# HY-12 User Manual

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In HY-12, there are three possible water flow conditions, all of which are shown in Figure 1. Water could be flowing overland in a watershed, in a channel (either in a gutter, ditch, stream, or some other kind of channel), or in a storm drain.

#### Watershed Parameters

HY-12 handles rational method computations to compute a watershed flow value or a hydrograph. The input parameters required for a rational method analysis include a runoff coefficient (C), rainfall intensity (i), and watershed area (A). The output from a rational method simulation is a peak flow value (Q) for the watershed. The rainfall intensity is dependent on other factors such as the watershed time of concentration (Tc) and Intensity-Duration-Frequency (IDF) rainfall parameters for a watershed.

HY-12 utilizes the same approach and computation as the FHWA Hydraulic Toolbox for the rational method computations.

Besides computing a peak flow and a hydrograph using the rational method from watershed parameters, HY-12 allows users to enter a specified peak flow or a hydrograph that was determined outside of the toolkit.

#### **Channel Parameters**

The storm drain analysis toolkit handles several different open-channel flow scenarios. In all of these scenarios, the open channel flow velocities and depths are computed using Manning's equation,  $V = (k/n)R_h^{2/3}\sqrt{S}$ , where V is the velocity, k is 1.486 (CU) or 1.0 (SI units), n is Manning's coefficient,  $R_h$  is the hydraulic radius (Flow area/Flow wetted perimeter), and S is the longitudinal slope of the water surface.

The input and output parameters defining how Manning's equation is used depend on the type of channel being simulated. HY-12 handles roadway flow, roadside flow and spread, curb and gutter flow, and simple prismatic channel flow. The parameters for handling roadway, roadside, and simple prismatic flow are similar and include the geometry of the channel (width, side slopes, curb height if applicable, etc.), its slope, and the Manning's coefficient. The parameters for handling gutter flow are more specialized and include the longitudinal slope of road, the cross slope of the pavement, the cross slope of the gutter, the gutter width, and Manning's coefficient. In either of these cases, the useful output would include the flow depth, top width, area, velocity, flow regime, and (for gutter flow) the ratio of gutter flow to total flow.

HY-12 uses the same computations as the FHWA Hydraulic Toolbox to find roadside and open channel velocities and depths as well as storm drain inlet depths, inlet efficiencies, and inlet bypass flows.

When using a hydrograph as input into a storm drain network, notice that the input to a storm drain changes with time. If you have a storm drain along a sag, for example, the storm water discharge entering the sag inlet changes as the depth of water at the sag inlet increases and decreases. This scenario, where you have a sag inlet, involves routing computations that have been implemented in HY-12.

#### **Storm Drain Parameters**

The HY-12 toolkit will compute the depth of water or energy of the water at each pipe junction in a buried storm drain network, which is normally composed of circular pipes. The input parameters for a storm drain network include the size of each pipe along with the Manning's roughness value and the pipe invert elevation at each pipe junction. In addition, if access holes exist at a pipe junction, the width

and type of access hole is important for the analysis. Finally, if a detention basin exists at a location in the storm drain network, the storage-capacity curve and the detention basin outflow parameters are needed.

A buried storm drain network could operate in either open channel or pressure flow conditions. The result from running a storm drain simulation is the hydraulic grade line elevation at each pipe junction, which is equal to the depth added to the velocity head for open channel conditions and which includes the pressure head in the pipe for pressure flow conditions. The flow regime and flow velocities are computed for each pipe and at the outfall of the storm drain network. The hydraulic grade line and water surface elevations are useful for hydraulic engineers designing storm drain networks associated with roadway construction.

The HY-12 storm drain analysis toolkit will also handle several water transfer mechanisms. For example, water is transferred from a channel to a storm drain through some sort of storm drain inlet such as a grate or a curb opening. At each on-grade storm drain inlet, some water enters the storm drain and some water bypasses the storm drain. HY-12 computes the amount that enters and bypasses the storm drain from the FHWA Hydraulic Toolbox code that does these calculations. Using the **ASSUMEFULLCAPTURE** card in the HY-12 Project Data Template (see the Project Data Template documentation), users can specify whether all the flow at inlets is captured or whether HY-12 computes the capture and bypass flow and only assumes the captured flow enters an inlet. Water is also transferred to channels or to a storm drain from a watershed.

A hydraulic engineer needs to know where the water is flowing, how much water is flowing, and what the depth or potential depth of the water is at each location in the storm drain network. The HY-12 toolkit computes these parameters for each storm drain network pipe or open channel, whether above or below ground, in the storm drain network, as described above.

#### Design of new systems

In addition to having the ability to enter storm drain network parameters, there is a need to find optimum pipe sizes and inlet locations when designing a new system. HY-12 allows users to enter a minimum pipe diameter, minimum depth, minimum depth of cover, and minimum velocity for each pipe in the storm drain network and computes optimum pipe sizes.

#### Analysis of existing systems

The analysis of existing systems requires the input of the pipe sizes and other parameters described above for the existing system and an analysis to be run.

#### Steady flow

HY-12 handles the steady flow case. In this case, a single discharge value is defined at locations in the model and the resulting energy head and depth is computed for each reach in the storm drain network. All other watershed, channel flow, and storm drain parameters are computed as described above. Refer to the rational tutorial document included in the installation to learn how to setup a steady state flow design simulation.

# Hydrographic (time-dependent) flow

HY-12 also handles the hydrographic flow case. In this case, a hydrograph is defined either as a direct input or from a rational method computation and all the parameters are computed at each time

step in the simulation. The user may specify the time step that HY12 uses for calculations and for hydrographs in the report. Using a shorter time step will result with more precision in a hydrograph which will yield more stability in the routing; however, it also increases the amount of time required to compute a model. Refer to the hydrographic tutorial document included in the installation to learn how to setup a hydrographic simulation.

# **Structure Computations**

#### Model Overview

HY-12 begins at an upstream hydraulic structure and computes flow, velocity, and other parameters for each structure until it reaches the outfall. Then HY-12 starts at the outfall and computes the hydraulic grade line and energy grade in the upstream direction at every point in the model.

#### Access Hole

Losses are computed in an access hole using the following equation (See HEC 22 Urban Drainage Design Manual, chapter 7, page 7-16):

$$E_a = E_{ai} H_B H_{\theta} H_P$$

Where:

Ea	=	Revised access hole energy level
E <sub>ai</sub>	=	Initial energy level in the access hole structure
Η <sub>B</sub>	=	Additional energy loss for benching (floor configuration)
$H_{\theta}$	=	Additional energy loss for angled inflows other than 180 degrees
Η <sub>P</sub>	=	Additional energy loss for plunging flows

If the access hole energy level ( $E_a$ ) determined is less than the outflow pipe energy head ( $E_i$ ), then  $E_a$  is set to equal  $E_i$ .

# **Pipe Junction**

If more than two pipes are connected, HY-12 uses the access hole loss calculation. Otherwise, it uses the following equation (See the June 2008 edition of HDS 4, Introduction to Highway Hydraulics, page 7-7, equation 7.7:

$$H_{j} = \frac{(Q_{0}V_{0}) - (Q_{i}V_{i}) - (Q_{1}V_{1}\cos\theta)}{0.5g(A_{0} + A_{i})} + h_{i} - h_{0}$$

Where:

Hj	=	Adjusted headloss coefficient
Q <sub>0</sub> , Q <sub>i</sub> ,	Q <sub>1</sub>	= Outlet, inlet, and lateral flows, respectively, m <sup>3</sup> /s (ft <sup>3</sup> /s)
۷ <sub>0</sub> , ۷ <sub>i</sub> , ۱	/ <sub>1</sub>	= Outlet, inlet, and lateral velocities, respectively, m/s (ft/s)
H <sub>0</sub> , h <sub>i</sub>	=	Outlet and inlet velocity heads, m (ft)
A <sub>0</sub> , A <sub>i</sub>	=	Outlet and inlet cross-sectional areas, m <sup>2</sup> (ft <sup>2</sup> )
θ	=	Angle of lateral with respect to certerline of outlet pipe, degrees
g	=	Gravitational acceleration, 9.81 m/s <sup>2</sup> (32.2 ft/s <sup>2</sup> )

#### Outfall

There are no computations performed at the outfall; however, the depth, velocity and pressure head need to be set by the user.

# **Gutter Inlet**

HY-12 utilizes the same approach and computation as the FHWA Hydraulic Toolbox for the Gutter Inlet computations.

#### Reservoir

HY-12 utilizes the same approach and computation as the FHWA Hydraulic Toolbox for the Reservoir computations.

#### Channel

HY-12 utilizes the same approach and computation as the FHWA Hydraulic Toolbox for the Channel computations.

#### **Curb and Gutter**

HY-12 utilizes the same approach and computation as the FHWA Hydraulic Toolbox for the Curb and Gutter computations.

#### Pipe

When the pipe is not flowing full, the pipe's flow computations are determined using Manning's equation for open-channel flow. When the pipe is flowing full, the continuity and energy equations are used to determine the velocity and pressure heads at the ends of each pipe.

The continuity equation follows:

Q=VA

Where:

Q	=	Flow
V	=	Velocity
Α	=	Area

The energy equation follows:

$$\frac{V_1^2}{2g} + Y_1 + Z_1 = \frac{V_2^2}{2g} + Y_2 + Z_2 + h_1$$

Where:

V <sub>1</sub>	=	Velocity at location 1
$V_2$	=	Velocity at location 2
$Y_1$	=	pressure head at location 1
Y <sub>2</sub>	=	pressure head at location 2
$Z_1$	=	water surface elevation at location 1
<b>Z</b> <sub>2</sub>	=	water surface elevation at location 2
ΗL	=	Headloss due to friction

g = graviational constant

# **Pipe Storage**

A pipe storage structure assumes the storage pipes are level. In steady flow, the initial storage of the pipe storage is set to the value where the outflow matches the inflow. In unsteady flow, the hydrograph is routed using the modified puls method.

# **Pump Station**

A proposed future addition to HY-12 is to add an option to run pump station computations that follow those that are specified in the document HEC 24: Highway Storm Water Pump Station Design.

# File I/O

# Input File

The rational and hydrographic tutorial documents will help you get started creating an input file. HY-12 input files are in a "text and card" format where each line in the file defines a separate input parameter to the program. If you have questions about an HY-12 input parameter or how a particular computation is defined, you can view the file format documentation included with HY-12 to create or troubleshoot the input file.

#### **Report File**

The report file can be customized by modifying the material database file. Documentation describing how to customize the report file can be found in the default material database file created from HY-12 and distributed with the HY-12 installation.

#### Material Database

The material database file contains the parameters for typical hydraulic structures such as pipe sizes, roughness coefficients and minor loss coefficients. HY-12 users can also customize the report from this text file. The file is written to be understood and modified by the user.