CHAPTER 7

ENERGY DISSIPATION

7.7 HY8 Energy Dissipator Analysis – Microcomputer Program

Example Application

7.7.1 Introduction

The HYDRAIN Culvert Analysis microcomputer program HY8 consists of three main options:

(1) Culvert Analysis,
(2) Hydrograph Generationn, and
(3) Routing.

The culvert analysis portion of the HYDRAIN model includes a sub-model for the design and analysis of energy dissipators. The purpose of this Section is to provide the user with analysis approaches to use with Energy Dissipator portion of the program.

Although the model is specifically designed for energy dissipators associated with culverts, by modifying the culvert discharge data, energy dissipators from other facilities (i.e., weirs from detention facilities) can also be designed using this model.

The model has several user-friendly features which permit easy data entry, changing input data to determine the effects on the energy dissipation design, and output of summary design information. Very little input data are required which makes this model easy to use. The design procedures included in the model follow the design procedures used in the Federal Highway Publication – HEC No. 14. This publication was also used to develop most of the concepts and design procedures included in this chapter of the City of Lawrenceville Stormwater Design Manual.

The Energy Dissipator Model includes the design of many dissipators that will probably not be used within small urban drainage systems. These dissipators were designed for large flood control structures. The scourhole estimation procedure and the design of riprap basins are the most useful and the thus these portions of the model will be included in this section.

7.7.2 Example Application Data

The following example application will provide instruction in data entry, file modification and energy dissipation design. The user should work through the problem on the computer while following the text so as to become familiar with

the program. New users may want to consult the README file that accompanies the program. HY8, VERSION 6.0 was used for this example.

The following data are taken from the culvert analysis problem given in Section 7.7 of the Culvert Chapter. Note: The model uses the data from the file established when the culvert analysis problem was done.

Design Discharge = 60 cfs
Velocity at Culvert Outlet = 16.09 ft/s
Dept of Water at Culvert Outlet = 1.57 ft

7.7.3 Scourhole Estimation

Using the Energy Dissipator Model estimate the scourhole at the exit to the culvert.

From the HY-8 Program Options Menu select <J> Dissipator under Design Options.

```
  OPTION MENU:        PRESS     <LETTER>

CULVERT FILE          SINGLE CULVER  (NO OVERTOPPING)
<C> Create            <S> Calculate
<E> Edit              <M> Minimize Width
<N> Name              <R> Report – Display or Print
<D> Directory         <F> File – Same PC and LST files

AVAILABLE FILES       MULTIPLE CULVERTS & OVERTOPPING
Culvert:  TEST . INP  <O> Overtopping
Output:  TEST . PC    <R> Report – Display or Print
Report:  None         <L> List – Save PC and LST files

DESIGN OPTIONS        DEFAULT OPTIONS
<H> Hydrograph        <U> Units Used – English
<I> Routing           <W> Outlet Control – Profiles
<J> Dissipator        <P> Paths for files & Defaults

<Enter>     for Documentation Menu
    <Q>     Quit
```

Note that this program will only design a dissipator for one culvert at a time. Thus if more than one culvert exists at a site, the user must specify the culvert for which the dissipator is to be designed.

The user must then input the culvert data file name. If you want to design a dissipator for something other than a culvert, input a culvert file and then edit the file to include the data needed for the design.

INPUT THE CULVERT DATA FILE NAME ===> TEST

TYPE <F> FOR A LISTING OF CULVERT DATA FILES.

From the Design Menu select <2> Scourhole Geometry Estimate.

DESIGN MENU

<1> Edit Culvert Characteristics (Within Current Data File)

<2> Scourhole Geometry Estimate

<3> Design Internal Dissipator (Box or Circular Culvert Only)

<4> Design External Dissipator

<5> Choose A Different Culvert (Within Current Data File)

<6> Exit Program

<7> Return to File Menu

Select Appropriate # 2

Input the following data for scourhole estimation:

Noncohesive or Cohesive Soil (Noncohesive was used in this example).

D16 and D84 particle sizes – this indicates the percent (16 or 84) particles that are finer than the size input. Thus in the following example, 16 percent of the particles are finer than 1 mm.

CULVERT OUTLET SOIL PARAMETERS

ENTER TIME TO PEAK OF STORM HYDROGRAPH (MIN)
*** IF UNKNOWN ENTER 30 MIN *** 30

INDICATE SOIL TYPE (1) NONCHESIVE (2) COHESIVE 1

ENTER A VALUE FOR D16 (mm) 1

ENTER A VALUE FOR D84 (mm) 5*

The model will then determine the dimensions of the scourhole for the design conditions.

SCOURHOLE GEOMETRY

LENGTH = 38.517 ft WIDTH = 21.561 ft

DEPTH = 3.867 VOLUME = 1584.673 cf

MAXIMUM SCOUR OCCURS 15.407 ft DOWNSTREAM OF CULVERT

DOWNSTREAM CHANNEL BOTTOM WIDTH = 5.000 ft

NORMAL DEPTH IN DOWNSTREAM CHANNEL IS 1.773 ft FOR A FLOW OF 60.000 cfs

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<ENTER> TO PRINT REPORT
<ESC> TO RETURN
<R> TO REDO DESIGN

The user than has the option of printing a summary report. Note: Under option <C> the user can change the ASCIL number – using number 45 will produce dashed lines in the summary report.

PRINTING OPTIONS

<H> HEADING
* (1) ON EACH PAGE
(2) ON FIRST PAGE ONLY

<R> REPORT TYPE
* (1) FULL
(2) SUMMARY

<N> FIRST PAGE NUMBER = 1

<C> LINE CHARACTER = -
ASCIL NUMBER = 45

```
<L>  PAGE NUMBER LOCATION
 *   (1) AT RIGHT TOP CORNER OF PAGE          <S>  TO SAVE SELECTIONS
     (2) NO PAGE NUMBER                        *   CURRENT SELECTIONS

<O>  OUTPUT DEVICE
 *   (1) PRINTER
     (2) FILENAME. PRN IN DATA DIRECTORY
     (3) SCREEN

                    <LETTER>   TO EDIT
                     <ENTER>   TO PRINT
                       <ESC>   TO RETURN
```

Following is a summary of culvert data, channel data, scourhole geometry, and soil data for the example application.

```
-----------------------------------------------------------------------------
                          CULVERT AND CHANNEL DATA
-----------------------------------------------------------------------------
      CULVERT NO.  1                          DOWNSTREAM CHANNEL

CULVERT TYPE:    3.000 ft CIRCULAR            CHANNEL TYPE :  RECTANGULAR

CULVERT LENGTH     =    75.060 ft            BOTTOM WIDTH       =    5.000 ft

NO. OF BARRELS     =     1.0                 TAILWATER DEPTH    =    1.773 ft

FLOW PER BARREL    =    60.000 cfs           TOTAL DESIGN FLOW  =   60.000 cfs

INVERT ELEVATION   =   947.000 ft             BOTTOM ELEVATION   =  947.000 ft

OUTLET VELOCITY    =    16.090 fps           NORMAL VELOCITY    =    6.768 fps

OUTLET DEPT        =     1.570 ft
-----------------------------------------------------------------------------
```

SCOUR HOLE GEOMETRY AND SOIL DATA

LENGTH	=	38.517 ft	WIDTH	=	21.561 ft
DEPTH	=	3.867 ft	VOLUME	=	1584.673 ft ^3

MAXIMUM SCOUR OCCURS 15.407 ft DOWNSTREAM OF CULVERT

SOIL TYPE : NONCOHESIVE

SAND SIZES:

D16 = 1.00 mm
D84 = 5.00 mm

7.7.4 Energy Dissipator Design

Design an energy dissipator to control the exit velocity from the culvert.

From the Design Menu select <4> Design External Dissipator.

DESIGN MENU

<1> Edit Culvert Characteristics (Within Current Data File)

<2> Scourhole Geometry Estimate

<3> Design Internal Dissipator (Box or Circular Culvert only)

<4> Design External Dissipator

<5> Choose A Different Culvert (Within Current Data File)

<6> Exit Program

<7> Return to File Menu

Select Appropriate # 4

From the External Dissipator Categories select <C> At-Streambed-Level Structures.

EXTERNAL DISSIPATOR CATEGORIES

(A) DROP STRUCTURES

(B) STILLING BASINS

(C) AT-STREAMBED-LEVEL STRUCTURES

SELECT LETTER OF DESIRED CATEGORY C
<ESC> TO RETURN TO OPTION MENU

From the table of At-Streambed-Level Structures select number 11 – Riprap Basic (Consult HEC 14 for the description of the other dissipator types).

AT-STREAMBED-LEVEL STRUCTURES

DISSIPATOR TYPE	FROUDE # FR	TAILWATER TW	SPECIAL LIMITATIONS	FEASIBILITY	REASON(S)
10 CSU BASIN	<3	------	--------	OK	
11 RIPRAP BASIN	<3	-----	-------	OK	
13 HOOK	1.8 TI 3	-----	------	OK	
14 USBR-6	----	DESIRABLE	Q < 400 cfs VO < 50 fps	OK	
12 CONTRA COSTA	<3	<.5D	------	NO GOOD	TW TOO HIGH

ENTER # OF APPLICABLE DISSIPATOR – IF MORE THAN 1, ENTER 1 AT A TIME ONCE ALL DESIRED # ‘S ARE ENTERED, PRESS <ENTER> TO COMMENCE DESIGN 11*

Choose the condition to be used to compute basin outlet velocity – it is recommended that <C> Critical Depth At Outlet be used except when the culvert is discharging into a lake or ponded area downstream. D50 and DMAX represent the mean and the maximum riprap size respectively

RIPRAP STILLING BASIN

CHOOSE CONDITION TO BD USED TO COMPUTE BASIN OUTLET VELOCITY
<N> NORMAL DEPTH AT OUTLET <C> CRITICAL DEPTH AT OUTLET
c

ENTER D50 (ft) OF THE RIPRAP MIXTURE .8

ENTER DMAX (ft) OF THE RIPRAP MIXTURE 1.5*

The user can then print a summary of the dissipator design.

CULVERT AND CHANNEL DATA

CULVERT NO.1			DOWNSTREAM CHANNEL		
CULVERT TYPE:	3.000 ft CIRCULAR		CHANNEL TYPE: RECTANGULAR		
CULVERT LENGTH	=	75.060 ft	BOTTOM WIDTH	=	5.000 ft
NO. OF BARRELS	=	1.0	TAILWATER DEPTH	=	1.773 ft
FLOW PER BARREL	=	60.000 cfs	TOTAL DESIGN FLOW	=	60.000 cfs
INVERT ELEVATION	=	947.000 ft	BOTTOM ELEVATION	=	947.000 ft
OUTLET VELOCITY	=	16.090 fps	NORMAL VELOCITY	=	6.768 fps
OUTLET DEPTH	=	1.570 ft			

RIPRAP STILLING BASIN – FINAL DESIGN

THE LENGTH OF THE BASIN	=	32.863 ft
THE LENGTH OF THE POOL	=	21.909 ft
THE LENGTH OF THE APRON	=	10.954 ft
THE WIDTH OF THE BASIN AT THE OUTLET	=	5.000 ft
THE DEPTH OF POOL BELOW CULVERT INVERT	=	2.191 ft
THE THICKNESS OF THE RIPRAP ON THE APRON	=	3.000 ft
THE THICKNESS OF THE RIPRAP ON THE REST OF THE BASIN	=	2.250 ft
THE BASIN OUTLET VELOCITY	=	8.799 fps
THE DEPTH OF FLOW AT BASIN OUTLET	=	1.364 ft

END OF SECTION A.7