springfield, Va. 22161. Single copies of the introductory volume are available without charge from Program Analysis (HRD-3), Offices of Research and Development, Federal Highway Administration, Washington, D.C. 20590.

