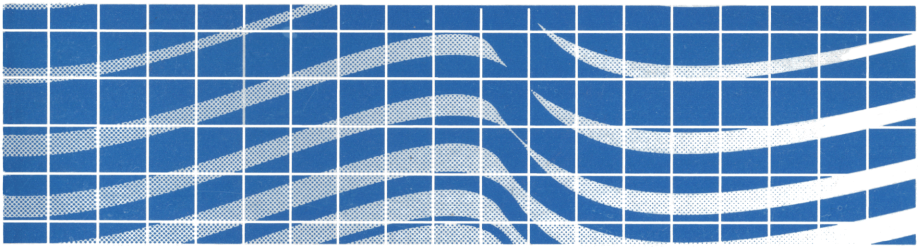

HYDRA*TOOLS*

Version 2.0

Hydraulic
Calculator
for the HP48

Reference Manual

Tackling the toughest jobs *head on.*

HYDRATOOLS

Version 2.0

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NOTICE

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Table of Contents

HYDRATOOLS

Introduction

HYDRATOOLS includes programs to solve hydraulic problems with ease. You can compute Channel, Gutter, Orifice, Pipe Gravity, Pipe Pressure, and Weir flows. Its informal use among local engineers prompted us to develop and distribute the software nationwide. We're sure once you begin using **HYDRATOOLS**, you will find it easy to use and helpful in your hydraulic computations.

HYDRATOOLS is capable of running on the HP48S, SX, G, and GX computers. The HP48S and G can only run the RAM based version which is supplied on disk, as they do not contain expansion ports. We will refer to all models as the HP48 throughout this manual.

HYDRATOOLS was designed to use a graphical user interface for ease of use. Operating in graphics mode also allows more data to be displayed on screen.

HYDRATOOLS creates and uses its own directory on the HP48. The directory contains the variables used by the software. The directory is created within the HOME directory on the HP48.

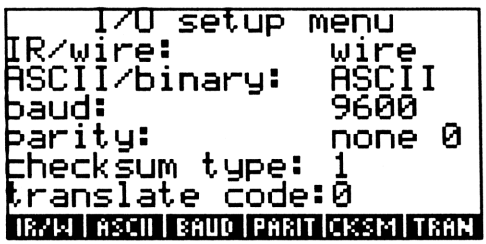
Installation Instructions For Software Supplied On Disk

HYDRATOOLS is supplied on a DOS format disk. The software must be loaded from a PC to the HP48 via the serial port. You will need an HP48 PC interface cable to download the software.

1 Connect the HP48 to the PC with the serial cable.

2 On the HP48 press ◁ I/O IOPAR (SOFTKEY) to display the I/O parameters.

3 Set the I/O parameters as shown below by pressing the softkeys.



4 On the HP48 press the ON key to abort the I/O menu.

5 On the HP48 type **RECV** and press the ENTER key to receive the software from the PC.

6 On the PC type **A:** and press the ENTER key.

7 On the PC type **AUTOLOAD** and press the ENTER key.

Please note the prompts which allow you to select which serial port to use on the PC. This should match the port number to which the cable is connected.

Installing HYDRATOOLS (Continued)

8 You should be able to see that the transfer is taking place by looking at either the PC or the HP 48.

9 Once the transfer is complete you can disconnect the HP48 from the PC.

10 Press the [VAR] key to display the variables on the HP 48.

11 Press the TOOLS softkey (letter A).

12 Press the number [0] and press the [ENTER] key.

13 Press ['] TOOLS (softkey) to place the image name in quotes.

14 Press [←] [PURGE] to delete the original copy.

15 Press [STO] key to store the library image in port 0.

16 Turn the HP 48 OFF and ON. Type the command **TOOLS** and press [ENTER] to begin using the software.

Installation Of HYDRATOOLS Card

To install HYDRATOOLS when supplied on a ROM card follow these instructions.

1 Turn off the HP48, remove the port cover, and insert the HYDRATOOLS ROM in either port 1 or port 2.

2 Turn on the HP48. The message "Attaching HYDRAtools" should be displayed briefly when the HP48 starts.

3 Type the command **TOOLS** and press **ENTER** to begin using the software.

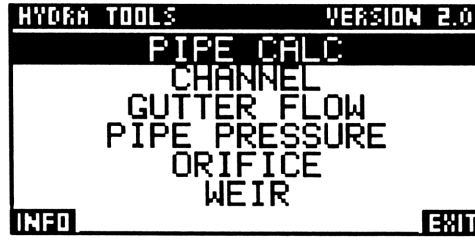
Using HYDRATOOLS

There are 3 ways to enter the **HYDRATOOLS** program.

1 The first way is to type in the command **TOOLS** and press the ENTER key.

2 The second way is to list the libraries on the HP48 and selecting the TOOLS library. You can do this by pressing ◀ LIBRARY and pressing the TOOLS softkey to get into the **HYDRATOOLS** library. After that simply press the TOOLS softkey to the far left to start using the software.

3 The third way is to assign the command TOOLS to a user key. See chapter 15 of your HP48 owners manual for more information on making user key assignments.



4 When first started **HYDRATOOLS** will display the main menu shown above. The selection bar can be scrolled up and down using the arrow keys. To select an item in the menu press ENTER. To exit the program press the EXIT softkey.

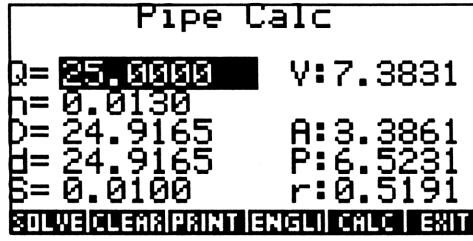
Using HYDRATOOLS (Continued)

HYDRATOOLS consists of 6 programs that help you solve the day to day computations used in storm drain and stormwater management design. Each program operates in the same manner. Data is entered for all the variables except for one. You then press the **SOLVE** softkey or **ENTER** to compute the unknown variable. The arrow keys are used to scroll up and down through the variables. The **CLEAR** softkey clears all the variables except for the defaults. You can also print the results to a printer by pressing the **PRINT** softkey. Please note that the I/O parameters for printing are set within the I/O program on the HP48. The **ENGLI** or **METRI** softkey displays the current unit mode and allows you to switch modes. The **EXIT** softkey will exit the current menu. The **INFO** softkey will display the copyright notice, our company logo, address and phone number for technical support.

HYDRATOOLS can print to a infrared or serial printer. You should set the I/O parameters within HP's I/O menu before attempting to print out results.

HYDRATOOLS - Pipe Calc

Pipe Calc is a software program designed to replace nomographs and other forms of graphical tools and tables used in the design of pipes not under pressure operation. The program is totally automatic and can provide quick solutions to full and partial flow pipe design problems. It can also be used to verify the hydraulics of existing storm drains. This program is based on Manning's equation.



After computing any of the above variables the program will display the Velocity, Area, Wetted Perimeter, and the Hydraulic Radius.

Units of Measurement

Name	Description	English Unit	Metric Unit
Q	Discharge	cfs	m^3/s
n	Manning's Coefficient of Roughness (unitless)		
D	Pipe Diameter	inches	m
d	Normal Depth	inches	m
S	Pipe Slope	unit/unit	unit/unit
V	Velocity	ft/s	m/s
A	Flow Area	sf	m^2
P	Wetted Perimeter	ft	m
r	Hydraulic Radius	ft	m

HYDRATOOLS - Pipe Calc

Computing Discharge

To compute a Discharge you must define the following:

n factor
Pipe Diameter
Normal Depth
Slope of Pipe

This method calculates the design discharge of a pipe flowing full or partially full at normal depths.

Computing the n Factor

To compute an n factor you must define the following:

Peak Discharge
Pipe Diameter
Normal Depth
Slope of Pipe

This method allows you to select the type of pipe to be used on the basis of an n factor. For example:

0.011 = PVC pipe
0.013 = Concrete
0.024 = Corrugated Metal

HYDRATOOLS - Pipe Calc

Computing the Pipe Diameter

To compute a Pipe Diameter you must define the following:

Peak Discharge
n Factor
Slope of Pipe

This method allows you to compute the pipe size for a design discharge. **Note:** This is the only time that you would have two unknowns to solve for. The program will solve for a full flow solution, that is where normal depth is equal to pipe diameter.

Computing Normal Depth

To compute Normal Depth you must define the following:

Peak Discharge
n Factor
Diameter of Pipe
Slope of Pipe

This method uses multiple equations to compute the Normal Depth of partial pipe flows. Consequently, the computed Normal Depth can have a error range of +/- 0.005% from the true depth. This approximation should not affect your storm drain design, however, you should be aware of this.

Normal Depth, (d), is the depth at which the slope of the water surface and the slope of the pipe are parallel.

HYDRATOOLS - Pipe Calc

Computing Slope of Pipe

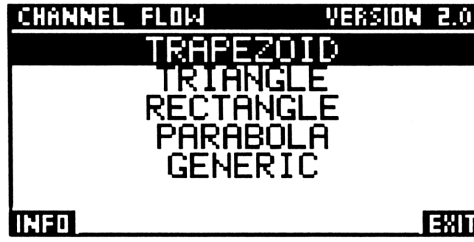
To compute the required slope of pipe you must define the following:

Peak Discharge
n Factor
Diameter of Pipe
Normal Depth

This method allows you to compute the required slope for a run of pipe given a discharge and a pipe diameter. You may compute a maximum and minimum slope with minimum slope based on pipe full and maximum slope based on some minimum acceptable flow depth.

HYDRATOOLS - Channel Flows

This program is used to solve channel flow problems. We allow you to solve TRAPEZOIDAL, TRIANGULAR, RECTANGULAR, PARABOLIC, and GENERIC cross sections. Each program works in the same way. You supply all the variables except for one and press **ENTER** or the **SOLVE** softkey to solve for the unknown variable.



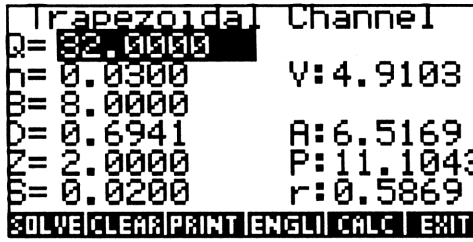
After computing for the unknown variable the program will display the Velocity, Area, Wetted Perimeter, and the Hydraulic Radius.

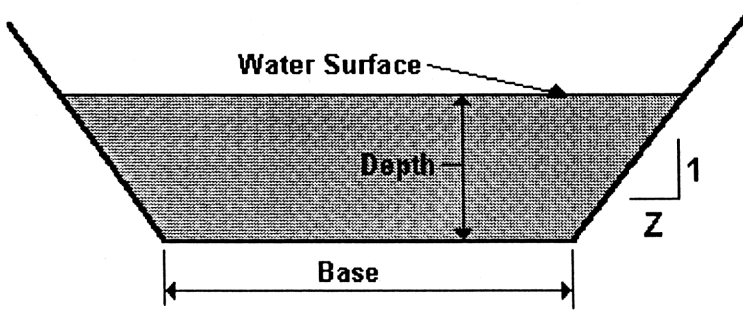
Variables Used In All Channel Flow Equations

Name	Description	English Unit	Metric Unit
Q	Discharge	cfs	m^3/s
n	Manning's Coefficient of Roughness (unitless)		
D	Depth	feet	m
S	Channel Slope	unit/unit	unit/unit
A	Flow Area	sf	m^2
P	Wetted Perimeter	ft	m
r	Hydraulic Radius	ft	m

HYDRATOOLS - Channel - TRAPEZOIDAL

This program is used to solve trapezoidal cross sections. The figure below is associated with the variables in the program.

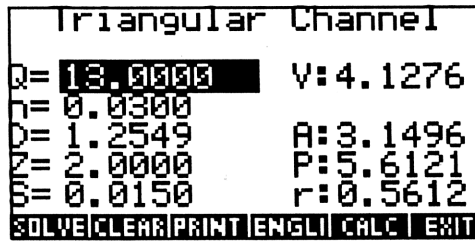


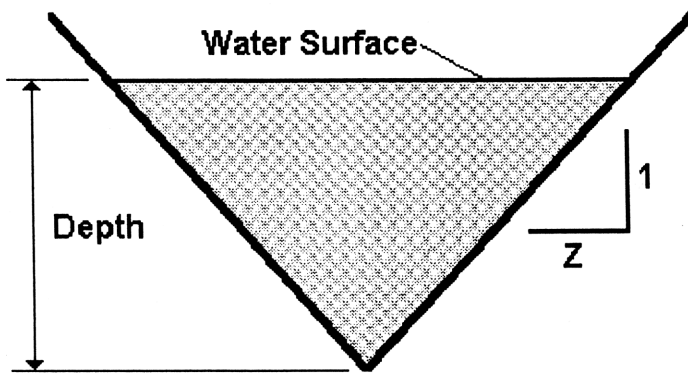


Q= Discharge in cfs or m^3/s
n= Manning's coefficient of roughness
B= Bottom width in feet or meters
D= Depth in feet or meters
Z= Side Slope, Ratio of Horizontal to Vertical
Example: Z=2 if 2:1
S= Channel Slope (unit/unit)

HYDRATOOLS - Channel - TRIANGULAR

This program is used to solve triangular cross sections. The figure below is associated with the variables in the program.

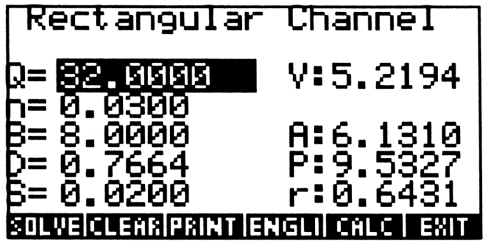


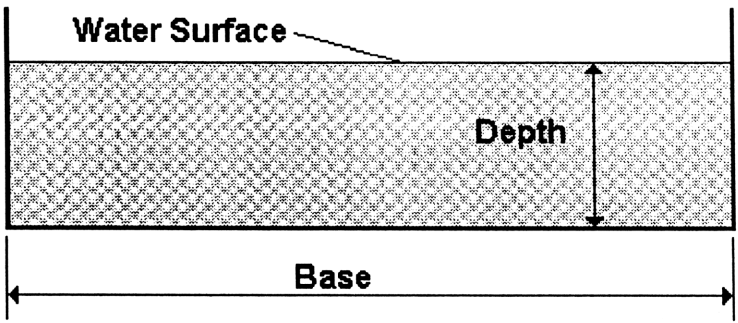


Q= Discharge in cfs or m^3/s
n= Manning's coefficient of roughness
D= Depth in feet or meters
Z= Side Slope, Ratio of Horizontal to Vertical Example: Z=2 if 2:1
S= Channel Slope (unit/unit)

HYDRATOOLS - Channel - RECTANGULAR

This program is used to solve rectangular cross sections. The figure below is associated with the variables in the program.

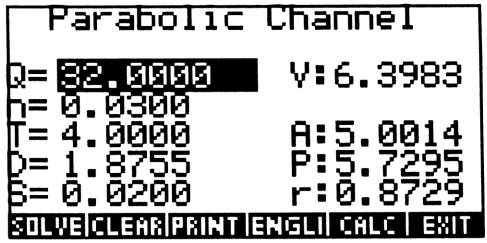


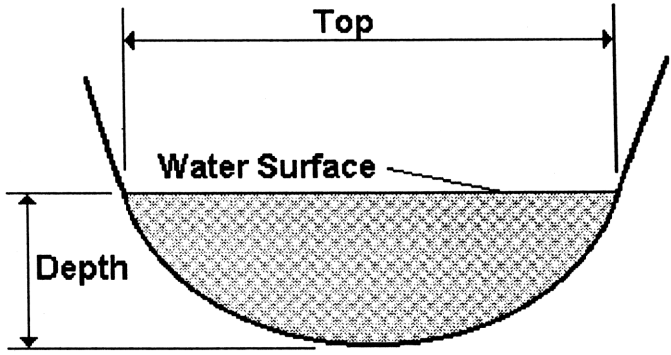


Q= Discharge in cfs or m^3/s
n= Manning's coefficient of roughness
B= Bottom Width in feet or meters
D= Depth in feet or meters
S= Channel Slope (unit/unit)

HYDRATOOLS - Channel - PARABOLIC

This program is used to solve parabolic cross sections. The figure below is associated with the variables in the program.

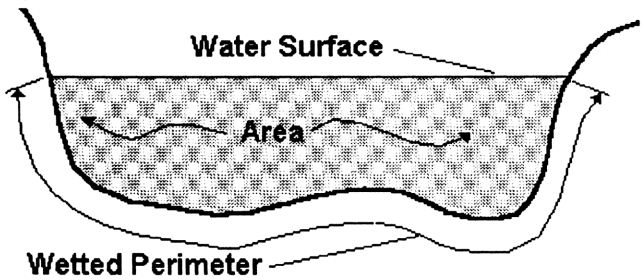




Q= Discharge in cfs or m^3/s
n= Manning's coefficient of roughness
T= Top width in feet or meters
D= Depth in feet or meters
S= Channel Slope (unit/unit)

HYDRATOOLS - Channel - GENERIC

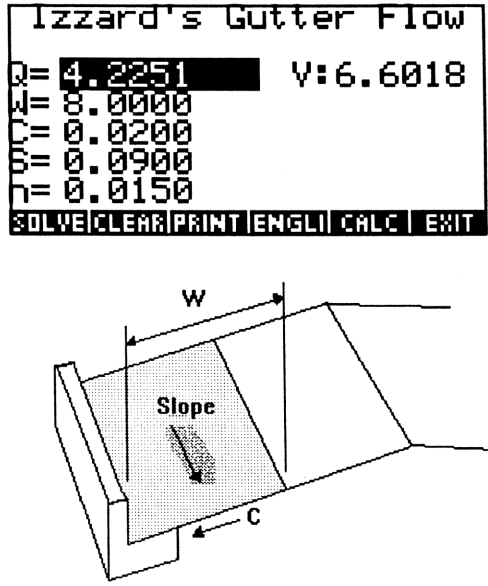
This program is used to solve irregular cross sections. You may enter an area and wetted perimeter to solve problems involving cross sections other than those handled by other programs. The figure below is associated with the variables in the program.



Q=Discharge in cfs or m^3/s
n=Manning's coefficient of roughness
A=Area in ft^2 or m^2
P=Wetted Perimeter in feet or meters
S=Channel Slope (unit/unit)

HYDRATOOLS - Gutter Flow

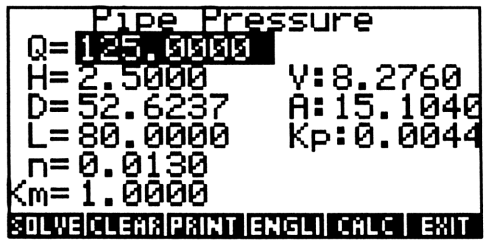
HYDRATOOLS contains two programs to compute gutter flow. Both are described here because their input and output are exactly the same. The two programs differ only by the equation used to compute discharge. Izzard's equation is a derivation of Manning's equation specific to gutter flow. Given the same values for W, Z, N, and S, Izzard's equation will produce a larger Q than Manning's. For this reason both equations are provided. The figure below is associated with the variables in the program.

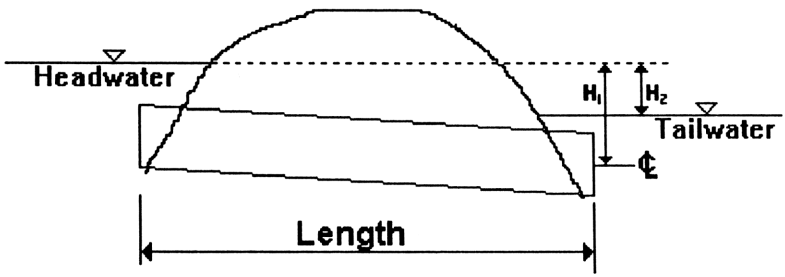


Q= Discharge in cfs or m^3/s
W= Width of Flow in feet or meters
C= Cross Slope (unit/unit)
n= Manning's coefficient of roughness
S= Gutter Slope (unit/unit)

HYDRATOOLS - Circular Pipe Pressure Flow

This program is used to solve Circular Pipe Pressure flow problems. See the following program for solutions involving box culverts or other shapes. The figure below is associated with the variables in the program.



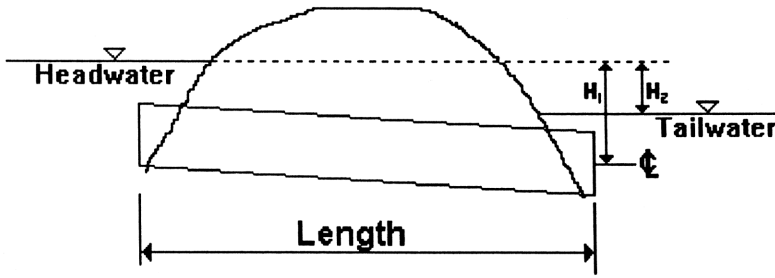


If pipe is in a free discharge condition with tailwater below the outlet centerline then the Head is measured between the outlet centerline and the Headwater (H_1). If the tailwater exceeds the outlet centerline then Head is measured between Headwater and Tailwater (H_2).

Q= Discharge in cfs or m^3/s
H= Head in feet or meters
D= Diameter of Pipe in inches or meters
L= Length of Pipe in feet or meters
n= Manning's coefficient of roughness
Km= Coefficient of minor losses

HYDRATOOLS - Pipe Pressure Flow

This program is used to solve Pressure flow problems involving non-circular cross sections. The figure below is associated with the variables in the program.

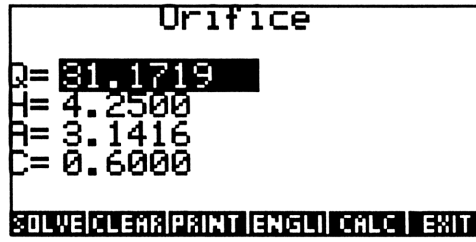


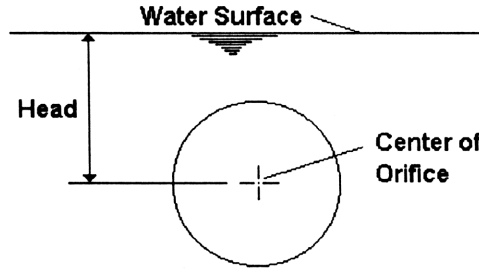
If pipe is in a free discharge condition with tailwater below the outlet centerline then the Head is measured between the outlet centerline and the Headwater (H_1). If the tailwater exceeds the outlet centerline then Head is measured between Headwater and Tailwater (H_2).

Q=	Discharge in cfs or m^3/s
H=	Head in feet or meters
A=	Area of Pipe in square feet or m^2
L=	Length of Pipe in feet or meters
Km=	Coefficient of minor losses
Kp=	Pipe Friction Coefficient

HYDRATOOLS - Orifice Flow

This program is used to solve orifice flow problems. In the example below we show a circle, but the orifice can be of any shape. The figure below is associated with the variables in the program. A typical value for the orifice coefficient is 0.6.



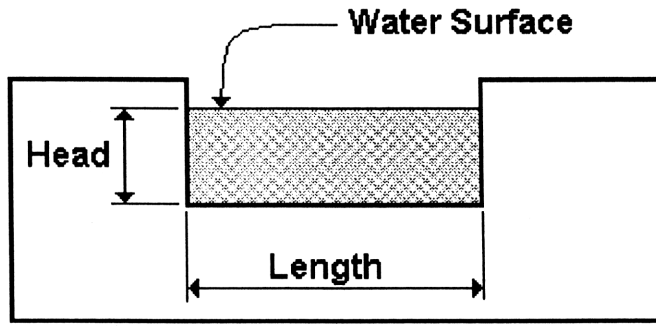


If orifice is in a free discharge condition with tailwater below the orifice centerline then the Head is measured between the orifice centerline and the Headwater. If the tailwater exceeds the orifice centerline then Head is measured between Headwater and Tailwater.

Q= Discharge in cfs or m^3/s
C= Coefficient of orifice
A= Area of orifice in square feet or m^2
H= Orifice Head in feet or meters

HYDRATOOLS - Weir Flow

This program is used to solve weir flow problems. The figure below is associated with the variables in the program. Typical values for C are 3.1 for sharp edged weirs, and 2.65 for earthen spillways.



Q= Rate of Discharge in cfs or m^3/s
C= Weir Coefficient
L= Length of weir in feet or meters
H= Weir Head in feet or meters

Appendix A: Manning's n Values

This table contains some typical values for Manning's coefficient of roughness. Consult your local government agencies to determine what values you should use.

n	Description
0.025	Bare Earth
0.040	Grass- Flow > 0.5'
0.060	Grass- Flow < 0.5'
0.080-0.120	Weeds & Brush
0.030	Erosion Control Matting
0.013	Concrete
0.037	Solid Rock
0.031	3" DIA. Rip-rap
0.035	6" DIA. Rip-rap
0.038	9" DIA. Rip-rap
0.040	12" DIA. Rip-rap
0.042	18" DIA. Rip-rap
0.011	PVC Pipe
0.013	Concrete Pipe
0.024	Corrugated Metal Pipe

Appendix B: Equations

Manning's Equation

$$Q=A\frac{1.486}{n}S^{\frac{1}{2}}R^{\frac{2}{3}}$$

Izzard's Equation

$$Q=\frac{.56}{nC}D^{\frac{8}{3}}S^{\frac{1}{2}}$$

Pipe Pressure Equation

$$Q=A\sqrt{\frac{2gH}{1+K_M+K_PL}}$$

Kp Equation

$$K_P=\frac{29.16n^2}{r^{\frac{4}{3}}}$$

Orifice Flow Equation

$$Q=CA\sqrt{2gH}$$

Weir Flow Equation

$$Q=CLH^{\frac{3}{2}}$$

Appendix C: Km Values for Entrances and Bends

The value of Km, the coefficient of minor losses, is equal to the sum of Ke (entrance loss) and Kb (bend loss). The following charts give some example values for these coefficients. For more information on entrance, bend, enlargement, contraction, and valve losses see Handbook of Hydraulics by H.W. King, fourth edition, pg 6-18, or SCS Engineering Field Manual, Exibit 3-8.

Ke	Entrance Condition
0.04	Bell Mouth*
0.23	Slightly Rounded*
0.50	Sharp Cornered*
0.78	Inward Projecting
1.00	Hooded Inlet

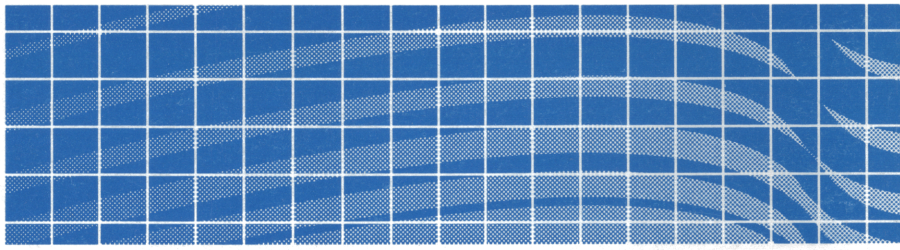
* Pipe end flush with headwall

Kb	Bend Condition
0.42	Standard 45 degree elbow
0.90	Standard 90 degree elbow
0.60	Long radius 90 degree elbow

These values are for prefabricated fittings. Bends generated in the field will generally have higher losses.

Appendix D: Kp Values For Square Conduit

Size	Area	n				
feet	sf	.012	.013	.014	.015	.016
2.0x2.0	4.00	.01058	.01242	.01440	.01653	.0188
2.5x2.5	6.25	.00786	.00922	.01070	.01228	.01397
3.0x3.0	9.00	.00616	.00723	.00839	.00963	.01096
3.5x3.5	12.25	.00502	.00589	.00683	.00784	.00892
4.0x4.0	16.00	.00420	.00493	.00572	.00656	.00746
4.5x4.5	20.25	.00359	.00421	.00488	.00561	.00638
5.0x5.0	25.00	.00312	.00366	.00425	.00487	.00554
5.5x5.5	30.25	.00275	.00322	.00374	.00429	.00488
6.0x6.0	36.00	.00245	.00287	.00333	.00382	.00435
6.5x6.5	42.25	.00220	.00258	.00299	.00343	.00391
7.0x7.0	49.00	.00199	.00234	.00271	.00311	.00354
7.5x7.5	56.25	.00182	.00213	.00247	.00284	.00323
8.0x8.0	64.00	.00167	.00196	.00227	.00260	.00296
8.5x8.5	72.25	.00154	.00180	.00209	.00240	.00273
9.0x9.0	81.00	.00142	.00167	.00194	.00223	.00253
9.5x9.5	90.25	.00133	.00156	.00180	.00207	.00236
10x10	100.0	.00124	.00145	.00168	.00193	.00220



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