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Energy Losses Through Junction Manholes

Volume I: Research Report and Design Guide

Research and Development
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FOREWORD

This study focuses on energy losses experienced at junction manholes. Experiments were conducted at the Federal Highway Administration's (FHWA) Hydraulics Laboratory located in McLean, Virginia.

This publication discusses energy losses associated with manhole junctions. It offers three techniques which may be used to estimate energy losses under free-surface and pressure-flow conditions. This booklet is written primarily for design engineers concerned with energy losses in storm drain systems. The results of this study can be reproduced utilizing the HYDRAIN software package. This is volume I of a two volume publication. Volume I provides an overview of the hydraulic conditions at junction manholes. Volume II provides a log of the experimental data.

Charles J. Nemmers, P.E.
Director, Office of Engineering and Highway
Operations Research and Development

NOTICE

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16. Abstract

The objective of this report is to develop and test methodologies for computing energy losses at junction manholes. Laboratory data obtained over a 6-year period at the Federal Highway Administration's (FHWA) Hydraulics Laboratory are analyzed within the framework of three methodologies: the energy grade line, power loss, and neural networks. Descriptions of the methods are presented, along with a statistical analysis comparing the accuracy with which each method computes observed depth in the junction manhole.

Volume I provides an overview of the hydraulic conditions at junction manholes and identifies the need to supplement existing data for development of predictive equations for computing energy losses. Also discussed are prior research results, three analytical methods for determining junction losses, and the experimental configurations in the laboratory. This report also provides a detailed analysis and performance comparison of each of the three methodologies analyzed. Guidance is given as to which methodology may be most appropriate in computing the energy losses through a pipe system. Volume II documents the physical and hydraulic data collected for each of the 739 laboratory experiments performed.

This volume is the first in a series. The other volume in the series is:

FHWA-RD-94-081 Volume II: Experimental Data

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

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INTRODUCTION

Junction manholes are an important part of a highway storm drainage system. They provide access to the drainage system for maintenance and repair and allow for the joining of conduits at different elevations and directions. However, because of the expansion, contraction, and general turbulence in the manhole, energy losses are experienced. In many systems, this energy loss must be accurately estimated to design an economical and effective highway storm drainage system. Although a highway storm drainage system is usually designed to achieve free surface flow for a design storm, it must be checked for a range of other larger storms that could cause surcharges. Therefore, an energy-loss estimation methodology must cover free-surface and pressure-flow conditions.

OBJECTIVES

The available knowledge on energy losses through junction manholes covers only certain junction conditions. Additional data for free-surface flows are required to supplement existing data and to develop equations for computing energy losses at manholes for wide ranges of flow conditions. This study supplements previous laboratory studies and is directed toward developing a method to estimate energy losses at junctions for free-surface, transitional, and pressure flows. Data collection focuses on two-pipe, three-pipe, and four-pipe systems. The specific objectives of this study are to:

1. Review available data pertaining to energy losses for square and round junctions.

2. Conduct additional laboratory tests for round junction manholes to determine energy losses for pressure flows as well as free-surface flows. (A plan view schematic of a junction manhole is shown in figure 1.) The tests include variations of the following physical parameters:

   (a) Manhole size (relative to the outlet main pipe).
   (b) Floor configuration.
   (c) Plunging height.
   (d) Angle of pipe orientation.

3. Develop a practical method to estimate energy losses at junctions for various flow conditions.

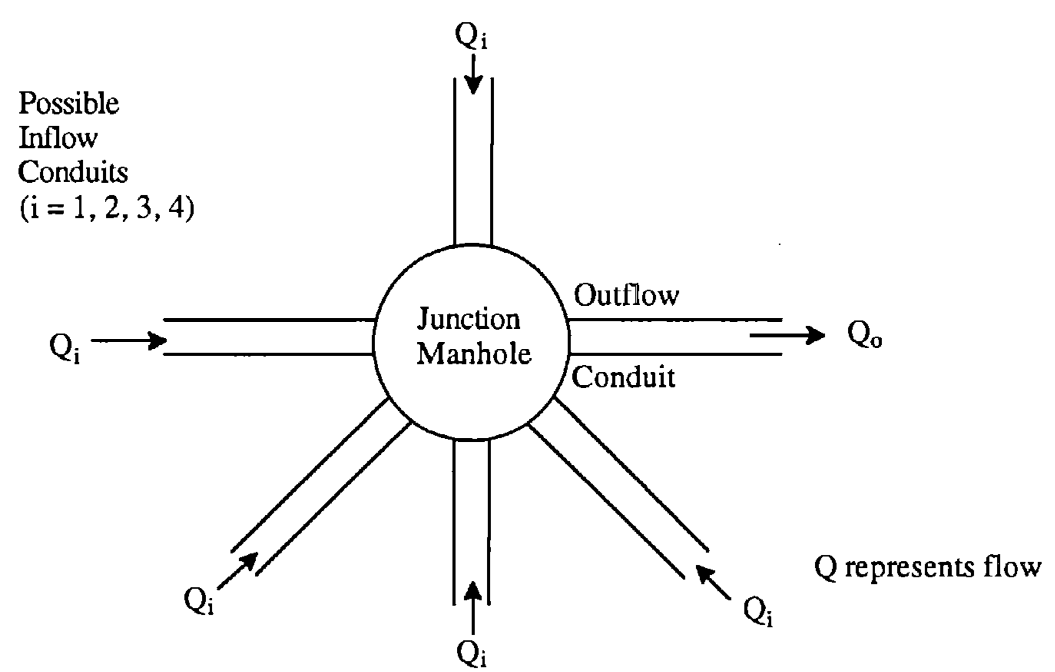

Figure 1. Head-loss schematic.

PRIOR RESEARCH

Many researchers have investigated various physical configurations and hydraulic conditions found in junction manholes of storm drain systems. Sangster, et al., studied pressure changes at storm drain junction manholes for pressure-flow conditions.[1] The majority of the tests involved a rectangular junction manhole. To a limited extent, square and round junction manholes were investigated. Sangster's manhole sizes ranged from 1.0 to 4.6 times the outlet pipe diameter. Sangster's tests also included several different pipes sizes. This enabled analysis of the effects of changing pipe diameters at a manhole.

An experimental study by Lorah used a junction box for one lateral joining the main flow at two different levels.[2] Free-surface flows were investigated. A control volume approach was applied to determine the total power loss at the junction by considering all forces exerted on the control volume.

Marsalek conducted model tests on square and round manholes to determine head losses and to study practical means of reducing such losses.[3] Most experiments were conducted for pressurized flow; limited investigations were conducted for free-surface flow to compare the relative magnitude of losses in free-surface flow. Marsalek studied manhole sizes that were from 1.0 to 4.6 times the outlet pipe diameter. He also performed extensive experiments on benching.

Recently, Johnston and Volker presented their experimental study of head losses at junction boxes with a three-pipe configuration.[4] Unfortunately, their data analysis, based on the pressure head change, is fundamentally incorrect; therefore, the conclusions of their work are questionable.

Pedersen and Mark applied the submerged jet flow approach to estimate the manhole loss with moderate success.[5] However, their work is restricted to the simplest case of straight-through flow with fully submerged inlet and outlet pipes of equal size and a relative manhole size (circular) of four times the diameter of the outlet pipe or less. This approach may not apply to any other manhole conditions as the flow turbulence in other configurations may greatly invalidate the analogy of a submerged jet flow.

Sere, et al., recently completed a series of tests with a 90-degree jet entering a much larger pipe.[6] These tests expand the range of data for relative pipe diameters. They also proposed a turbulence-based explanation for analyzing such conditions.

ANALYTICAL CONSIDERATIONS

In order to accurately estimate junction energy losses, the underlying causes of those losses must be understood. Energy losses are traditionally characterized as some coefficient (K) times the velocity head of the outlet pipe. This approach is reviewed as well as others that expand the analytical framework. This section provides background information on this effort, including a description of the causes of energy losses, a review of energy-loss estimation methods, and an overview of some of the explanatory variables (dimensional analysis).

CAUSES OF ENERGY LOSS

Junction energy loss is composed of an expansion loss at the outlet of the incoming pipe or pipes, contraction energy loss at the mouth of the outgoing pipe, potential energy losses resulting from plunging flows, and other losses resulting from the interaction of incoming flows. For a very large junction manhole, without plunging flows, these losses can be estimated independently, considering no interference of the flows at the outlet of the incoming pipe and at the mouth of the outgoing pipe. The junction energy loss is then the addition of the expansion loss at the outlet of the incoming pipe and the contraction loss at the mouth of the outgoing pipe. For a "very large" manhole, the coefficient of expansion loss at the outlet of a pipe is approximately 1.0 and the coefficient of contraction loss for a square-edge inlet is approximately 0.5. Therefore, it is reasonable to assume that the energy-loss coefficient is approximately 1.5 if the inflow and outflow pipe diameters are equal.

The problem becomes more complicated for a smaller junction manhole in which the incoming flow cannot complete the expansion before being contracted near the mouth of the outgoing pipe. In this case, both the expansion loss and contraction loss, i.e., the junction loss, would be reduced. For a very small junction manhole in which the outlet of the incoming pipe is very close to the mouth of the outgoing pipe, the junction energy-loss coefficient will be small because the incoming flow will proceed directly into the outgoing pipe without expanding significantly. In between the two extremes of a very large and a very small manhole, the coefficient becomes smaller as the size of the junction manhole becomes smaller.

In cases where pipes of different diameters are attached to a manhole, an adjustment is required to estimate the loss coefficient because the idealized representations discussed above assume equal pipe diameters. For example, the outflow pipe is frequently larger than the inflow pipe. This means that flow contraction–and therefore contraction losses–is not as significant as it would be if a smaller outflow pipe was present.

For a junction with pipes connected at an angle other than 180 degrees, the energy loss will increase. In a junction manhole where the incoming pipe and the outgoing pipe intersect at a 90-degree angle, the flow is analogous to the flow in an elbow. The flow changes direction and must expend energy. The coefficient of energy loss at an elbow is normally about 0.9. For a small junction manhole where two pipes meet at 90 degrees and flow is fairly confined, the energy-loss coefficient will be about 0.9 or slightly larger. For a large junction manhole where flow is not confined, this value normally becomes larger. Considering the expansion of the incoming flow and the contraction of the redirected outgoing flow, the energy-loss coefficient becomes much larger due to the turbulence in the junction.

For a junction manhole where the lateral flow meets with the main flow at a different level, the energy-loss coefficient increases drastically because the turbulence developed by the falling flow inhibits the main flow from smoothly entering the outlet pipe. For drops exceeding 300 mm, air is entrained that further restricts flow and increases energy losses.

In summary, energy losses are related to the magnitude of turbulence in a junction manhole–the higher the intensity of turbulence, the larger the energy losses. A theoretical analysis of turbulence in a junction manhole is difficult, therefore, the investigation of junction energy losses depends on experimental investigations.

METHODS FOR ESTIMATING ENERGY LOSS

There are three traditional ways to estimate energy losses at a junction (or manhole) of a drainage system: energy grade line, pressure loss, and power loss. These methods are summarized below.

Energy Grade Line

The most common approach for estimating energy losses is use of the one-dimensional energy grade line of the incoming and outgoing flow. The total energy includes velocity head, elevation head, and pressure head. The energy relationships can be expressed in comparing the outlet energy to energy to any of the inlet pipes:

$$\frac{V_i^2}{2g} + \frac{P_i}{\gamma} + d_i + Z_i = \frac{V_o^2}{2g} + \frac{P_o}{\gamma} + d_o + Z_o + \Delta E_i \qquad (1)$$

where:

V_i, V_o	=	Velocity (i = inflow, o = outflow), m/s.
g	=	Acceleration due to gravity, 9.81 m/s^2.
P_i, P_o	=	Pressure, N/m^2.
γ	=	Specific gravity, N/m^3.
d_i, d_o	=	Depth of flow in the pipe, m.
Z_i, Z_o	=	Pipe invert elevation measured from a common datum, m.
ΔE_i	=	Energy loss for inflow pipe *i*, m.

Figure 2 is a schematic illustration of these quantities under surcharged conditions where D represents pipe diameter.[1] (A pipe is considered surcharged when the water elevation in the manhole exceeds the crown elevation of the pipe.) In the surcharged case, d = D and P/γ represents the distance between the hydraulic grade line and the pipe crown. Under free-surface conditions, $d \leq D$ and $P/\gamma = 0$.

If the inflow and outflow conditions are known, the lost energy can be calculated. However, when designing a system, these conditions are not given. Therefore, the energy loss is commonly represented as being proportional to the velocity head at the outlet pipe. Using K to signify this constant of proportionality, the energy loss is approximated as:

$$\Delta E_i = K_i \frac{V_o^2}{2g} \tag{2}$$

Substituting equation (2) into equation (1), K_i can be calculated by solving equation (1) as follows:

$$K_i = \frac{\left(\frac{V_i^2}{2g} + \frac{P_i}{\gamma} + d_i + Z_i\right) - \left(\frac{V_o^2}{2g} + \frac{P_o}{\gamma} + d_o + Z_o\right)}{\frac{V_o^2}{2g}} \tag{3}$$

This coefficient is generally determined by model tests, and the results of the model tests are then used in the design of prototype drainage systems. For junction manholes with more than one inflow pipe, the K_i values may vary significantly from one another.

Pressure Loss

The energy loss at a junction may also be analyzed in the form of the pressure loss. Using this approach, the velocity heads are excluded from equation (3) and only the piezometric pressure drop across a junction is considered. For the mainline loss, the pressure loss coefficient (K_p) can be expressed as:

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[1]The representation of the potential energy component in equation (1) and figure 2 is not conventional for surcharged conditions. Convention defines Z from the horizontal datum to the center of the pipe and P/γ from the center of the pipe to the hydraulic grade line. A more general representation was chosen to represent non-surcharged conditions without the use of negative pressure values.

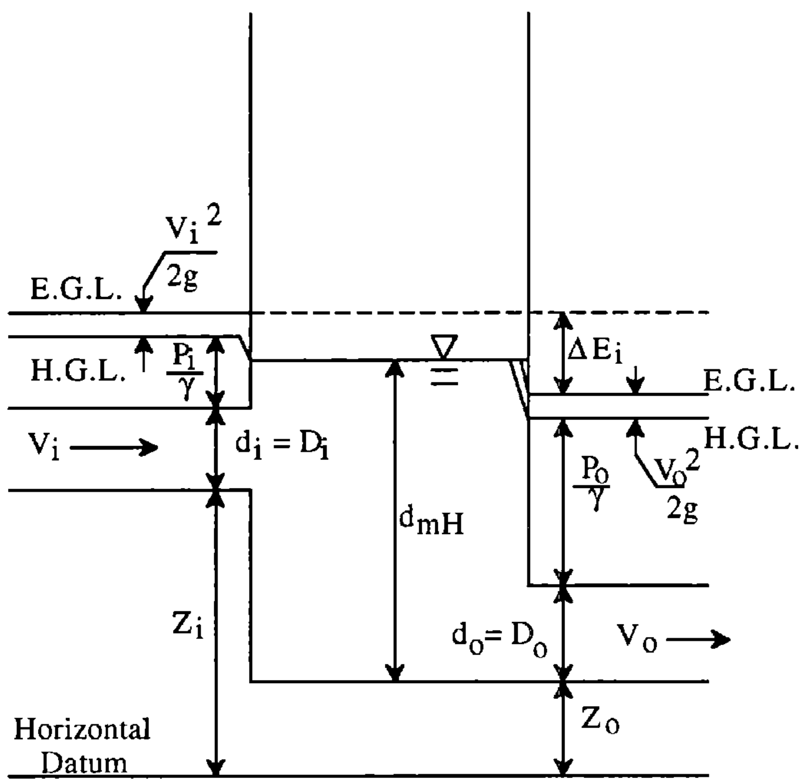


Figure 2. Energy grade line at a junction manhole.

$$K_{i,p} = \frac{\left(\frac{P_i}{\gamma} + d_i + Z_i\right) - \left(\frac{P_o}{\gamma} + d_o + Z_o\right)}{\frac{V_o^2}{2g}} \tag{4}$$

The use of pressure loss is a simplification appropriate when velocities are small and/or equal in the inlet and outlet pipes. The relationship between K and K_p becomes apparent in comparing equations (3) and (4) and is expressed as:

$$K_i = \left[\left(\frac{V_i}{V_o}\right)^2 - 1\right] + K_{i,p} \tag{5}$$

Power Loss

Another form of expressing energy loss at a junction is through the power loss approach. This approach attempts to estimate energy loss by balancing the total power of the incoming flows with the outflow power. Although not common among practicing engineers, it is theoretically more valid, particularly for a junction connecting more than two pipes. Power is expressed by multiplying total energy by the mass flow rate, γ x Q, where γ is the specific weight of fluid and Q is the volumetric discharge. Referring to a junction with multiple incoming flows and one outgoing flow as shown in figure 1, the power balance can be written as:

$$\gamma \sum_{i=1}^{n} (H_i \times Q_i) = \gamma (H_o + \Delta E) \times Q_o \tag{6}$$

where:

H_o,H_i	=	The total head ($V^2/2g + P/\gamma + d + Z$), m.
Q_o,Q_i	=	Volumetric discharge, m^3/s.
n	=	Number of inflow pipes.
γ	=	Specific gravity, N/m^3.
ΔE	=	Composite energy loss, m.

The theoretical advantages of the power approach are: (1) the junction is treated as a whole so the losses are balanced in all of the inflow pipes simultaneously, and (2) the estimation of losses is not exclusively tied to the outflow velocity head as shown in equation (2). If the velocity, pressure, and depth conditions are known in each pipe, then the energy loss can be calculated from equation (6) after solving it in terms of ΔE. As was stated earlier, all conditions are not known in design and an approximation must be made. One of many possible empirically based formulations is shown below.

$$\Delta E = \alpha_1 \frac{V_o^2}{2g} + \sum_{i=1}^{n} \frac{Q_i}{Q_o} \alpha_{2,i} \frac{V_i^2}{2g} + \sum_{j=1}^{m} \alpha_{3,j} \frac{Q_j}{Q_o}\left(Z_j + d_j - d_{mH}\right) + \sum_{j=1}^{m} \frac{Q_j}{Q_o} \alpha_{4,j} \frac{V_j^2}{2g} \qquad (7)$$

where:

α_1	=	Contraction-loss coefficient.
$\alpha_{2,i}$	=	Expansion-loss coefficient for each submerged inflow pipe *i*.
$\alpha_{3,j}$	=	Plunging-loss coefficient for each plunging pipe *j*.
$\alpha_{4,j}$	=	Expansion-loss coefficient for each plunging pipe *j*.
d_{mH}	=	Water depth in the manhole relative to the common datum, m.
D_o	=	Diameter of the outflow pipe, m.
n	=	Number of inflow pipes that are submerged.
m	=	Number of inflow pipes that are plunging.

In the earlier discussion of the causes of energy losses, it was observed that these losses are related to flow expansion, flow contraction, and manhole turbulence. Each term in equation (7) attempts to describe a component of the overall loss at the manhole. The first term expresses the contraction loss of flows leaving the manhole. The coefficient associated with this term (α_1) may vary with relative manhole size, relative depth in the manhole, and floor configuration. The second term accounts for the expansion loss associated with each submerged inflow pipe. Its associated coefficient ($\alpha_{2,i}$) varies with each inflow and may be a function of relative manhole size, relative depth in the manhole, floor configuration, and inflow angle. The remaining two terms express portions of losses contributed by inflow pipes with plunging flow. The third and fourth terms account for the potential energy loss and the expansion (kinetic energy) losses of the plunging inflows, respectively. The coefficient ($\alpha_{4,j}$) may be related to inflow angle.

As is true for the estimate of K_i in equation (2), the coefficients α_1, $\alpha_{2,i}$, $\alpha_{3,j}$, and $\alpha_{4,j}$ must be developed based on experimental data. Equation (7) is not a theoretical equation.

Summary

The energy grade line, pressure-loss, and power-loss methodologies represent three alternatives for calculating energy losses at manholes. In fact, the pressure-loss methodology is a subset of the energy grade line methodology. Since the concern in this study covers a broader range of applications than may be captured by the pressure-loss approach, i.e., where $V_i \neq V_o$, no further exploration of it is made.

The remaining two methodologies both strive to estimate total energy losses in a junction. The energy grade line approach estimates losses for each inflow pipe separately as given in equation (2). The power approach estimates energy losses for the junction as a whole as shown in equation (7). Both equations (2) and (7) are empirical equations that require estimates of dimensionless coefficients based on experimental testing. The data obtained in this and other studies are used to estimate the coefficients and evaluate the relative utility of these two approaches. The results of these analyses are described in subsequent sections of this report.

DIMENSIONAL ANALYSIS

A dimensional analysis of the parameters and variables that contribute to energy losses at a junction manhole suggests a starting point for developing equations for K_i (energy grade line) or α_1, $\alpha_{2,i}$, $\alpha_{3,j}$, and $\alpha_{4,j}$ (power loss). The coefficients K_i, α_1, $\alpha_{2,i}$, $\alpha_{3,j}$, and $\alpha_{4,j}$ are all dimensionless and may be functions of various parameters and variables shown in the following expression:

$$\text{Energy-Loss Coefficients} = f\left[\frac{V_o}{\sqrt{gd_o}}, \frac{V_o d_o}{\nu}, \frac{Q_i}{Q_o}, \frac{d_{mH}}{D_o}, \frac{b}{D_o}, \frac{D_i}{D_o}, \frac{Z_i - Z_o}{D_o}, \theta_i, FC\right] \quad (8)$$

where:

f	=	Some function for energy-loss coefficient (different for each coefficient).
V_o	=	Mean velocity in the outlet pipe, m/s.
Q_o	=	Discharge in the outlet pipe, m^3/s.
Q_i	=	Discharge in inflow pipe *i*, m^3/s.
b	=	Manhole diameter, m.
d_o	=	Depth in the outlet pipe, m.
d_i	=	Depth in inflow pipe *i*, m.
d_{mH}	=	Depth in the manhole relative to the outlet pipe invert, m.
D_o	=	Diameter of the outflow pipe, m.
D_i	=	Diameter of inflow pipe *i*, m.
Z_i	=	Elevation of invert for the inflow pipe *i*, m.
Z_o	=	Elevation of invert for the outlet pipe, m.
θ_i	=	Angle of deflection of inflow pipe *i* from the outflow pipe, degrees.

ν	=	Kinematic viscosity of fluid, m^2/s.
g	=	Gravitational acceleration, 9.81 m/s.
FC	=	Floor configuration.

The first four terms are related to flow characteristics; the latter five represent physical geometry of the junction manhole. The flow parameters are the outlet Froude number, the outlet Reynolds number, relative flow contribution of each inflow pipe, and the relative water depth in the manhole.

According to Sangster and Marsalek, the Froude number is not a determining influence on energy loss for pressure-flow conditions. It is also not considered to influence loss coefficients calculated for free-surface experiments conducted for this study.

Sangster and Marsalek also stated that for flows in manholes, the Reynolds number effect on energy loss may be neglected. Energy losses for suddenly expanded or contracted flow does not depend on the Reynolds number because of the existence of high-intensity turbulence. With high turbulence, the viscous effect of the fluid becomes insignificant. Therefore, it is reasonable to assume that energy loss in a manhole is independent of the Reynolds number.

These assumptions lead to a simplified representation of the possible determining factors based on a dimensional analysis as follows:

$$\text{Energy-Loss Coefficients} = f'\left[\frac{Q_i}{Q_o}, \frac{d_{mH}}{D_o}, \frac{b}{D_o}, \frac{D_i}{D_o}, \frac{Z_i - Z_o}{D_o}, \theta_i, FC\right] \quad (9)$$

The data collected for this study, combined with data from prior studies, are used to determine the influence of these non-dimensional parameters on the energy-loss coefficient. In addition, the influence of benching is explored.

EXPERIMENTAL ARRANGEMENT

The experimental approach is described in terms of the determining factors, the equipment and physical configurations, and the alternative hydraulic loads applied to the test equipment and the subsequent data acquisition. All tests were documented after reaching steady-state conditions. Appendix A contains photographs of the actual laboratory setup used to conduct the experiments. Volume II provides detailed documentation of the test results.

DETERMINING FACTORS

An experimental program was developed that centered around the common multiple-pipe junction manhole. Experimental tests were devised and conducted using variations on a basic configuration to explore the factors outlined previously, including:

1. Alternative manhole diameters (b/D_o ratio of 2 and 4). Relative manhole diameter is expected to influence energy losses because smaller manholes would not allow full expansion of incoming flows. This would tend to reduce losses.

2. Alternative hydraulic loading conditions from open-channel to surcharged conditions represented as changes in manhole depths (d_{mH} / D_o). The effect of water depth was not studied in detail in previous studies. All of Sangster's tests were conducted for pressurized flows. Marsalek extended his experimental work to include limited cases of free-surface flows, but stated that the data for free-surface flows were insufficient. In this experimental study, an emphasis is placed on finding the effects of water depth on energy losses at a manhole. For each experimental arrangement, the observations were made for at least three water depths in the manhole, covering free-surface to pressurized-flow conditions.

3. Alternative ratios of Q_i / Q_o. All the previous data show that the energy losses increased with increasing lateral inflows. Based on experimental observations, it was concluded that relative lateral discharge is a major independent variable affecting energy losses in a manhole. Additional tests were made for four values of the relative lateral discharge for both free-surface flows and pressurized flows. Some pressurized-flow experiments were, therefore, duplicates of Sangster's experiments, and were used to confirm his results.

4. Variations in the height of plunging flows into the manhole, $(Z_i - Z_o)/D_o$. For plunging-flow experiments, two values of $(Z_i - Z_o) / D_o = 2$ and 4 were used that covered the range of most practical cases. These arrangements correspond to cases where inverts of the elevated pipes are located at two and four times the outlet-pipe diameter above the bottom of the manhole.

5. One to three inflow pipes entering the manhole at various combinations of 45 degrees, 90 degrees, 135 degrees, and 180 degrees.

6. Alternative floor configurations, including level, depressed, and benched. As the benching effects on energy losses at a manhole were studied extensively by Marsalek, a modest effort was made to extend his study. Three types of manhole floors were studied: full, half, and zero benching.

The possible variations are staggering, however, so the following conditions are maintained throughout this study:

- All pipe diameters are of the same size ($D_i/D_o = 1$).
- All pipes are of zero physical slope.
- For lateral inflow tests, the main inflow pipe and the outlet pipe have the same invert elevation, except in a few cases with one inflow pipe entering at a 90-degree angle.

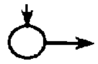
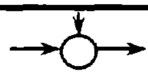
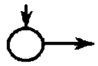
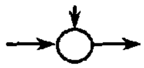
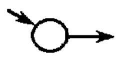
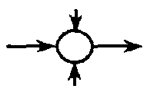
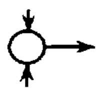
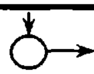
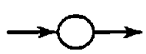
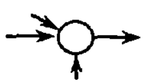
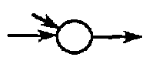
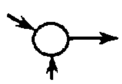
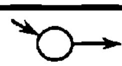
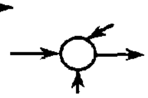
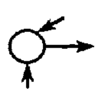
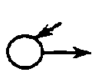
The effects of relative pipe diameters were not further evaluated in this study. Sangster's tests covered several different sizes of pipes to determine the effects of pipe sizes. Marsalek also conducted a number of tests that included two sizes of lateral pipes. The results of their studies were considered sufficient to obtain the effects of relative pipe size on energy losses and, thus, no attempt was made to repeat their experiments.

EQUIPMENT AND PHYSICAL CONFIGURATIONS

A total of 25 physical configurations are investigated in these experiments using the same basic test equipment. Plan view schematics of the configurations are summarized in table 1. The table shows the number of inflow pipes, their orientation, the relative manhole diameter, and the floor configurations. Floor configurations are depicted in figure 3. Variations within a physical configuration also include inflow pipe invert (Z_i).

Junction manholes with 300- and 600-mm diameters were tested. The experimental facility for the 600-mm-diameter manhole is shown in figure 4 for configuration 4. It consists of a 600-mm-diameter tank as the model manhole and a 900-mm-diameter tank for the water supply tank. These tanks are interconnected with three 150-mm-diameter pipes at different invert elevations to study the effect of plunging flows on junction energy losses. A 150-mm-outflow pipe is connected to the manhole on the opposite side of the three pipes, and is aligned with the lowest pipe of the three interconnecting pipes. A 150-mm lateral inflow pipe is also connected at a 90-degree angle with the outflow pipe at the same elevation. The figure shows a depressed-floor configuration.

Table 1. Physical configurations tested.

Configuration	Plan View	Relative Manhole Diameter (b/D_o)	Floor Configuration
1.		4	level
2.		4	depressed
3.		4	depressed
4.		4	depressed
5.		4	level
6.		4	level
7.		4	benched
8.		4	benched
9.		4	benched
10.		4	depressed
11.		4	depressed
12.		4	depressed
13.		2	level
14.		2	level
15.		2	level
16.		2	level
17.		2	level
18.		2	level
19.		2	level
20.		2	level
21.		2	level
22.		2	level
23.		2	level
24.		2	level
25.		2	level

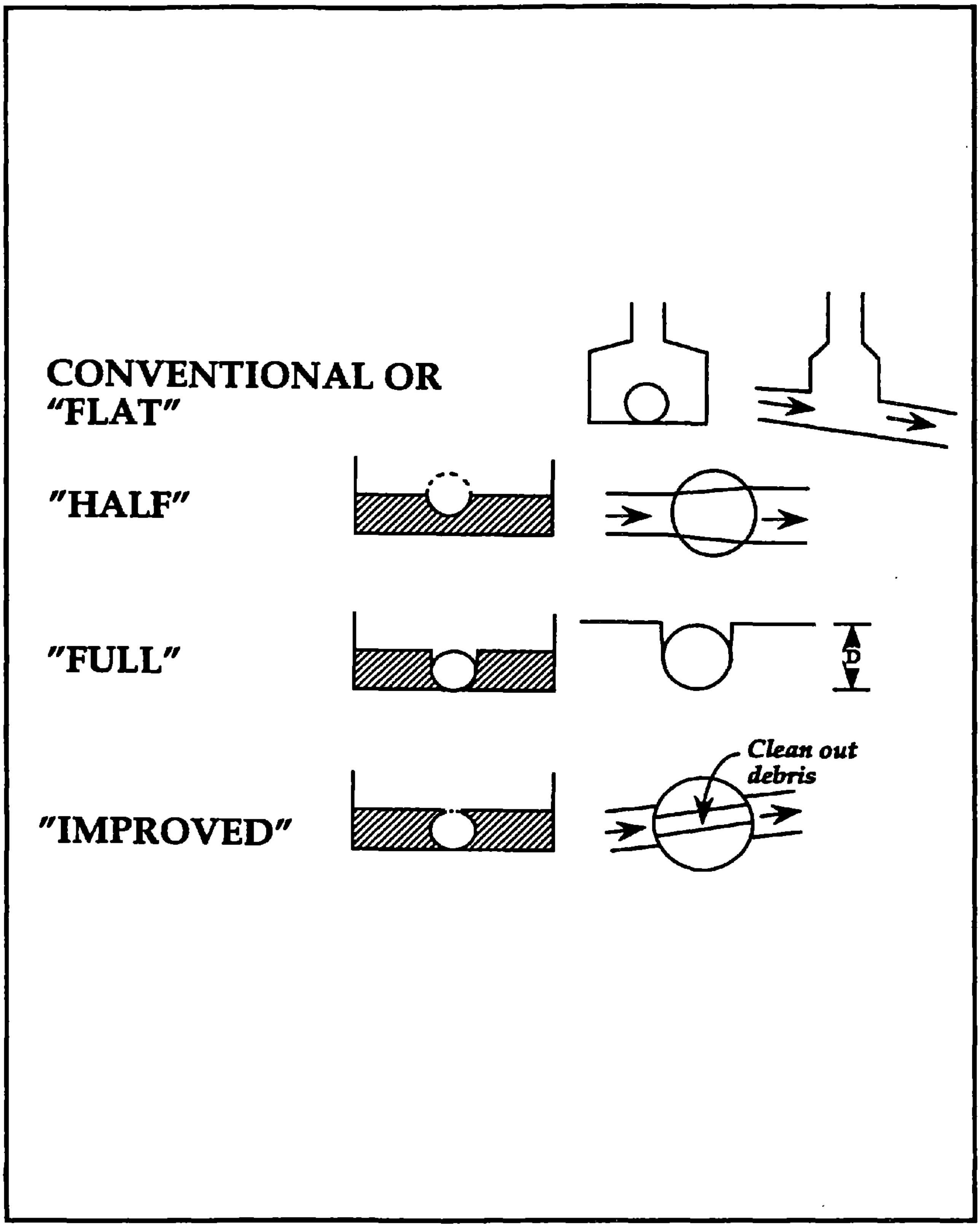


Figure 3. Description of benched floor configurations tested.

The lengths of all pipes are at least 3.0 m and the outflow pipe is discharged into a wide-open channel before returning to the water reservoir. Seven 3.2-mm-diameter pressure taps were installed 300 mm apart at the bottom of each inflow pipe to measure piezometric head. To cope with the turbulence and air entrainment in the outflow pipe, 12 pressure taps were installed to increase accuracy. The pressure taps were connected to a pressure transducer and the piezometric pressure heads were computed and recorded using a microcomputer. Prior to each run, the pressure transducer was calibrated using the pressure difference between two still-water wells. All tubing connecting the pressure taps and the transducer were transparent to allow continuous checking for trapped air. Four pressure taps at equal distances apart were installed around the circumference of the model manhole bottom to measure the average piezometric pressure of the water in the manhole and, therefore, the water depths.

The experimental facility for the 300-mm-diameter manhole is shown in figure 5 as used in configuration 18. It consists of a 300-mm-diameter cylindrical tank as the model manhole. The tank is made of three 300-mm sections of 300-mm-diameter fiber-glass pipe, stacked vertically to form a 900-mm-high junction manhole. The bottom section of the manhole was fabricated with four 150-mm-diameter openings with their axes mutually perpendicular and their inverts at the manhole bottom to allow testing of the physical configurations depicted in table 1. One of the openings is connected to the outflow pipe for all of the experimental runs. For the top two sections of the manhole, two 150-mm-diameter openings are fabricated with their axes aligned. These openings connect the lateral inflow pipes. The top two sections are made to rotate about the manhole axis so that the lateral inflow pipes may be arranged at two different elevations and at various angles with the outflow pipe.

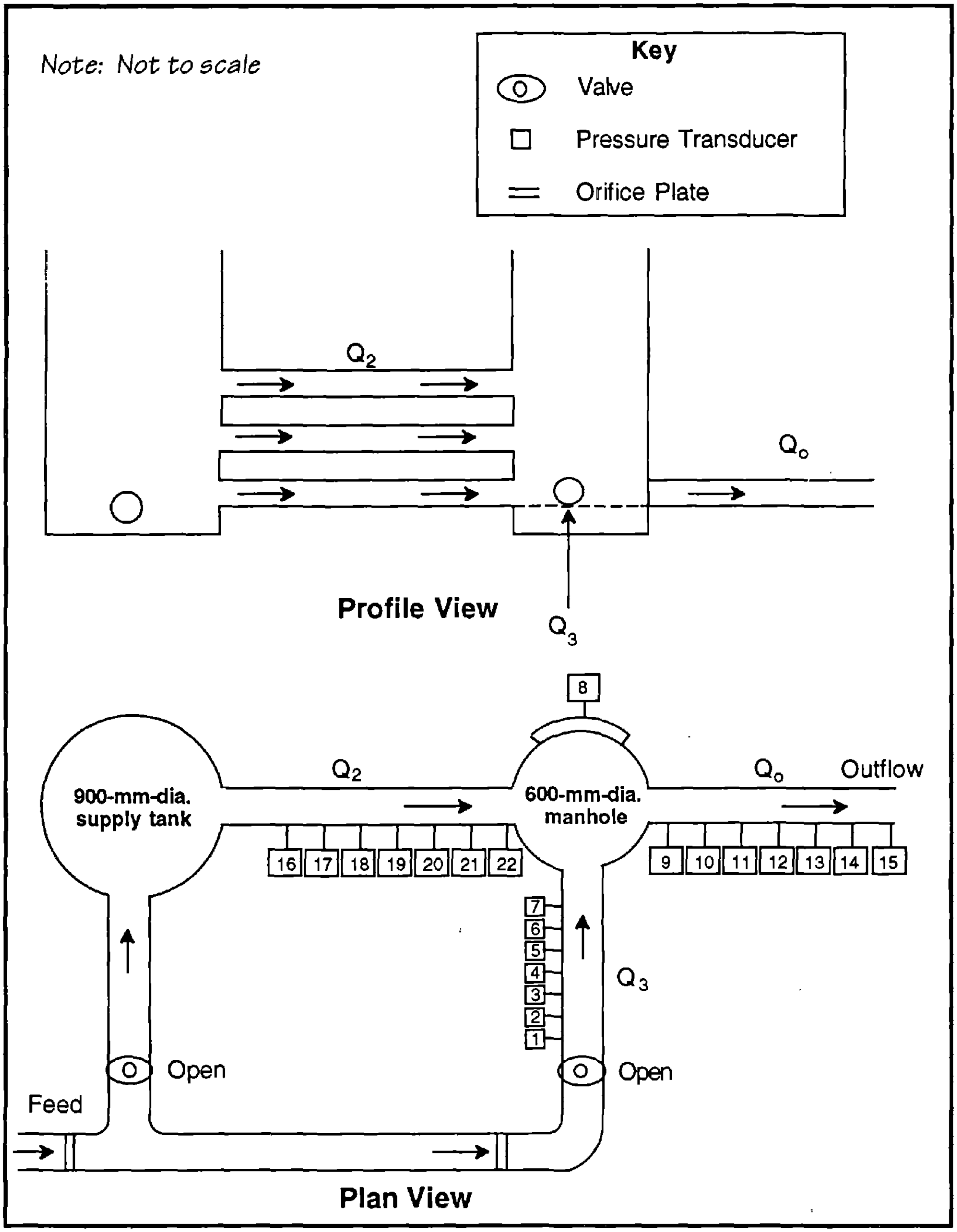


Figure 4. Schematic for configuration 4.

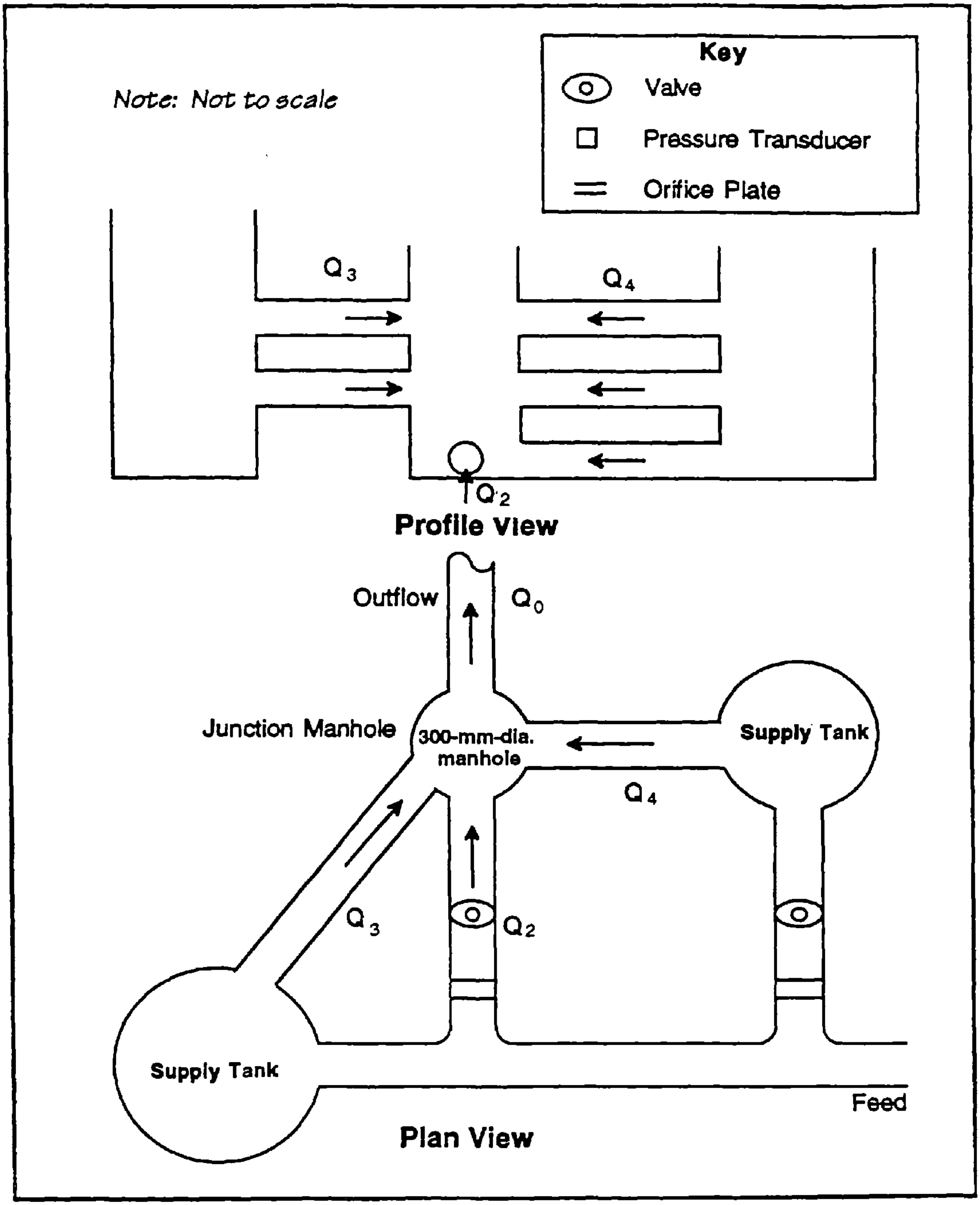


Figure 5. Schematic for configuration 18.

HYDRAULIC CONDITIONS AND DATA ACQUISITION

Hydraulic conditions applied to the physical configurations varied both in their distribution between inflow pipes, when more than one existed, and in total discharge. Varying the total discharge, given a constant outlet-pipe diameter, results in alternative water depths in the manhole. For a given physical configuration and flow distribution, higher discharge results in greater manhole depths.

For each hydraulic condition, pressures were measured by the pressure transducer and recorded by a microcomputer. Using a software package specially developed for this experiment, the pressure head, flow depth, and the total head were computed. The total heads at the pressure taps were plotted by computer.

Like Sangster and Marsalek, the energy losses of the manhole were determined at the centerline of the manhole by measuring the vertical distance between the two intersection points of the two energy grade lines (of the inflow and the outflow) with the centerline of the manhole. Both algebraic and graphical methods were used to estimate energy losses. The linear regression method was used to compute the intersection point of the energy grade line and the centerline. For this, all data points for each pipe were used to determine the best fit line. For the outflow pipe in the 300-mm-manhole experiments, the data at the first three and the last two pressure tap stations were ignored. The data points at these locations in some runs with high plunging flows exhibited a very wild pattern, making the resulting regression equation unreliable. For the graphical method, the best average line was drawn through the data points discounting data points that appeared obviously unreliable. In most cases, all seven data points for each pipe were used. As the regression analysis included some wild data points for the analyses, the results of the analyses showed slightly less consistency compared with those by the graphical method. However, both results appear in general agreement.

To obtain the velocities for the velocity-head computations, the discharges were divided by the average cross-sectional areas of the flow in the pipe. The cross-sectional areas for the pressurized flows were the cross-sectional area of the pipe itself. For the free-surface flows, the flow depths were first computed by subtracting the invert elevations of the pipe from the piezometric pressure readings. Then, the average cross-sectional area was computed from the average flow depth using the equation for the partial area of a circle. A summary of the data collected is found in appendix B. Appendix C provides design guidance. Volume II provides a comprehensive presentation of the data.

ANALYSIS OF RESULTS

The data collected in this study were analyzed under the framework of three different methodologies. The energy grade line methodology is used to develop an empirical equation that estimates the energy lost through a manhole based on the outflow velocity head coefficient, K. The power-loss approach is based on conservation of power through a manhole and expresses inflow power as the sum of outflow power and the power lost. An iterative procedure for determining water depth in the manhole, given a set of physical and hydraulic conditions, is developed for each of these approaches. The third methodology, the neural network analysis, applies an artificial neural network system. The neural network "learns" how to solve problems from a limited set of example solutions–in this case, the data collected in the junction-loss experiments performed in this study.

ENERGY GRADE LINE ANALYSIS

The energy grade line (EGL) analysis through a junction manhole focuses on the calculation of the energy loss from the main inflow pipe to the outflow pipe. Once this loss is computed, a water depth in the manhole is estimated. Subsequently, if lateral pipes also discharge into the manhole, the energy losses for each lateral pipe may be computed based on the discharge and the estimated manhole depth.

The analysis presented here assumes that a main inflow exists and that it is 180 degrees from the outflow pipe and shares the same invert elevation with the outflow pipe. The analysis further assumes that no more than two additional laterals discharge to the junction manhole. However, since many of the experimental runs do not meet both of these conditions, the methodology was tested for its extension to these cases, and it performed relatively well (as will be shown later). For cases where an inflow main did not exist at 180 degrees from the outlet and at the same invert as the outlet, it was assumed that such a pipe does exist, but with zero discharge. For cases where more than two lateral discharges existed, the lateral(s) with the smallest discharge was neglected.

The energy grade line methodology starts with equation (2) that describes the energy loss for an inflow pipe:

$$\Delta E_i = K_i \frac{V_o^2}{2g} \tag{10}$$

The methodology is completed by using the determining factors identified in the dimensional analysis to predict K_i for a given physical configuration and hydraulic loading. It is proposed that:

$$K_i = (C_1 \; C_2 \; C_3 + C_4)\omega \tag{11}$$

where:

K_i	=	Composite energy-loss coefficient for the main inflow pipe.
C_1	=	Coefficient related to relative manhole size.
C_2	=	Coefficient related to water depth in the manhole.
C_3	=	Coefficient related to lateral flow, lateral angle, and plunging flow.
C_4	=	Coefficient related to relative pipe diameters.
ω	=	Coefficient related to floor configuration.

Equations (10) and (11) are combined to yield the following equation:

$$\Delta E_i = (C_1\ C_2\ C_3 + C_4)\ \omega\ \frac{V_o^2}{2g} \tag{12}$$

Equation (12) provides an energy-loss estimate for a straight (θ_i = 180 degrees) inflow pipe with an invert at the same elevation as the outlet pipe. The calculation of C_1, C_2, C_3, and C_4 is accomplished with respect to the main inflow pipe.

Several determining factors affect the computation of the energy-loss coefficient in the EGL methodology. They are the manhole size relative to the outlet pipe diameter, depth in the manhole, amount of lateral inflow, lateral inflow angle, lateral plunge height, relative pipe diameter, and floor configuration. Empirical equations for each of these determining factors are developed from analysis of the data collected in this study.

Relative Manhole Size

The role of relative manhole diameter (manhole diameter/outlet pipe diameter, b/D_o) is evaluated using data having a single inflow pipe at the same invert as the outflow pipe representing straight-through flow. The energy-loss coefficient, in this case, increases with relative manhole size. The larger the manhole is relative to the outlet pipe, the greater the space and time needed for the flow to expand and dissipate the velocity head. Similarly, the greater the expansion into the manhole, the greater the energy losses in contracting to leave through the outlet pipe. According to Marsalek, the energy-loss coefficient is unaffected by changes in relative manhole diameter within the range of $2 \leq b/D_o \leq 6$. Sangster's study showed that the energy-loss coefficient is more affected in the range of $b/D_o < 3$.[1,3] The proposed formulation for this methodology is that for b/D_o values up to 4.0, the coefficient related to manhole size (C_1) is calculated with the following equation:

$$C_1 = \frac{0.9\left[\frac{b}{D_o}\right]}{\left[6 + \frac{b}{D_o}\right]} \tag{13}$$

where:

b	=	Manhole diameter, m.
D_o	=	Outflow pipe diameter, m.

Selected data from Sangster and Marsalek, along with data from the current study, are presented in figure 6. For the data shown in the figure, other controlling parameters are held approximately constant. Therefore, the energy-loss coefficient (K) is equal to C_1. The data suggest that the relationship between the coefficient C_1 and the relative manhole diameter (b/D_o) is nearly linear up to the point where b/D_o is approximately 4.0. Beyond this value, the relative manhole diameter has no effect on the head-loss coefficient (C_1). Once the manhole diameter is four times the outlet pipe diameter or larger, the manhole is "large" and the coefficient C_1 is assumed to be a constant equal to 0.36.

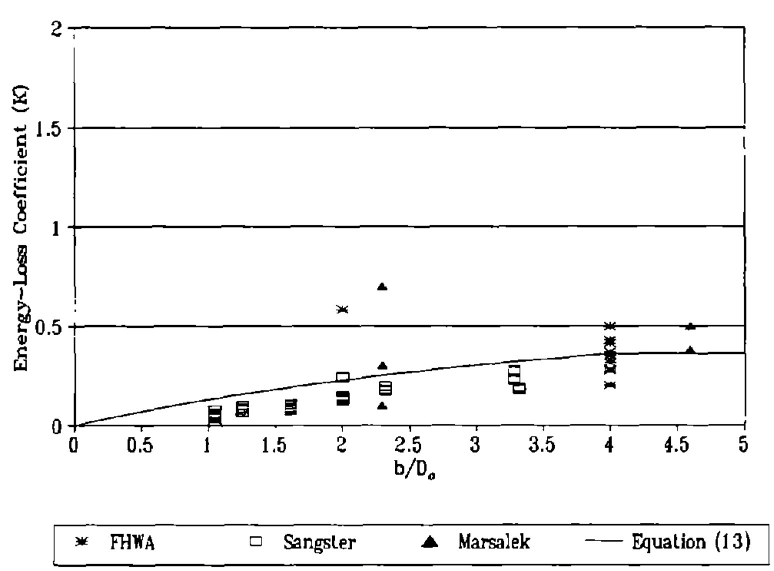


Figure 6. Energy-loss coefficient for straight-through flow.

Water Depth in the Manhole

The coefficient (C_2) related to manhole water depth increases rapidly with relative water depth (d_{mH}/D_o)–up to 2. The rate of the increase slows when d_{mH}/D_o is larger than 2.0 and approaches a constant as d_{mH}/D_o reaches approximately 3. This type of the curve can be expressed as a third-order polynomial. The following equation was found to fit the data reasonably well:

$$C_2 = 0.24\left(\frac{d_{mH}}{D_o}\right)^2 - 0.05\left(\frac{d_{mH}}{D_o}\right)^3 \tag{14}$$

where:

d_{mH} = Depth in the manhole relative to the outlet pipe invert, m.

Figure 7 shows equation (14) plotted versus computed C_2 values from the current study. The data represented in the figure are from experiments with a physical configuration of two inflow pipes (a 90-degree lateral and a 180-degree main), a 600-mm manhole, and a level floor. Neither inflow pipe is plunging. For this subset of the data, the derived equation for C_2 fits fairly well and, overall, is a good predictor for the coefficient related to water depth in the manhole.

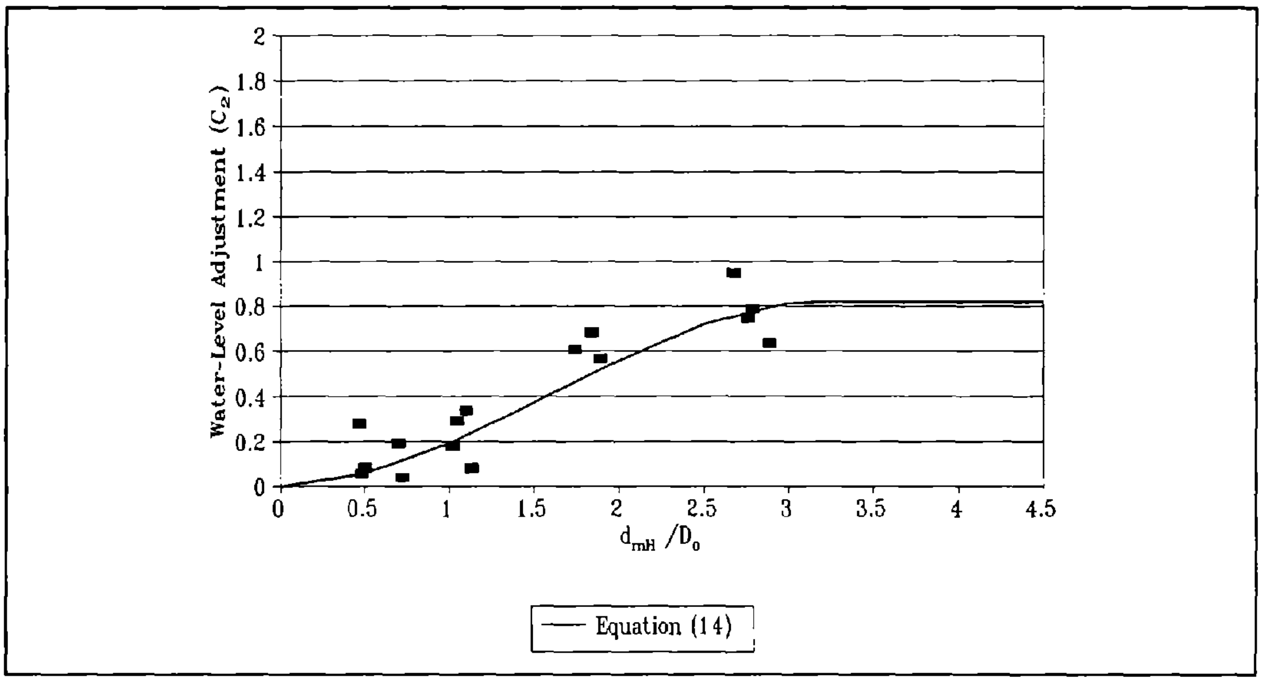


Figure 7. Water-level adjustment coefficient (C_2).

The computed water-level adjustment (C_2) is an estimate calculated by solving for C_2 in equation (11) using the observed values of K. The coefficients C_1 and C_3 are estimated using equations (13) and (15), respectively. C_4 is equal to zero because the inflow and outflow pipe diameters are equal. Since the floor configuration is level, ω equals 1.0.

Lateral Inflows

The coefficient related to lateral flows (C_3) is the most complex term in the composite energy-loss coefficient equation. The effect of lateral flows on the energy loss were studied with respect to three parameters: flow rate, connecting angle of the lateral pipe, and elevation of the lateral pipe. To select the form of the equation, the data were first plotted in groups according to the above three parameters to observe the variations in energy losses. The data are quite scattered because of air entrainment and turbulence. This was particularly true for plunging flows discharging into shallow water depths in the manhole. Based on the analysis, the following equation can be used to calculate the coefficient C_3:

$$C_3 = 1 + \sum_{i=2}^{3} \left(\frac{Q_i}{Q_0}\right)^{0.75} \left[1 + 2\left(\frac{Z_i}{D_0} - \frac{d_{mH}}{D_0}\right)^{0.3} \left(\frac{Z_i}{D_0}\right)^{0.3}\right]$$

$$+ \; 4 \sum_{i=2}^{3} \frac{\left\{ \operatorname{Cos}\theta_i \left[0.85 - \left(\frac{Z_i}{D_0}\right)\left(\frac{Q_i}{Q_0}\right)^{0.75}\right]\right\}}{\left(\frac{d_{mH}}{D_0}\right)^{0.3}}$$

$$+ \left| \left(\frac{Q_2}{Q_0}\right)^{0.75} \operatorname{Sin}\theta_2 + \left(\frac{Q_3}{Q_0}\right)^{0.75} \operatorname{Sin}\theta_3 \right| + 0.8 \left| \frac{Z_2}{D_0} - \frac{Z_3}{D_0} \right| \qquad (15)$$

where:

Q_0	=	Total discharge in the outlet pipe, m^3/s.
Q_2, Q_3	=	Pipe discharge in lateral pipes 2 and 3, m^3/s.
Z_2, Z_3	=	Invert elevation of lateral pipes 2 and 3 relative to the outlet pipe invert, m.
D_0	=	Outlet pipe diameter, m.
b	=	Manhole diameter, m.
d_{mH}	=	Depth in the manhole relative to the outlet pipe invert, m.
θ_2, θ_3	=	Angle between the outlet main and lateral pipes 2 and 3, degrees.

Z_1, Q_1, and θ_1 do not appear in equation (15) because the main inflow pipe is the pipe for which K is being calculated. That is, θ_1=180 degrees, Z_1=Z_o= 0.0, and Q_1=Q_o-Q_2-Q_3. The first term (the numeral one) is necessary for the equation to be applicable to cases with no lateral flow. In such cases, C_3 reduces to 1.0.

The second term in equation (15) captures the energy losses from plunging lateral flows. This term reflects the fact that flows plunging from greater heights result in greater turbulence and, therefore, higher energy losses. As shown by the summation in the second term, the computation is valid for one or two lateral inflows (over and above the main inflow). If Z_i is less than or equal to the water depth in the manhole, then no plunge exists and this term is set to zero.

The third term attempts to capture the effects that the lateral angle (with respect to the outflow pipe) has on energy losses. For lateral inflows at a given invert (Z_i) and relative discharge (Q_i/Q_o), the cosine function provides for a higher energy-loss coefficient when the lateral inflow opposes ($\theta \leq 90$ degrees) the main inflow and a lower energy-loss coefficient when the lateral inflow supports ($\theta > 90$ degrees) the main inflow.

The invert elevation, manhole depth, and relative inflow are also included in the third term to capture extremely complex interactions. For a 135-degree skewed plunging flow, for example, the velocity component of the flow in the main flow direction increases, which results in lower energy losses because the momentum is predominantly in the direction of the outflow pipe. But, a higher lateral flow velocity creates higher turbulence, thereby increasing the energy loss. If the skewed lateral pipe is raised further so that the flow hits the opposite wall of the manhole during the fall, a different situation develops. The plunging flow dives along the manhole wall and moves in the opposite direction as the flow reaches the manhole bottom. The velocity component of the flow at the manhole bottom is then in the opposite direction that it entered, reversing the energy-loss effect. In cases where water depth in the manhole is significant, the velocity of the diving flow will be reduced.

The remaining terms only apply when two laterals enter a junction manhole on opposite sides of the main inflow. If only one lateral inflow exists (or two exist but enter on the same side of the main inflow), the third term is calculated for the existing lateral(s), and the fourth term is dropped.

Inspection of the remaining terms of equation (15) reveals that if two laterals enter a junction manhole 180 degrees apart from one another, with equal discharges and at the same invert elevation, they both reduce to zero.[2] This means that opposing laterals tend to neutralize, to a degree, the turbulence each would cause individually. For cases where discharge, angle, and/or invert elevation are different, additional energy losses occur.

Figure 8 shows the estimated C_3 coefficient versus the lateral flow ratio. Equation (15) is plotted to view conformity of the data points with the predictive equation. The data points shown are from a three-pipe configuration with a 90-degree lateral, a 600-mm manhole, and a level floor. All pipe inverts at the junction are equal (i.e., no plunging flow). As lateral flow increases, the coefficient related to lateral flow increases. For the data set shown in figure 8, C_3 ranges from 1.0 (no lateral flow) to 3.0 (100-percent lateral flow).

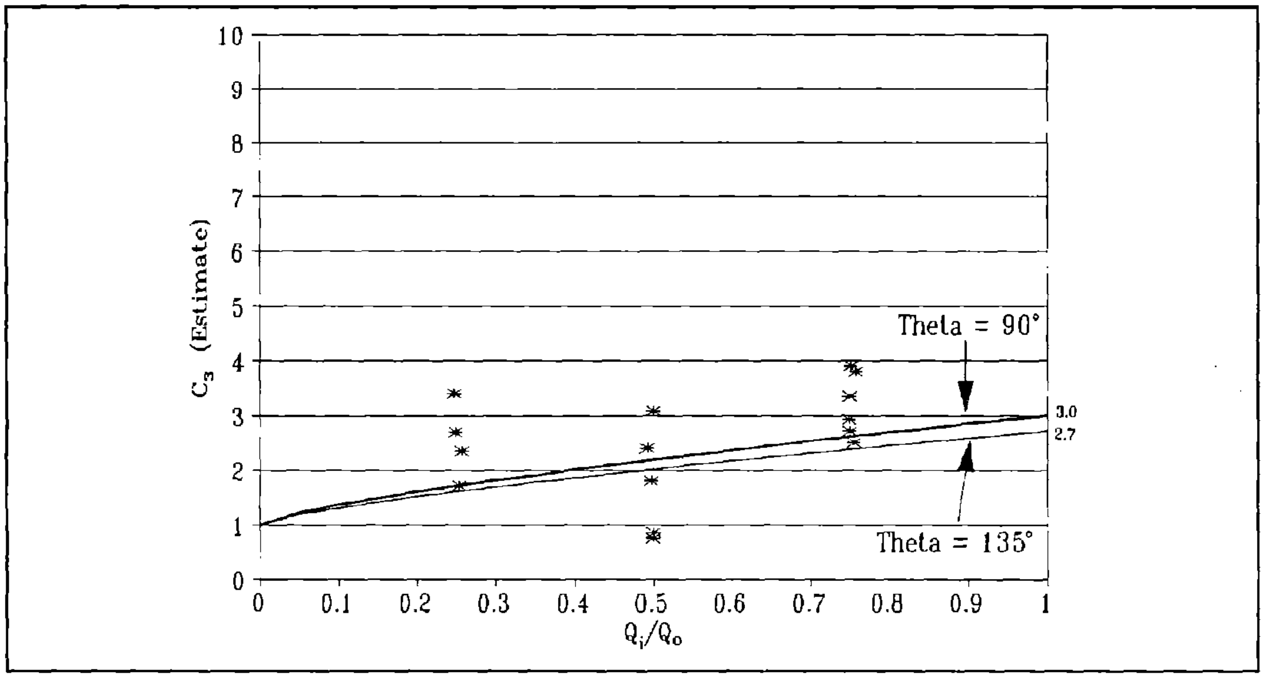


Figure 8. Lateral coefficient (C_3) versus lateral inflow, no plunge.

Additional data from this study were selected and examined in order to analyze the effect of a plunging lateral on the estimated C_3 coefficient. The physical configurations of this data set employ more of the component terms of equation (15), as illustrated in figure 9. The selected

[2]For purposes of this calculation, one lateral angle (θ_2) must be between 0 and 180 degrees, while the other (θ_3) must be between 180 and 360 degrees. Either a clockwise or counterclockwise convention may be adopted.

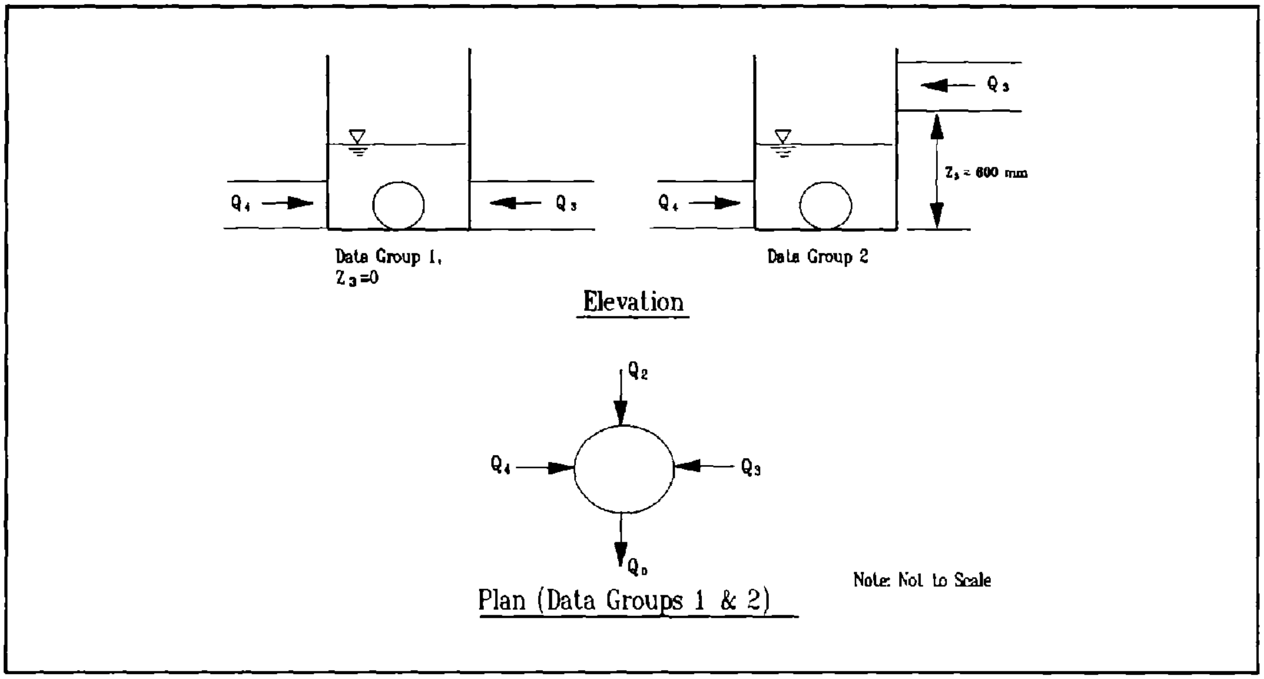


Figure 9. Plan and elevation views of data subgroups.

set of data is divided into two subgroups, one with no plunging flow (data group 1), and one with an elevated lateral (data group 2).

The subgroups of data are identical in terms of corresponding flow ratios and manhole depths and differ only in the elevation of the Q_3 lateral. The purpose of choosing these two data groups was to isolate the effect that the lateral plunge height has on the estimation of the junction-loss coefficient, and compare the estimated C_3 values with the projected C_3 value as computed by application of equation (15).

The results of this analysis are shown in figure 10. The computed values for C_3 are represented as a range of values due to the changing flow ratios in the data sets–this partially illustrates the difficulty in analyzing equation (15). It is a function of four variables: flow ratio, plunge height, depth in the manhole, and lateral angle. Ideally, all points should lie within this range according to equation (15). The data is very scattered, but the general trend that is predicted by equation (15) is present in the data. In general, the equation tends to overpredict the C_3 coefficient (more so at the higher lateral plunge heights). The results of this analysis illustrate the complexity of equation (15). This particular analysis attempts to isolate one variable–the lateral plunge height–to illustrate its effect on the junction energy loss.

Application limits for equation (15) range from 1.0 (no lateral flow) to 10.0. The predicted C_3 coefficient increases dramatically as the height of the plunging lateral increases. In reality, the estimate of the C_3 coefficient from the empirical data does increase at higher plunge

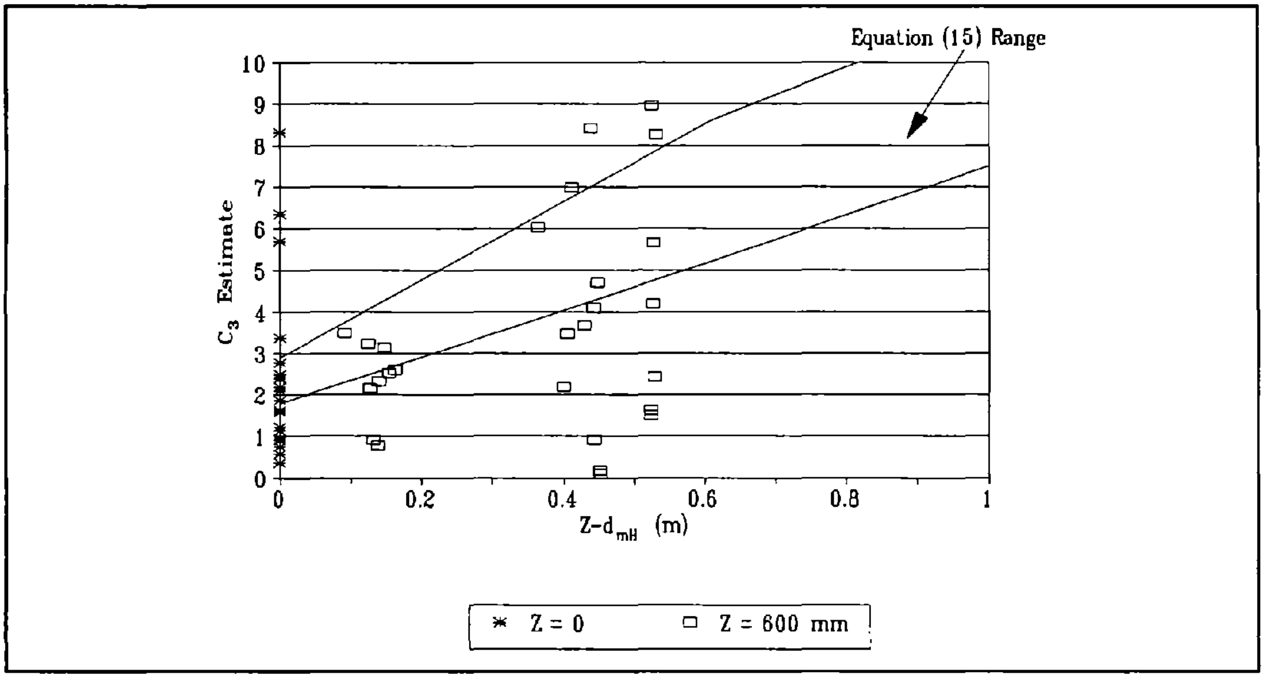


Figure 10. Lateral coefficient (C_3) with plunging flow.

heights, but the data are very scattered. The C_3 coefficient in figure 10 ranges from 0.1 to 9.0 at Z = 600 mm. In other words, the empirical data does not support the dramatic upward trend that equation (15) predicts at greater plunge heights. Therefore, the chosen upper limit of 10.0 is a realistic ceiling for the range of data analyzed in this study.

Relative Pipe Diameters

Although no experiments were performed with different pipe diameters in this study, a correction for such a case is required in the energy grade line analysis. Equation (16) is proposed for this purpose:

$$C_4 = \left[1 - \left(\frac{D_o}{D_I}\right)^2\right]^2 \tag{16}$$

where:

D_o = Outlet pipe diameter, m.

D_i = Inlet pipe diameter, m.

Equation (16) is an equation that is theoretically derived for the following simplified condition:

- Two-pipe configuration.
- Both pipes are flowing full.
- Inflow pipe is at 180 degrees.
- $D_o \geq D_i$.

Sangster reported a theoretical equation, supported by laboratory data, for the effect of manhole diameter on the pressure-loss coefficient (K_p):

$$K_p = 2\left[1 - \left(\frac{D_o}{D_i}\right)^2\right] \tag{17}$$

where:

K_p = Head-loss coefficient based on hydraulic grade line.

Equation (17), combined with equation (5), allows derivation of equation (16) for the pipe-diameter coefficient (C_4). Equation (5) is repeated below for convenience:

$$K = \left[\left(\frac{V_i}{V_o}\right)^2 - 1\right] + K_p \tag{18}$$

where:

K = Energy-loss coefficient based on energy grade line.

Figure 11 graphically shows the functional behavior of the coefficient related to relative pipe diameters (C_4). A higher loss coefficient for pipe diameter reflects increasingly constricted flow in the inlet pipe for a given outlet pipe diameter and velocity head. Energy lost as a result of differing pipe diameters was found to be significant only in pressure flow situations when the depth in the manhole-to-outlet-pipe-diameter ratio (d_{mH}/D_o) is greater than 3.2. This equation is applied only in such cases. Application of equation (16) would be limited to a D_o/D_i ratio of 2.0, where C_4 is equal to 9.0.

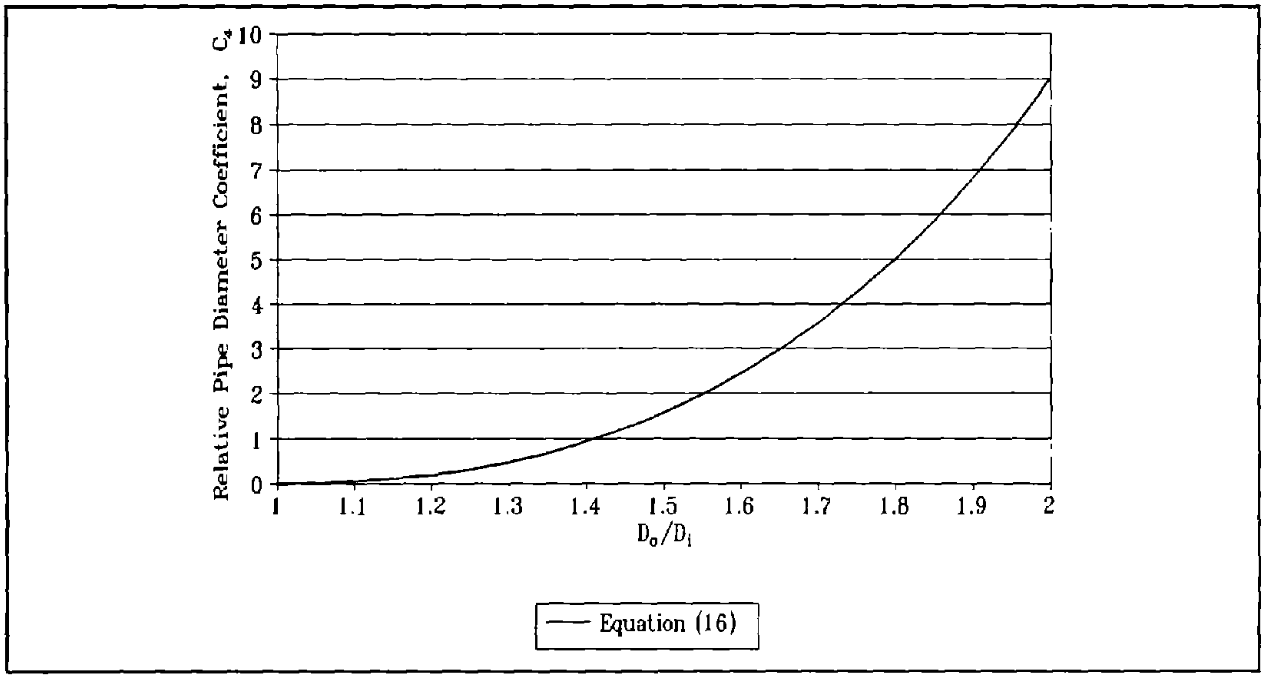


Figure 11. Functional behavior of C_4.

Floor Configuration

Manhole benching affects head loss because the bending channels guide the flow smoothly into the outlet pipe, reducing disturbance in the flow. The reduction in the head loss is dictated by the type and extent of benching. The reduction of head loss is greater when all incoming flow is smoothly reflected by the benching facility.

Marsalek tested three types of benchings that are commonly used in drainage practice. These benching types are illustrated in figure 3. One type is a half-benching for which the lower half of the pipe extends through the junction and horizontal benches are extended from the semi-circular channel to the junction wall. In the plan view, the channel axis follows a 90-degree segment of a circle with a radius equal to one-half of the manhole diameter. The second type is a full-benching that is an improved variation on the half-benching obtained by extending the mold side wall to the pipe-crown elevation. The third type is an improved variation of the full-benching that adds smooth transition sections to the inflow and outflow pipes. The inflow was gradually enlarged 30 percent in diameter and was then smoothly contracted into the outflow pipe.

Marsalek's test data showed that the half- and the full-benchings reduced head losses by 5 percent and 25 percent, respectively, for pressure flows. For free-surface flows, the reductions were 85 percent and 93 percent, respectively. The improved full-benching experienced a reduction rate of 60 percent for the pressurized flows and nearly 100 percent for the open-channel flows. It is no surprise that the reduction rates were different for these flows. The water depths were shallow for the free-surface flow and, thus, all or most of the flows were confined within and were guided through the molded channel smoothly. For the pressure flow, the water in the manhole was deep, and the incoming flow was not totally confined and was allowed to expand upward, causing agitation. Therefore, the energy-loss reductions were not as significant. The final selection of the type of benching depends on economics. There will be a substantial reduction in the head loss for the improved benching, however, a question of the additional cost required should be addressed in making the final decision. For half-benching, or even for full-benching, the improvement as related to the reduction in the head losses of 5 percent or 25 percent may not be sufficient to override the extra cost required to mold the bench.

Because Marsalek placed his emphasis on studying the effects of junction benching on head losses and searching for ways to reduce these losses, his data related to manhole benching are sufficient. Therefore, only a series of tests for half-benching and depressed floor conditions were conducted to verify Marselek's data.

In practice, the correction factors obtained from Marsalek's data and shown in table 2 may be used. The correction factors (ω) should be multiplied by the head-loss coefficient for a manhole with a flat floor. For conditions that are between clear pressure flow ($d_{mH}/D_o > 3.2$) and clear free-surface flow ($d_{mH}/D_o < 1.0$), a linear interpolation is an appropriate approximation.

Table 2. Correction factors (ω) for benching.

	Bench Submerged*	Bench Unsubmerged**
Flat Floor	1.0	1.0
Benched one-half pipe diameter high	0.95	0.15
Benched one pipe diameter high	0.75	0.07
Improved	0.40	0.02

* Pressure flow, $d_{mH}/D_o > 3.2$
** Free-surface flow, $d_{mH}/D_o < 1.0$

POWER-LOSS ANALYSIS

The power-loss approach to estimating energy losses through a pipe-junction configuration is based on conservation of power through the manhole. The inflow power entering the manhole can be equated to the sum of the outflow power and the power lost. The following equation expresses the concept:

$$PWR_i = PWR_o + \Delta E_p \qquad (19)$$

where:

PWR_i	=	Inflow power supplied into the manhole.
PWR_o	=	Outflow power leaving the manhole.
ΔE_p	=	Total power lost as water passes through the manhole.

Inflow power is equal to the summation of the power provided by each inflow pipe to the junction. The outflow power added to the power lost as the water passes through the manhole is, theoretically, equal to the total inflow power. (Power computations are referenced to the invert of the outlet pipe.) The main focus of the power-loss concept is to develop a methodology for estimating the power loss (ΔE_p). The following equation was developed and provides for an estimation of the losses through the manhole:

$$\Delta E = \alpha_1 \frac{V_o^2}{2g} + \sum_{i=1}^{n} \alpha_{2,i} \frac{Q_i}{Q_o} \frac{V_i^2}{2g} + \sum_{j=1}^{m} \alpha_{3,j} \frac{Q_j}{Q_o}(Z_j + d_j - d_{mH}) + \sum_{j=1}^{m} \alpha_{4,j} \frac{Q_j}{Q_o} \frac{V_j^2}{2g} \qquad (20)$$

where:

ΔE	=	Total energy lost, m.
α_1	=	Contraction-loss coefficient.
$\alpha_{2,i}$	=	Expansion-loss coefficient for each submerged inflow pipe, i.
$\alpha_{3,j}$	=	Plunging-loss coefficient for each plunging inflow pipe, j.
$\alpha_{4,j}$	=	Expansion-loss coefficient for each plunging inflow pipe, j.

ΔE represents the energy lost in terms of head. Multiplying ΔE by the unit weight of water (γ) and inflow (Q_o) yields the total power lost (ΔE_p).

The estimated energy losses through the manhole are broken down into four components, as represented in equation (20). For each loss component, an alpha coefficient accounts for variability in the physical configuration of the junction (such as b/D_o). The alpha coefficients incorporate determining factors in the computation of the losses through a manhole. The factors accounted for by the coefficients include relative manhole diameter (b/D_o), floor configuration (benched, level, or depressed), inflow angle (θ_i), relative outflow hydraulic gradeline (HGL_o/D_o), and manhole diameter relative to the outlet velocity head ($b/(V_o^2/2g)$).

Contraction-Loss Coefficient (α_1)

The first term in equation (20) attempts to account for the loss created when the expanded flow within the manhole contracts into the outlet pipe. The equation developed for estimating α_1 incorporates variables that would be expected to influence the contraction loss. They include relative manhole diameter (b/D_o), relative outflow hydraulic grade line (HGL_o/D_o), manhole diameter relative to outflow velocity head ($b/(V_o^2/2g)$), and floor configuration. The α_1 equation is formulated as follows:

$$\alpha_1 = a_1 C_1 C_2 C_3 f \tag{21}$$

where:

a_1	=	Adjustment coefficient.
C_1, C_2, C_3	=	Empirically derived coefficients that quantify portions of the energy loss based on the determining factors.[3]
f	=	Floor-configuration coefficient.

The equation representing the C_1 coefficient is related to the relative diameter of the manhole and is expressed as follows:

$$C_1 = \left(\frac{b}{D_o}\right)^{0.55} \tag{22}$$

Figure 12 shows the estimated C_1 coefficient plotted against the relative manhole diameter (b/D_o) for laboratory values obtained in this study. Laboratory data compiled by Sangster and Johnston are included in the analysis for comparison.[1,8] The Marsalek data was not complete and is excluded from the analysis. The data points in the figure represent laboratory runs with a physical configuration consisting of a single non-plunging inflow pipe at 180 degrees from the outlet, with a level floor. This simple case was used to develop the basic formulation of the C_1 equation. The form of the C_1 equation is obtained by determining the best-fit curve through these data points. Based on the available data for this analysis, the maximum b/D_o value is fixed at 5.0, for a maximum C_1 value of 2.4. For relative manhole diameters greater than 5.0, the effects of the expanded flow contracting into the outlet pipe are considered to have reached a maximum.

The C_2 coefficient is related to the outlet hydraulic gradeline and is represented as follows:

$$C_2 = 4.5 - 2\left(\frac{HGL_o}{D_o}\right)^{0.25} \tag{23}$$

The formulation of the C_2 equation is derived from analysis of the data presented in figure 13. These data are derived from the same laboratory experiments that were analyzed in the previous figure and show significant scatter. Equation (23) is valid in the range where HGL_o/D_o is greater than 1.0 and less than 6.0. In this range, the C_2 coefficient gradually

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[3]The definition of these coefficients differs from their use in the energy grade line methodology.

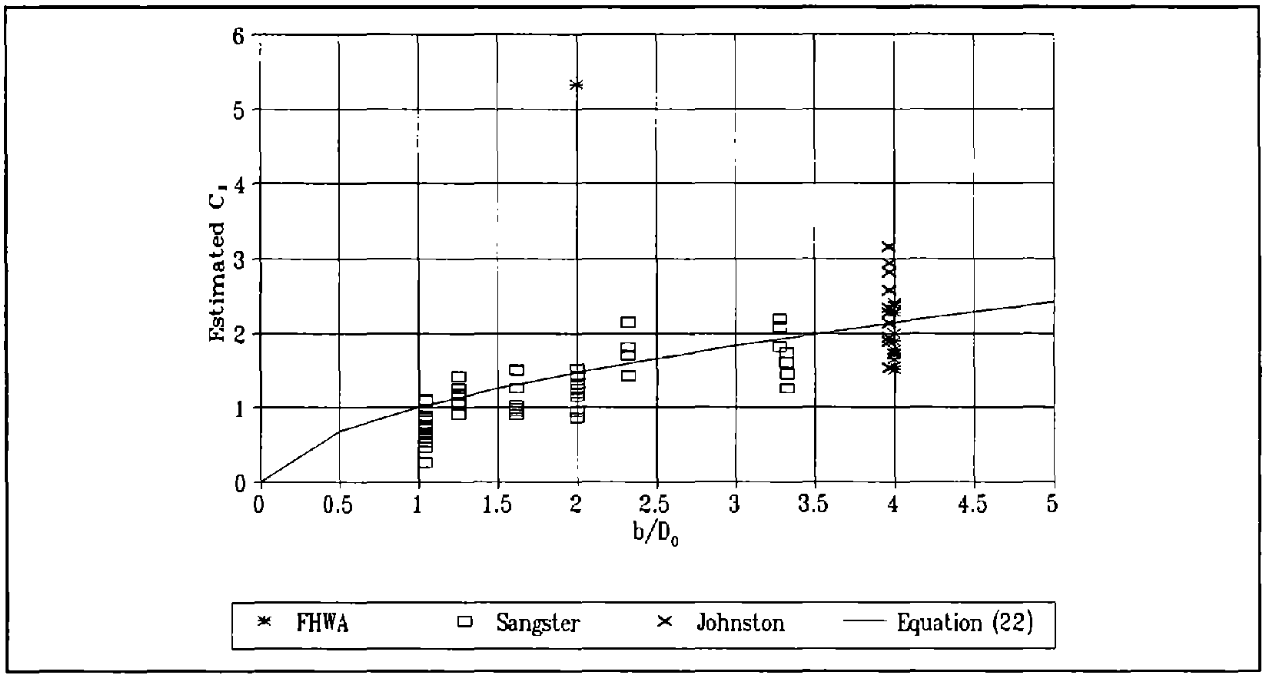

Figure 12. Estimated C_1 coefficient for selected laboratory experiments.

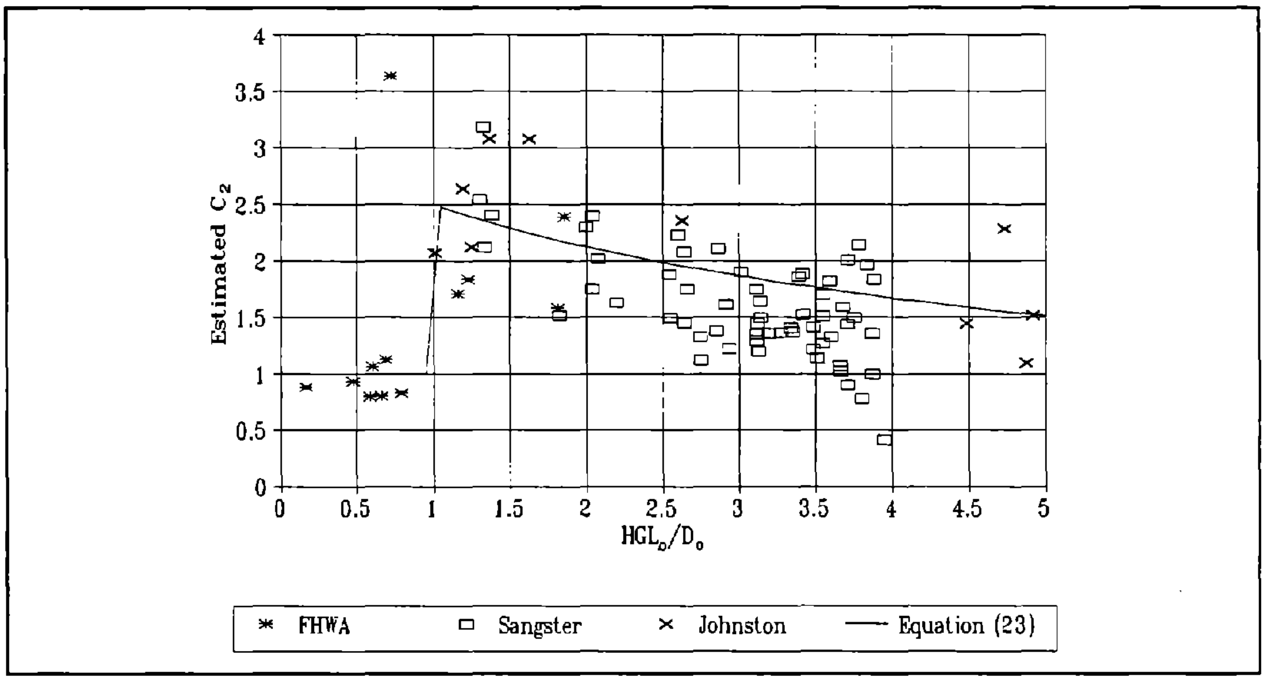

Figure 13. Estimated C_2 coefficient for selected laboratory experiments.

decreases as the surcharge in the manhole increases in the pressurized flow range. Below this range, C_2 is fixed at 1.0. For values of HGL_o/D_o greater than 6.0, C_2 is set to 1.3. The transition from free-surface flow to pressure flow ($HGL_o/D_o > 1.0$) is accounted for by the C_2 coefficient and is illustrated quite dramatically by the data in figure 13. Below an HGL_o/D_o value of 1.0, the estimated C_2 coefficient remains relatively constant at 1.0 until the transition from free surface to pressure flow is made and the C_2 estimate jumps to approximately 2.5.

The C_3 coefficient represents a loss term that accounts for manhole size relative to the outflow velocity head:

$$C_3 = \left(\frac{b}{\left(\frac{V_o^2}{2g} \right)} \right)^{0.5} \tag{24}$$

The ratio of manhole diameter to the outflow velocity head $(b/(V_o^2/2g))$ can be thought of conceptually as the residence time of the discharge in the junction manhole. The greater this residence is, the more flow expansion is allowed to take place.[4] Low-outlet velocity heads imply that flow has an opportunity to expand within the manhole before entering the outlet, thus increasing the energy loss. At higher outlet velocity heads, water moves more quickly through the manhole, decreasing the energy loss. Relating this to the size of the manhole provides an analysis variable $(b/(V_o^2/2g))$ that quantifies, to some degree, the energy loss attributable to flow contraction from manhole to the outlet.

Figure 14 shows the results of the analysis for the C_3 coefficient. Equation (24) is applied only in the cases where b/D_o is greater than 2.0 and $(b/(V_o^2/2g))$ is less than 200. For b/D_o values greater than 200, C_3 is fixed at 14. When b/D_o is less than 2, the outlet pipe diameter and the manhole diameter are similar in size. In such a case, flow contraction is negligible in contributing to the energy loss and C_3 is set equal to 1.0.

Table 3 gives values for *f* for the various floor configurations tested in this study. Energy losses for depressed junction manholes are approximately 12 percent larger than for level-floor configurations. Comparisons between benched and level floors did not show any quantifiable benefits.

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[4]The quantity may also be thought of as the inverse of the manhole Froude number squared.

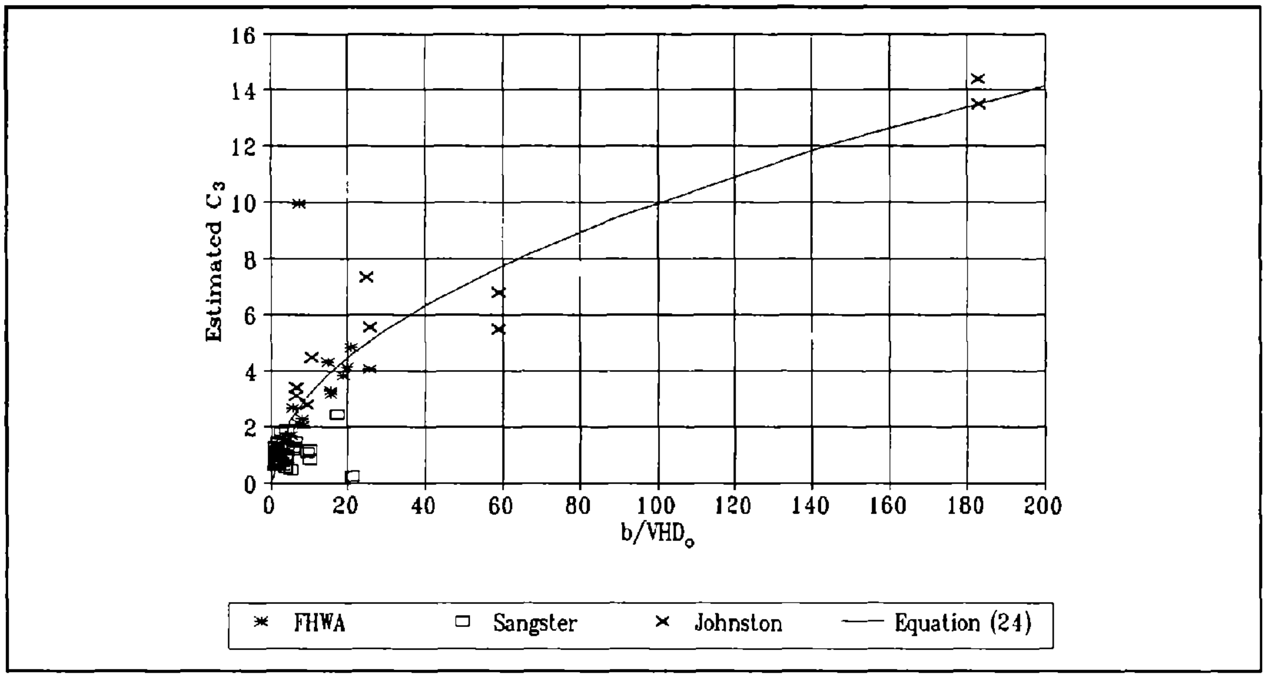

Figure 14. Estimated C_3 coefficient for selected laboratory experiments.

Table 3. Floor-configuration adjustment coefficients (*f*).

Floor Configuration	*f*
Level	1.0
Depressed	1.12
Benched	1.0*

* No significant difference between level- and benched-floor configuration was observed in the analysis of the data collected in this study.

The adjustment coefficient (a_1) is varied to minimize the root mean square error (RMS) when applying this methodology to the data collected in this study. As part of this analysis, the methodology was applied to the experimental runs to calculate a manhole water depth. The calculated depths are compared to the observed depths obtained in the laboratory by means of the RMS error. The adjustment factor (a_1) was varied in order to minimize the error and was determined to be 0.026.

Expansion-Loss Coefficient for Submerged Pipes ($\alpha_{2,i}$)

The second term in the loss-estimation equation (equation (20)) accounts for the expansion loss into a manhole for a submerged inflow pipe.[5] An equation was developed for the α_2 coefficient that adjusts for the same determining factors as α_1, but also includes a term for the influence of varying inflow line angles. The form of the equation is as follows:

$$\alpha_{2,i} = a_2 C_1 C_2 C_3 f \beta \tag{25}$$

where:

a_2	=	Adjustment coefficient.
C_1, C_2, C_3	=	Empirically derived coefficient that quantifies portions of the energy loss based on the determining factors.
β	=	Inflow-angle adjustment coefficient.

The C_1 coefficient equation is identical to the one formulated for α_1, and is represented in equation (22). The C_2 coefficient has the same form as equation 23, but uses manhole depth relative to the inflow pipe diameter as the determining variable:

$$C_2 = 4.5 - 2\left(\frac{d_{mH}}{D_i}\right)^{0.25} \tag{26}$$

The equation representing C_3 assumes a similar form to equation (24) and is expressed as follows:

$$C_3 = \left(\frac{b}{\left(\frac{V_i^2}{2g}\right)}\right)^{0.5} \tag{27}$$

The minimum and maximum limits of the equations for C_2 and C_3 are identical to those limits for the α_1 prediction coefficient. The C_2 coefficient in this formulation uses relative depth in the manhole (d_{mH}/D_i) rather than relative outlet hydraulic grade line (HGL_o/D_o) as the determining variable to compute this portion of the loss coefficient for submerged inflow pipes. The equation for the C_3 coefficient is similarly changed to reflect the velocity heads of submerged inflow pipes.

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[5]A pipe is considered submerged if the elevation of water in the junction manhole is equal to or greater than the elevation of the water surface in the pipe, assuming normal flow depth.

Equation (28) represents the adjustment coefficient for varying inflow angles:

$$\beta = \frac{(360 - \theta_i)}{180} \tag{28}$$

where:

θ_i = Lateral angle relative to the outflow pipe.

An adjustment for varying inflow angles is accomplished through application of equation (28). Conceptually, as angle decreases from 180 degrees (straight-line flow) to 0 degrees, the associated loss increases because the skewed inflow prevents the main flow from smoothly transitioning to the outlet pipe. All angles are represented between 0 and 180 degrees for this equation.

The a_2 coefficient, determined to be 0.054, is approximately two times the value of a_1. Theoretically, as water flows into a tank through a pipe, the energy loss is equal to the entire velocity head (1.0 $V^2/2g$). As the water contracts from the tank into an outflow pipe, the energy loss is approximately equal to one-half the velocity head (0.5 $V^2/2g$). This is the basis by which the a_1 coefficient (contraction loss) and the a_2 coefficient (expansion loss) are proportioned as they are.

Potential Energy-Loss Coefficient for Plunging Pipes ($\alpha_{3,j}$)

The third term in equation (20) accounts for the potential energy lost from an inflow line whose flow plunges into the manhole. (The subscript "i" denotes a submerged inflow pipe, whereas a plunging pipe is assigned a "j" subscript.) Analysis performed on the data in this study indicates an α_3-value of approximately 1.1. This suggests that the plunging flow into the manhole created an energy loss. This additional loss can be viewed as a 10-percent penalty resulting from additional turbulence in the manhole.

Expansion-Loss Coefficient for Plunging Inflow Pipes ($\alpha_{4,j}$)

The fourth and final term in the energy-loss estimation equation accounts for the expansion loss resulting from plunging inflow pipes. Influence variables on this term include only the inflow angle; thus, the equation for α_4 assumes the following form:

$$\alpha_{4,j} = a_4 \beta \tag{29}$$

where:

a_4 = Adjustment factor.
β = Adjustment coefficient for varying inflow angle as defined in equation (28).

The adjustment factor (a_4) was determined to be 1.2. The expansion loss resulting from plunging pipes is dependent not only on the angle of the plunging flow, but on the turbulence that is created in the manhole by the expanding plunging inflow. The adjustment factor (a_4) was designed to account for this phenomenon.

APPLICATION OF A NEURAL NETWORK

A neural network is a computing device that performs sophisticated data-fitting analyses to determine the response of a system to various stimuli. For analyzing energy losses in junction manholes, the analysis software is given input data that includes many variables, and "learns" how to arrive at the corresponding response.[7] This response may include one or more output variables. Once a network is "trained," it may be used to predict an unknown output variable, such as manhole depth, from the known input variables.

The process for training and applying a neural network to predict a water depth in a manhole was performed as part of this study. The process is described as follows. First, the network is trained using 490 actual laboratory runs, representing a random selection of approximately two-thirds of the available 736 runs. Table 4 summarizes the 16 input variables for each of the 490 runs that the neural network used to learn how to predict manhole depth. The table shows an additional input, representing the output in prediction, used to train the network.

Table 4. Input variables for training the neural network.

Inputs (16)		Inputs (1) that the neural network was trained to predict	
HGL of outlet	1	Manhole water depth	1
Velocity head of outlet	1		
Manhole diameter	1	total =	1
Floor configuration	1		
Inflow value for 3 pipes	3		
Inflow invert for 3 pipes	3		
Inflow angle for 3 pipes	3		
Inflow slope for 3 pipes	3		
total =	16		

The remaining 246 (one-third) of the 736 lab runs are processed into the "trained" network to see how well it had learned the pattern, and how well the data behaved. This time, the 1 input in the right column is not entered, but is predicted as output for the 246 runs.

One way to better train the network is to add "neurons," or learning steps. The more neurons that the network has, the more likely it is to learn how to predict manhole depth accurately. An analysis was performed to determine the optimum amount of neurons which would minimize the RMS error for the tested 246 manhole experiments. Figures 15 and 16 show the results of this analysis. The average error, the worst error, and the RMS continue to drop and reach a minimum when approximately 200 neurons are used to "train" the network. The addition of neurons beyond this value does not improve prediction. The minimum RMS for the predicted manhole depth using the neural network trained with 200 neurons is 33 mm, or 14 percent of the mean manhole depth.

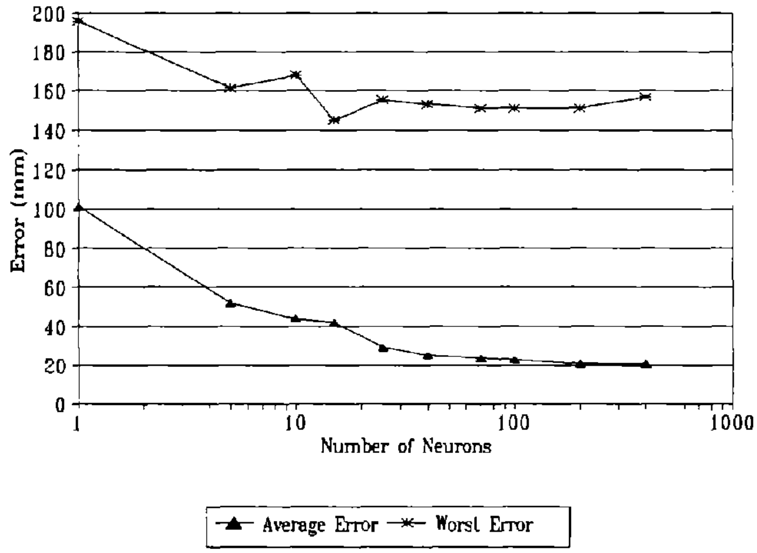


Figure 15. Average and worst error versus number of neurons.

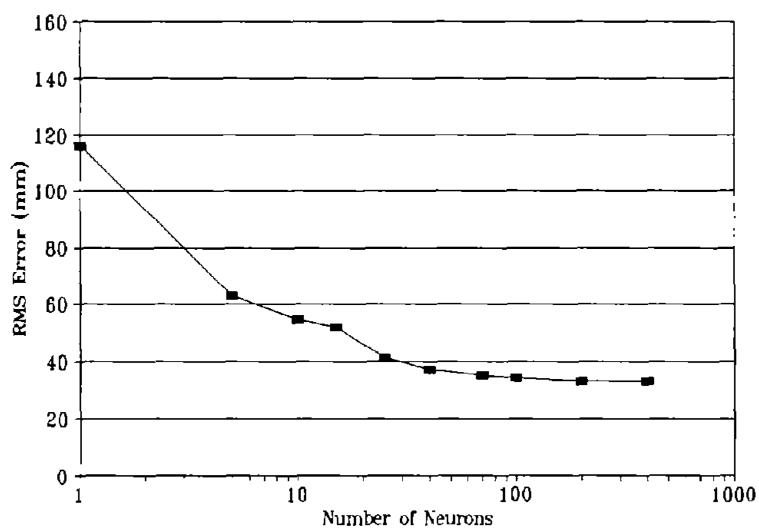


Figure 16. Root mean square error versus number of neurons.

PERFORMANCE COMPARISON

The energy-loss methodologies developed are evaluated based on accuracy, robustness, and adaptability to design. The accuracy criterion provides a comparison of the prediction of conditions in the manhole given physical and hydraulic circumstances. Robustness refers to the ability of a methodology to reasonably extrapolate to situations that may occur in the field, but are not represented in the laboratory data. Adaptability to design relates to how well a methodology can be adapted to operation in a design environment.

ACCURACY

Given the physical manhole configuration, pipe discharges, and the energy grade line in the outflow pipe, each methodology produces an estimate of the manhole water depth. For the energy grade line methodology, a total energy loss (ΔE) for the main inflow pipe is estimated and manhole water depth is derived from ΔE. With the power-loss methodology, the total energy loss in all inflow pipes is estimated simultaneously with a calculation of manhole water depth such that power into and out of the manhole is conserved. The neural network is trained to estimate manhole water depth directly.

Manhole water depth is used to evaluate methodology accuracy because it is an important parameter and it is estimated by all three methodologies. Table 5 summarizes the comparison using the root mean square (RMS) error of predicted versus observed manhole water depths for 736 experiments performed in the FHWA laboratory. The data are disaggregated by relative manhole size (b/D_o) and floor configuration (level, depressed, benched). For all experiments, the energy grade line and power methodologies produce results that achieve the same level of accuracy. The normalized RMS errors of 48 mm and 47 mm, respectively, are 16 percent of the typical manhole depth and 32 percent of the outflow pipe diameter. The neural network methodology (applied only to the 246 runs on which the network was not trained) demonstrates greater accuracy. The 36-mm RMS error is normalized to only 12 percent of the typical manhole depth and 24 percent of the outflow pipe diameter.

Figures 17, 18, and 19 graphically display predicted versus observed manhole depths for the energy grade line, power, and neural network methodologies, respectively. Figures 17 and 18 reflect equivalent RMS errors as shown in table 5, but show that the energy grade line methodology tends to predict more accurately at the lower depths and less accurately at the higher depths compared with the power-loss methodology. The neural network analysis shows a closer fit than both of the other methodologies.

Table 5. Comparison of results.							
		Energy Grade Line Analysis		Power Analysis		Neural Network Analysis	
		Number of Runs	Root Mean Square Error (mm)	Number of Runs	Root Mean Square Error (mm)	Number of Runs	Root Mean Square Error (mm)
$b/D_o = 2$	Level	393	59	393	56	131	43
$b/D_o = 4$	Level	89	31	89	47	30	27
$b/D_o = 4$	Depressed	226	33	226	32	76	30
$b/D_o = 4$	Benched	28	26	28	24	9	9
Total of all runs		736	48	736	47	246	36
As a % of $\bar{d}_{mH}$*			16%		16%		12%
As a % of D_o			32%		31%		24%

*$\bar{d}_{mH}$ = 300 mm; D_o = 150 mm.

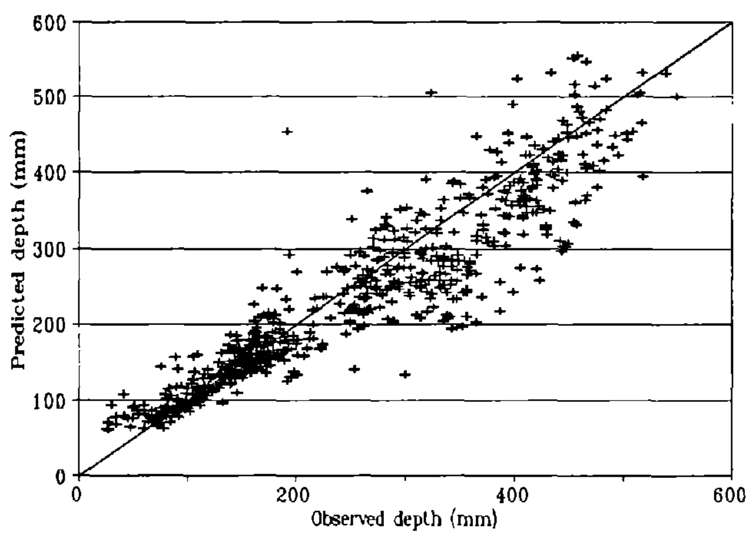


Figure 17. Energy grade line analysis–predicted versus observed.

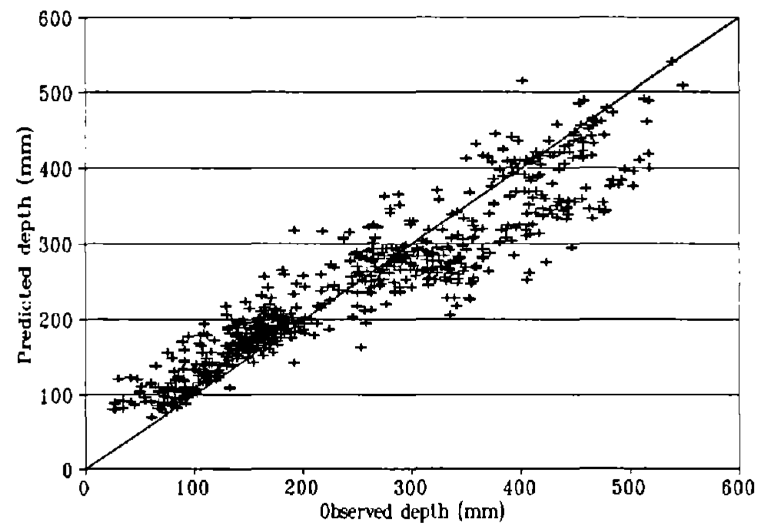


Figure 18. Power analysis–predicted versus observed.

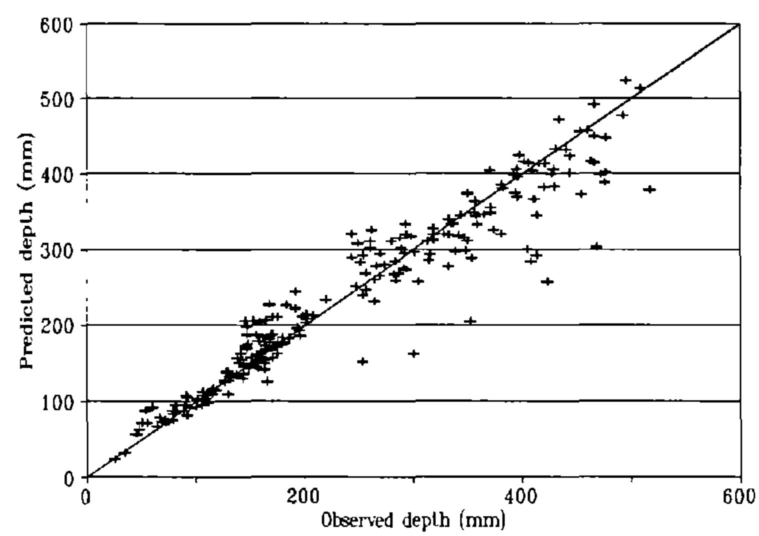


Figure 19. Neural analysis with 400 neurons–predicted versus observed.

Many of the experiments included in the comparison represent highly complex flow conditions. Up to three inflow pipes entering the junction at a variety of angles and elevations are present in the data, so some error is expected. Figures 20, 21, and 22 display performance of the energy grade line, power-loss, and neural network analyses, respectively, for the simplest condition of one inflow main with an invert elevation equal to the outflow pipe invert and straight-through (θ = 180 degrees) flow. Data from Johnston are also included and the figures are normalized with respect to D_o to allow direct comparison.[8]

The energy grade line and power methodologies, figures 20 and 21, respectively, both show good prediction capability for these simple cases. The neural net also shows reasonably good agreement when d_{mH}/D_o is less than 3, but greatly underestimates manhole water depth for the five Johnston data points where d_{mH}/D_o is greater than 3. None of the data on which the network is trained exhibits d_{mH}/D_o greater than 3, so the network is forced to extrapolate beyond its experience for these cases. Figure 22 shows that its success in extrapolation is weak under these circumstances.

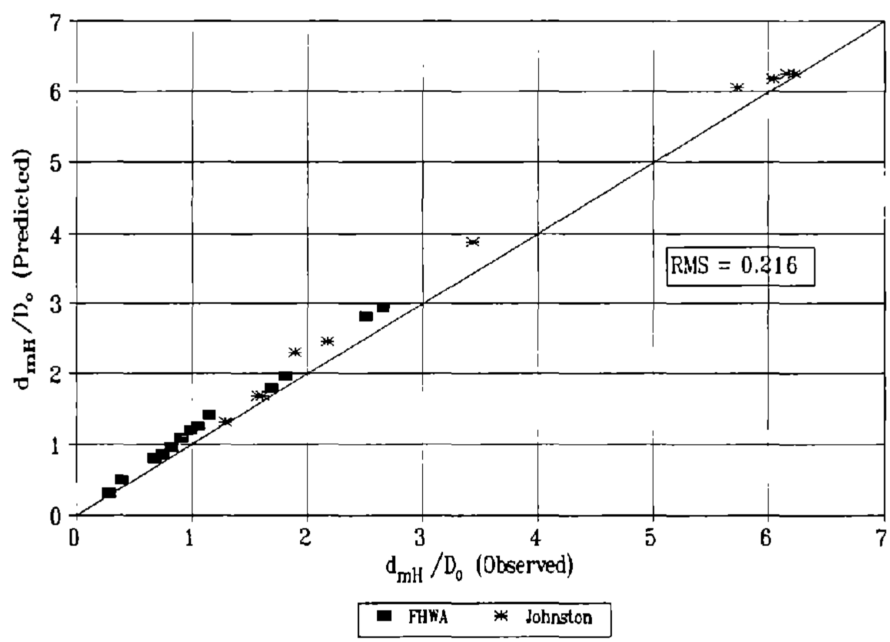


Figure 20. Energy grade line performance, two-pipe configuration.

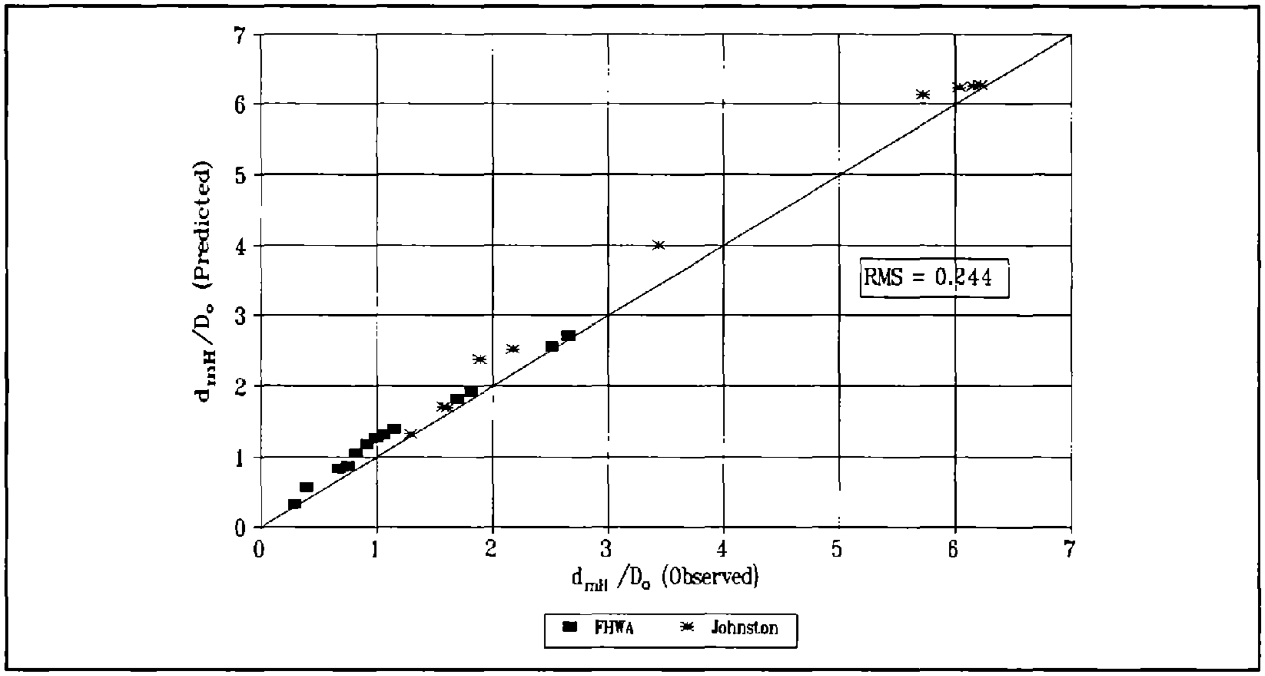


Figure 21. Power-loss performance, two-pipe configuration.

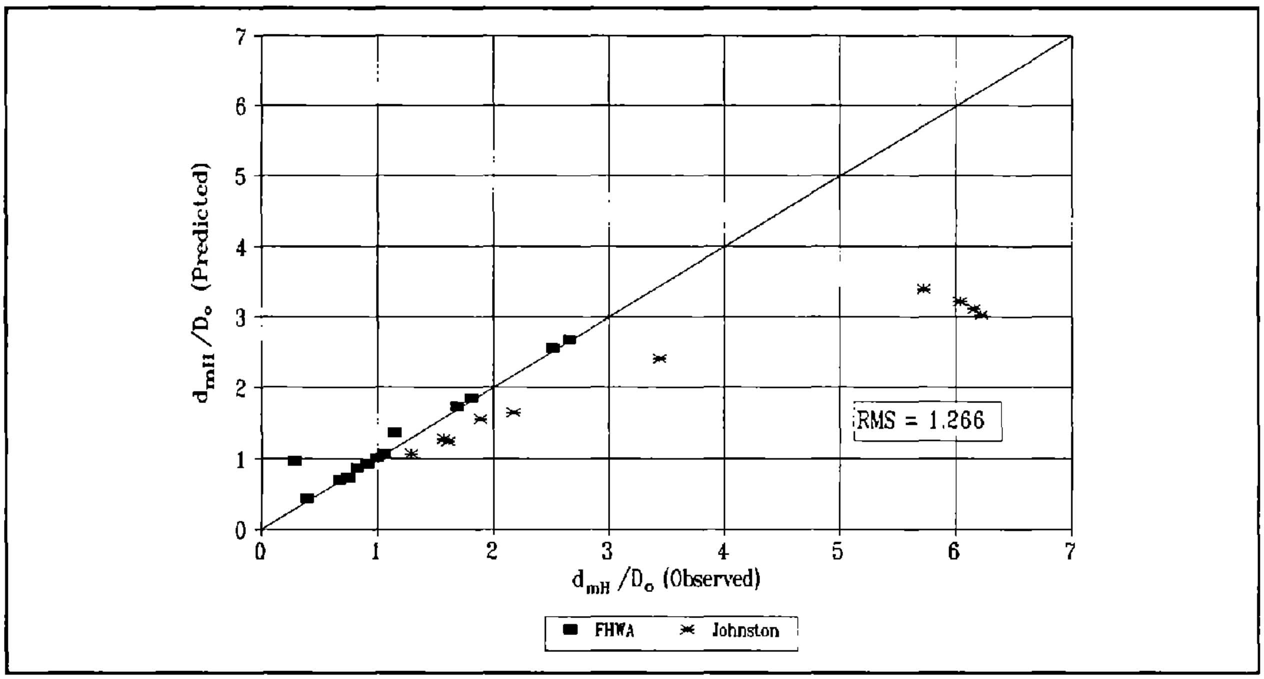


Figure 22. Neural network performance, two-pipe configuration.

ROBUSTNESS

The robustness criterion addresses the ability of a methodology to respond reasonably to a broad range of circumstances, including those not represented in the laboratory data base. To accomplish this evaluation, hypothetical physical configuration, inflow, and outflow data are used to explore the resulting manhole water-depth estimates of each of the three methodologies. These data include the type of information a designer would have available to calculate energy losses. In contrast to the laboratory data, an "observed" manhole water depth is not available. The methodologies provide estimates of the manhole water depth, but it is left to professional judgment which methodology is producing the most reasonable results and is, therefore, most robust.

Figure 23 schematically describes the hypothetical data. All of the data include a manhole with a 150-mm outflow pipe. The invert of the outflow pipe is flush with the bottom of the manhole, which is taken as the elevation datum.

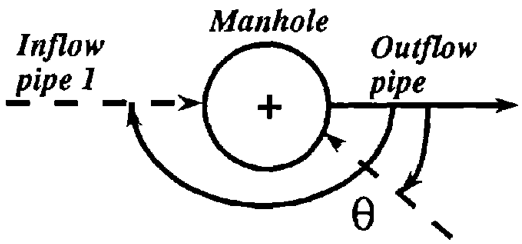
The first group of data, labeled as "A" in figure 23, includes a simple two-pipe (one inflow and one outflow) case where the angle of the inflow pipe varies from 30 degrees to 180 degrees. All other parameters are constant. The second group of data, labeled as "B", represents a more complex situation with three inflow pipes at different angles and invert elevations. The only varying parameter in these data is the discharge. The final group of data, labeled as "C", represents two inflow pipes, including a fixed 90-degree lateral. For these data, the main inflow pipe diameter is varied, but crown matching is maintained. Table 6 summarizes the hypothetical data.

Figures 24, 25, and 26 show the results of the analysis for the hypothetical data. Figure 24 shows the manhole depth estimate for the three methodologies in general agreement when varying the inflow angle. The results presented in figures 25 and 26 show that the energy grade line and power methodologies provide similar, consistent results for estimated depth, while the neural network method results differ greatly. These results suggest that the neural network approach, relative to the energy grade line and power methods, does not extrapolate reliably when it is applied to data outside of the range of data for which it was trained. In terms of robustness, the energy grade line and power methods appear to respond more reasonably when applied to non-laboratory data.

ADAPTABILITY TO DESIGN

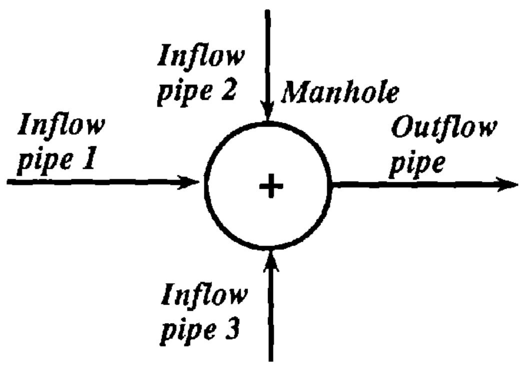
The third, and final, criterion employed for evaluation is the adaptability of a methodology for design. Specifically, this criterion addresses modification of a methodology to include an appropriate level of engineering conservatism for design. The accuracy evaluation shown in figures 17, 18, and 19 illustrate that each methodology underpredicts a substantial portion of the laboratory manhole water depths. For design purposes, it is desirable to adapt a methodology to be more conservative. For this evaluation, it is assumed that allowing no more than 10 percent of the predictions to be low is adequate, especially in systems where several manholes are evaluated in series.

(A) θ varies from 30° to 180°



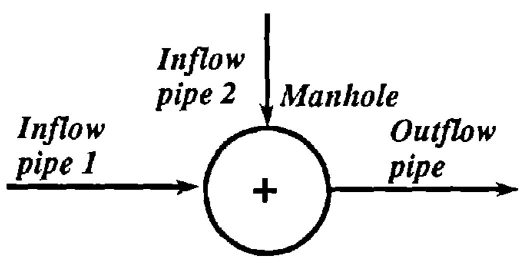
Z_1	=	0.0 mm
D_0	=	150 mm
D_1	=	150 mm
b	=	600 mm

(B) Q_0 varies from 0.0028 m^3/s to 0.0071 m^3/s



Z_1	=	0.0 mm
Z_2	=	300 mm
Z_3	=	300 mm
D_0	=	150 mm
D_1	=	150 mm
D_2	=	150 mm
D_3	=	150 mm
b	=	600 mm

(C) D_1 varies from 150 mm to 300 mm



Z_1 varies from 150 mm to 0.0 mm		
Z_2	=	1500 mm
D_0	=	300 mm
D_1 varies from 150 mm to 300 mm		
D_2	=	300 mm
b	=	900 mm

Figure 23. Schematic for hypothetical experiments.

Table 6. Hypothetical data.

Run ID	Inflow Pipe	Theta (deg)	Zi (m)	Di (m)	Si (m/m)	Qi (m^3/s)	Qo (m^3/s)	Vo (m/s)	$Vo^2/2g$ (m)	do (m)	Floor Config	P/γ_i (m)	P/γ_o (m)	b (m)
VARIABLE INFLOW ANGLE														
A030	1	30.0	0.000	0.15	0.00232	0.0088	0.0088	0.77	0.030	0.091	level	0.000	0.000	0.6
A060	1	60.0	0.000	0.15	0.00232	0.0088	0.0088	0.77	0.030	0.091	level	0.000	0.000	0.6
A090	1	90.0	0.000	0.15	0.00232	0.0088	0.0088	0.77	0.030	0.091	level	0.000	0.000	0.6
A120	1	120.0	0.000	0.15	0.00232	0.0088	0.0088	0.77	0.030	0.091	level	0.000	0.000	0.6
A150	1	150.0	0.000	0.15	0.00232	0.0088	0.0088	0.77	0.030	0.091	level	0.000	0.000	0.6
A180	1	180.0	0.000	0.15	0.00232	0.0088	0.0088	0.77	0.030	0.091	level	0.000	0.000	0.6
VARIABLE OUTFLOW														
B0250	1	180.0	0.000	0.15	0.00609	0.00142	0.0028	0.31	0.0049	0.076	level	0.000	0.000	0.6
	2	90.0	0.305	0.15	0.00866	0.00085		0.31	0.0049			0.000		0.6
	3	90.0	0.305	0.15	0.01399	0.00057		0.31	0.0049			0.000		0.6
B0375	1	180.0	0.000	0.15	0.00181	0.00178	0.0035	0.24	0.0030	0.114	level	0.000	0.000	0.6
	2	90.0	0.305	0.15	0.00284	0.00108		0.24	0.0030			0.000		0.6
	3	90.0	0.305	0.15	0.00359	0.00071		0.24	0.0030			0.000		0.6
B0500	1	180.0	0.000	0.15	0.00113	0.00212	0.0042	0.23	0.0027	0.152	level	0.000	0.000	0.6
	2	90.0	0.305	0.15	0.00157	0.00127		0.23	0.0027			0.000		0.6
	3	90.0	0.305	0.15	0.00219	0.00085		0.23	0.0027			0.000		0.6
B0575	1	180.0	0.000	0.15	0.00093	0.00249	0.0050	0.27	0.0037	0.152	level	0.000	0.023	0.6
	2	90.0	0.305	0.15	0.00127	0.00150		0.27	0.0037			0.000		0.6
	3	90.0	0.305	0.15	0.00175	0.00099		0.27	0.0037			0.000		0.6
B0650	1	180.0	0.000	0.15	0.00056	0.00283	0.0057	0.31	0.0049	0.152	level	0.000	0.046	0.6
	2	90.0	0.305	0.15	0.00041	0.00170		0.31	0.0049			0.000		0.6
	3	90.0	0.305	0.15	0.00047	0.00113		0.31	0.0049			0.000		0.6
B0725	1	180.0	0.000	0.15	0.00030	0.00320	0.0064	0.35	0.0061	0.152	level	0.000	0.069	0.6
	2	90.0	0.305	0.15	0.00041	0.00193		0.35	0.0061			0.000		0.6
	3	90.0	0.305	0.15	0.00049	0.00127		0.35	0.0061			0.000		0.6
B0800	1	180.0	0.000	0.15	0.00036	0.00354	0.0071	0.39	0.0076	0.152	level	0.050	0.091	0.6
	2	90.0	0.305	0.15	0.00035	0.00212		0.39	0.0076			0.000		0.6
	3	90.0	0.305	0.15	0.00050	0.00142		0.39	0.0076			0.000		0.6
VARIABLE INFLOW DIAMETER														
C0050	1	180.0	0.152	0.15	0.005	0.0249	0.0311	0.427	0.0091	0.305	level	0.183	0.152	0.9
	2	90.0	1.524		0.00241	0.0062		0.427	0.0091	0.305	level	0.000	0.152	0.9
C0060	1	180.0	0.122	0.18	0.005	0.0249	0.0311	0.427	0.0091	0.305	level	0.122	0.152	0.9
	2	90.0	1.524		0.00241	0.0062		0.427	0.0091	0.305	level	0.000	0.152	0.9
C0070	1	180.0	0.091	0.21	0.005	0.0249	0.0311	0.427	0.0091	0.305	level	0.061	0.152	0.9
	2	90.0	1.524		0.00241	0.0062		0.427	0.0091	0.305	level	0.000	0.152	0.9
C0080	1	180.0	0.061	0.24	0.005	0.0249	0.0311	0.427	0.0091	0.305	level	0.000	0.152	0.9
	2	90.0	1.524		0.00241	0.0062		0.427	0.0091	0.305	level	0.000	0.152	0.9
C0090	1	180.0	0.030	0.27	0.005	0.0249	0.0311	0.427	0.0091	0.305	level	0.000	0.152	0.9
	2	90.0	1.524		0.00241	0.0062		0.427	0.0091	0.305	level	0.000	0.152	0.9
C0100	1	180.0	0.000	0.3	0.005	0.0249	0.0311	0.427	0.0091	0.305	level	0.000	0.152	0.9
	2	90.0	1.524		0.00241	0.0062		0.427	0.0091	0.305	level	0.000	0.152	0.9

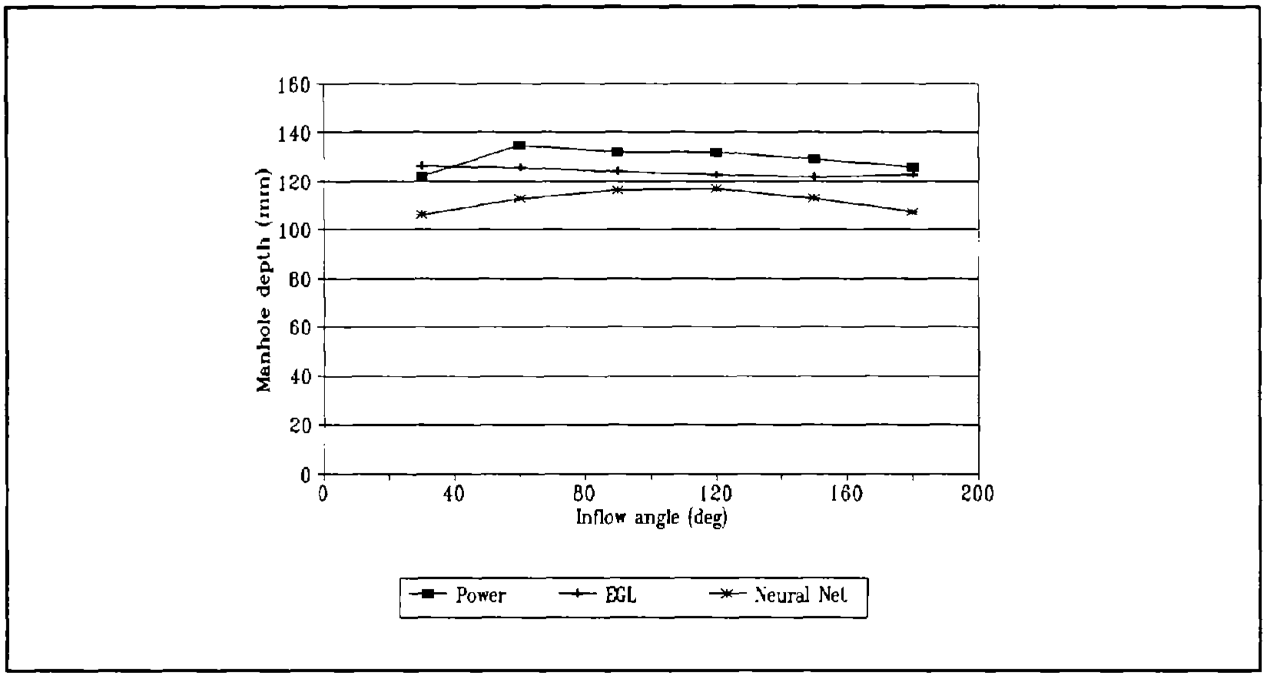


Figure 24. Comparison of three methodologies–manhole depth versus inflow angle.

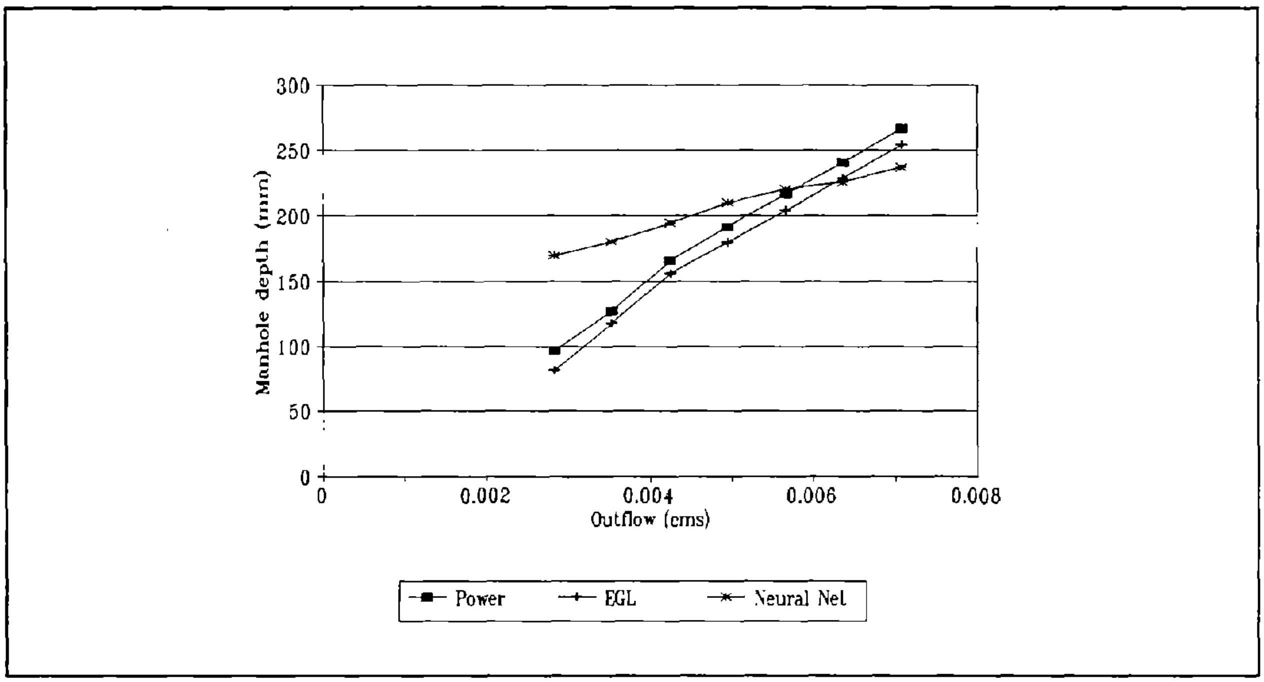


Figure 25. Comparison of three methodologies–manhole depth versus outflow.

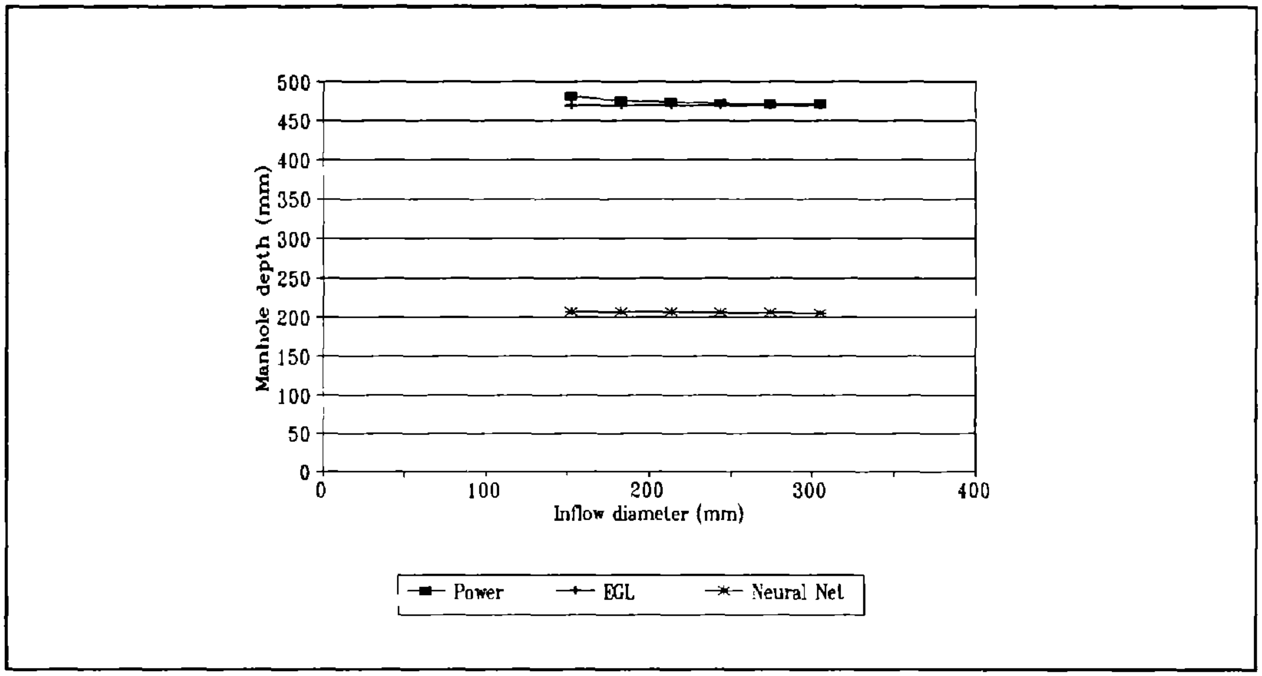


Figure 26. Comparison of three methodologies–manhole depth versus inflow diameter.

Of the estimates produced using the energy grade line methodology, shown in figure 17, 60 percent are underestimates. To achieve an underprediction rate no greater than 10 percent, the energy losses calculated in equation (12) must be multiplied by a safety factor of 10. The estimated manhole water depths using a modified equation versus observed depths are shown in figure 27. The RMS error is 510 mm, which is 240 percent of the outflow pipe diameter. Recall that the accuracy comparison in table 5 showed an RMS error of 48 mm (32 percent of the outflow pipe diameter.)

Much of the RMS error is the result of estimated depths that are significantly overpredicted as is seen in figure 27. These runs, with predicted depths greater than 750 mm, typically include three inflow pipes with high observed manhole water depths with at least one inflow pipe plunging from an invert of 610 mm. The energy grade line methodology seems to respond poorly to these extreme conditions. Figure 28 presents the same performance comparison as figure 27, but on a different scale.

Of the manhole water depth estimates produced using the power-loss approach (shown in figure 18), 42 percent are underestimates. To achieve an underprediction rate no greater than 10 percent, the power losses calculated in equation (20) must be multiplied by a safety factor of 2. The results are shown in figure 29. In this case, the RMS error is 110 mm, which, in relative terms, is 73 percent of the outflow pipe diameter. In table 5, the RMS without the safety factor is 47 mm, or 31 percent of the outflow pipe diameter.

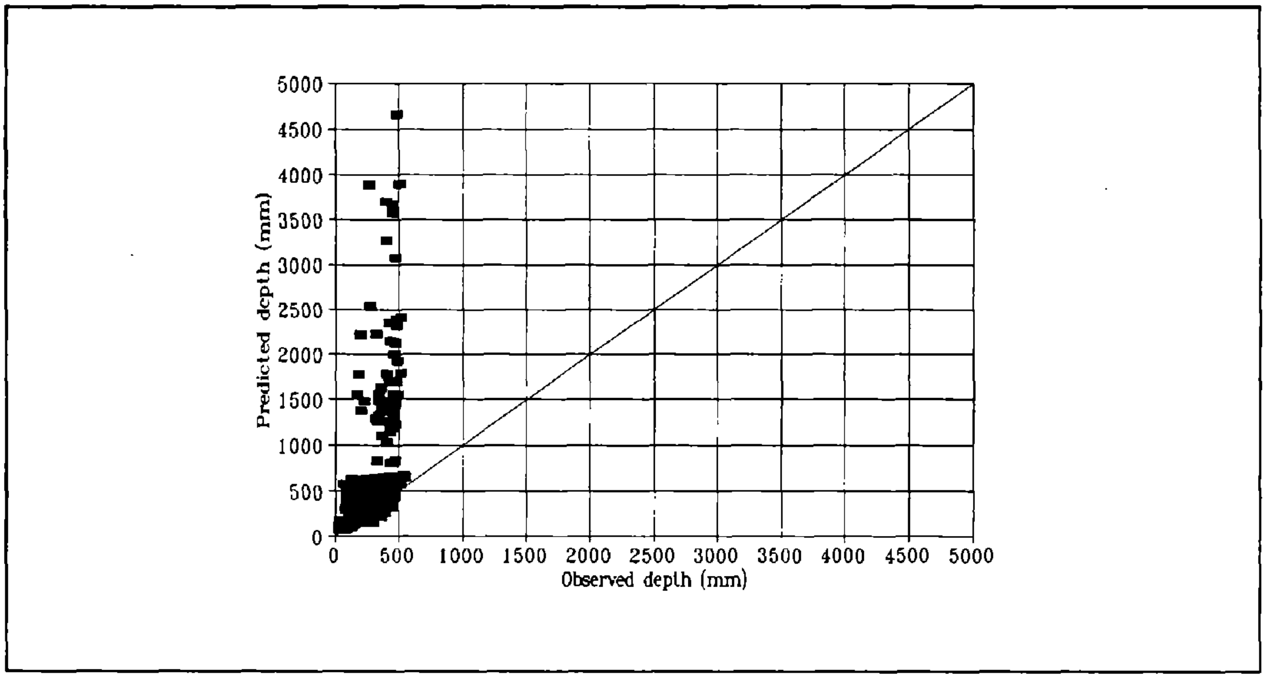


Figure 27. Energy grade line method, with safety factor.

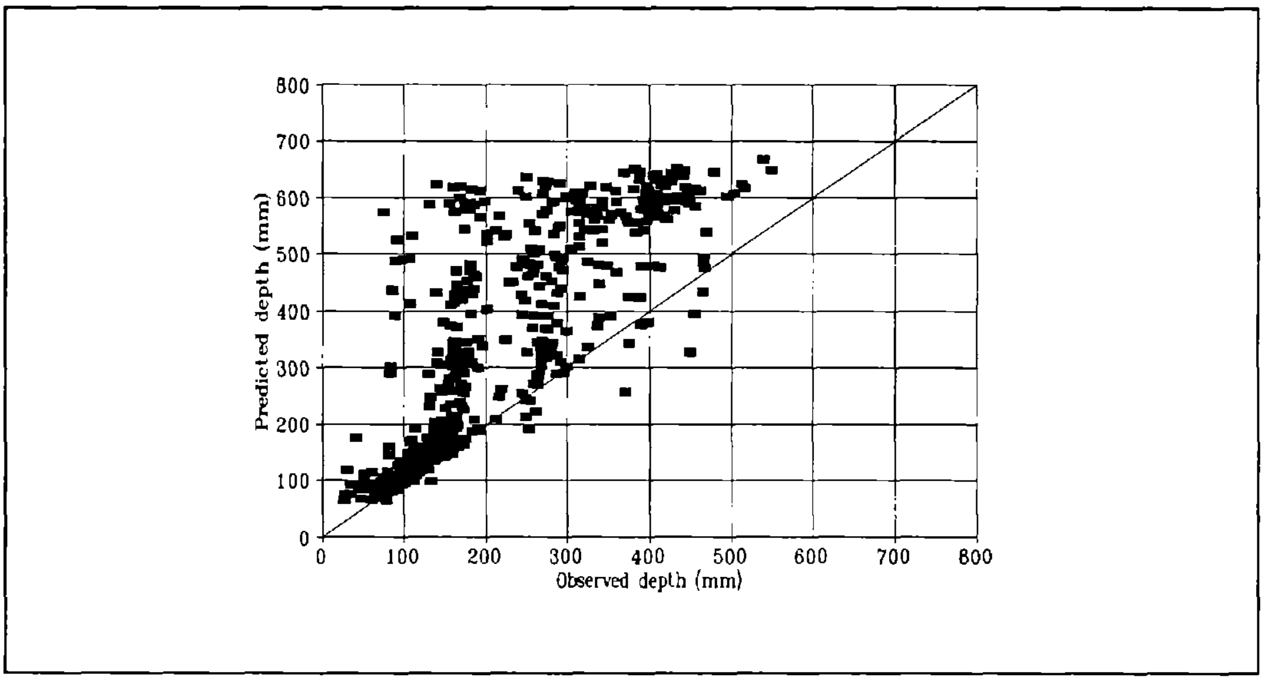


Figure 28. Energy grade line with safety factor, different scale.

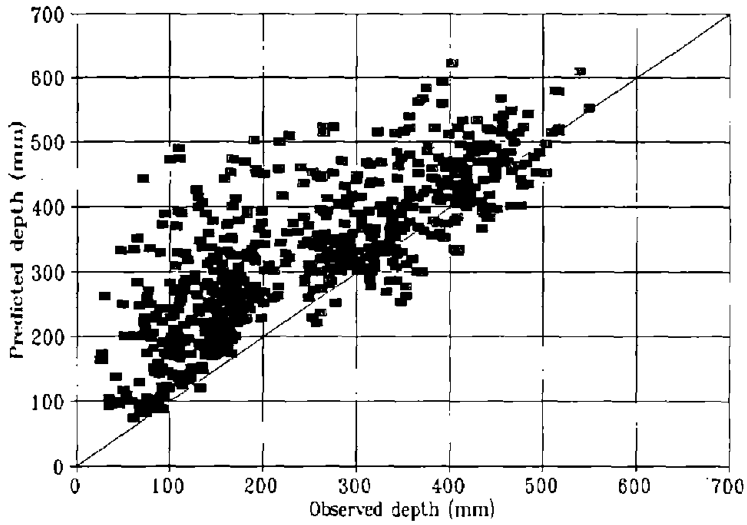


Figure 29. Power-loss method, with safety factor.

Comparison of figure 29 with figures 27 and 28 demonstrate that the power-loss methodology is much more adaptable to design than the energy grade line analysis. Significant RMS error is still observed, but there is none of the wild overprediction experienced using the energy grade line approach. This is primarily because the power-loss approach considers all inflows simultaneously in determining energy losses. The energy grade line approach focuses on the main inflow pipe (180 degrees from the outflow with $Z = Z_o$) and then evaluates the other inflow pipes separately. When the main inflow carries a smaller portion of the flows, the two-step methodology exhibits weaknesses.

The neural network approach resulted in 51-percent underprediction of manhole water depths as is shown in figure 19. Adaptation to design cannot be accomplished by use of a safety factor because the methodology is not based on relatively simple empirical equations as are the other two methodologies. Rather, the training data set must be modified to replace observed manhole depths with higher "design" manhole depths. The network is then trained and evaluated on the test data set for the frequency of underprediction. This process is repeated until a 10 percent underprediction is achieved.

Development of a "design-oriented" neural network was not pursued as a part of this study for two reasons. First, selection of "design" manhole water depths can be made in a variety of ways, which makes their development somewhat arbitrary. Second, since one cannot be confident in the performance of a network in extrapolation, the neural network approach was discounted for application to design until further investigation suggests otherwise.

SUMMARY AND RECOMMENDATIONS

This report describes and evaluates three methodologies for determining the energy losses that occur when water flows through a junction manhole. The first method, the energy grade line approach, considers the influence of plunging height, inflow angle, relative manhole diameter, inflow rates, and floor configuration on energy losses. The second method, the power analysis approach, applies the conservation of power principle by equating total inflow power with the summation of the outflow power and the energy lost. Empirical equations are derived from the laboratory data to estimate the power lost. The third method is the neural network approach. Development and application of a neural network makes use of sophisticated data-fitting routines rather than empirical implementation of hydraulic intuition.

Three criteria are presented to evaluate the performance of each methodology in predicting conditions in a junction manhole using laboratory data and hypothetical field data. The three criteria are as follows:

1. *Accuracy* - How well does the methodology perform in predicting water level in a junction manhole given the physical pipe configuration, the inflows, and the outflow energy grade line?

2. *Robustness* - How reliable is the methodology when it is applied to circumstances beyond the limited array of controlled laboratory experiments?

3. *Adaptability to design* - Can the methodology be reasonably and responsibly adapted for use in a conservative design environment?

The neural network methodology proved to be the most accurate methodology when applied to data similar to those on which it was trained. However, when applied to data that require extrapolation, such as those of Johnston and the hypothetical design data, the neural network significantly underestimated energy losses. This result suggests (at least for the neural network tested) that the neural network approach is insufficiently robust to merit further consideration for design use.[6]

The energy grade line and power-loss methodologies performed equivalently in predicting manhole water depths for the laboratory data, including those of Johnston. They were also equivalent when applied to the hypothetical field data that suggested comparable robustness. However, when evaluated with respect to adaptability to design, the performance of the energy grade line approach deteriorated. It required a much larger safety factor (10 versus 2) and it greatly overpredicted manhole water depth for several of the more complicated laboratory runs. The holistic perspective of considering all inflow pipes simultaneously restrains the power-loss methodology from such wild predictions.

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[6]Other neural network formulations could be designed and tested. The conclusions here are not intended to discount the concept in its entirety.

Overall, the power-loss methodology provides the best balance of accuracy, robustness, and adaptability to design of the three approaches considered. Although not superior in all respects, the method also does not suffer poor ratings against any of the criteria as do the energy grade line (adaptability to design) or the neural network (robustness) approaches. As additional data become available, particularly field data, and as other options are identified, these conclusions may be reevaluated.

APPENDIX A. PHOTOGRAPHS

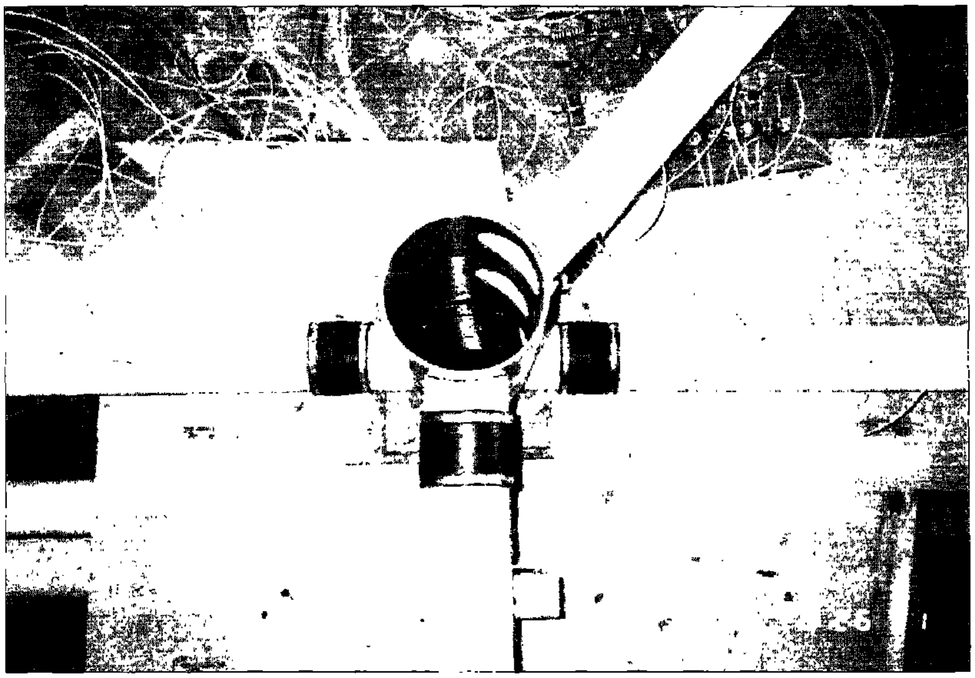

Figure 30. Laboratory junction with 150-mm-diameter pipes and 300-mm-diameter manhole.

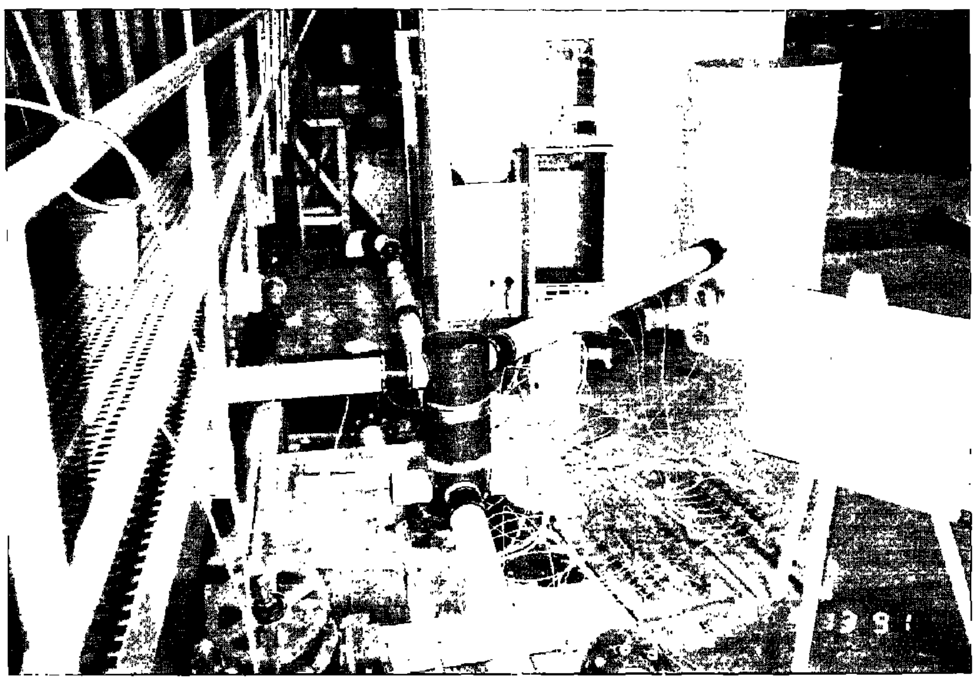

Figure 31. Four-pipe configuration with three inflow pipes; two inflow pipes plunging from a height of 600 mm.

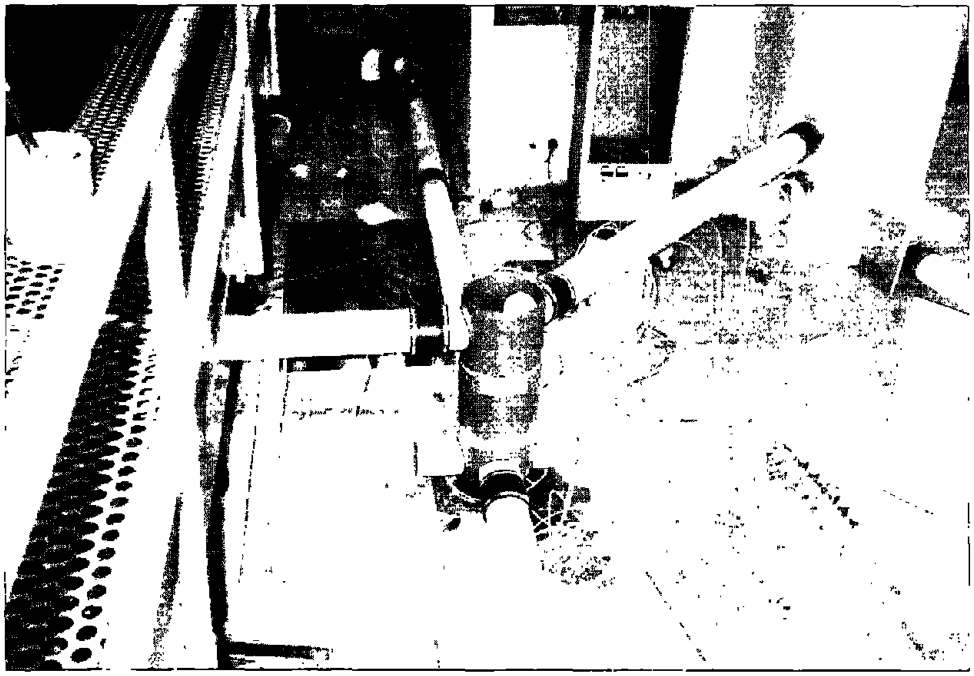

Figure 32. Manhole configuration allows for several alternative lateral inflow pipe locations.

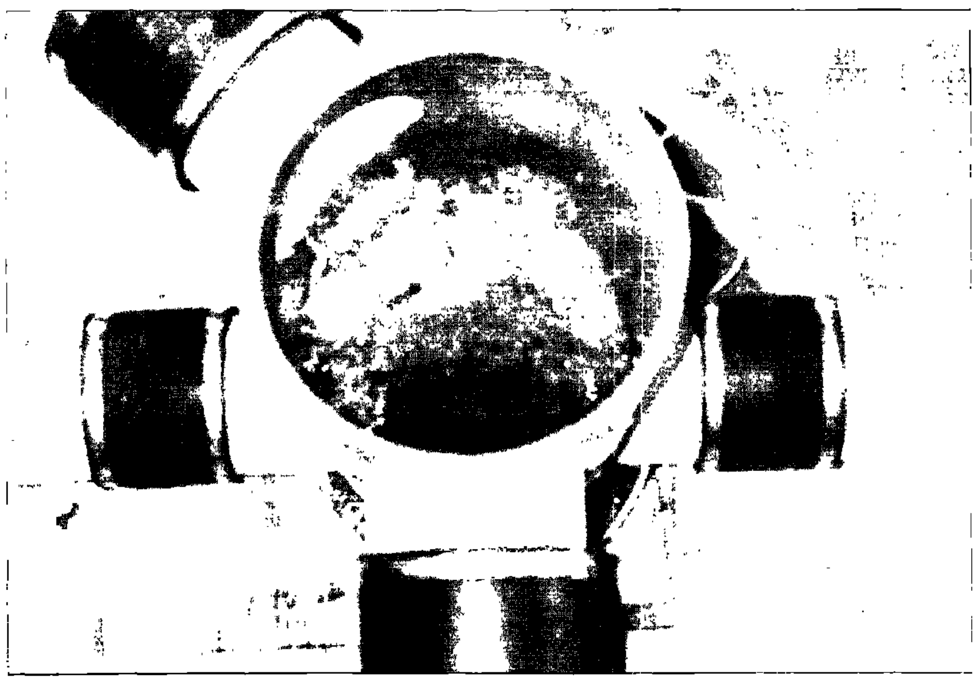

Figure 33. Manhole configuration with two plunging laterals.

APPENDIX B. DATA SUMMARY

The experiments performed in this study are separated into groups by test matrix. Each matrix represents a physical pipe configuration. Matrix one is a simple two-pipe system with the inflow and outflow pipes at 180 degrees relative to each other and at equal inverts. As the physical configurations become more complex (i.e., the addition of laterals, benching, plunging pipes), a new test matrix is created for the particular configuration. Eight matrices were developed and tested. This appendix summarizes the data collected by test matrix. Each line of data represents physical and hydraulic parameters for individual inflow lines entering a manhole. The parameters are defined on the first page of the summary under "variable definitions." Volume II contains the raw data for each individual experiment performed in this study.

MATRIX 1

Variable definitions:

Di = diameter of the inflow pipe
Do = diameter of the outflow pipe
b = manhole diameter
Theta = angle between inflow pipe and outflow pipe
Zi = invert of inflow pipe
Zo = invert of outlet pipe
d = manhole water depth
Qi = inflow pipe discharge
Qo = outflow pipe discharge
Vi = average velocity in the inflow pipe
Vo = average velocity in the outflow pipe
di = avg water depth in inlet pipe
do = avg water depth in outlet pipe
Pi = pressure in the inflow pipe
Po = pressure in the outflow pipe
PWRi = power into manhole
PWRo = power out of manhole
EFF = PWRo / sum(PWRi)

MH shape = round
Di (m) 0.152
Do (m) 0.152
b (m) 0.610
Zo (m) 0.000 = Datum

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	JCT111	10/23/86	2	180	0.000	0.106	0.0088	0.0088	0.671	0.023	0.779	0.031	0.103	0.091	level	0.000	0.000	10.94	10.55	0.964
	JCT112	10/30/86	2	180	0.000	0.116	0.0091	0.0091	0.621	0.020	0.681	0.024	0.114	0.105	level	0.000	0.000	11.91	11.43	0.959
	JCT113	10/23/86	2	180	0.000	0.143	0.0140	0.0140	0.799	0.032	0.872	0.039	0.139	0.125	level	0.000	0.000	23.52	22.41	0.953
	JCT114	10/30/86	2	180	0.000	0.163	0.0158	0.0158	0.865	0.038	0.874	0.039	0.152	0.147	level	0.009	0.000	30.83	28.79	0.934
	JCT115	10/23/86	2	180	0.000	0.180	0.0208	0.0208	1.139	0.066	1.202	0.074	0.152	0.137	level	0.023	0.000	49.20	42.96	0.873
	JCT116	11/05/86	2	180	0.000	0.282	0.0232	0.0232	1.274	0.083	1.274	0.083	0.152	0.152	level	0.124	0.055	81.96	66.05	0.806
	JCT117	11/05/86	2	180	0.000	0.402	0.0273	0.0273	1.496	0.114	1.496	0.114	0.152	0.152	level	0.232	0.144	133.34	109.93	0.824
	JCT121	11/13/86	2	180	0.305	0.130	0.0056	0.0056	0.574	0.017	0.408	0.008	0.081	0.108	level	0.000	0.000	22.23	6.43	0.289
	JCT122	11/13/86	2	180	0.305	0.148	0.0086	0.0086	0.753	0.029	0.558	0.016	0.091	0.120	level	0.000	0.000	35.88	11.48	0.320
	JCT123	11/13/86	2	180	0.305	0.191	0.0129	0.0129	0.920	0.043	0.709	0.026	0.110	0.152	level	0.000	0.001	58.07	22.67	0.390
	JCT124	11/13/86	2	180	0.305	0.281	0.0172	0.0172	0.992	0.050	0.941	0.045	0.137	0.152	level	0.000	0.087	82.80	47.79	0.577
	JCT125	11/13/86	2	180	0.305	0.360	0.0232	0.0232	1.324	0.089	1.274	0.083	0.140	0.152	level	0.000	0.121	121.80	81.12	0.666
	JCT131	12/05/86	2	180	0.610	0.109	0.0078	0.0078	0.744	0.028	0.976	0.049	0.085	0.069	level	0.000	0.000	55.41	9.00	0.162
	JCT132	12/05/86	2	180	0.610	0.129	0.0117	0.0117	0.929	0.044	1.115	0.063	0.099	0.085	level	0.000	0.000	86.09	16.98	0.197
	JCT133	12/05/86	2	180	0.610	0.218	0.0168	0.0168	1.073	0.059	0.921	0.043	0.122	0.152	level	0.000	0.036	130.10	38.07	0.293
	JCT134	12/05/86	2	180	0.610	0.265	0.0207	0.0207	1.264	0.081	1.133	0.065	0.128	0.152	level	0.000	0.013	165.99	46.75	0.282
	JCT135	12/05/86	2	180	0.610	0.375	0.0245	0.0245	1.442	0.106	1.344	0.092	0.134	0.152	level	0.000	0.061	204.30	73.45	0.36

MATRIX 2

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	J22231R1	5/26/88	2	180	0.610	0.075	0.0017	0.0034	0.369	0.007	0.790	0.032	0.046	0.043	level	0.000	0.000	11.03	2.48	0.208
			3	90	0.000	0.075	0.0017	0.0034	0.321	0.005	0.790	0.032	0.050	0.043	level	0.000	0.000	0.90		
	J22231R2	5/24/88	2	180	0.610	0.008	0.0017	0.0034	0.561	0.016	1.050	0.056	0.034	0.035	level	0.000	0.000	10.80	3.03	0.259
			3	90	0.000	0.008	0.0017	0.0034	0.654	0.022	1.050	0.056	0.030	0.035	level	0.000	0.000	0.87		
	J22232	5/27/88	2	180	0.610	0.133	0.0054	0.0104	0.628	0.020	0.718	0.026	0.073	0.113	level	0.000	0.000	37.46	14.17	0.326
			3	90	0.000	0.133	0.0050	0.0104	0.325	0.005	0.718	0.026	0.119	0.113	level	0.000	0.000	6.04		
	J22233	5/31/88	2	180	0.610	0.158	0.0064	0.0127	0.606	0.019	0.731	0.027	0.085	0.138	level	0.000	0.000	44.58	20.64	0.382
			3	90	0.000	0.158	0.0063	0.0127	0.354	0.006	0.731	0.027	0.145	0.138	level	0.000	0.000	9.40		
	J22234	6/ 1/88	2	180	0.610	0.283	0.0077	0.0153	0.705	0.025	0.840	0.036	0.088	0.152	level	0.000	0.054	54.82	36.44	0.483
			3	90	0.000	0.283	0.0076	0.0153	0.418	0.009	0.840	0.036	0.152	0.152	level	0.116	0.054	20.69		
	J22235	7/13/88	2	180	0.610	0.365	0.0105	0.0212	1.073	0.059	1.161	0.069	0.081	0.152	level	0.000	0.143	77.36	75.67	0.654
			3	90	0.000	0.365	0.0106	0.0212	0.584	0.017	1.161	0.069	0.152	0.152	level	0.198	0.143	38.40		
	J21331R1	7/28/88	2	180	0.610	0.079	0.0011	0.0044	0.371	0.007	0.914	0.043	0.034	0.047	level	0.000	0.000	7.04	3.83	0.413
			3	90	0.000	0.079	0.0033	0.0044	0.595	0.018	0.914	0.043	0.052	0.047	level	0.000	0.000	2.23		
	J21331R2	7/28/88	2	180	0.610	0.077	0.0011	0.0044	0.371	0.007	0.947	0.046	0.034	0.046	level	0.000	0.000	7.04	3.91	0.418
			3	90	0.000	0.077	0.0033	0.0044	0.478	0.012	0.947	0.046	0.061	0.046	level	0.000	0.000	2.32		
	J21332	7/28/88	2	180	0.610	0.115	0.0019	0.0075	0.406	0.008	0.634	0.020	0.046	0.094	level	0.000	0.000	12.16	8.49	0.464
			3	90	0.000	0.115	0.0057	0.0075	0.443	0.010	0.634	0.020	0.101	0.094	level	0.000	0.000	6.14		
	J21333	7/28/88	2	180	0.610	0.163	0.0032	0.0128	0.541	0.015	0.781	0.031	0.055	0.129	level	0.000	0.000	21.31	20.09	0.550
			3	90	0.000	0.163	0.0096	0.0128	0.535	0.015	0.781	0.031	0.146	0.129	level	0.000	0.000	15.19		
	J21334	7/28/88	2	180	0.610	0.240	0.0041	0.0165	0.519	0.014	0.907	0.042	0.069	0.152	level	0.000	0.035	28.04	37.14	0.637
			3	90	0.000	0.240	0.0124	0.0165	0.680	0.024	0.907	0.042	0.152	0.152	level	0.073	0.035	30.29		
	J21335R1	7/28/88	2	180	0.610	0.443	0.0047	0.0188	0.356	0.006	1.031	0.054	0.104	0.152	level	0.000	0.177	33.17	70.78	0.741
			3	90	0.000	0.443	0.0141	0.0188	0.773	0.030	1.031	0.054	0.152	0.152	level	0.268	0.177	62.36		
	J21335R2	7/28/88	2	180	0.610	0.416	0.0047	0.0188	0.350	0.006	1.031	0.054	0.105	0.152	level	0.000	0.149	33.23	65.50	0.714
			3	90	0.000	0.416	0.0141	0.0188	0.773	0.030	1.031	0.054	0.152	0.152	level	0.241	0.149	58.57		
	J21321	7/29/88	2	180	0.305	0.082	0.0009	0.0038	0.314	0.005	0.667	0.023	0.034	0.053	level	0.000	0.000	3.15	2.80	0.538
			3	90	0.000	0.082	0.0028	0.0038	0.366	0.007	0.667	0.023	0.067	0.053	level	0.000	0.000	2.05		
	J21322	7/29/88	2	180	0.305	0.122	0.0026	0.0106	0.699	0.025	0.821	0.034	0.040	0.101	level	0.000	0.000	9.54	14.04	0.733
			3	90	0.000	0.122	0.0079	0.0106	0.581	0.017	0.821	0.034	0.107	0.101	level	0.000	0.000	9.63		
	J21323	7/29/88	2	180	0.305	0.149	0.0034	0.0137	0.711	0.026	0.933	0.044	0.047	0.115	level	0.000	0.000	12.69	21.41	0.767
			3	90	0.000	0.149	0.0103	0.0137	0.618	0.019	0.933	0.044	0.131	0.115	level	0.000	0.000	15.21		
	J21324	7/30/88	2	180	0.305	0.258	0.0051	0.0204	0.659	0.022	1.119	0.064	0.067	0.152	level	0.000	0.008	19.69	44.88	0.755
			3	90	0.000	0.258	0.0153	0.0204	0.840	0.036	1.119	0.064	0.152	0.152	level	0.076	0.008	39.73		
	J21325	8/ 5/88	2	180	0.305	0.412	0.0063	0.0249	0.387	0.008	1.366	0.095	0.126	0.152	level	0.000	0.113	26.93	88.03	0.827
			3	90	0.000	0.412	0.0187	0.0249	1.023	0.053	1.366	0.095	0.152	0.152	level	0.229	0.113	79.47		
	J21021	8/ 1/88	2	180	0.305	0.080	0.0070	0.0070	0.767	0.030	0.854	0.037	0.076	0.070	level	0.000	0.000	28.18	7.36	0.261
	J21022	8/ 1/88	2	180	0.305	0.105	0.0093	0.0093	0.751	0.029	0.727	0.027	0.098	0.100	level	0.000	0.000	39.13	11.55	0.295
	J21023	8/ 1/88	2	180	0.305	0.148	0.0144	0.0144	0.807	0.033	0.801	0.033	0.143	0.145	level	0.000	0.000	67.73	25.03	0.369
	J21024	8/ 1/88	2	180	0.305	0.269	0.0184	0.0184	1.011	0.052	1.011	0.052	0.152	0.152	level	0.058	0.052	102.50	46.32	0.452
	J21025	8/ 5/88	2	180	0.305	0.450	0.0125	0.0125	0.683	0.024	0.683	0.024	0.152	0.152	level	0.128	0.128	74.39	37.16	0.500
	J23121	8/ 2/88	2	180	0.305	0.081	0.0034	0.0046	0.495	0.012	0.758	0.029	0.061	0.056	level	0.000	0.000	12.49	3.86	0.290
			3	90	0.000	0.081	0.0012	0.0046	0.161	0.001	0.758	0.029	0.067	0.056	level	0.000	0.000	0.84		
	J23122	8/ 2/88	2	180	0.305	0.130	0.0071	0.0094	0.645	0.021	0.648	0.021	0.088	0.113	level	0.000	0.000	28.76	12.33	0.393
			3	90	0.000	0.130	0.0023	0.0094	0.154	0.001	0.648	0.021	0.116	0.113	level	0.000	0.000	2.63		
	J23123	8/ 2/88	2	180	0.305	0.151	0.0102	0.0135	0.856	0.037	0.816	0.034	0.094	0.130	level	0.000	0.000	43.51	21.69	0.451
			3	90	0.000	0.151	0.0033	0.0135	0.193	0.002	0.816	0.034	0.137	0.130	level	0.000	0.000	4.56		
	J23124	8/ 2/88	2	180	0.305	0.301	0.0161	0.0215	0.933	0.044	1.180	0.071	0.137	0.152	level	0.000	0.087	76.96	65.39	0.707
			3	90	0.000	0.301	0.0054	0.0215	0.295	0.004	1.180	0.071	0.152	0.152	level	0.137	0.087	15.51		
	J23124R1	8/ 5/88	2	180	0.305	0.303	0.0155	0.0208	0.931	0.044	1.138	0.066	0.131	0.152	level	0.000	0.082	73.17	61.07	0.696
			3	90	0.000	0.303	0.0052	0.0208	0.286	0.004	1.138	0.066	0.152	0.152	level	0.128	0.082	14.54		
	J23125	8/ 2/88	2	180	0.305	0.420	0.0187	0.0249	1.064	0.058	1.366	0.095	0.140	0.152	level	0.000	0.119	92.12	89.45	0.765
			3	90	0.000	0.420	0.0062	0.0249	0.342	0.006	1.366	0.095	0.152	0.152	level	0.247	0.119	24.75		
	J20411	8/10/88	3	90	0.012	0.095	0.0042	0.0042	1.016	0.053	0.632	0.020	0.043	0.060	level	0.000	0.000	4.49	3.36	0.749
	J20412	8/10/88	3	90	0.012	0.152	0.0105	0.0105	0.628	0.020	0.652	0.022	0.131	0.126	level	0.000	0.000	16.81	15.12	0.900
	J20413	8/10/88	3	90	0.012	0.181	0.0139	0.0139	0.761	0.029	0.785	0.031	0.152	0.142	level	0.006	0.000	27.27	23.55	0.864
	J20414R1	8/10/88	3	90	0.012	0.285	0.0204	0.0204	1.118	0.064	1.118	0.064	0.152	0.152	level	0.091	0.028	63.97	48.80	0.763
	J20414R2	8/10/88	3	90	0.012	0.280	0.0204	0.0204	1.118	0.064	1.118	0.064	0.152	0.152	level	0.098	0.024	65.19	47.95	0.736
	J20415R1	8/10/88	3	90	0.012	0.437	0.0244	0.0244	1.335	0.091	1.335	0.091	0.152	0.152	level	0.253	0.130	121.47	89.01	0.733
	J20415R2	8/10/88	3	90	0.012	0.411	0.0244	0.0244	1.335	0.091	1.335	0.091	0.152	0.152	level	0.232	0.104	116.37	82.90	0.712
	J21011	8/11/88	2	180	0.006	0.062	0.0030	0.0030	0.448	0.010	0.859	0.038	0.061	0.038	level	0.000	0.000	2.29	2.24	0.980
	J21012	8/11/88	2	180	0.006	0.128	0.0110	0.0110	0.680	0.024	0.743	0.028	0.126	0.115	level	0.000	0.000	16.71	15.37	0.920
	J21013	8/11/88	2	180	0.006	0.153	0.0153	0.0153	0.838	0.036	0.871	0.039	0.151	0.140	level	0.000	0.000	28.89	26.72	0.925
	J21014	8/11/88	2	180	0.006	0.260	0.0216	0.0216	1.184	0.071	1.184	0.071	0.152	0.152	level	0.106	0.043	71.13	56.47	0.794
	J21015R1	8/11/88	2	180	0.006	0.413	0.0262	0.0262	1.437	0.105	1.437	0.105	0.152	0.152	level	0.253	0.173	132.87	110.77	0.834
	J21015R2	8/11/88	2	180	0.006	0.407	0.0262	0.0262	1.437	0.105	1.437	0.105	0.152	0.152	level	0.237	0.166	128.79	108.89	0.845
	J22221	8/30/88	2	180	0.305	0.107	0.0022	0.0045	0.277	0.004	0.504	0.013	0.069	0.075	level	0.000	0.000	8.17	3.88	0.375
			3	90	0.000	0.107	0.0023	0.0045	0.193	0.002	0.504	0.013	0.094	0.075	level	0.000	0.000	2.17		
	J22222	8/30/88	2	180	0.305	0.146	0.0041	0.0082	0.359	0.007	0.527	0.014	0.091	0.121	level	0.000	0.000	16.21	10.84	0.503
			3	90	0.000	0.146	0.0041	0.0082	0.244	0.003	0.527	0.014	0.131	0.121	level	0.000	0.000	5.36		
	J22223	8/31/88	2	180	0.305	0.183	0.0064	0.0127	0.460	0.011	0.698	0.025	0.108	0.151	level	0.000	0.006	26.47	22.73	0.613
			3	90	0.000	0.183	0.0063	0.0127	0.348	0.006	0.698	0.025	0.152	0.151	level	0.012	0.006	10.62		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	J22224	8/29/88	2	180	0.305	0.256	0.0108	0.0215	0.815	0.034	1.180	0.071	0.104	0.152	level	0.000	0.039	46.66	55.36	0.752
			3	90	0.000	0.256	0.0108	0.0215	0.590	0.018	1.180	0.071	0.152	0.152	level	0.085	0.039	26.95		
	J22225	8/11/88	2	180	0.305	0.373	0.0121	0.0241	0.899	0.041	1.321	0.089	0.105	0.152	level	0.000	0.083	53.35	76.54	0.784
			3	90	0.000	0.373	0.0120	0.0241	0.660	0.022	1.321	0.089	0.152	0.152	level	0.201	0.083	44.33		
1	J23111	8/30/88	2	180	0.006	0.070	0.0029	0.0038	0.370	0.007	0.820	0.034	0.067	0.044	level	0.000	0.000	2.25	2.92	0.998
			3	90	0.014	0.070	0.0010	0.0038	0.157	0.001	0.820	0.034	0.056	0.044	level	0.000	0.000	0.68		
	J23112	8/30/88	2	180	0.006	0.106	0.0056	0.0074	0.424	0.009	0.993	0.050	0.104	0.066	level	0.000	0.000	6.54	8.46	0.999
			3	90	0.014	0.106	0.0018	0.0074	0.161	0.001	0.993	0.050	0.091	0.066	level	0.000	0.000	1.93		
	J23113	8/31/88	2	180	0.006	0.168	0.0121	0.0161	0.661	0.022	0.938	0.045	0.152	0.135	level	0.014	0.000	23.00	28.36	0.950
			3	90	0.014	0.168	0.0040	0.0161	0.219	0.002	0.938	0.045	0.152	0.135	level	0.006	0.000	6.85		
	J23114	8/29/88	2	180	0.006	0.265	0.0161	0.0217	0.883	0.040	1.189	0.072	0.152	0.152	level	0.110	0.028	48.65	53.70	0.843
			3	90	0.014	0.265	0.0056	0.0217	0.306	0.005	1.189	0.072	0.152	0.152	level	0.104	0.028	15.03		
	J23115	8/11/88	2	180	0.006	0.421	0.0191	0.0257	1.049	0.056	1.406	0.101	0.152	0.152	level	0.253	0.146	87.76	100.35	0.871
			3	90	0.014	0.421	0.0065	0.0257	0.357	0.006	1.406	0.101	0.152	0.152	level	0.256	0.146	27.39		
1	J22211	8/30/88	2	180	0.006	0.073	0.0020	0.0039	0.246	0.003	0.832	0.035	0.069	0.043	level	0.000	0.000	1.52	3.01	0.999
			3	90	0.014	0.073	0.0019	0.0039	0.283	0.004	0.832	0.035	0.061	0.043	level	0.000	0.000	1.49		
	J22212	8/30/88	2	180	0.006	0.109	0.0036	0.0072	0.273	0.004	0.967	0.048	0.104	0.066	level	0.000	0.000	4.06	8.04	0.995
			3	90	0.014	0.109	0.0036	0.0072	0.305	0.005	0.967	0.048	0.094	0.066	level	0.000	0.000	4.02		
	J22213	8/31/88	2	180	0.006	0.173	0.0080	0.0161	0.441	0.010	0.977	0.049	0.152	0.129	level	0.015	0.000	14.48	27.92	0.969
			3	90	0.014	0.173	0.0080	0.0161	0.439	0.010	0.977	0.049	0.152	0.129	level	0.006	0.000	14.33		
	J22214	8/29/88	2	180	0.006	0.280	0.0109	0.0217	0.596	0.018	1.192	0.072	0.152	0.152	level	0.119	0.021	31.50	52.37	0.842
			3	90	0.014	0.280	0.0109	0.0217	0.596	0.018	1.192	0.072	0.152	0.152	level	0.104	0.021	30.72		
	J22215	8/29/88	2	180	0.006	0.441	0.0129	0.0257	0.708	0.026	1.410	0.101	0.152	0.152	level	0.287	0.138	59.57	98.84	0.835
			3	90	0.014	0.441	0.0128	0.0257	0.702	0.025	1.410	0.101	0.152	0.152	level	0.277	0.138	58.84		
	J21311R1	8/30/88	2	180	0.006	0.077	0.0010	0.0041	0.118	0.001	0.884	0.040	0.073	0.044	level	0.000	0.000	0.80	3.38	1.000
			3	90	0.014	0.077	0.0031	0.0041	0.453	0.010	0.884	0.040	0.061	0.044	level	0.000	0.000	2.59		
	J21312	8/11/88	2	180	0.006	0.155	0.0026	0.0108	0.151	0.001	0.712	0.026	0.139	0.118	level	0.000	0.000	3.78	15.21	0.954
			3	90	0.014	0.155	0.0082	0.0108	0.509	0.013	0.712	0.026	0.125	0.118	level	0.000	0.000	12.17		
	J21313	8/10/88	2	180	0.006	0.159	0.0029	0.0118	0.157	0.001	0.734	0.027	0.152	0.126	level	0.001	0.000	4.50	17.72	0.923
			3	90	0.014	0.159	0.0089	0.0118	0.510	0.013	0.734	0.027	0.140	0.126	level	0.000	0.000	14.69		
	J21314	8/10/88	2	180	0.006	0.288	0.0053	0.0210	0.289	0.004	1.150	0.067	0.152	0.152	level	0.137	0.032	15.49	51.75	0.799
			3	90	0.014	0.288	0.0157	0.0210	0.862	0.038	1.150	0.067	0.152	0.152	level	0.116	0.032	49.32		
	J21315R1	8/10/88	2	180	0.006	0.426	0.0059	0.0236	0.323	0.005	1.296	0.086	0.152	0.152	level	0.277	0.114	25.47	81.61	0.775
			3	90	0.014	0.426	0.0178	0.0236	0.973	0.048	1.296	0.086	0.152	0.152	level	0.244	0.114	79.82		
	J21315R2	8/10/88	2	180	0.006	0.408	0.0059	0.0236	0.323	0.005	1.296	0.086	0.152	0.152	level	0.274	0.112	25.30	81.05	0.771
			3	90	0.014	0.408	0.0178	0.0236	0.973	0.048	1.296	0.086	0.152	0.152	level	0.244	0.112	79.82		
	J21031	1/ 6/88	2	180	0.610	0.078	0.0022	0.0022	0.262	0.004	0.357	0.007	0.072	0.057	level	0.000	0.000	14.83	1.37	0.092
	J21031R1	1/21/88	2	180	0.610	0.065	0.0036	0.0036	0.627	0.020	0.853	0.037	0.053	0.043	level	0.000	0.000	23.89	2.79	0.117
	J21031R2	1/29/88	2	180	0.610	0.048	0.0020	0.0020	0.458	0.011	0.833	0.035	0.044	0.029	level	0.000	0.000	13.10	1.27	0.097
	J21032	1/ 6/ 8	2	180	0.610	0.134	0.0091	0.0091	0.669	0.023	0.579	0.017	0.107	0.123	level	0.000	0.000	66.07	12.51	0.189
	J21032R1	1/29/88	2	180	0.610	0.095	0.0078	0.0078	0.681	0.024	0.632	0.020	0.091	0.098	level	0.000	0.000	55.33	9.00	0.163
	J21033	1/29/88	2	180	0.610	0.165	0.0126	0.0126	0.857	0.037	0.689	0.024	0.114	0.152	level	0.000	0.004	93.84	22.30	0.238
	J21034	2/ 1/88	2	180	0.610	0.275	0.0157	0.0157	1.001	0.051	0.858	0.038	0.122	0.152	level	0.000	0.092	120.14	43.34	0.361
	J21035	2/ 1/88	2	180	0.610	0.392	0.0188	0.0188	1.127	0.065	1.031	0.054	0.131	0.152	level	0.000	0.108	148.46	57.97	0.390
	J21035R1	2/ 2/88	2	180	0.610	0.455	0.0188	0.0188	1.175	0.070	1.031	0.054	0.125	0.152	level	0.000	0.122	148.37	60.61	0.408
1	J33111	8/31/88	2	180	0.007	0.069	0.0027	0.0037	0.359	0.007	0.811	0.033	0.066	0.043	benched	0.000	0.000	2.09	2.75	0.998
			3	90	0.012	0.069	0.0010	0.0037	0.168	0.001	0.811	0.033	0.055	0.043	benched	0.000	0.000	0.67		
	J33112	9/ 1/88	2	180	0.007	0.129	0.0017	0.0034	0.107	0.001	0.297	0.005	0.126	0.091	benched	0.000	0.000	2.27	3.20	0.721
			3	90	0.012	0.129	0.0017	0.0034	0.109	0.001	0.297	0.005	0.119	0.091	benched	0.000	0.000	2.16		
	J33113	9/ 1/88	2	180	0.007	0.152	0.0083	0.0110	0.455	0.011	0.779	0.031	0.149	0.110	benched	0.000	0.000	13.53	15.12	0.850
			3	90	0.012	0.152	0.0027	0.0110	0.149	0.001	0.779	0.031	0.148	0.110	benched	0.000	0.000	4.26		
	J33114	9/ 2/88	2	180	0.007	0.255	0.0138	0.0184	0.759	0.029	1.123	0.064	0.152	0.128	benched	0.102	0.000	39.49	34.66	0.674
			3	90	0.012	0.255	0.0045	0.0184	0.248	0.003	1.123	0.064	0.152	0.128	benched	0.101	0.000	11.93		
	J33115	9/ 2/88	2	180	0.007	0.411	0.0177	0.0235	0.969	0.048	1.290	0.085	0.152	0.152	benched	0.256	0.151	80.28	89.50	0.854
			3	90	0.012	0.411	0.0059	0.0235	0.321	0.005	1.290	0.085	0.152	0.152	benched	0.257	0.151	24.54		
1	J32211R1	8/31/88	2	180	0.007	0.071	0.0017	0.0034	0.227	0.003	0.771	0.030	0.066	0.042	benched	0.000	0.000	1.25	2.38	0.999
			3	90	0.012	0.071	0.0017	0.0034	0.305	0.005	0.771	0.030	0.052	0.042	benched	0.000	0.000	1.13		
1	J32211R2	8/31/88	2	180	0.007	0.068	0.0017	0.0034	0.241	0.003	0.789	0.032	0.062	0.039	benched	0.000	0.000	1.21	2.34	1.000
			3	90	0.012	0.068	0.0017	0.0034	0.305	0.005	0.789	0.032	0.052	0.039	benched	0.000	0.000	1.13		
	J32212	9/ 1/88	2	180	0.007	0.130	0.0040	0.0082	0.245	0.003	0.553	0.016	0.130	0.115	benched	0.000	0.000	5.54	10.43	0.942
			3	90	0.012	0.130	0.0041	0.0082	0.262	0.003	0.553	0.016	0.122	0.115	benched	0.000	0.000	5.53		
	J32213	9/ 1/88	2	180	0.007	0.157	0.0056	0.0112	0.304	0.005	0.674	0.023	0.152	0.130	benched	0.005	0.000	9.18	16.73	0.912
			3	90	0.012	0.157	0.0056	0.0112	0.309	0.005	0.674	0.023	0.149	0.130	benched	0.000	0.000	9.16		
	J32214	9/ 2/88	2	180	0.007	0.272	0.0093	0.0186	0.512	0.013	1.020	0.053	0.152	0.152	benched	0.116	0.027	26.44	42.31	0.801
			3	90	0.012	0.272	0.0093	0.0186	0.508	0.013	1.020	0.053	0.152	0.152	benched	0.113	0.027	26.40		
	J32215	9/ 2/88	2	180	0.007	0.447	0.0117	0.0233	0.641	0.021	1.279	0.083	0.152	0.152	benched	0.290	0.139	53.88	85.74	0.798
			3	90	0.012	0.447	0.0116	0.0233	0.638	0.021	1.279	0.083	0.152	0.152	benched	0.283	0.139	53.52		
	J31311R1	8/31/88	2	180	0.007	0.070	0.0008	0.0033	0.109	0.001	0.792	0.032	0.066	0.043	benched	0.000	0.000	0.59	2.43	0.661
			3	90	0.012	0.070	0.0025	0.0033	1.323	0.089	0.792	0.032	0.024	0.043	benched	0.000	0.000	3.08		
	J31311R2	8/31/88	2	180	0.007	0.067	0.0008	0.0033	0.116	0.001	0.870	0.039	0.063	0.040	benched	0.000	0.000	0.57	2.55	0.554
			3	90	0.012	0.067	0.0025	0.0033	1.605	0.131	0.870	0.039	0.021	0.040	benched	0.000	0.000	4.04		
	J31312	9/ 1/88	2	180	0.007	0.129	0.0021	0.0082	0.128	0.001	0.557	0.016	0.126	0.114	benched	0.000	0.000	2.72	10.38	0.953
			3	90	0.012	0.129	0.0061	0.0082	0.409	0.009	0.557	0.016	0.116	0.114	benched	0.000	0.000	8.17		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	J31313	9/ 1/88	2	180	0.007	0.153	0.0026	0.0102	0.142	0.001	0.626	0.020	0.151	0.128	benched	0.000	0.000	4.01	14.80	0.903
			3	90	0.012	0.153	0.0076	0.0102	0.430	0.009	0.626	0.020	0.143	0.128	benched	0.000	0.000	12.38		
	J31314R1	9/ 2/88	2	180	0.007	0.288	0.0048	0.0191	0.262	0.004	1.049	0.056	0.152	0.152	benched	0.134	0.035	13.94	45.66	0.766
			3	90	0.012	0.288	0.0144	0.0191	0.787	0.032	1.049	0.056	0.152	0.152	benched	0.128	0.035	45.67		
	J31314R2	9/ 2/88	2	180	0.007	0.283	0.0048	0.0191	0.262	0.004	1.049	0.056	0.152	0.152	benched	0.128	0.029	13.65	44.52	0.761
			3	90	0.012	0.283	0.0144	0.0191	0.787	0.032	1.049	0.056	0.152	0.152	benched	0.122	0.029	44.81		
	J31315	9/ 2/88	2	180	0.007	0.414	0.0085	0.0227	0.467	0.011	1.242	0.079	0.152	0.152	benched	0.253	0.114	35.39	76.63	0.692
			3	90	0.012	0.414	0.0170	0.0227	0.930	0.044	1.242	0.079	0.152	0.152	benched	0.244	0.114	75.30		
	J31011	9/14/88	2	180	0.000	0.077	0.0048	0.0048	0.473	0.011	0.527	0.014	0.082	0.076	benched	0.000	0.000	4.37	4.19	0.958
	J31012	9/14/88	2	180	0.000	0.120	0.0084	0.0084	0.536	0.015	0.596	0.018	0.122	0.110	benched	0.000	0.000	11.22	10.51	0.936
	J31013	9/14/88	2	180	0.000	0.143	0.0108	0.0108	0.624	0.020	0.741	0.028	0.137	0.113	benched	0.000	0.000	16.61	14.96	0.901
	J31014	9/14/88	2	180	0.000	0.212	0.0178	0.0170	0.978	0.049	0.978	0.049	0.152	0.152	benched	0.064	0.015	46.38	37.74	0.814
	J31015	9/14/88	2	180	0.000	0.379	0.0232	0.0232	1.273	0.083	1.273	0.083	0.152	0.152	benched	0.238	0.130	107.62	83.20	0.773
	J30411	9/14/88	3	90	0.000	0.102	0.0057	0.0057	0.496	0.013	0.530	0.014	0.091	0.087	benched	0.000	0.000	5.77	5.60	0.970
	J30412	9/14/88	3	90	0.000	0.131	0.0085	0.0085	0.537	0.015	0.584	0.017	0.123	0.113	benched	0.000	0.000	11.50	10.89	0.947
	J30413	9/14/88	3	90	0.000	0.152	0.0105	0.0105	0.601	0.018	0.657	0.022	0.139	0.124	benched	0.000	0.000	16.14	15.04	0.932
	J30414	9/14/88	3	90	0.000	0.308	0.0190	0.0190	1.040	0.055	1.040	0.055	0.152	0.152	benched	0.140	0.052	64.69	48.19	0.745
	J30415	9/14/88	3	90	0.000	0.415	0.0221	0.0221	1.211	0.075	1.211	0.075	0.152	0.152	benched	0.256	0.114	104.63	73.94	0.707
	J10411	8/17/87	3	90	0.012	0.060	0.0040	0.0040	2.267	0.262	2.183	0.243	0.023	0.024	depress	0.000	0.000	11.57	10.37	0.896
	J10411R1	10/ 7/87	3	90	0.012	0.089	0.0048	0.0048	1.335	0.091	0.840	0.036	0.038	0.054	depress	0.000	0.000	6.69	4.23	0.632
	J10411R2	10/ 9/87	3	90	0.012	0.080	0.0051	0.0051	2.050	0.214	1.068	0.058	0.030	0.047	depress	0.000	0.000	12.81	5.25	0.410
	J10411R3	10/19/87	3	90	0.012	0.071	0.0034	0.0034	1.980	0.200	0.829	0.035	0.023	0.042	depress	0.000	0.000	7.84	2.57	0.328
	J10411R4	10/19/87	3	90	0.012	0.068	0.0028	0.0028	1.716	0.150	0.728	0.027	0.022	0.041	depress	0.000	0.000	5.14	1.88	0.365
	J10412	8/18/87	3	90	0.012	0.153	0.0085	0.0085	0.484	0.012	0.479	0.012	0.140	0.143	depress	0.000	0.000	13.71	12.85	0.937
	J10412R1	10/ 9/87	3	90	0.012	0.114	0.0079	0.0079	0.643	0.021	0.699	0.025	0.098	0.091	depress	0.000	0.000	10.19	9.00	0.883
	J10413	8/20/87	3	90	0.012	0.131	0.0096	0.0096	0.578	0.017	0.697	0.025	0.131	0.108	depress	0.000	0.000	15.13	12.52	0.828
	J10413R1	8/21/87	3	90	0.000	0.144	0.0113	0.0113	0.645	0.021	0.778	0.031	0.140	0.113	depress	0.000	0.000	17.93	16.02	0.894
	J10413R2	10/ 9/87	3	90	0.012	0.164	0.0130	0.0130	0.724	0.027	0.807	0.033	0.146	0.126	depress	0.000	0.000	23.69	20.35	0.859
	J10414	8/20/87	3	90	0.000	0.209	0.0176	0.0176	0.962	0.047	1.029	0.054	0.152	0.135	depress	0.201	0.000	68.88	32.48	0.472
	J10414R1	8/20/87	3	90	0.000	0.264	0.0198	0.0190	1.087	0.060	1.087	0.060	0.152	0.152	depress	0.101	0.022	60.86	45.58	0.749
	J10414R2	8/21/87	3	90	0.000	0.271	0.0193	0.0193	1.056	0.057	1.056	0.057	0.152	0.152	depress	0.106	0.032	59.58	45.60	0.765
	J10414R3	10/ 9/87	3	90	0.012	0.250	0.0201	0.0201	1.102	0.062	1.102	0.062	0.152	0.152	depress	0.078	0.013	60.15	44.77	0.744
	J10414R4	10/19/87	3	90	0.012	0.263	0.0201	0.0201	1.102	0.062	1.102	0.062	0.152	0.152	depress	0.160	0.013	76.25	44.77	0.587
	J10415	8/21/87	3	90	0.000	0.419	0.0238	0.0238	1.304	0.087	1.304	0.087	0.152	0.152	depress	0.236	0.138	110.70	87.96	0.795
	J10415R1	10/14/87	3	90	0.012	0.457	0.0252	0.0252	1.382	0.097	1.382	0.097	0.152	0.152	depress	0.276	0.152	132.87	99.36	0.748
	J10415R2	10/19/87	3	90	0.012	0.449	0.0252	0.0252	1.382	0.097	1.382	0.097	0.152	0.152	depress	0.262	0.139	129.63	96.04	0.741
	J13111	8/31/87	2	180	0.009	0.085	0.0034	0.0045	0.355	0.006	0.576	0.017	0.079	0.068	depress	0.000	0.000	3.17	3.77	0.905
			3	90	0.016	0.085	0.0011	0.0045	0.130	0.001	0.576	0.017	0.073	0.068	depress	0.000	0.000	1.00		
	J13112	9/ 2/87	2	180	0.008	0.130	0.0071	0.0093	0.464	0.011	0.651	0.022	0.119	0.112	depress	0.000	0.000	9.58	12.23	0.974
			3	90	0.014	0.130	0.0023	0.0093	0.140	0.001	0.651	0.022	0.119	0.112	depress	0.000	0.000	2.98		
	J13112R1	9/ 4/87	2	180	0.006	0.121	0.0059	0.0076	0.417	0.009	0.607	0.019	0.111	0.099	depress	0.000	0.000	7.36	8.86	0.964
			3	90	0.005	0.121	0.0017	0.0076	0.129	0.001	0.607	0.019	0.104	0.099	depress	0.000	0.000	1.83		
	J13113	9/14/87	2	180	0.009	0.176	0.0085	0.0113	0.466	0.011	0.653	0.022	0.152	0.138	depress	0.005	0.000	14.83	17.71	0.907
			3	90	0.018	0.176	0.0028	0.0113	0.156	0.001	0.653	0.022	0.149	0.138	depress	0.000	0.000	4.69		
	J13114	9/18/87	2	180	0.000	0.284	0.0127	0.0173	0.699	0.025	0.947	0.046	0.152	0.152	depress	0.128	0.062	38.18	43.98	0.864
			3	90	0.009	0.284	0.0045	0.0173	0.248	0.003	0.947	0.046	0.152	0.152	depress	0.122	0.062	12.74		
	J13115	9/30/87	2	180	0.005	0.387	0.0181	0.0244	0.993	0.050	1.335	0.091	0.152	0.152	depress	0.216	0.108	75.34	83.92	0.849
			3	90	0.014	0.387	0.0062	0.0244	0.342	0.006	1.335	0.091	0.152	0.152	depress	0.213	0.108	23.56		
	J13115R1	10/21/87	2	180	0.005	0.451	0.0198	0.0261	1.087	0.060	1.428	0.104	0.152	0.152	depress	0.290	0.163	98.65	107.21	0.845
			3	90	0.014	0.451	0.0062	0.0261	0.342	0.006	1.428	0.104	0.152	0.152	depress	0.290	0.163	28.21		
1	J12211	9/ 9/87	2	180	0.003	0.093	0.0034	0.0065	0.303	0.005	0.689	0.024	0.090	0.073	depress	0.000	0.000	3.25	6.18	0.998
			3	90	0.012	0.093	0.0031	0.0065	0.325	0.005	0.689	0.024	0.079	0.073	depress	0.000	0.000	2.94		
	J12212	9/ 4/87	2	180	0.006	0.123	0.0040	0.0074	0.256	0.003	0.597	0.018	0.120	0.098	depress	0.000	0.000	5.05	8.35	0.901
			3	90	0.005	0.123	0.0037	0.0074	0.266	0.004	0.597	0.018	0.108	0.098	depress	0.000	0.000	4.22		
	J12213	9/16/87	2	180	0.009	0.145	0.0054	0.0113	0.304	0.005	0.742	0.028	0.142	0.119	depress	0.000	0.000	8.19	16.32	0.959
			3	90	0.016	0.145	0.0057	0.0113	0.328	0.005	0.742	0.028	0.137	0.119	depress	0.000	0.000	8.82		
	J12214	9/18/87	2	180	0.000	0.322	0.0093	0.0184	0.512	0.013	1.009	0.052	0.152	0.152	depress	0.165	0.073	30.29	49.96	0.842
			3	90	0.009	0.322	0.0091	0.0184	0.497	0.013	1.009	0.052	0.152	0.152	depress	0.152	0.073	29.03		
	J12215	9/30/87	2	180	0.005	0.425	0.0122	0.0241	0.668	0.023	1.319	0.089	0.152	0.152	depress	0.259	0.130	52.41	87.70	0.845
			3	90	0.014	0.425	0.0119	0.0241	0.652	0.022	1.319	0.089	0.152	0.152	depress	0.253	0.130	51.43		
	J12215R1	10/21/87	2	180	0.005	0.488	0.0133	0.0266	0.730	0.027	1.459	0.108	0.152	0.152	depress	0.326	0.174	66.62	113.44	0.859
			3	90	0.014	0.488	0.0133	0.0266	0.730	0.027	1.459	0.108	0.152	0.152	depress	0.308	0.174	65.42		
	J11311	9/10/87	2	180	0.011	0.085	0.0011	0.0042	0.116	0.001	0.570	0.017	0.080	0.065	depress	0.000	0.000	1.03	3.41	0.715
			3	90	0.019	0.085	0.0031	0.0042	1.199	0.073	0.570	0.017	0.030	0.065	depress	0.000	0.000	3.74		
	J11312	9/10/87	2	180	0.011	0.119	0.0017	0.0074	0.116	0.001	0.615	0.019	0.114	0.095	depress	0.000	0.000	2.09	8.26	0.919
			3	90	0.019	0.119	0.0054	0.0074	0.407	0.008	0.615	0.019	0.104	0.095	depress	0.000	0.000	6.89		
	J11313	9/16/87	2	180	0.009	0.144	0.0028	0.0113	0.160	0.001	0.768	0.030	0.142	0.115	depress	0.000	0.000	4.22	16.10	0.910
			3	90	0.016	0.144	0.0085	0.0113	0.504	0.013	0.768	0.030	0.133	0.115	depress	0.000	0.000	13.47		
	J11314	9/21/87	2	180	0.012	0.344	0.0045	0.0187	0.248	0.003	1.025	0.053	0.152	0.152	depress	0.181	0.083	15.49	52.87	0.812
			3	90	0.018	0.344	0.0139	0.0187	0.761	0.029	1.025	0.053	0.152	0.152	depress	0.165	0.083	49.62		
	J11315	9/21/87	2	180	0.012	0.563	0.0057	0.0227	0.310	0.005	1.242	0.079	0.152	0.152	depress	0.405	0.239	31.90	104.38	0.805
			3	90	0.018	0.563	0.0170	0.0227	0.931	0.044	1.242	0.079	0.152	0.152	depress	0.372	0.239	97.74		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	J12221	10/25/87	2	180	0.289	0.072	0.0019	0.0038	0.540	0.015	0.955	0.046	0.038	0.041	depress	0.000	0.000	6.46	3.26	0.412
			3	90	0.015	0.072	0.0019	0.0038	0.274	0.004	0.955	0.046	0.061	0.041	depress	0.000	0.000	1.46		
	J12222	10/25/87	2	180	0.289	0.109	0.0034	0.0068	0.580	0.017	0.676	0.023	0.055	0.082	depress	0.000	0.000	12.13	7.04	0.438
			3	90	0.015	0.109	0.0034	0.0068	0.264	0.004	0.676	0.023	0.101	0.082	depress	0.000	0.000	3.92		
	J12223	10/28/87	2	180	0.286	0.145	0.0054	0.0109	0.638	0.021	0.737	0.028	0.072	0.115	depress	0.000	0.000	20.18	15.27	0.535
			3	90	0.014	0.145	0.0055	0.0109	0.316	0.005	0.737	0.028	0.137	0.115	depress	0.000	0.000	8.39		
	J12223R1	10/30/87	2	180	0.305	0.147	0.0057	0.0115	0.672	0.023	0.777	0.031	0.072	0.115	depress	0.000	0.000	22.43	16.46	0.527
			3	90	0.012	0.147	0.0058	0.0115	0.334	0.006	0.777	0.031	0.137	0.115	depress	0.000	0.000	8.80		
	J12224	10/28/87	2	180	0.305	0.211	0.0102	0.0204	0.892	0.041	1.118	0.064	0.091	0.152	depress	0.000	0.021	43.66	47.34	0.677
			3	90	0.012	0.211	0.0102	0.0204	0.559	0.016	1.118	0.064	0.152	0.152	depress	0.082	0.021	26.30		
	J12224R1	11/ 2/87	2	180	0.305	0.274	0.0102	0.0205	0.800	0.033	1.125	0.065	0.101	0.152	depress	0.000	0.035	43.90	50.79	0.702
			3	90	0.012	0.274	0.0103	0.0205	0.565	0.016	1.125	0.065	0.152	0.152	depress	0.101	0.035	28.47		
	J12225	11/ 2/87	2	180	0.305	0.408	0.0122	0.0247	0.764	0.030	1.352	0.093	0.125	0.152	depress	0.000	0.118	55.11	87.99	0.819
			3	90	0.012	0.408	0.0124	0.0247	0.681	0.024	1.352	0.093	0.152	0.152	depress	0.241	0.118	52.33		
	J11321	11/ 4/87	2	180	0.305	0.091	0.0010	0.0050	0.311	0.005	0.737	0.028	0.037	0.060	depress	0.000	0.000	3.56	4.28	0.584
			3	90	0.012	0.091	0.0039	0.0050	0.424	0.009	0.737	0.028	0.077	0.060	depress	0.000	0.000	3.77		
	J11322	11/ 4/87	2	180	0.305	0.112	0.0016	0.0070	0.378	0.007	0.625	0.020	0.043	0.090	depress	0.000	0.000	5.62	7.48	0.626
			3	90	0.012	0.112	0.0054	0.0070	0.429	0.009	0.625	0.020	0.098	0.090	depress	0.000	0.000	6.31		
	J11323	11/ 8/87	2	180	0.305	0.144	0.0024	0.0094	0.473	0.011	0.598	0.018	0.049	0.123	depress	0.000	0.000	8.51	12.97	0.700
			3	90	0.000	0.144	0.0070	0.0094	0.406	0.008	0.598	0.018	0.137	0.123	depress	0.000	0.000	10.02		
	J11324	11/ 6/87	2	180	0.305	0.266	0.0052	0.0209	0.633	0.020	1.144	0.067	0.070	0.152	depress	0.000	0.023	20.08	49.45	0.744
			3	90	0.012	0.266	0.0157	0.0209	0.860	0.038	1.144	0.067	0.152	0.152	depress	0.099	0.023	46.40		
	J11325	11/ 2/87	2	180	0.305	0.412	0.0125	0.0244	0.778	0.031	1.340	0.091	0.125	0.152	depress	0.000	0.116	56.27	86.19	0.807
			3	90	0.012	0.412	0.0120	0.0244	0.657	0.022	1.340	0.091	0.152	0.152	depress	0.244	0.116	50.58		
	J13131	11/20/87	2	180	0.591	0.045	0.0025	0.0033	0.476	0.012	0.556	0.016	0.051	0.055	depress	0.000	0.000	16.15	2.27	0.136
			3	90	0.015	0.045	0.0008	0.0033	0.125	0.001	0.556	0.016	0.056	0.055	depress	0.000	0.000	0.54		
	J13131R2	2/17/88	2	180	0.610	0.067	0.0020	0.0029	0.423	0.009	0.790	0.032	0.046	0.039	depress	0.000	0.000	12.92	2.05	0.152
			3	90	0.012	0.067	0.0010	0.0029	0.175	0.002	0.790	0.032	0.052	0.039	depress	0.000	0.000	0.62		
	J13132R1	2/17/88	2	180	0.610	0.103	0.0043	0.0058	0.529	0.014	0.591	0.018	0.070	0.080	depress	0.000	0.000	29.48	5.57	0.180
			3	90	0.012	0.103	0.0014	0.0058	0.134	0.001	0.591	0.018	0.087	0.080	depress	0.000	0.000	1.42		
	J13133R1	2/18/88	2	180	0.610	0.159	0.0073	0.0099	0.744	0.028	0.588	0.018	0.081	0.132	depress	0.000	0.000	51.47	14.43	0.259
			3	90	0.012	0.159	0.0025	0.0099	0.140	0.001	0.588	0.018	0.152	0.132	depress	0.002	0.000	4.18		
	J13134R1	2/18/88	2	180	0.610	0.249	0.0106	0.0141	0.896	0.041	0.773	0.030	0.094	0.152	depress	0.000	0.048	77.77	31.94	0.368
			3	90	0.012	0.249	0.0035	0.0141	0.189	0.002	0.773	0.030	0.152	0.152	depress	0.099	0.048	9.00		
	J13134R2	2/18/88	2	180	0.610	0.240	0.0106	0.0141	0.896	0.041	0.773	0.030	0.094	0.152	depress	0.000	0.049	77.77	32.11	0.371
			3	90	0.012	0.240	0.0035	0.0141	0.189	0.002	0.773	0.030	0.152	0.152	depress	0.094	0.049	8.82		
	J13134R3	2/18/88	2	180	0.610	0.247	0.0106	0.0141	0.864	0.038	0.773	0.030	0.098	0.152	depress	0.000	0.049	77.78	32.11	0.370
			3	90	0.012	0.247	0.0035	0.0141	0.189	0.002	0.773	0.030	0.152	0.152	depress	0.098	0.049	8.95		
	J13135R1	2/18/88	2	180	0.610	0.418	0.0148	0.0197	0.945	0.045	1.082	0.060	0.122	0.152	depress	0.000	0.123	112.60	64.75	0.488
			3	90	0.012	0.418	0.0049	0.0197	0.271	0.004	1.082	0.060	0.152	0.152	depress	0.247	0.123	20.13		
	J12231	11/25/87	2	180	0.610	0.078	0.0019	0.0038	0.447	0.010	0.525	0.014	0.043	0.063	depress	0.000	0.000	12.14	2.86	0.212
			3	90	0.012	0.078	0.0019	0.0038	0.321	0.005	0.525	0.014	0.055	0.063	depress	0.000	0.000	1.35		
	J12231R2	2/19/88	2	180	0.610	0.084	0.0021	0.0042	0.455	0.011	0.678	0.023	0.046	0.057	depress	0.000	0.000	13.68	3.33	0.217
			3	90	0.012	0.084	0.0021	0.0042	0.292	0.004	0.678	0.023	0.064	0.057	depress	0.000	0.000	1.68		
	J12232	12/24/87	2	180	0.610	0.119	0.0038	0.0073	0.518	0.014	0.652	0.022	0.064	0.090	depress	0.000	0.000	25.38	7.94	0.269
			3	90	0.012	0.119	0.0035	0.0073	0.266	0.004	0.652	0.022	0.104	0.090	depress	0.000	0.000	4.12		
	J12232R1	2/19/88	2	180	0.610	0.115	0.0035	0.0070	0.515	0.014	0.600	0.018	0.061	0.093	depress	0.000	0.000	23.55	7.63	0.276
			3	90	0.012	0.115	0.0035	0.0070	0.264	0.004	0.600	0.018	0.104	0.093	depress	0.000	0.000	4.09		
	J12233	12/24/87	2	180	0.610	0.138	0.0049	0.0093	0.566	0.016	0.669	0.023	0.073	0.109	depress	0.000	0.000	33.57	11.96	0.301
			3	90	0.012	0.138	0.0044	0.0093	0.268	0.004	0.669	0.023	0.128	0.109	depress	0.000	0.000	6.20		
	J12233R1	2/19/88	2	180	0.610	0.144	0.0048	0.0096	0.591	0.018	0.652	0.022	0.070	0.115	depress	0.000	0.000	33.11	12.83	0.322
			3	90	0.012	0.144	0.0048	0.0096	0.291	0.004	0.652	0.022	0.128	0.115	depress	0.000	0.000	6.75		
	J12234	12/24/87	2	180	0.610	0.247	0.0065	0.0134	0.622	0.020	0.733	0.027	0.085	0.152	depress	0.000	0.031	45.83	27.63	0.441
			3	90	0.012	0.247	0.0068	0.0134	0.374	0.007	0.733	0.027	0.152	0.152	depress	0.079	0.031	16.81		
	J12234R1	2/19/88	2	180	0.610	0.306	0.0074	0.0148	0.706	0.025	0.810	0.033	0.085	0.152	depress	0.000	0.095	52.39	40.72	0.546
			3	90	0.012	0.306	0.0074	0.0148	0.404	0.008	0.810	0.033	0.152	0.152	depress	0.134	0.095	22.18		
	J12235	12/24/87	2	180	0.610	0.301	0.0072	0.0146	0.670	0.023	0.798	0.032	0.087	0.152	depress	0.000	0.059	50.72	34.77	0.480
			3	90	0.012	0.301	0.0074	0.0146	0.404	0.008	0.798	0.032	0.152	0.152	depress	0.128	0.059	21.74		
	J12235R1	2/19/88	2	180	0.610	0.388	0.0094	0.0188	0.791	0.032	1.032	0.054	0.094	0.152	depress	0.000	0.173	67.84	70.02	0.669
			3	90	0.012	0.388	0.0094	0.0188	0.517	0.014	1.032	0.054	0.152	0.152	depress	0.219	0.173	36.79		
	J11331	11/30/87	2	180	0.610	0.067	0.0008	0.0031	0.406	0.008	0.459	0.011	0.024	0.060	depress	0.000	0.000	4.81	2.15	0.174
			3	90	0.012	0.067	0.0023	0.0031	2.446	0.305	0.459	0.011	0.015	0.060	depress	0.000	0.000	7.58		
	J11331R1	11/30/87	2	180	0.610	0.090	0.0012	0.0046	0.345	0.006	0.490	0.012	0.037	0.077	depress	0.000	0.000	7.42	4.01	0.385
			3	90	0.012	0.090	0.0034	0.0046	0.440	0.010	0.490	0.012	0.067	0.077	depress	0.000	0.000	2.98		
	J11331R2	11/30/87	2	180	0.610	0.061	0.0006	0.0025	0.378	0.007	0.497	0.013	0.022	0.049	depress	0.000	0.000	3.90	1.52	0.186
			3	90	0.012	0.061	0.0019	0.0025	1.998	0.203	0.497	0.013	0.015	0.049	depress	0.000	0.000	4.30		
	J11331R3	12/ 2/87	2	180	0.610	0.064	0.0006	0.0025	0.356	0.006	0.461	0.011	0.023	0.052	depress	0.000	0.000	3.90	1.55	0.189
			3	90	0.012	0.064	0.0019	0.0025	1.998	0.203	0.461	0.011	0.015	0.052	depress	0.000	0.000	4.30		
	J11331R4	12/ 2/87	2	180	0.610	0.064	0.0006	0.0025	0.337	0.006	0.465	0.011	0.024	0.052	depress	0.000	0.000	3.91	1.54	0.162
			3	90	0.012	0.064	0.0019	0.0025	2.333	0.277	0.465	0.011	0.014	0.052	depress	0.000	0.000	5.65		
	J11331R6	2/23/88	2	180	0.610	0.076	0.0022	0.0038	0.441	0.010	0.667	0.023	0.049	0.053	depress	0.000	0.000	14.66	2.80	0.176
			3	90	0.012	0.076	0.0015	0.0038	0.210	0.002	0.667	0.023	0.064	0.053	depress	0.000	0.000	1.18		
	J11332R1	2/23/88	2	180	0.610	0.104	0.0014	0.0056	0.295	0.004	0.553	0.016	0.046	0.083	depress	0.000	0.000	8.79	5.37	0.401
			3	90	0.012	0.104	0.0042	0.0056	0.369	0.007	0.553	0.016	0.091	0.083	depress	0.000	0.000	4.59		
	J11334R1	4/21/88	2	180	0.610	0.251	0.0077	0.0190	1.308	0.087	1.042	0.055	0.055	0.152	depress	0.000	0.050	56.97	48.01	0.558
			3	90	0.000	0.251	0.0113	0.0190	0.618	0.019	1.042	0.055	0.152	0.152	depress	0.091	0.050	29.09		
	J11335R1	4/21/88	2	180	0.610	0.563	0.0095	0.0261	0.769	0.030	1.431	0.104	0.098	0.152	depress	0.000	0.237	68.57	126.44	0.774
			3	90	0.000	0.563	0.0166	0.0261	0.911	0.042	1.431	0.104	0.152	0.152	depress	0.387	0.237	94.81		

MATRIX 3

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	JS14011	4/ 4/89	2	180	0.305	0.086	0.0038	0.0038	0.999	0.051	0.497	0.013	0.040	0.066	depress	0.000	0.000	14.60	2.94	0.201
	JS14012	4/ 4/89	2	180	0.305	0.111	0.0063	0.0063	1.108	0.063	0.580	0.017	0.053	0.087	depress	0.000	0.000	25.80	6.40	0.248
	JS14013	4/ 4/89	2	180	0.305	0.158	0.0101	0.0101	1.193	0.073	0.678	0.023	0.072	0.116	depress	0.000	0.000	44.53	13.83	0.311
	JS14014	4/ 4/89	2	180	0.305	0.249	0.0165	0.0165	1.379	0.097	0.905	0.042	0.095	0.152	depress	0.000	0.023	80.42	35.08	0.436
	JS14015	4/25/89	2	180	0.305	0.288	0.0223	0.0223	1.371	0.096	1.222	0.076	0.127	0.152	depress	0.000	0.059	115.30	62.78	0.544
	JS14021	5/11/89	2	180	0.305	0.091	0.0043	0.0043	0.619	0.020	0.538	0.015	0.062	0.069	depress	0.000	0.000	16.42	3.57	0.217
	JS14022	5/11/89	2	180	0.305	0.109	0.0061	0.0061	0.685	0.024	0.562	0.016	0.074	0.087	depress	0.000	0.000	23.95	6.13	0.256
	JS14023	5/11/89	2	180	0.305	0.160	0.0097	0.0097	0.824	0.035	0.595	0.018	0.094	0.128	depress	0.000	0.000	41.26	13.88	0.336
	JS14024	5/11/89	2	180	0.305	0.298	0.0151	0.0151	0.932	0.044	0.830	0.035	0.127	0.152	depress	0.000	0.084	70.73	40.31	0.570
	JS14025	5/11/89	2	180	0.305	0.326	0.0161	0.0161	1.023	0.053	0.882	0.040	0.123	0.152	depress	0.000	0.105	75.80	46.82	0.618
1	JS10411	3/28/89	3	180	0.000	0.050	0.0048	0.0050	0.827	0.035	0.920	0.043	0.054	0.043	depress	0.000	0.000	4.21	4.20	0.998
	JS10412	3/29/89	3	180	0.000	0.112	0.0078	0.0081	0.525	0.014	0.674	0.023	0.116	0.096	depress	0.000	0.000	9.95	9.47	0.951
	JS10413	3/28/89	3	180	0.000	0.145	0.0121	0.0122	0.679	0.024	0.797	0.032	0.143	0.119	depress	0.000	0.000	19.77	18.14	0.917
	JS10414	4/27/89	3	180	0.000	0.212	0.0215	0.0215	1.181	0.071	1.489	0.113	0.152	0.113	depress	0.039	0.000	55.47	47.71	0.860
	JS13121	5/30/89	3	180	0.000	0.113	0.0017	0.0065	0.113	0.001	0.591	0.018	0.117	0.089	depress	0.000	0.000	1.96	6.80	0.195
			2	180	0.610	0.113	0.0048	0.0065	0.646	0.021	0.591	0.018	0.065	0.089	depress	0.000	0.000	32.85		
	JS13122	5/25/89	3	180	0.000	0.129	0.0024	0.0094	0.138	0.001	0.714	0.026	0.135	0.104	depress	0.000	0.000	3.13	11.98	0.227
			2	180	0.610	0.129	0.0071	0.0094	0.784	0.031	0.714	0.026	0.076	0.104	depress	0.000	0.000	49.73		
	JS13123	5/25/89	3	180	0.000	0.165	0.0026	0.0104	0.143	0.001	0.626	0.020	0.152	0.131	depress	0.020	0.000	4.43	15.47	0.258
			2	180	0.610	0.165	0.0078	0.0104	0.746	0.028	0.626	0.020	0.085	0.131	depress	0.000	0.000	55.62		
	JS13124	5/25/89	3	180	0.000	0.371	0.0031	0.0123	0.169	0.001	0.677	0.023	0.152	0.152	depress	0.223	0.135	11.41	37.65	0.483
			2	180	0.610	0.371	0.0092	0.0123	0.771	0.030	0.677	0.023	0.095	0.152	depress	0.000	0.135	66.52		
	JS13125	5/ 9/89	3	180	0.000	0.473	0.0050	0.0207	0.275	0.004	1.136	0.066	0.152	0.152	depress	0.315	0.162	23.13	77.30	0.530
			2	180	0.610	0.473	0.0157	0.0207	0.995	0.050	1.136	0.066	0.123	0.152	depress	0.000	0.162	120.68		
	JS13111	4/11/89	3	180	0.000	0.112	0.0015	0.0057	0.102	0.001	0.523	0.014	0.115	0.088	depress	0.000	0.000	1.69	5.68	0.317
			2	180	0.305	0.112	0.0042	0.0057	0.936	0.045	0.523	0.014	0.045	0.088	depress	0.000	0.000	16.20		
	JS13112	4/11/89	3	180	0.000	0.145	0.0024	0.0091	0.129	0.001	0.641	0.021	0.151	0.110	depress	0.000	0.000	3.49	11.66	0.370
			2	180	0.305	0.145	0.0067	0.0091	1.123	0.064	0.641	0.021	0.055	0.110	depress	0.000	0.000	28.05		
	JS13113	4/11/89	3	180	0.000	0.187	0.0033	0.0131	0.182	0.002	0.834	0.035	0.152	0.122	depress	0.032	0.000	6.04	20.15	0.416
			2	180	0.305	0.187	0.0097	0.0131	1.137	0.066	0.834	0.035	0.073	0.122	depress	0.000	0.000	42.34		
	JS13114	4/11/89	3	180	0.000	0.263	0.0046	0.0189	0.255	0.003	1.034	0.054	0.152	0.152	depress	0.113	0.014	12.25	40.90	0.519
			2	180	0.305	0.263	0.0142	0.0189	1.280	0.083	1.034	0.054	0.089	0.152	depress	0.000	0.014	66.56		
	JS13115	4/25/89	3	180	0.000	0.338	0.0056	0.0227	0.307	0.005	1.247	0.079	0.152	0.152	depress	0.185	0.024	18.79	57.01	0.565
			2	180	0.305	0.338	0.0171	0.0227	1.041	0.055	1.247	0.079	0.129	0.152	depress	0.000	0.024	82.13		
	JS12221	5/30/89	3	180	0.000	0.108	0.0031	0.0063	0.220	0.002	0.588	0.018	0.112	0.086	depress	0.000	0.000	3.51	6.37	0.263
			2	180	0.610	0.108	0.0031	0.0063	0.579	0.017	0.588	0.018	0.051	0.086	depress	0.000	0.000	20.70		
	JS12222	5/30/89	3	180	0.000	0.123	0.0039	0.0077	0.239	0.003	0.620	0.020	0.127	0.098	depress	0.000	0.000	4.93	8.95	0.290
			2	180	0.610	0.123	0.0039	0.0077	0.593	0.018	0.620	0.020	0.059	0.098	depress	0.000	0.000	25.91		
	JS12223	5/30/89	3	180	0.000	0.161	0.0058	0.0118	0.318	0.005	0.755	0.029	0.152	0.121	depress	0.014	0.000	9.76	17.32	0.341
			2	180	0.610	0.161	0.0059	0.0118	0.714	0.026	0.755	0.029	0.071	0.121	depress	0.000	0.000	40.98		
	JS12224	5/30/89	3	180	0.000	0.288	0.0076	0.0150	0.414	0.009	0.824	0.035	0.152	0.152	depress	0.143	0.070	22.52	37.91	0.500
			2	180	0.610	0.288	0.0075	0.0150	0.750	0.029	0.824	0.035	0.082	0.152	depress	0.000	0.070	53.27		
	JS12225	5/ 9/89	3	180	0.000	0.457	0.0107	0.0215	0.588	0.018	1.181	0.071	0.152	0.152	depress	0.314	0.191	50.92	87.54	0.671
			2	180	0.610	0.457	0.0108	0.0215	0.832	0.035	1.181	0.071	0.102	0.152	depress	0.000	0.191	79.46		
	JS12211	4/18/89	3	180	0.000	0.098	0.0025	0.0049	0.198	0.002	0.531	0.014	0.099	0.077	depress	0.000	0.000	2.48	4.34	0.387
			2	180	0.305	0.098	0.0024	0.0049	0.866	0.038	0.531	0.014	0.032	0.077	depress	0.000	0.000	8.74		
	JS12212	4/18/89	3	180	0.000	0.116	0.0031	0.0064	0.200	0.002	0.569	0.016	0.119	0.090	depress	0.000	0.000	3.63	6.65	0.416
			2	180	0.305	0.116	0.0033	0.0064	0.881	0.040	0.569	0.016	0.039	0.090	depress	0.000	0.000	12.36		
	JS12213	4/18/89	3	180	0.000	0.176	0.0062	0.0121	0.342	0.006	0.738	0.028	0.152	0.129	depress	0.023	0.000	11.05	18.66	0.537
			2	180	0.305	0.176	0.0059	0.0121	0.958	0.047	0.738	0.028	0.057	0.129	depress	0.000	0.000	23.69		
	JS12214	4/18/89	3	180	0.000	0.286	0.0109	0.0222	0.596	0.018	1.219	0.076	0.152	0.151	depress	0.135	0.010	32.60	51.59	0.616
			2	180	0.305	0.286	0.0113	0.0222	1.248	0.079	1.219	0.076	0.076	0.151	depress	0.000	0.010	51.10		
	JS12215	4/27/89	3	180	0.000	0.479	0.0127	0.0254	0.695	0.025	1.391	0.099	0.152	0.152	depress	0.313	0.126	60.99	93.68	0.740
			2	180	0.305	0.479	0.0127	0.0254	0.697	0.025	1.391	0.099	0.152	0.152	depress	0.044	0.126	65.58		
	JS11321	5/26/89	3	180	0.000	0.096	0.0035	0.0048	0.275	0.004	0.551	0.015	0.101	0.074	depress	0.000	0.000	3.65	4.25	0.355
			2	180	0.610	0.096	0.0013	0.0048	0.421	0.009	0.551	0.015	0.034	0.074	depress	0.000	0.000	8.34		
	JS11322	5/26/89	3	180	0.000	0.121	0.0049	0.0067	0.313	0.005	0.544	0.015	0.123	0.097	depress	0.000	0.000	6.17	7.31	0.421
			2	180	0.610	0.121	0.0017	0.0067	0.458	0.011	0.544	0.015	0.040	0.097	depress	0.000	0.000	11.18		
	JS11323	5/26/89	3	180	0.000	0.088	0.0082	0.0109	0.447	0.010	0.712	0.026	0.152	0.119	depress	0.006	0.000	13.46	15.58	0.490
			2	180	0.610	0.088	0.0028	0.0109	0.533	0.014	0.712	0.026	0.050	0.119	depress	0.000	0.000	18.34		
	JS11324	5/26/89	3	180	0.000	0.287	0.0125	0.0167	0.683	0.024	0.914	0.043	0.152	0.152	depress	0.134	0.059	37.90	41.61	0.626
			2	180	0.610	0.287	0.0042	0.0167	0.588	0.018	0.914	0.043	0.063	0.152	depress	0.000	0.059	28.57		
	JS11325	5/ 9/89	3	180	0.000	0.402	0.0138	0.0187	0.758	0.029	1.023	0.053	0.152	0.152	depress	0.238	0.121	56.82	59.73	0.666
			2	180	0.610	0.402	0.0048	0.0187	0.578	0.017	1.023	0.053	0.071	0.152	depress	0.000	0.121	32.92		
	JS11311	4/13/89	3	180	0.000	0.103	0.0048	0.0063	0.357	0.007	0.649	0.021	0.105	0.080	depress	0.000	0.000	5.28	6.34	0.578
			2	180	0.305	0.103	0.0015	0.0063	1.028	0.054	0.649	0.021	0.021	0.080	depress	0.000	0.000	5.69		
	JS11312	4/13/89	3	180	0.000	0.128	0.0064	0.0085	0.382	0.007	0.699	0.025	0.132	0.097	depress	0.000	0.000	8.73	10.16	0.610
			2	180	0.305	0.128	0.0021	0.0085	0.982	0.049	0.699	0.025	0.027	0.097	depress	0.000	0.000	7.93		
	JS11313	4/13/89	3	180	0.000	0.190	0.0107	0.0144	0.588	0.018	1.115	0.063	0.152	0.101	depress	0.034	0.000	21.48	23.25	0.652
			2	180	0.305	0.190	0.0037	0.0144	1.013	0.052	1.115	0.063	0.038	0.101	depress	0.000	0.000	14.16		
	JS11314	4/13/89	3	180	0.000	0.202	0.0128	0.0171	0.702	0.025	1.246	0.079	0.152	0.107	depress	0.064	0.000	30.31	31.27	0.661
			2	180	0.305	0.202	0.0043	0.0171	1.050	0.056	1.246	0.079	0.042	0.107	depress	0.000	0.000	17.01		
	JS11315	4/27/89	3	180	0.000	0.327	0.0157	0.0210	0.863	0.038	1.150	0.067	0.152	0.152	depress	0.162	0.034	54.42	52.32	0.697
			2	180	0.305	0.327	0.0053	0.0210	0.871	0.039	1.150	0.067	0.056	0.152	depress	0.000	0.034	20.62		

MATRIX 4

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	JN10411	7/ 5/89	3	180	0.000	0.086	0.0052	0.0052	0.459	0.011	0.674	0.023	0.091	0.067	depress	0.000	0.000	5.14	4.57	0.888
	JN10412	7/ 5/89	3	180	0.000	0.113	0.0082	0.0082	0.537	0.015	0.686	0.024	0.119	0.095	depress	0.000	0.000	10.84	9.64	0.891
	JN10413	7/ 5/89	3	180	0.000	0.148	0.0134	0.0142	0.734	0.027	0.858	0.038	0.152	0.130	depress	0.004	0.000	24.10	23.42	0.972
	JN10414	7/14/89	3	180	0.000	0.255	0.0226	0.0226	1.239	0.078	1.239	0.078	0.152	0.152	depress	0.117	0.032	77.03	58.26	0.756
	JN14011	7/ 6/89	2	90	0.305	0.074	0.0029	0.0029	0.450	0.010	0.658	0.022	0.058	0.044	depress	0.000	0.000	10.46	1.85	0.177
	JN14012	7/ 6/89	2	90	0.305	0.102	0.0054	0.0054	0.584	0.017	0.649	0.021	0.077	0.071	depress	0.000	0.000	21.30	4.95	0.233
	JN14013	7/ 6/89	2	90	0.305	0.129	0.0075	0.0075	0.644	0.021	0.644	0.021	0.093	0.093	depress	0.000	0.000	30.68	8.34	0.271
	JN14014	7/ 6/89	2	90	0.305	0.267	0.0158	0.0163	1.074	0.059	0.891	0.040	0.115	0.152	depress	0.000	0.016	74.08	33.21	0.452
	JN14015	7/14/89	2	90	0.305	0.430	0.0221	0.0221	1.249	0.079	1.212	0.075	0.142	0.152	depress	0.000	0.067	114.13	63.83	0.560
	JN13111	7/10/89	3	180	0.000	0.069	0.0009	0.0039	0.109	0.001	0.746	0.028	0.073	0.050	depress	0.000	0.000	0.67	2.95	0.299
			2	90	0.305	0.069	0.0025	0.0039	0.474	0.011	0.746	0.028	0.051	0.050	depress	0.000	0.000	9.18		
	JN13112	7/10/89	3	180	0.000	0.099	0.0013	0.0068	0.099	0.001	0.784	0.031	0.105	0.073	depress	0.000	0.000	1.37	7.01	0.378
			2	90	0.305	0.099	0.0045	0.0068	0.556	0.016	0.784	0.031	0.069	0.073	depress	0.000	0.000	17.09		
	JN13113	7/10/89	3	180	0.000	0.126	0.0022	0.0085	0.135	0.001	0.718	0.026	0.130	0.094	depress	0.000	0.000	2.88	9.98	0.340
			2	90	0.305	0.126	0.0066	0.0085	0.669	0.023	0.718	0.026	0.081	0.094	depress	0.000	0.000	26.44		
	JN13114	7/10/89	3	180	0.000	0.238	0.0043	0.0168	0.234	0.003	0.924	0.043	0.152	0.152	depress	0.099	0.010	10.65	34.07	0.465
			2	90	0.305	0.238	0.0137	0.0168	0.851	0.037	0.924	0.043	0.126	0.152	depress	0.000	0.010	62.65		
	JN13115	7/10/89	3	180	0.000	0.359	0.0051	0.0196	0.281	0.004	1.073	0.059	0.152	0.152	depress	0.196	0.060	17.71	51.95	0.621
			2	90	0.305	0.359	0.0144	0.0196	0.971	0.048	1.073	0.059	0.116	0.152	depress	0.000	0.060	66.36		
	JN12211	7/13/89	3	180	0.000	0.081	0.0029	0.0057	0.289	0.004	0.904	0.042	0.082	0.058	depress	0.000	0.000	2.44	5.61	0.434
			2	90	0.305	0.081	0.0029	0.0057	0.838	0.036	0.904	0.042	0.037	0.058	depress	0.000	0.000	10.70		
	JN12212	7/13/89	3	180	0.000	0.106	0.0035	0.0069	0.250	0.003	0.735	0.028	0.109	0.078	depress	0.000	0.000	3.82	7.15	0.431
			2	90	0.305	0.106	0.0035	0.0069	0.580	0.017	0.735	0.028	0.055	0.078	depress	0.000	0.000	12.77		
	JN12213	7/13/89	3	180	0.000	0.137	0.0039	0.0078	0.224	0.003	0.620	0.020	0.139	0.099	depress	0.000	0.000	5.43	9.12	0.447
			2	90	0.305	0.137	0.0039	0.0078	0.437	0.010	0.620	0.020	0.075	0.099	depress	0.000	0.000	14.92		
	JN12214	7/13/89	3	180	0.000	0.281	0.0102	0.0205	0.559	0.016	1.124	0.064	0.152	0.152	depress	0.131	0.012	29.92	46.09	0.622
			2	90	0.305	0.281	0.0103	0.0205	0.801	0.033	1.124	0.064	0.101	0.152	depress	0.000	0.012	44.34		
	JN12215	7/13/89	3	180	0.000	0.421	0.0119	0.0236	0.654	0.022	1.292	0.085	0.152	0.152	depress	0.256	0.105	50.32	79.07	0.765
			2	90	0.305	0.421	0.0116	0.0236	0.660	0.023	1.292	0.085	0.139	0.152	depress	0.000	0.105	53.19		
	JN11311	7/11/89	3	180	0.000	0.093	0.0037	0.0050	0.299	0.005	0.588	0.018	0.098	0.072	depress	0.000	0.000	3.68	4.42	0.530
			2	90	0.305	0.093	0.0013	0.0050	0.279	0.004	0.588	0.018	0.047	0.072	depress	0.000	0.000	4.64		
	JN11312	7/11/89	3	180	0.000	0.107	0.0049	0.0064	0.342	0.006	0.634	0.020	0.111	0.083	depress	0.000	0.000	5.58	6.52	0.589
			2	90	0.305	0.107	0.0016	0.0064	0.309	0.005	0.634	0.020	0.049	0.083	depress	0.000	0.000	5.47		
	JN11313	7/11/89	3	180	0.000	0.156	0.0088	0.0118	0.481	0.012	0.794	0.032	0.152	0.115	depress	0.007	0.000	14.73	16.98	0.660
			2	90	0.305	0.156	0.0030	0.0118	0.414	0.009	0.794	0.032	0.063	0.115	depress	0.000	0.000	10.99		
	JN11314	7/11/89	3	180	0.000	0.262	0.0146	0.0195	0.799	0.033	1.075	0.059	0.152	0.149	depress	0.116	0.004	43.05	40.47	0.653
			2	90	0.305	0.262	0.0049	0.0195	0.521	0.014	1.075	0.059	0.078	0.149	depress	0.000	0.004	19.05		
	JN11315	7/14/89	3	180	0.000	0.429	0.0200	0.0267	1.096	0.061	1.464	0.109	0.152	0.152	depress	0.278	0.132	96.42	103.05	0.809
			2	90	0.305	0.429	0.0067	0.0267	0.367	0.007	1.464	0.109	0.151	0.152	depress	0.009	0.132	30.88		
	JN14021	7/18/89	2	90	0.610	0.091	0.0052	0.0052	0.596	0.018	0.662	0.022	0.074	0.068	depress	0.000	0.000	35.83	4.61	0.129
	JN14022	7/18/89	2	90	0.610	0.112	0.0068	0.0068	0.649	0.021	0.655	0.022	0.085	0.084	depress	0.000	0.000	47.71	7.08	0.149
	JN14023	7/18/89	2	90	0.610	0.130	0.0088	0.0092	0.742	0.028	0.733	0.027	0.094	0.099	depress	0.000	0.000	62.98	11.47	0.182
	JN14024	7/18/89	2	90	0.610	0.265	0.0150	0.0153	0.899	0.041	0.841	0.036	0.130	0.152	depress	0.000	0.034	114.52	33.45	0.292
	JN14025	7/18/89	2	90	0.610	0.392	0.0185	0.0185	1.105	0.062	1.017	0.053	0.132	0.152	depress	0.000	0.116	146.17	58.36	0.400
	JN13121	7/20/89	3	180	0.000	0.102	0.0014	0.0055	0.099	0.000	0.593	0.018	0.107	0.077	depress	0.000	0.000	1.44	5.08	0.173
			2	90	0.610	0.102	0.0041	0.0055	0.496	0.013	0.593	0.018	0.071	0.077	depress	0.000	0.000	27.89		
	JN13122	7/20/89	3	180	0.000	0.127	0.0024	0.0093	0.141	0.001	0.770	0.030	0.133	0.096	depress	0.000	0.000	3.12	11.53	0.222
			2	90	0.610	0.127	0.0069	0.0093	0.745	0.028	0.770	0.030	0.077	0.096	depress	0.000	0.000	48.65		
	JN13123	7/20/89	3	180	0.000	0.160	0.0030	0.0118	0.163	0.001	0.785	0.031	0.152	0.117	depress	0.008	0.000	4.70	17.19	0.252
			2	90	0.610	0.160	0.0088	0.0118	0.714	0.026	0.785	0.031	0.098	0.117	depress	0.000	0.000	63.53		
	JN13124	7/20/89	3	180	0.000	0.244	0.0038	0.0160	0.210	0.002	0.877	0.039	0.152	0.152	depress	0.101	0.019	9.58	32.97	0.355
			2	90	0.610	0.244	0.0113	0.0160	0.799	0.033	0.877	0.039	0.110	0.152	depress	0.000	0.019	83.35		
	JN13125	7/19/89	3	180	0.000	0.381	0.0064	0.0250	0.351	0.006	1.372	0.096	0.152	0.152	depress	0.225	0.112	24.07	12.20	0.517
			2	90	0.610	0.381	0.0186	0.0250	1.108	0.063	1.372	0.096	0.132	0.152	depress	0.000	0.112	146.95		
	JN12221	7/21/89	3	180	0.000	0.108	0.0028	0.0056	0.197	0.002	0.563	0.016	0.112	0.081	depress	0.000	0.000	3.17	5.33	0.250
			2	90	0.610	0.108	0.0027	0.0056	0.472	0.011	0.563	0.016	0.054	0.081	depress	0.000	0.000	18.18		
	JN12222	7/21/89	3	180	0.000	0.120	0.0041	0.0082	0.253	0.003	0.721	0.026	0.127	0.091	depress	0.000	0.000	5.24	9.53	0.207
			2	90	0.610	0.120	0.0041	0.0082	0.587	0.018	0.721	0.026	0.062	0.091	depress	0.000	0.000	27.95		
	JN12223	7/21/89	3	180	0.000	0.160	0.0074	0.0148	0.407	0.008	0.988	0.050	0.152	0.117	depress	0.013	0.000	12.63	24.17	0.373
			2	90	0.610	0.160	0.0074	0.0148	0.794	0.032	0.988	0.050	0.077	0.117	depress	0.000	0.000	52.11		
	JN12224	7/21/89	3	180	0.000	0.238	0.0087	0.0173	0.478	0.012	0.956	0.047	0.152	0.148	depress	0.080	0.001	20.86	33.19	0.405
			2	90	0.610	0.238	0.0086	0.0173	0.748	0.029	0.956	0.047	0.092	0.148	depress	0.000	0.001	61.39		
	JN12225	7/19/89	3	180	0.000	0.401	0.0167	0.0331	0.917	0.043	1.813	0.167	0.152	0.152	depress	0.250	0.115	73.05	140.94	0.707
			2	90	0.610	0.401	0.0163	0.0331	1.249	0.080	1.813	0.167	0.103	0.152	depress	0.000	0.115	126.85		
	JN11321	7/24/89	3	180	0.000	0.098	0.0040	0.0052	0.307	0.005	0.571	0.017	0.102	0.076	depress	0.000	0.000	4.19	4.74	0.371
			2	90	0.610	0.098	0.0013	0.0052	0.276	0.004	0.571	0.017	0.047	0.076	depress	0.000	0.000	8.62		
	JN11322	7/24/89	3	180	0.000	0.120	0.0055	0.0073	0.344	0.006	0.617	0.019	0.124	0.094	depress	0.000	0.000	6.95	8.19	0.428
			2	90	0.610	0.120	0.0019	0.0073	0.385	0.008	0.617	0.019	0.048	0.094	depress	0.000	0.000	12.18		
	JN11323	7/24/89	3	180	0.000	0.163	0.0102	0.0136	0.560	0.016	0.875	0.039	0.152	0.121	depress	0.016	0.000	18.50	21.41	0.525
			2	90	0.610	0.163	0.0033	0.0136	0.533	0.014	0.875	0.039	0.057	0.121	depress	0.000	0.000	22.32		
	JN11324	7/24/89	3	180	0.000	0.252	0.0131	0.0175	0.719	0.026	0.961	0.047	0.152	0.152	depress	0.105	0.007	36.45	35.54	0.534
			2	90	0.610	0.252	0.0044	0.0175	0.558	0.016	0.961	0.047	0.068	0.152	depress	0.000	0.007	30.04		
	JN11325	7/19/89	3	180	0.000	0.391	0.0181	0.0249	0.993	0.050	1.365	0.095	0.152	0.152	depress	0.251	0.104	80.64	85.80	0.706
			2	90	0.610	0.391	0.0059	0.0249	0.649	0.021	1.365	0.095	0.076	0.152	depress	0.000	0.104	41.04		

MATRIX 5

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	JM10411	8/ 3/89	3	180	0.000	0.091	0.0050	0.0050	0.418	0.009	0.602	0.018	0.095	0.071	depress	0.000	0.000	5.07	4.36	0.860
	JM10412	8/ 3/89	3	180	0.000	0.116	0.0077	0.0077	0.500	0.013	0.717	0.026	0.120	0.087	depress	0.000	0.000	10.03	8.54	0.851
	JM10413	8/ 3/89	3	180	0.000	0.135	0.0112	0.0112	0.636	0.021	0.831	0.035	0.141	0.105	depress	0.000	0.000	17.67	15.42	0.873
	JM10414	8/ 3/89	3	180	0.000	0.269	0.0227	0.0227	1.242	0.079	1.242	0.079	0.152	0.152	depress	0.122	0.047	78.32	61.81	0.789
	JM14011	8/11/89	2	135	0.000	0.088	0.0045	0.0045	0.398	0.008	0.503	0.013	0.090	0.075	depress	0.000	0.000	4.31	3.84	0.891
	JM14012	8/11/89	2	135	0.000	0.112	0.0066	0.0066	0.453	0.010	0.564	0.016	0.113	0.093	depress	0.000	0.000	8.01	7.08	0.884
	JM14013	8/11/89	2	135	0.000	0.135	0.0095	0.0095	0.549	0.015	0.696	0.025	0.137	0.107	depress	0.000	0.000	14.18	12.22	0.861
	JM14014	8/11/89	2	135	0.000	0.221	0.0176	0.0176	0.967	0.048	1.147	0.067	0.152	0.120	depress	0.061	0.002	45.15	32.64	0.723
	JM14015	8/22/89	2	135	0.000	0.393	0.0247	0.0247	1.352	0.093	1.352	0.093	0.152	0.152	depress	0.251	0.105	120.20	84.89	0.706
	JM13111	8/15/89	3	180	0.000	0.074	0.0007	0.0027	0.073	0.000	0.385	0.008	0.075	0.062	depress	0.000	0.000	0.48	1.84	0.908
			2	135	0.000	0.074	0.0020	0.0027	0.229	0.003	0.385	0.008	0.075	0.062	depress	0.000	0.000	1.55	0.00	
	JM13112	8/15/89	3	180	0.000	0.097	0.0015	0.0061	0.121	0.001	0.611	0.019	0.099	0.082	depress	0.000	0.000	1.50	6.01	0.967
			2	135	0.000	0.097	0.0046	0.0061	0.365	0.007	0.611	0.019	0.099	0.082	depress	0.000	0.000	4.72	0.00	
	JM13113	8/15/89	3	180	0.000	0.134	0.0029	0.0114	0.168	0.001	0.841	0.036	0.134	0.106	depress	0.000	0.000	3.81	15.98	0.981
			2	135	0.000	0.134	0.0086	0.0114	0.497	0.013	0.841	0.036	0.136	0.106	depress	0.000	0.000	12.48	0.00	
	JM13114	8/15/89	3	180	0.000	0.265	0.0052	0.0205	0.283	0.004	1.144	0.067	0.152	0.145	depress	0.113	0.000	13.63	42.70	0.732
			2	135	0.000	0.265	0.0154	0.0205	0.843	0.036	1.144	0.067	0.152	0.145	depress	0.108	0.000	44.70	0.00	
	JM13115	8/15/89	3	180	0.000	0.379	0.0059	0.0232	0.321	0.005	1.273	0.083	0.152	0.152	depress	0.229	0.000	22.20	53.50	0.578
			2	135	0.000	0.379	0.0174	0.0232	0.952	0.046	1.273	0.083	0.152	0.152	depress	0.215	0.000	70.36	0.00	
1	JM12211	8/16/89	3	180	0.000	0.062	0.0014	0.0027	0.206	0.002	0.475	0.012	0.061	0.052	depress	0.000	0.000	0.88	1.71	0.999
			2	135	0.000	0.062	0.0014	0.0027	0.201	0.002	0.475	0.012	0.061	0.052	depress	0.000	0.000	0.84	0.00	
	JM12212	8/16/89	3	180	0.000	0.112	0.0037	0.0073	0.257	0.003	0.624	0.020	0.111	0.093	depress	0.000	0.000	4.09	8.10	0.986
			2	135	0.000	0.112	0.0037	0.0073	0.259	0.003	0.624	0.020	0.111	0.093	depress	0.000	0.000	4.13	0.00	
1	JM12213	8/17/89	3	180	0.000	0.219	0.0076	0.0152	0.418	0.009	0.969	0.048	0.151	0.112	depress	0.000	0.000	11.93	23.86	0.998
			2	135	0.000	0.219	0.0076	0.0152	0.416	0.009	0.969	0.048	0.152	0.112	depress	0.000	0.000	11.97	0.00	
	JM12214	8/17/89	3	180	0.000	0.248	0.0100	0.0199	0.546	0.015	1.144	0.067	0.152	0.138	depress	0.100	0.000	26.12	40.09	0.775
			2	135	0.000	0.248	0.0099	0.0199	0.545	0.015	1.144	0.067	0.152	0.138	depress	0.095	0.000	25.62	0.00	
	JM12215	8/17/89	3	180	0.000	0.395	0.0129	0.0258	0.708	0.026	1.416	0.102	0.152	0.152	depress	0.247	0.100	53.78	89.85	0.838
			2	135	0.000	0.395	0.0129	0.0258	0.708	0.026	1.416	0.102	0.152	0.152	depress	0.244	0.100	53.39	0.00	
	JM11311	8/18/89	3	180	0.000	0.080	0.0025	0.0033	0.253	0.003	0.408	0.008	0.081	0.069	depress	0.000	0.000	2.06	2.50	0.933
			2	135	0.000	0.080	0.0008	0.0033	0.082	0.000	0.408	0.008	0.080	0.069	depress	0.000	0.000	0.62	0.00	
	JM11312	8/18/89	3	180	0.000	0.111	0.0046	0.0062	0.319	0.005	0.505	0.013	0.113	0.098	depress	0.000	0.000	5.40	6.75	0.948
			2	135	0.000	0.111	0.0016	0.0062	0.112	0.001	0.505	0.013	0.110	0.098	depress	0.000	0.000	1.73	0.00	
	JM11313	8/18/89	3	180	0.000	0.144	0.0090	0.0120	0.505	0.013	0.837	0.036	0.145	0.112	depress	0.000	0.000	13.97	17.30	0.956
			2	135	0.000	0.144	0.0029	0.0120	0.167	0.001	0.837	0.036	0.141	0.112	depress	0.000	0.000	4.12	0.00	
	JM11314	8/22/89	3	180	0.000	0.247	0.0154	0.0206	0.843	0.036	1.131	0.065	0.152	0.152	depress	0.105	0.002	44.19	44.34	0.777
			2	135	0.000	0.247	0.0052	0.0206	0.287	0.004	1.131	0.065	0.152	0.152	depress	0.094	0.002	12.85	0.00	
	JM11315	8/22/89	3	180	0.000	0.456	0.0190	0.0255	1.040	0.055	1.399	0.100	0.152	0.152	depress	0.315	0.161	97.17	103.40	0.815
			2	135	0.000	0.456	0.0065	0.0255	0.359	0.007	1.399	0.100	0.152	0.152	depress	0.305	0.161	29.74	0.00	
	JM14021	8/28/89	2	135	0.305	0.073	0.0023	0.0023	0.388	0.008	0.346	0.006	0.055	0.060	depress	0.000	0.000	8.26	1.48	0.179
	JM14022	8/28/89	2	135	0.305	0.104	0.0045	0.0045	0.520	0.014	0.442	0.010	0.073	0.083	depress	0.000	0.000	17.29	4.11	0.238
	JM14023	8/28/89	2	135	0.305	0.156	0.0100	0.0100	0.769	0.030	0.701	0.025	0.102	0.111	depress	0.000	0.000	42.83	13.36	0.312
	JM14024	8/23/89	2	135	0.305	0.261	0.0175	0.0175	1.092	0.061	0.961	0.047	0.125	0.152	depress	0.000	0.030	84.36	39.47	0.468
	JM14025	8/23/89	2	135	0.305	0.370	0.0234	0.0234	1.336	0.091	1.284	0.084	0.140	0.152	depress	0.000	0.057	122.98	67.37	0.548
	JM13121	8/24/89	3	180	0.000	0.072	0.0008	0.0035	0.098	0.000	0.528	0.014	0.073	0.059	depress	0.000	0.000	0.61	2.48	0.249
			2	135	0.305	0.072	0.0026	0.0035	0.541	0.015	0.528	0.014	0.047	0.059	depress	0.000	0.000	9.37	0.00	
	JM13122	8/24/89	3	180	0.000	0.113	0.0015	0.0058	0.101	0.001	0.517	0.014	0.115	0.091	depress	0.000	0.000	1.70	5.96	0.327
			2	135	0.305	0.113	0.0043	0.0058	0.551	0.015	0.517	0.014	0.068	0.091	depress	0.000	0.000	16.49	0.00	
	JM13123	8/24/89	3	180	0.000	0.135	0.0022	0.0087	0.126	0.001	0.660	0.022	0.138	0.103	depress	0.000	0.000	2.96	10.64	0.368
			2	135	0.305	0.135	0.0065	0.0087	0.661	0.022	0.660	0.022	0.081	0.103	depress	0.000	0.000	25.93	0.00	
	JM13124	8/24/89	3	180	0.000	0.256	0.0045	0.0177	0.247	0.003	0.970	0.048	0.152	0.151	depress	0.099	0.005	11.24	35.40	0.498
			2	135	0.305	0.256	0.0132	0.0177	0.834	0.035	0.970	0.048	0.123	0.151	depress	0.000	0.005	59.82	0.00	
	JM13125	8/28/89	3	180	0.000	0.328	0.0053	0.0212	0.289	0.004	1.160	0.069	0.152	0.152	depress	0.176	0.036	17.17	53.35	0.579
			2	135	0.305	0.328	0.0159	0.0212	0.948	0.046	1.160	0.069	0.131	0.152	depress	0.000	0.036	74.94	0.00	
	JM12221	8/25/89	3	180	0.000	0.094	0.0020	0.0039	0.157	0.001	0.418	0.009	0.098	0.078	depress	0.000	0.000	1.90	3.32	0.377
			2	135	0.305	0.094	0.0020	0.0039	0.402	0.008	0.418	0.009	0.048	0.078	depress	0.000	0.000	6.91	0.00	
	JM12222	8/25/89	3	180	0.000	0.116	0.0030	0.0061	0.197	0.002	0.473	0.011	0.120	0.101	depress	0.000	0.000	3.62	6.72	0.453
			2	135	0.305	0.116	0.0031	0.0061	0.495	0.012	0.473	0.011	0.057	0.101	depress	0.000	0.000	11.21	0.00	
	JM12223	8/25/89	3	180	0.000	0.256	0.0052	0.0104	0.287	0.004	0.739	0.028	0.152	0.110	depress	0.101	0.000	13.24	14.02	0.422
			2	135	0.305	0.256	0.0052	0.0104	0.612	0.019	0.739	0.028	0.072	0.110	depress	0.000	0.000	19.98	0.00	
	JM12224	8/25/89	3	180	0.000	0.258	0.0092	0.0187	0.506	0.013	1.036	0.055	0.152	0.148	depress	0.110	0.002	24.90	37.56	0.575
			2	135	0.305	0.258	0.0095	0.0187	0.725	0.027	1.036	0.055	0.103	0.148	depress	0.000	0.002	40.39	0.00	
	JM12225	8/28/89	3	180	0.000	0.395	0.0113	0.0229	0.621	0.020	1.257	0.081	0.152	0.152	depress	0.238	0.084	45.51	71.18	0.730
			2	135	0.305	0.395	0.0116	0.0229	0.725	0.027	1.257	0.081	0.125	0.152	depress	0.000	0.084	51.97	0.00	
	JM11321	8/29/89	3	180	0.000	0.090	0.0042	0.0056	0.372	0.007	0.582	0.017	0.091	0.080	depress	0.000	0.000	4.10	5.32	0.567
			2	135	0.305	0.090	0.0014	0.0056	1.213	0.075	0.582	0.017	0.017	0.080	depress	0.000	0.000	5.29	0.00	
	JM11322	8/29/89	3	180	0.000	0.120	0.0048	0.0064	0.301	0.005	0.517	0.014	0.123	0.098	depress	0.000	0.000	5.97	6.94	0.598
			2	135	0.305	0.120	0.0016	0.0064	0.361	0.007	0.517	0.014	0.045	0.098	depress	0.000	0.000	5.64	0.00	
	JM11323	8/29/89	3	180	0.000	0.145	0.0074	0.0100	0.410	0.009	0.711	0.026	0.149	0.109	depress	0.000	0.000	11.53	13.21	0.641
			2	135	0.305	0.145	0.0025	0.0100	0.443	0.010	0.711	0.026	0.053	0.109	depress	0.000	0.000	9.10	0.00	
	JM11324	8/23/89	3	180	0.000	0.255	0.0177	0.0238	0.972	0.048	1.302	0.086	0.152	0.152	depress	0.108	0.012	53.66	58.41	0.755
			2	135	0.305	0.255	0.0060	0.0238	0.800	0.033	1.302	0.086	0.066	0.152	depress	0.000	0.012	23.72	0.00	
	JM11325	8/23/89	3	180	0.000	0.416	0.0211	0.0281	1.156	0.068	1.538	0.121	0.152	0.152	depress	0.274	0.135	102.36	112.28	0.839
			2	135	0.305	0.416	0.0069	0.0281	0.382	0.007	1.538	0.121	0.149	0.152	depress	0.000	0.135	31.40	0.00	
	JM14031	8/ 4/89	2	135	0.610	0.061	0.0025	0.0025	0.447	0.010	0.540	0.015	0.052	0.045	depress	0.000	0.000	16.23	1.46	0.090
	JM14032	8/ 4/89	2	135	0.610	0.107	0.0054	0.0054	0.564	0.016	0.618	0.019	0.080	0.074	depress	0.000	0.000	37.60	4.99	0.133

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	JM14033	8/ 4/89	2	135	0.610	0.131	0.0082	0.0082	0.686	0.024	0.863	0.038	0.094	0.078	depress	0.000	0.000	58.21	9.30	0.160
	JM14034	8/ 4/89	2	135	0.610	0.216	0.0133	0.0133	0.853	0.037	0.749	0.029	0.122	0.144	depress	0.000	0.005	100.49	23.19	0.231
	JM14035	8/ 4/89	2	135	0.610	0.371	0.0172	0.0172	1.053	0.056	0.944	0.045	0.128	0.152	depress	0.000	0.107	134.03	51.40	0.383
	JM13131	8/ 9/89	3	180	0.000	0.087	0.0009	0.0037	0.083	0.000	0.424	0.009	0.090	0.073	depress	0.000	0.000	0.83	2.94	0.156
			2	135	0.610	0.087	0.0027	0.0037	0.443	0.010	0.424	0.009	0.056	0.073	depress	0.000	0.000	18.02	0.00	
	JM13132	8/ 9/89	3	180	0.000	0.105	0.0015	0.0059	0.106	0.001	0.534	0.015	0.110	0.088	depress	0.000	0.000	1.63	5.92	0.189
			2	135	0.610	0.105	0.0044	0.0059	0.574	0.017	0.534	0.015	0.066	0.088	depress	0.000	0.000	29.61	0.00	
	JM13133	8/ 9/89	3	180	0.000	0.134	0.0020	0.0080	0.110	0.001	0.589	0.018	0.144	0.106	depress	0.000	0.000	2.77	9.63	0.216
			2	135	0.610	0.134	0.0060	0.0080	0.597	0.018	0.589	0.018	0.082	0.106	depress	0.000	0.000	41.79	0.00	
	JM13134	8/ 9/89	3	180	0.000	0.255	0.0037	0.0148	0.202	0.002	0.813	0.034	0.152	0.152	depress	0.122	0.034	9.97	32.09	0.349
			2	135	0.610	0.255	0.0111	0.0148	0.791	0.032	0.813	0.034	0.110	0.152	depress	0.000	0.034	81.96	0.00	
	JM13135	8/ 9/89	3	180	0.000	0.401	0.0048	0.0192	0.262	0.004	1.052	0.056	0.152	0.152	depress	0.258	0.136	19.43	64.90	0.503
			2	135	0.610	0.401	0.0144	0.0192	0.900	0.041	1.052	0.056	0.125	0.152	depress	0.000	0.136	109.64	0.00	
	JM12231	8/ 7/89	3	180	0.000	0.109	0.0015	0.0030	0.105	0.001	0.273	0.004	0.112	0.089	depress	0.000	0.000	1.65	2.77	0.238
			2	135	0.610	0.109	0.0015	0.0030	0.280	0.004	0.273	0.004	0.052	0.089	depress	0.000	0.000	9.97	0.00	
	JM12232	8/ 7/89	3	180	0.000	0.137	0.0032	0.0064	0.182	0.002	0.456	0.011	0.140	0.109	depress	0.000	0.000	4.45	7.48	0.294
			2	135	0.610	0.137	0.0031	0.0064	0.461	0.011	0.456	0.011	0.061	0.109	depress	0.000	0.000	21.00	0.00	
	JM12233	8/ 7/89	3	180	0.000	0.149	0.0044	0.0088	0.243	0.003	0.615	0.019	0.151	0.111	depress	0.000	0.000	6.66	11.24	0.310
			2	135	0.610	0.149	0.0044	0.0088	0.578	0.017	0.615	0.019	0.066	0.111	depress	0.000	0.000	29.60	0.00	
	JM12234	8/ 7/89	3	180	0.000	0.271	0.0078	0.0158	0.430	0.009	0.865	0.038	0.152	0.152	depress	0.139	0.036	23.11	35.02	0.441
			2	135	0.610	0.271	0.0079	0.0158	0.708	0.026	0.865	0.038	0.090	0.152	depress	0.000	0.036	56.36	0.00	
	JM12235	8/ 7/89	3	180	0.000	0.450	0.0110	0.0223	0.604	0.019	1.220	0.076	0.152	0.152	depress	0.305	0.143	51.38	81.01	0.604
			2	135	0.610	0.450	0.0112	0.0223	0.824	0.035	1.220	0.076	0.107	0.152	depress	0.000	0.143	82.76	0.00	
	JM11331	8/10/89	3	180	0.000	0.089	0.0031	0.0042	0.268	0.004	0.451	0.010	0.094	0.078	depress	0.000	0.000	3.00	3.64	0.370
			2	135	0.610	0.089	0.0011	0.0042	0.348	0.006	0.451	0.010	0.034	0.078	depress	0.000	0.000	6.86	0.00	
	JM11332	8/10/89	3	180	0.000	0.104	0.0040	0.0054	0.293	0.004	0.491	0.012	0.108	0.089	depress	0.000	0.000	4.46	5.35	0.406
			2	135	0.610	0.104	0.0014	0.0054	0.390	0.008	0.491	0.012	0.037	0.089	depress	0.000	0.000	8.73	0.00	
	JM11333	8/10/89	3	180	0.000	0.141	0.0071	0.0095	0.391	0.008	0.657	0.022	0.147	0.112	depress	0.000	0.000	10.69	12.44	0.469
			2	135	0.610	0.141	0.0024	0.0095	0.430	0.009	0.657	0.022	0.053	0.112	depress	0.000	0.000	15.85	0.00	
	JM11334	8/10/89	3	180	0.000	0.294	0.0135	0.0180	0.740	0.028	0.987	0.050	0.152	0.152	depress	0.152	0.054	44.06	45.21	0.605
			2	135	0.610	0.294	0.0045	0.0180	0.540	0.015	0.987	0.050	0.071	0.152	depress	0.000	0.054	30.70	0.00	
	JM11335	8/10/89	3	180	0.000	0.375	0.0152	0.0201	0.834	0.035	1.104	0.062	0.152	0.152	depress	0.219	0.089	60.72	59.85	0.633
			2	135	0.610	0.375	0.0049	0.0201	0.566	0.016	1.104	0.062	0.073	0.152	depress	0.000	0.089	33.78	0.00	

MATRIX 6

Variable definitions:

- Di = diameter of the inflow pipe
- Do = diameter of the outflow pipe
- b = manhole diameter
- Theta = angle between inflow pipe and outflow pipo
- Zi = invert of inflow pipe
- Zo = invert of outlet pipe
- d = manhole water depth
- Qi = inflow pipe discharge
- Qo = outflow pipe discharge
- Vi = average velocity in tho inflow pipe
- Vo = average velocity in the outflow pipe
- di = avg water depth in inlet pipo
- do = avg water depth in outlet pipe
- Pi = pressure in the inflow pipe
- Po = pressure in the outflow pipe
- PWRi = power into manhole
- PWRo = power out of manhole
- EFF = PWRo / sum(PWRi)

MH shape = round
Di (m) 0.152
Do (m) 0.152
b (m) 0.305
Zo (m) 0.000 = Datum

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
1	J331111RE	3/13/90	2	180	0.000	0.065	0.0029	0.0039	0.347	0.006	0.902	0.041	0.071	0.034	Level	0.000	0.000	2.18	2.87	0.999
			3	90	0.000	0.065	0.0007	0.0039	0.089	0.000	0.902	0.041	0.070	0.034	Level	0.000	0.000	0.51		
			4	90	0.000	0.065	0.0003	0.0039	0.032	0.000	0.902	0.041	0.069	0.034	Lovel	0.000	0.000	0.17		
1	J331112RE	3/13/90	2	180	0.000	0.141	0.0103	0.0138	0.572	0.017	1.305	0.087	0.148	0.073	Level	0.000	0.000	16.67	21.54	0.998
			3	90	0.000	0.141	0.0026	0.0138	0.143	0.001	1.305	0.087	0.146	0.073	Level	0.000	0.000	3.71		
			4	90	0.000	0.141	0.0008	0.0138	0.048	0.000	1.305	0.087	0.144	0.073	Level	0.000	0.000	1.20		
	J331113RE	3/19/90	2	180	0.000	0.385	0.0218	0.0291	1.195	0.073	1.594	0.129	0.152	0.152	Level	0.243	0.148	100.14	122.73	0.957
			3	90	0.000	0.385	0.0054	0.0291	0.298	0.005	1.594	0.129	0.152	0.152	Level	0.240	0.148	21.17		
			4	90	0.000	0.385	0.0018	0.0291	0.101	0.001	1.594	0.129	0.152	0.152	Level	0.230	0.148	6.91		
1	J222112	3/29/90	2	180	0.000	0.145	0.0065	0.0129	0.359	0.007	1.305	0.087	0.152	0.069	Level	0.001	0.000	10.23	19.63	0.997
			3	90	0.000	0.145	0.0032	0.0129	0.176	0.002	1.305	0.087	0.151	0.069	Level	0.000	0.000	4.78		
			4	90	0.000	0.145	0.0031	0.0129	0.173	0.002	1.305	0.087	0.150	0.069	Level	0.000	0.000	4.67		
	J222113	3/23/90	2	180	0.000	0.455	0.0146	0.0291	0.799	0.033	1.597	0.130	0.152	0.152	Level	0.297	0.151	68.98	123.98	0.925
			3	90	0.000	0.455	0.0073	0.0291	0.399	0.008	1.597	0.130	0.152	0.152	Level	0.296	0.151	32.57		
			4	90	0.000	0.455	0.0073	0.0291	0.399	0.008	1.597	0.130	0.152	0.152	Level	0.296	0.151	32.55		
1	J213112	3/22/90	2	180	0.000	0.148	0.0065	0.0124	0.355	0.006	1.259	0.081	0.150	0.073	Level	0.000	0.000	9.92	18.76	0.998
			3	90	0.000	0.148	0.0016	0.0124	0.090	0.000	1.259	0.081	0.152	0.073	Lovel	0.006	0.000	2.56		
			4	90	0.000	0.148	0.0043	0.0124	0.239	0.003	1.259	0.081	0.147	0.073	Level	0.000	0.000	6.32		
	J213113	3/22/90	2	180	0.000	0.451	0.0142	0.0281	0.777	0.031	1.543	0.121	0.152	0.152	Level	0.301	0.153	67.25	117.78	0.910
			3	90	0.000	0.451	0.0035	0.0281	0.191	0.002	1.543	0.121	0.152	0.152	Lovel	0.305	0.153	15.70		
			4	90	0.000	0.451	0.0104	0.0281	0.568	0.016	1.543	0.121	0.152	0.152	Level	0.289	0.153	46.52		
1	J231111	3/23/90	2	180	0.000	0.081	0.0027	0.0053	0.249	0.003	0.939	0.045	0.087	0.045	Lovel	0.000	0.000	2.34	4.62	0.999
			3	90	0.000	0.081	0.0020	0.0053	0.183	0.002	0.939	0.045	0.088	0.045	Level	0.000	0.000	1.78		
			4	90	0.000	0.081	0.0006	0.0053	0.062	0.000	0.939	0.045	0.082	0.045	Level	0.000	0.000	0.50		
1	J231112	3/28/90	2	180	0.000	0.144	0.0061	0.0122	0.338	0.006	1.253	0.080	0.149	0.073	Lovel	0.000	0.000	9.35	18.37	0.999
			3	90	0.000	0.144	0.0046	0.0122	0.254	0.003	1.253	0.080	0.151	0.073	Level	0.000	0.000	6.96		
			4	90	0.000	0.144	0.0015	0.0122	0.083	0.000	1.253	0.080	0.143	0.073	Lovel	0.000	0.000	2.07		
	J231113	3/14/90	2	180	0.000	0.363	0.0142	0.0283	0.776	0.031	1.551	0.123	0.152	0.152	Level	0.225	0.091	56.68	101.55	0.925
			3	90	0.000	0.363	0.0106	0.0283	0.582	0.017	1.551	0.123	0.152	0.152	Level	0.219	0.091	40.48		
			4	90	0.000	0.363	0.0035	0.0283	0.192	0.002	1.551	0.123	0.152	0.152	Level	0.212	0.091	12.59		
1	J322111	3/23/90	2	180	0.000	0.068	0.0027	0.0037	0.287	0.004	0.887	0.040	0.079	0.041	Level	0.000	0.000	2.25	2.92	0.997
			3	90	0.000	0.068	0.0005	0.0037	0.047	0.000	0.887	0.040	0.080	0.041	Level	0.000	0.000	0.35		
			4	90	0.000	0.068	0.0005	0.0037	0.052	0.000	0.887	0.040	0.074	0.041	Level	0.000	0.000	0.33		
1	J322112	4/ 2/90	2	180	0.000	0.242	0.0109	0.0146	0.604	0.019	1.344	0.092	0.148	0.068	Level	0.000	0.000	17.84	22.98	0.998
			3	90	0.000	0.242	0.0018	0.0146	0.102	0.001	1.344	0.092	0.148	0.068	Level	0.000	0.000	2.67		
			4	90	0.000	0.242	0.0018	0.0146	0.103	0.001	1.344	0.092	0.141	0.068	Level	0.000	0.000	2.52		
	J322113	3/27/90	2	180	0.000	0.389	0.0238	0.0313	1.304	0.087	1.718	0.150	0.152	0.152	Level	0.249	0.161	113.90	142.57	0.997
			3	90	0.000	0.389	0.0038	0.0313	0.210	0.002	1.718	0.150	0.152	0.152	Level	0.238	0.161	14.73		
			4	90	0.000	0.389	0.0037	0.0313	0.205	0.002	1.718	0.150	0.152	0.152	Level	0.237	0.161	14.35		
	J313113	3/27/90	2	180	0.000	0.444	0.0223	0.0297	1.223	0.076	1.630	0.135	0.152	0.152	Lovel	0.305	0.192	116.84	139.89	0.934
			3	90	0.000	0.444	0.0018	0.0297	0.101	0.001	1.630	0.135	0.152	0.152	Level	0.302	0.192	8.20		
			4	90	0.000	0.444	0.0056	0.0297	0.306	0.005	1.630	0.135	0.152	0.152	Level	0.296	0.192	24.80		
1	J131111	3/29/90	2	180	0.000	0.076	0.0012	0.0047	0.128	0.001	0.933	0.044	0.080	0.038	Level	0.000	0.000	0.99	3.79	0.998
			3	90	0.000	0.076	0.0026	0.0047	0.264	0.004	0.933	0.044	0.080	0.038	Level	0.000	0.000	2.12		
			4	90	0.000	0.076	0.0009	0.0047	0.092	0.000	0.933	0.044	0.079	0.038	Level	0.000	0.000	0.68		
1	J131112	3/30/90	2	180	0.000	0.151	0.0035	0.0139	0.191	0.002	1.372	0.096	0.152	0.064	Lovel	0.002	0.000	5.35	21.76	0.999
			3	90	0.000	0.151	0.0080	0.0139	0.438	0.010	1.372	0.096	0.152	0.064	Level	0.002	0.000	12.84		
			4	90	0.000	0.151	0.0024	0.0139	0.132	0.001	1.372	0.096	0.151	0.064	Level	0.000	0.000	3.59		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
1	J131113	3/30/90	2	180	0.000	0.376	0.0072	0.0282	0.393	0.008	0.415	0.009	0.152	0.152	Level	0.238	0.250	27.95	113.75	0.999
			3	90	0.000	0.376	0.0157	0.0282	0.863	0.038	0.415	0.009	0.152	0.152	Level	0.235	0.250	65.61		
			4	90	0.000	0.376	0.0053	0.0282	0.290	0.004	0.415	0.009	0.152	0.152	Level	0.233	0.250	20.25		
1	J122111	4/ 2/90	2	180	0.000	0.184	0.0012	0.0052	0.122	0.001	0.951	0.046	0.084	0.039	Level	0.000	0.000	1.03	4.33	0.999
			3	90	0.000	0.184	0.0020	0.0052	0.187	0.002	0.951	0.046	0.086	0.039	Level	0.000	0.000	1.70		
			4	90	0.000	0.184	0.0020	0.0052	0.203	0.002	0.951	0.046	0.080	0.039	Level	0.000	0.000	1.60		
1	J122112	3/30/90	2	180	0.000	0.131	0.0027	0.0104	0.155	0.001	1.198	0.073	0.136	0.064	Level	0.000	0.000	3.59	14.05	0.997
			3	90	0.000	0.131	0.0040	0.0104	0.229	0.003	1.198	0.073	0.138	0.064	Level	0.000	0.000	5.46		
			4	90	0.000	0.131	0.0039	0.0104	0.231	0.003	1.198	0.073	0.131	0.064	Level	0.000	0.000	5.05		
	J122113	4/ 3/90	2	180	0.000	0.458	0.0074	0.0295	0.405	0.008	1.618	0.133	0.152	0.152	Level	0.308	0.150	33.95	126.15	0.911
			3	90	0.000	0.458	0.0111	0.0295	0.607	0.019	1.618	0.133	0.152	0.152	Level	0.318	0.150	53.09		
			4	90	0.000	0.458	0.0110	0.0295	0.605	0.019	1.618	0.133	0.152	0.152	Level	0.304	0.150	51.49		
	J113111	4/ 3/90	2	180	0.000	0.090	0.0009	0.0037	0.074	0.000	0.794	0.032	0.095	0.046	Level	0.000	0.000	0.82	2.79	0.832
			3	90	0.000	0.090	0.0006	0.0037	0.051	0.000	0.794	0.032	0.096	0.046	Level	0.000	0.000	0.59		
			4	90	0.000	0.090	0.0022	0.0037	0.191	0.002	0.794	0.032	0.090	0.046	Level	0.000	0.000	1.94		
1	J113112	4/ 3/90	2	180	0.000	0.144	0.0027	0.0110	0.150	0.001	1.241	0.078	0.149	0.069	Level	0.000	0.000	3.99	15.87	0.999
			3	90	0.000	0.144	0.0021	0.0110	0.113	0.001	1.241	0.078	0.152	0.069	Level	0.000	0.000	3.09		
			4	90	0.000	0.144	0.0060	0.0110	0.336	0.006	1.241	0.078	0.144	0.069	Level	0.000	0.000	8.80		
	J113113	4/ 4/90	2	180	0.000	0.439	0.0069	0.0277	0.380	0.007	1.517	0.117	0.152	0.152	Level	0.292	0.140	30.73	111.18	0.892
			3	90	0.000	0.439	0.0052	0.0277	0.283	0.004	1.517	0.117	0.152	0.152	Level	0.294	0.140	22.75		
			4	90	0.000	0.439	0.0155	0.0277	0.852	0.037	1.517	0.117	0.152	0.152	Level	0.277	0.140	71.14		
	J122232	8/ 8/90	2	180	0.000	0.325	0.0054	0.0217	0.298	0.005	1.810	0.167	0.152	0.095	Level	0.181	0.000	18.00	55.96	0.472
			3	90	0.305	0.325	0.0082	0.0217	0.447	0.010	1.810	0.167	0.152	0.095	Level	0.060	0.000	42.19		
			4	90	0.610	0.325	0.0082	0.0217	0.652	0.022	1.810	0.167	0.099	0.095	Level	0.000	0.000	58.37		
	J122232R	8/16/90	2	180	0.000	0.321	0.0057	0.0240	0.312	0.005	1.414	0.102	0.152	0.134	Level	0.182	0.001	18.93	55.45	0.410
			3	90	0.305	0.321	0.0092	0.0240	0.503	0.013	1.414	0.102	0.152	0.134	Level	0.091	0.001	50.51		
			4	90	0.610	0.321	0.0091	0.0240	0.724	0.027	1.414	0.102	0.099	0.134	Level	0.000	0.001	65.76		
	J122232RR	8/22/90	2	180	0.000	0.331	0.0060	0.0225	0.331	0.006	1.760	0.158	0.152	0.101	Level	0.176	0.000	19.74	57.00	0.470
			3	90	0.305	0.331	0.0083	0.0225	0.455	0.011	1.760	0.158	0.152	0.101	Level	0.062	0.000	43.05		
			4	90	0.610	0.331	0.0082	0.0225	0.647	0.021	1.760	0.158	0.099	0.101	Level	0.000	0.000	58.39		
	J31021	8/14/90	2	180	0.000	0.147	0.0105	0.0140	0.577	0.017	1.398	0.100	0.152	0.082	Level	0.011	0.000	18.66	25.05	0.790
			3	90	0.305	0.147	0.0035	0.0140	0.509	0.013	1.398	0.100	0.062	0.082	Level	0.000	0.000	13.07		
	J31022	8/14/90	2	180	0.000	0.278	0.0205	0.0274	1.241	0.079	1.732	0.153	0.129	0.123	Level	0.129	0.000	67.65	74.06	0.778
			3	90	0.305	0.278	0.0069	0.0274	0.722	0.027	1.732	0.153	0.079	0.123	Level	0.000	0.000	27.55		
	J22021	8/14/90	2	180	0.000	0.178	0.0076	0.0153	0.416	0.009	1.249	0.080	0.152	0.097	Level	0.037	0.000	14.78	26.46	0.577
			3	90	0.305	0.178	0.0076	0.0153	0.695	0.025	1.249	0.080	0.088	0.097	Level	0.000	0.000	31.06		
	J22022	8/14/90	2	180	0.000	0.335	0.0128	0.0257	0.702	0.025	1.582	0.127	0.152	0.127	Level	0.142	0.000	40.06	64.20	0.655
			3	90	0.305	0.335	0.0129	0.0257	0.916	0.043	1.582	0.127	0.110	0.127	Level	0.000	0.000	57.93		
	J22023	8/21/90	2	180	0.000	0.432	0.0166	0.0331	0.910	0.042	1.815	0.168	0.152	0.152	Level	0.281	0.002	77.32	104.45	0.664
			3	90	0.305	0.432	0.0167	0.0331	0.983	0.049	1.815	0.168	0.134	0.152	Level	0.000	0.002	79.95		
	J13021	8/24/90	2	180	0.000	0.264	0.0034	0.0134	0.186	0.002	1.306	0.087	0.152	0.084	Level	0.024	0.000	5.93	22.34	0.460
			3	90	0.305	0.264	0.0100	0.0134	0.797	0.032	1.306	0.087	0.099	0.084	Level	0.000	0.000	42.60		
	J13022	8/24/90	2	180	0.000	0.312	0.0059	0.0238	0.321	0.005	1.430	0.104	0.152	0.131	Level	0.141	0.000	17.17	54.87	0.527
			3	90	0.305	0.312	0.0180	0.0238	1.102	0.062	1.430	0.104	0.127	0.131	Level	0.000	0.000	86.97		
	J04021	8/29/90	3	90	0.305	0.225	0.0111	0.0111	0.838	0.036	1.332	0.090	0.104	0.071	Level	0.000	0.000	48.37	17.58	0.363
	J04022	9/ 4/90	3	90	0.305	0.339	0.0187	0.0187	1.131	0.065	1.277	0.083	0.130	0.114	Level	0.000	0.000	91.53	36.12	0.395
1	J22011	9/ 6/90	2	180	0.000	0.162	0.0080	0.0162	0.439	0.010	1.277	0.083	0.152	0.097	Level	0.017	0.000	14.06	28.65	0.999
			3	90	0.000	0.162	0.0082	0.0162	0.450	0.010	1.277	0.083	0.152	0.097	Level	0.019	0.000	14.62		
	J22012	9/ 6/90	2	180	0.000	0.285	0.0152	0.0302	0.832	0.035	1.900	0.184	0.152	0.124	Level	0.158	0.000	51.51	91.29	0.890
			3	90	0.000	0.285	0.0151	0.0302	0.826	0.035	1.900	0.184	0.152	0.124	Level	0.158	0.000	51.05		
1	J13011	9/ 7/90	2	180	0.000	0.158	0.0036	0.0133	0.199	0.002	1.350	0.093	0.152	0.078	Level	0.009	0.000	5.81	22.26	0.997
			3	90	0.000	0.158	0.0096	0.0133	0.526	0.014	1.350	0.093	0.152	0.078	Level	0.009	0.000	16.50		
	J13012	9/ 7/90	2	180	0.000	0.239	0.0065	0.0249	0.357	0.006	1.653	0.139	0.152	0.117	Level	0.103	0.000	16.70	62.72	0.873
			3	90	0.000	0.239	0.0184	0.0249	1.009	0.052	1.653	0.139	0.152	0.117	Level	0.101	0.000	55.13		
	J322131	9/10/90	2	180	0.000	0.182	0.0108	0.0142	0.590	0.018	1.465	0.109	0.152	0.080	Level	0.028	0.000	20.87	26.47	0.741
			3	90	0.000	0.182	0.0017	0.0142	0.092	0.000	1.465	0.109	0.152	0.080	Level	0.035	0.000	3.08		
			4	90	0.610	0.182	0.0018	0.0142	0.394	0.008	1.465	0.109	0.046	0.080	Level	0.000	0.000	11.78		
	J322132	9/11/90	2	180	0.000	0.261	0.0190	0.0251	1.040	0.055	1.611	0.132	0.152	0.121	Level	0.115	0.000	59.92	62.41	0.705
			3	90	0.000	0.261	0.0031	0.0251	0.172	0.002	1.611	0.132	0.152	0.121	Level	0.137	0.000	8.98		
			4	90	0.610	0.261	0.0029	0.0251	0.413	0.009	1.611	0.132	0.063	0.121	Level	0.000	0.000	19.67		
	J331211	9/13/90	2	180	0.000	0.162	0.0098	0.0132	0.536	0.015	1.304	0.087	0.152	0.083	Level	0.004	0.000	16.41	21.86	0.814
			3	90	0.305	0.162	0.0025	0.0132	0.438	0.010	1.304	0.087	0.053	0.083	Level	0.000	0.000	8.99		
			4	90	0.000	0.162	0.0009	0.0132	0.051	0.000	1.304	0.087	0.152	0.083	Level	0.006	0.000	1.45		
	J331211R	9/21/90	2	180	0.000	0.169	0.0096	0.0131	0.526	0.014	1.258	0.081	0.152	0.085	Level	0.009	0.000	16.56	21.27	0.778
			3	90	0.305	0.169	0.0025	0.0131	0.417	0.009	1.258	0.081	0.056	0.085	Level	0.000	0.000	9.13		
			4	90	0.000	0.169	0.0010	0.0131	0.054	0.000	1.258	0.081	0.152	0.085	Level	0.019	0.000	1.67		
	J331212	9/13/90	2	180	0.000	0.306	0.0195	0.0260	1.070	0.058	1.860	0.176	0.152	0.109	Level	0.123	0.000	63.92	72.77	0.834
			3	90	0.305	0.306	0.0049	0.0260	0.612	0.019	1.860	0.176	0.069	0.109	Level	0.000	0.000	18.86		
			4	90	0.000	0.306	0.0016	0.0260	0.087	0.000	1.860	0.176	0.152	0.109	Level	0.132	0.000	4.43		
	J331212R	9/21/90	2	180	0.000	0.298	0.0193	0.0263	1.059	0.057	1.903	0.184	0.152	0.108	Level	0.096	0.000	57.80	75.38	0.907
			3	90	0.305	0.298	0.0053	0.0263	0.563	0.016	1.903	0.184	0.078	0.108	Level	0.000	0.000	20.59		
			4	90	0.000	0.298	0.0017	0.0263	0.093	0.000	1.903	0.184	0.152	0.108	Level	0.131	0.000	4.73		
	J322211	9/18/90	2	180	0.000	0.172	0.0103	0.0138	0.562	0.016	1.315	0.088	0.152	0.085	Level	0.014	0.000	18.37	23.50	0.852
			3	90	0.305	0.172	0.0019	0.0138	0.395	0.008	1.315	0.088	0.047	0.085	Level	0.000	0.000	6.58		
			4	90	0.000	0.172	0.0017	0.0138	0.093	0.000	1.315	0.088	0.152	0.085	Level	0.005	0.000	2.63		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	J322212	9/18/90	2	180	0.000	0.294	0.0198	0.0267	1.085	0.060	1.772	0.160	0.152	0.117	Level	0.118	0.000	64.05	72.63	0.841
			3	90	0.305	0.294	0.0035	0.0267	0.486	0.012	1.772	0.160	0.064	0.117	Level	0.000	0.000	13.10		
			4	90	0.000	0.294	0.0034	0.0267	0.186	0.002	1.772	0.160	0.152	0.117	Level	0.122	0.000	9.19		
	J313211	9/18/90	2	180	0.000	0.177	0.0104	0.0139	0.568	0.016	1.349	0.093	0.152	0.084	Level	0.009	0.000	18.09	24.17	0.946
			3	90	0.305	0.177	0.0010	0.0139	0.280	0.004	1.349	0.093	0.039	0.084	Level	0.000	0.000	3.47		
			4	90	0.000	0.177	0.0025	0.0139	0.140	0.001	1.349	0.093	0.152	0.084	Level	0.007	0.000	4.00		
1	J313212	9/19/90	2	180	0.000	0.269	0.0191	0.0257	1.046	0.056	2.118	0.229	0.152	0.084	Level	0.114	0.000	60.23	78.74	0.99
			3	90	0.305	0.269	0.0016	0.0257	0.326	0.005	2.118	0.229	0.048	0.084	Level	0.000	0.000	5.56		
			4	90	0.000	0.269	0.0050	0.0257	0.276	0.004	2.118	0.229	0.152	0.084	Level	0.108	0.000	13.04		
	J313212R	9/20/90	2	180	0.000	0.258	0.0208	0.0279	1.143	0.067	1.795	0.164	0.152	0.121	Level	0.123	0.000	69.90	78.27	0.867
			3	90	0.305	0.258	0.0019	0.0279	0.342	0.006	1.795	0.164	0.052	0.121	Level	0.000	0.000	6.64		
			4	90	0.000	0.258	0.0052	0.0279	0.287	0.004	1.795	0.164	0.152	0.121	Level	0.110	0.000	13.71		
	J231211	9/24/90	2	180	0.000	0.164	0.0069	0.0134	0.379	0.007	1.367	0.095	0.152	0.081	Level	0.009	0.000	11.44	23.17	0.701
			3	90	0.305	0.164	0.0049	0.0134	0.566	0.016	1.367	0.095	0.073	0.081	Level	0.000	0.000	18.94		
			4	90	0.000	0.164	0.0016	0.0134	0.088	0.000	1.367	0.095	0.152	0.081	Level	0.016	0.000	2.68		
	J231212	9/25/90	2	180	0.000	0.326	0.0131	0.0260	0.717	0.026	1.610	0.132	0.152	0.126	Level	0.142	0.000	41.13	65.83	0.710
			3	90	0.305	0.326	0.0097	0.0260	0.738	0.028	1.610	0.132	0.103	0.126	Level	0.000	0.000	41.50		
			4	90	0.000	0.326	0.0032	0.0260	0.175	0.002	1.610	0.132	0.152	0.126	Level	0.166	0.000	10.03		
	J231213	9/25/90	2	180	0.000	0.440	0.0177	0.0356	0.972	0.048	1.964	0.196	0.152	0.149	Level	0.285	0.002	84.43	121.58	0.739
			3	90	0.305	0.440	0.0132	0.0356	0.807	0.033	1.964	0.196	0.128	0.149	Level	0.000	0.002	60.28		
			4	90	0.000	0.440	0.0047	0.0356	0.258	0.003	1.964	0.196	0.152	0.149	Level	0.272	0.002	19.71		
	J222211	9/26/90	2	180	0.000	0.175	0.0068	0.0136	0.373	0.007	1.359	0.094	0.152	0.082	Level	0.028	0.000	12.47	23.47	0.768
			3	90	0.305	0.175	0.0033	0.0136	0.506	0.013	1.359	0.094	0.059	0.082	Level	0.000	0.000	12.25		
			4	90	0.000	0.175	0.0034	0.0136	0.186	0.002	1.359	0.094	0.152	0.082	Level	0.021	0.000	5.84		
	J222212	9/26/90	2	180	0.000	0.322	0.0138	0.0237	0.756	0.029	1.440	0.106	0.152	0.129	Level	0.160	0.000	46.14	54.53	0.574
			3	90	0.305	0.322	0.0067	0.0237	0.647	0.021	1.440	0.106	0.084	0.129	Level	0.000	0.000	27.01		
			4	90	0.000	0.322	0.0068	0.0237	0.373	0.007	1.440	0.106	0.152	0.129	Level	0.168	0.000	21.79		
	J222213	9/27/90	2	180	0.000	0.415	0.0170	0.0342	0.931	0.044	1.932	0.190	0.152	0.142	Level	0.286	0.000	80.32	111.48	0.716
			3	90	0.305	0.415	0.0088	0.0342	0.520	0.014	1.932	0.190	0.134	0.142	Level	0.000	0.000	39.03		
			4	90	0.000	0.415	0.0085	0.0342	0.466	0.011	1.932	0.190	0.152	0.142	Level	0.274	0.000	36.41		
	J213211	9/27/90	2	180	0.000	0.163	0.0053	0.0113	0.290	0.004	1.094	0.061	0.152	0.084	Level	0.012	0.000	8.74	16.08	0.751
			3	90	0.305	0.163	0.0016	0.0113	0.310	0.005	1.094	0.061	0.050	0.084	Level	0.000	0.000	5.69		
			4	90	0.000	0.163	0.0044	0.0113	0.241	0.003	1.094	0.061	0.152	0.084	Level	0.007	0.000	6.97		
	J213212	9/27/90	2	180	0.000	0.324	0.0135	0.0267	0.740	0.028	1.622	0.134	0.152	0.129	Level	0.167	0.000	45.96	68.89	0.771
			3	90	0.305	0.324	0.0030	0.0267	0.413	0.009	1.622	0.134	0.064	0.129	Level	0.000	0.000	11.11		
			4	90	0.000	0.324	0.0102	0.0267	0.559	0.016	1.622	0.134	0.152	0.129	Level	0.155	0.000	32.27		
	J213213	9/28/90	2	180	0.000	0.407	0.0164	0.0325	0.899	0.041	1.792	0.164	0.152	0.149	Level	0.256	0.000	72.32	99.69	0.715
			3	90	0.305	2.438	0.0038	0.0325	0.286	0.004	1.792	0.164	0.104	0.149	Level	0.000	0.000	15.36		
			4	90	0.000	0.407	0.0122	0.0325	0.669	0.023	1.792	0.164	0.152	0.149	Level	0.258	0.000	51.78		
	J131211	10/ 1/90	2	180	0.000	0.174	0.0029	0.0128	0.158	0.001	1.164	0.069	0.152	0.089	Level	0.035	0.000	5.34	19.85	0.491
			3	90	0.305	0.174	0.0074	0.0128	0.841	0.036	1.164	0.069	0.074	0.089	Level	0.000	0.000	29.93		
			4	90	0.000	0.174	0.0025	0.0128	0.140	0.001	1.164	0.069	0.152	0.089	Level	0.053	0.000	5.16		
	J131212	10/ 1/90	2	180	0.000	0.346	0.0062	0.0240	0.342	0.006	1.364	0.095	0.152	0.141	Level	0.166	0.002	19.83	55.71	0.586
			3	90	0.305	0.346	0.0133	0.0240	0.897	0.041	1.364	0.095	0.116	0.141	Level	0.000	0.002	60.36		
			4	90	0.000	0.346	0.0044	0.0240	0.242	0.003	1.364	0.095	0.152	0.141	Level	0.187	0.002	14.83		
	J131213	10/ 1/90	2	180	0.000	0.426	0.0080	0.0302	0.439	0.010	1.694	0.146	0.152	0.144	Level	0.257	0.003	32.91	86.80	0.646
			3	90	0.305	0.426	0.0165	0.0302	0.989	0.050	1.694	0.146	0.131	0.144	Level	0.000	0.003	78.80		
			4	90	0.000	0.426	0.0056	0.0302	0.309	0.005	1.694	0.146	0.152	0.144	Level	0.255	0.003	22.75		
	J122211	10/ 2/90	2	180	0.000	0.186	0.0031	0.0124	0.171	0.001	1.177	0.071	0.152	0.085	Level	0.020	0.000	5.32	18.93	0.594
			3	90	0.305	0.186	0.0047	0.0124	0.558	0.016	1.177	0.071	0.072	0.085	Level	0.000	0.000	18.20		
			4	90	0.000	0.186	0.0046	0.0124	0.250	0.003	1.177	0.071	0.152	0.085	Level	0.031	0.000	8.36		
	J122212	10/ 2/90	2	180	0.000	0.310	0.0059	0.0233	0.321	0.005	1.346	0.092	0.152	0.137	Level	0.151	0.002	17.71	52.80	0.638
			3	90	0.305	0.310	0.0087	0.0233	0.713	0.026	1.346	0.092	0.096	0.137	Level	0.000	0.002	36.28		
			4	90	0.000	0.310	0.0088	0.0233	0.481	0.012	1.346	0.092	0.152	0.137	Level	0.169	0.002	28.72		
	J122213	10/ 2/90	2	180	0.000	0.439	0.0079	0.0329	0.433	0.010	1.814	0.168	0.152	0.149	Level	0.290	0.009	35.00	105.45	0.701
			3	90	0.305	0.439	0.0125	0.0329	0.712	0.026	1.814	0.168	0.141	0.149	Level	0.000	0.009	57.81		
			4	90	0.000	0.439	0.0125	0.0329	0.688	0.024	1.814	0.168	0.152	0.149	Level	0.292	0.009	57.62		
	J113211	10/ 3/90	2	180	0.000	0.166	0.0027	0.0103	0.152	0.001	0.949	0.046	0.145	0.087	Level	0.000	0.001	3.91	13.50	0.690
			3	90	0.305	0.166	0.0018	0.0103	0.348	0.006	0.949	0.046	0.050	0.087	Level	0.000	0.001	6.41		
			4	90	0.000	0.166	0.0057	0.0103	0.315	0.005	0.949	0.046	0.152	0.087	Level	0.007	0.001	9.25		
	J113212	10/ 3/90	2	180	0.000	0.334	0.0068	0.0253	0.371	0.007	1.541	0.121	0.152	0.129	Level	0.196	0.000	23.58	61.99	0.674
			3	90	0.305	0.334	0.0047	0.0253	0.497	0.013	1.541	0.121	0.078	0.129	Level	0.000	0.000	18.11		
			4	90	0.000	0.334	0.0139	0.0253	0.761	0.029	1.541	0.121	0.152	0.129	Level	0.188	0.000	50.28		
	J031211	10/ 4/90	3	90	0.305	0.148	0.0098	0.0131	0.752	0.029	1.314	0.088	0.102	0.082	Level	0.000	0.000	41.73	21.90	0.439
			4	90	0.000	0.148	0.0034	0.0131	0.185	0.002	1.314	0.088	0.152	0.082	Level	0.093	0.000	8.17		
	J031212	10/ 4/90	3	90	0.305	0.339	0.0132	0.0181	0.856	0.037	1.191	0.072	0.120	0.118	Level	0.000	0.000	59.63	33.82	0.444
			4	90	0.000	0.339	0.0049	0.0181	0.270	0.004	1.191	0.072	0.152	0.118	Level	0.187	0.000	16.55		
	J031213	10/ 4/90	3	90	0.305	0.369	0.0178	0.0236	1.077	0.059	1.419	0.103	0.130	0.130	Level	0.000	0.000	86.37	53.91	0.503
			4	90	0.000	0.369	0.0057	0.0236	0.315	0.005	1.419	0.103	0.152	0.130	Level	0.212	0.000	20.85		
	J022211	10/ 5/90	3	90	0.305	0.162	0.0065	0.0124	0.622	0.020	1.249	0.079	0.084	0.081	Level	0.000	0.000	25.89	19.52	0.516
			4	90	0.000	0.162	0.0059	0.0124	0.324	0.005	1.249	0.079	0.152	0.081	Level	0.048	0.000	11.97		
	J022212	10/ 5/90	3	90	0.305	0.347	0.0108	0.0217	0.771	0.030	1.410	0.101	0.110	0.120	Level	0.000	0.000	47.30	47.23	0.550
			4	90	0.000	0.347	0.0109	0.0217	0.599	0.018	1.410	0.101	0.152	0.120	Level	0.190	0.000	38.61		
	J022213	10/ 9/90	3	90	0.305	0.422	0.0151	0.0304	0.921	0.043	1.773	0.160	0.129	0.136	Level	0.000	0.000	70.66	88.26	0.645
			4	90	0.000	0.422	0.0153	0.0304	0.838	0.036	1.773	0.160	0.152	0.136	Level	0.253	0.000	66.14		
	J013211	10/10/90	3	90	0.305	0.165	0.0032	0.0120	0.457	0.011	1.297	0.086	0.062	0.077	Level	0.000	0.000	11.85	19.17	0.711
			4	90	0.000	0.165	0.0088	0.0120	0.483	0.012	1.297	0.086	0.152	0.077	Level	0.011	0.000	15.10		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	J013212	10/10/90	3	90	0.305	0.398	0.0056	0.0221	0.540	0.015	1.391	0.099	0.084	0.124	Level	0.000	0.000	22.08	48.29	0.583
			4	90	0.000	0.398	0.0165	0.0221	0.907	0.042	1.391	0.099	0.152	0.124	Level	0.180	0.000	60.71		
	J04011	10/11/90	3	90	0.000	0.180	0.0129	0.0129	0.705	0.025	1.303	0.087	0.152	0.081	Level	0.010	0.000	23.63	21.14	0.895
	J04012	10/11/90	3	90	0.000	0.384	0.0193	0.0193	1.056	0.057	1.403	0.100	0.152	0.107	Level	0.105	0.000	59.40	39.21	0.660
	J31011	10/12/90	2	180	0.000	0.161	0.0110	0.0267	0.601	0.018	2.660	0.361	0.152	0.082	Level	0.016	0.000	20.09	116.14	0.998
			3	90	0.000	0.161	0.0039	0.0267	0.213	0.002	2.660	0.361	0.152	0.082	Level	0.007	0.000	6.16		
	J31012	10/17/90	2	180	0.000	0.240	0.0200	0.0267	1.094	0.061	1.747	0.155	0.152	0.119	Level	0.119	0.000	65.05	72.00	0.888
			3	90	0.000	0.240	0.0068	0.0267	0.371	0.007	1.747	0.155	0.152	0.119	Level	0.083	0.000	16.08		
	J322331	10/17/90	2	180	0.000	0.184	0.0100	0.0136	0.550	0.015	1.268	0.082	0.152	0.087	Level	0.027	0.000	19.16	22.42	0.528
			3	90	0.610	0.184	0.0018	0.0136	0.366	0.007	1.268	0.082	0.048	0.087	Level	0.000	0.000	11.81		
			4	90	0.610	0.184	0.0018	0.0136	0.739	0.028	1.268	0.082	0.029	0.087	Level	0.000	0.000	11.46		
	J322332	10/17/90	2	180	0.000	0.268	0.0171	0.0229	0.939	0.045	1.646	0.138	0.152	0.109	Level	0.131	0.000	55.21	55.54	0.590
			3	90	0.610	0.268	0.0031	0.0229	0.429	0.009	1.646	0.138	0.063	0.109	Level	0.000	0.000	20.45		
			4	90	0.610	0.268	0.0028	0.0229	0.805	0.033	1.646	0.138	0.037	0.109	Level	0.000	0.000	18.50		
	J331331R	10/18/90	2	180	0.000	0.141	0.0084	0.0113	0.474	0.011	1.288	0.085	0.142	0.074	Level	0.000	0.000	12.59	17.50	0.558
			3	90	0.610	0.141	0.0021	0.0113	0.416	0.009	1.288	0.085	0.049	0.074	Level	0.000	0.000	13.71		
			4	90	0.610	0.141	0.0008	0.0113	0.707	0.025	1.288	0.085	0.017	0.074	Level	0.000	0.000	5.07		
	J331332R	10/18/90	2	180	0.000	0.318	0.0221	0.0295	1.211	0.075	1.883	0.181	0.152	0.122	Level	0.162	0.000	84.24	87.77	0.651
			3	90	0.610	0.318	0.0056	0.0295	0.585	0.017	1.883	0.181	0.079	0.122	Level	0.000	0.000	38.40		
			4	90	0.610	0.318	0.0019	0.0295	0.786	0.031	1.883	0.181	0.029	0.122	Level	0.000	0.000	12.27		
	J322333R	10/23/90	2	180	0.000	0.447	0.0125	0.0167	0.688	0.024	0.914	0.043	0.152	0.152	Level	0.317	0.259	60.69	74.20	0.846
			3	90	0.610	0.447	0.0020	0.0167	0.379	0.007	0.914	0.043	0.051	0.152	Level	0.000	0.259	13.35		
			4	90	0.610	0.447	0.0021	0.0167	0.653	0.022	0.914	0.043	0.035	0.152	Level	0.000	0.259	13.70		
	J231331	6/20/90	2	180	0.000	0.173	0.0075	0.0150	0.410	0.009	1.266	0.082	0.152	0.094	Level	0.036	0.000	14.43	25.83	0.395
			3	90	0.610	0.173	0.0056	0.0150	0.588	0.018	1.266	0.082	0.079	0.094	Level	0.000	0.000	38.82		
			4	90	0.610	0.173	0.0019	0.0150	0.475	0.012	1.266	0.082	0.041	0.094	Level	0.000	0.000	12.13		
	J231332	6/20/90	2	180	0.000	0.338	0.0123	0.0247	0.675	0.023	1.407	0.101	0.152	0.140	Level	0.179	0.000	42.85	58.31	0.447
			3	90	0.610	0.338	0.0093	0.0247	0.735	0.028	1.407	0.101	0.099	0.140	Level	0.000	0.000	66.86		
			4	90	0.610	0.338	0.0031	0.0247	0.459	0.011	1.407	0.101	0.060	0.140	Level	0.000	0.000	20.60		
	J231333	6/21/90	2	180	0.000	0.501	0.0174	0.0349	0.956	0.047	1.911	0.186	0.152	0.152	Level	0.357	0.039	95.12	129.05	0.580
			3	90	0.610	0.501	0.0131	0.0349	0.917	0.043	1.911	0.186	0.111	0.152	Level	0.000	0.039	97.95		
			4	90	0.610	0.501	0.0044	0.0349	0.592	0.018	1.911	0.186	0.065	0.152	Level	0.000	0.039	29.59		
	J231333R	6/21/90	2	180	0.000	0.518	0.0177	0.0354	0.970	0.048	1.940	0.192	0.152	0.152	Level	0.365	0.041	98.18	133.90	0.587
			3	90	0.610	0.518	0.0133	0.0354	0.930	0.044	1.940	0.192	0.112	0.152	Level	0.000	0.041	99.85		
			4	90	0.610	0.518	0.0044	0.0354	0.578	0.017	1.940	0.192	0.066	0.152	Level	0.000	0.041	30.02		
	J222331	6/26/90	2	180	0.000	0.196	0.0054	0.0108	0.298	0.005	1.126	0.065	0.152	0.080	Level	0.021	0.000	9.46	15.33	0.336
			3	90	0.610	0.196	0.0027	0.0108	0.410	0.009	1.126	0.065	0.060	0.080	Level	0.000	0.000	18.07		
			4	90	0.610	0.196	0.0027	0.0108	0.424	0.009	1.126	0.065	0.058	0.080	Level	0.000	0.000	18.04		
	J222332	6/26/90	2	180	0.000	0.302	0.0110	0.0219	0.601	0.018	1.706	0.148	0.152	0.101	Level	0.161	0.000	35.64	53.72	0.482
			3	90	0.610	0.302	0.0055	0.0219	0.587	0.018	1.706	0.148	0.077	0.101	Level	0.000	0.000	37.75		
			4	90	0.610	0.302	0.0055	0.0219	0.584	0.017	1.706	0.148	0.078	0.101	Level	0.000	0.000	37.97		
	J222333	6/22/90	2	180	0.000	0.494	0.0174	0.0347	0.953	0.046	1.905	0.185	0.152	0.152	Level	0.352	0.029	93.83	124.90	0.571
			3	90	0.610	0.494	0.0087	0.0347	0.700	0.025	1.905	0.185	0.098	0.152	Level	0.000	0.029	62.45		
			4	90	0.610	0.494	0.0087	0.0347	0.713	0.026	1.905	0.185	0.097	0.152	Level	0.000	0.029	62.40		
	J131331	6/28/90	2	180	0.000	0.189	0.0031	0.0124	0.171	0.001	1.117	0.064	0.152	0.089	Level	0.030	0.000	5.63	18.59	0.265
			3	90	0.610	0.189	0.0070	0.0124	0.627	0.020	1.117	0.064	0.089	0.089	Level	0.000	0.000	49.10		
			4	90	0.610	0.189	0.0023	0.0124	0.376	0.007	1.117	0.064	0.057	0.089	Level	0.000	0.000	15.33		
	J131332	6/28/90	2	180	0.000	0.317	0.0045	0.0181	0.248	0.003	1.188	0.072	0.152	0.119	Level	0.132	0.000	12.77	33.81	0.308
			3	90	0.610	0.317	0.0102	0.0181	0.760	0.029	1.188	0.072	0.105	0.119	Level	0.000	0.000	74.14		
			4	90	0.610	0.317	0.0034	0.0181	0.442	0.010	1.188	0.072	0.067	0.119	Level	0.000	0.000	22.86		
	J131333	6/28/90	2	180	0.000	0.464	0.0074	0.0296	0.407	0.008	1.633	0.136	0.152	0.149	Level	0.304	0.011	33.82	86.22	0.428
			3	90	0.610	0.464	0.0167	0.0296	1.018	0.053	1.633	0.136	0.128	0.149	Level	0.000	0.011	129.03		
			4	90	0.610	0.464	0.0056	0.0296	0.557	0.016	1.633	0.136	0.082	0.149	Level	0.000	0.011	38.48		
	J22031R	6/29/90	2	180	0.000	0.130	0.0031	0.0063	0.214	0.002	1.068	0.058	0.114	0.055	Level	0.000	0.000	3.59	7.00	0.285
			3	90	0.610	0.130	0.0031	0.0063	0.461	0.011	1.068	0.058	0.061	0.055	Level	0.000	0.000	21.00		
	J22033R	6/29/90	2	180	0.000	0.439	0.0138	0.0277	0.759	0.029	1.551	0.123	0.152	0.144	Level	0.240	0.003	57.32	73.18	0.452
			3	90	0.610	0.439	0.0138	0.0277	0.900	0.041	1.551	0.123	0.120	0.144	Level	0.000	0.003	104.63		
	J122331	7/ 3/90	2	180	0.000	0.165	0.0025	0.0100	0.137	0.001	1.161	0.069	0.152	0.073	Level	0.009	0.000	3.98	13.87	0.251
			3	90	0.610	0.165	0.0037	0.0100	0.508	0.013	1.161	0.069	0.065	0.073	Level	0.000	0.000	25.19		
			4	90	0.610	0.165	0.0037	0.0100	1.165	0.069	1.161	0.069	0.035	0.073	Level	0.000	0.000	26.17		
	J122332	7/ 3/90	2	180	0.000	0.310	0.0054	0.0215	0.295	0.004	1.631	0.136	0.152	0.104	Level	0.164	0.000	16.91	50.57	0.382
			3	90	0.610	0.310	0.0081	0.0215	0.732	0.027	1.631	0.136	0.089	0.104	Level	0.000	0.000	57.64		
			4	90	0.610	0.310	0.0081	0.0215	0.615	0.019	1.631	0.136	0.103	0.104	Level	0.000	0.000	57.91		
	J122333	7/ 2/90	2	180	0.000	0.475	0.0082	0.0327	0.449	0.010	1.793	0.164	0.152	0.152	Level	0.343	0.021	40.58	108.08	0.484
			3	90	0.610	0.475	0.0123	0.0327	0.852	0.037	1.793	0.164	0.112	0.152	Level	0.000	0.021	91.21		
			4	90	0.610	0.475	0.0123	0.0327	0.829	0.035	1.793	0.164	0.115	0.152	Level	0.000	0.021	91.34		
	J031331	7/ 5/90	3	90	0.610	0.139	0.0062	0.0083	0.563	0.016	1.067	0.058	0.089	0.067	Level	0.000	0.000	43.65	10.20	0.178
			4	90	0.610	0.139	0.0021	0.0083	0.292	0.004	1.067	0.058	0.063	0.067	Level	0.000	0.000	13.71		
	J031332	7/ 5/90	3	90	0.610	0.343	0.0118	0.0158	0.813	0.034	1.179	0.071	0.113	0.105	Level	0.000	0.000	87.81	27.17	0.237
			4	90	0.610	0.343	0.0039	0.0158	0.403	0.008	1.179	0.071	0.080	0.105	Level	0.000	0.000	26.95		
	J031333	7/ 5/90	3	90	0.610	0.444	0.0188	0.0250	1.134	0.065	1.467	0.110	0.130	0.135	Level	0.000	0.001	148.16	60.15	0.313
			4	90	0.610	0.444	0.0063	0.0250	0.539	0.015	1.467	0.110	0.093	0.135	Level	0.000	0.001	43.99		
	J022331	7/ 9/90	3	90	0.610	0.181	0.0052	0.0103	0.527	0.014	1.166	0.069	0.080	0.074	Level	0.000	0.000	35.58	14.52	0.191
			4	90	0.610	0.181	0.0052	0.0103	1.755	0.157	1.166	0.069	0.033	0.074	Level	0.000	0.000	40.41		
	J022332	7/ 9/90	3	90	0.610	0.343	0.0114	0.0228	0.802	0.033	1.452	0.107	0.111	0.122	Level	0.000	0.000	84.04	51.27	0.304
			4	90	0.610	0.343	0.0114	0.0228	0.728	0.027	1.452	0.107	0.122	0.122	Level	0.000	0.000	84.65		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	J022333	7/ 9/90	3	90	0.610	0.414	0.0146	0.0291	0.907	0.042	1.657	0.140	0.126	0.141	Level	0.000	0.002	111.10	80.76	0.363
			4	90	0.610	0.414	0.0146	0.0291	0.890	0.040	1.657	0.140	0.128	0.141	Level	0.000	0.002	111.27		
	J022231	7/11/90	3	90	0.305	0.177	0.0045	0.0089	0.451	0.010	1.144	0.067	0.081	0.068	Level	0.000	0.000	17.39	11.79	0.246
			4	90	0.610	0.177	0.0045	0.0089	0.525	0.014	1.144	0.067	0.072	0.068	Level	0.000	0.000	30.52		
	J022232	7/11/90	3	90	0.305	0.305	0.0113	0.0225	0.618	0.019	1.333	0.091	0.152	0.133	Level	0.173	0.000	71.73	49.46	0.319
			4	90	0.610	0.305	0.0113	0.0225	0.774	0.031	1.333	0.091	0.113	0.133	Level	0.000	0.000	83.26		
	J022233	7/11/90	3	90	0.305	0.420	0.0148	0.0296	0.812	0.034	1.644	0.138	0.152	0.147	Level	0.178	0.003	97.10	83.75	0.398
			4	90	0.610	0.420	0.0148	0.0296	0.909	0.042	1.644	0.138	0.127	0.147	Level	0.000	0.003	113.13		
	J331231	7/12/90	2	180	0.000	0.188	0.0097	0.0129	0.531	0.014	1.207	0.074	0.152	0.087	Level	0.008	0.000	16.56	20.37	0.674
			3	90	0.305	0.188	0.0024	0.0129	0.462	0.011	1.207	0.074	0.050	0.087	Level	0.000	0.000	8.63		
			4	90	0.610	0.188	0.0008	0.0129	0.247	0.003	1.207	0.074	0.035	0.087	Level	0.000	0.000	5.04		
	J331232	7/12/90	2	180	0.000	0.322	0.0220	0.0293	1.206	0.074	1.688	0.145	0.152	0.138	Level	0.157	0.000	82.74	81.53	0.701
			3	90	0.305	0.322	0.0055	0.0293	0.615	0.019	1.688	0.145	0.075	0.138	Level	0.000	0.000	21.49		
			4	90	0.610	0.322	0.0018	0.0293	0.372	0.007	1.688	0.145	0.048	0.138	Level	0.000	0.000	12.00		
	J331232R	7/27/90	2	180	0.000	0.335	0.0220	0.0295	1.206	0.074	1.693	0.146	0.152	0.139	Level	0.166	0.002	84.77	83.02	0.695
			3	90	0.305	0.335	0.0056	0.0295	0.579	0.017	1.693	0.146	0.079	0.139	Level	0.000	0.002	21.83		
			4	90	0.610	0.335	0.0020	0.0295	0.291	0.004	1.693	0.146	0.060	0.139	Level	0.000	0.002	12.92		
	J222231	7/30/90	2	180	0.000	0.142	0.0066	0.0132	0.362	0.007	1.195	0.073	0.152	0.089	Level	0.019	0.000	11.49	20.85	0.456
			3	90	0.305	0.142	0.0033	0.0132	0.482	0.012	1.195	0.073	0.061	0.089	Level	0.000	0.000	12.16		
			4	90	0.610	0.142	0.0033	0.0132	0.413	0.009	1.195	0.073	0.069	0.089	Level	0.000	0.000	22.12		
	J222232	7/30/90	2	180	0.000	0.297	0.0117	0.0234	0.643	0.021	1.330	0.090	0.152	0.141	Level	0.169	0.001	39.38	53.38	0.504
			3	90	0.305	0.297	0.0059	0.0234	0.345	0.006	1.330	0.090	0.134	0.141	Level	0.000	0.001	25.57		
			4	90	0.610	0.297	0.0059	0.0234	0.548	0.015	1.330	0.090	0.087	0.141	Level	0.000	0.001	40.88		
	J222233	7/30/90	2	180	0.000	0.516	0.0175	0.0351	0.961	0.047	1.927	0.189	0.152	0.151	Level	0.340	0.021	92.73	124.24	0.594
			3	90	0.305	0.516	0.0088	0.0351	0.481	0.012	1.927	0.189	0.152	0.151	Level	0.143	0.021	52.66		
			4	90	0.610	0.516	0.0088	0.0351	0.608	0.019	1.927	0.189	0.112	0.151	Level	0.000	0.021	63.76		
	J313231	8/ 1/90	2	180	0.000	0.170	0.0088	0.0117	0.483	0.012	1.151	0.067	0.152	0.083	Level	0.024	0.000	16.26	17.32	0.522
			3	90	0.305	0.170	0.0007	0.0117	0.205	0.002	1.151	0.067	0.037	0.083	Level	0.000	0.000	2.39		
			4	90	0.610	0.170	0.0022	0.0117	0.357	0.007	1.151	0.067	0.057	0.083	Level	0.000	0.000	14.57		
	J313232	8/ 1/90	2	180	0.000	0.339	0.0194	0.0260	1.065	0.058	1.449	0.107	0.152	0.145	Level	0.201	0.004	78.40	65.12	0.549
			3	90	0.305	0.339	0.0017	0.0260	0.121	0.001	1.449	0.107	0.108	0.145	Level	0.000	0.006	6.77		
			4	90	0.610	0.339	0.0048	0.0260	0.469	0.011	1.449	0.107	0.084	0.145	Level	0.000	0.004	33.46		
	J313233	8/ 1/90	2	180	0.000	0.403	0.0214	0.0285	1.172	0.070	1.636	0.136	0.152	0.139	Level	0.256	0.002	100.35	77.53	0.534
			3	90	0.305	0.403	0.0018	0.0285	0.110	0.001	1.636	0.136	0.129	0.139	Level	0.000	0.002	7.72		
			4	90	0.610	0.403	0.0054	0.0285	0.494	0.012	1.636	0.136	0.087	0.139	Level	0.000	0.002	37.23		
	J231231	8/ 2/90	2	180	0.000	0.158	0.0056	0.0112	0.307	0.005	1.129	0.065	0.152	0.082	Level	0.017	0.000	9.58	16.17	0.464
			3	90	0.305	0.158	0.0042	0.0112	0.543	0.015	1.129	0.065	0.067	0.082	Level	0.000	0.000	16.01		
			4	90	0.610	0.158	0.0014	0.0112	0.263	0.004	1.129	0.065	0.051	0.082	Level	0.000	0.000	9.22		
	J231232	8/ 2/90	2	180	0.000	0.295	0.0110	0.0220	0.602	0.018	1.795	0.164	0.152	0.097	Level	0.138	0.000	33.25	56.29	0.656
			3	90	0.305	0.295	0.0082	0.0220	0.686	0.024	1.795	0.164	0.095	0.097	Level	0.000	0.000	34.27		
			4	90	0.610	0.295	0.0027	0.0220	0.400	0.008	1.795	0.164	0.061	0.097	Level	0.000	0.000	18.29		
	J231233	8/ 2/90	2	180	0.000	0.393	0.0161	0.0322	0.882	0.040	1.772	0.160	0.152	0.149	Level	0.254	0.007	70.27	99.71	0.654
			3	90	0.305	0.393	0.0121	0.0322	0.702	0.025	1.772	0.160	0.136	0.149	Level	0.000	0.007	55.10		
			4	90	0.610	0.393	0.0040	0.0322	0.442	0.010	1.772	0.160	0.076	0.149	Level	0.000	0.007	27.21		
	J322231	8/ 6/90	2	180	0.000	0.174	0.0079	0.0131	0.432	0.009	1.245	0.079	0.152	0.086	Level	0.033	0.000	15.06	21.21	0.504
			3	90	0.305	0.174	0.0026	0.0131	0.474	0.011	1.245	0.079	0.052	0.086	Level	0.000	0.000	9.52		
			4	90	0.610	0.174	0.0026	0.0131	0.403	0.008	1.245	0.079	0.059	0.086	Level	0.000	0.000	17.48		
	J322232	8/ 3/90	2	180	0.000	0.316	0.0153	0.0255	0.840	0.036	1.434	0.105	0.152	0.144	Level	0.171	0.004	53.97	63.19	0.572
			3	90	0.305	0.316	0.0051	0.0255	0.367	0.007	1.434	0.105	0.109	0.144	Level	0.000	0.004	21.14		
			4	90	0.610	0.316	0.0051	0.0255	0.500	0.013	1.434	0.105	0.083	0.144	Level	0.000	0.004	35.26		
	J322233	8/ 3/90	2	180	0.000	0.418	0.0194	0.0323	1.062	0.057	1.770	0.160	0.152	0.152	Level	0.269	0.014	90.96	103.16	0.565
			3	90	0.305	0.418	0.0065	0.0323	0.354	0.006	1.770	0.160	0.152	0.152	Level	0.267	0.014	46.24		
			4	90	0.610	0.418	0.0065	0.0323	0.548	0.015	1.770	0.160	0.094	0.152	Level	0.000	0.014	45.49		
	J213231	8/ 6/90	2	180	0.000	0.181	0.0044	0.0088	0.241	0.003	0.885	0.040	0.152	0.082	Level	0.040	0.000	8.40	10.50	0.293
			3	90	0.305	0.181	0.0011	0.0088	0.063	0.000	0.885	0.040	0.139	0.082	Level	0.000	0.000	4.80		
			4	90	0.610	0.181	0.0033	0.0088	0.302	0.005	0.885	0.040	0.088	0.082	Level	0.000	0.000	22.61		
	J213232	8/ 6/90	2	180	0.000	0.338	0.0119	0.0238	0.652	0.022	1.351	0.093	0.152	0.141	Level	0.185	0.002	41.83	55.11	0.453
			3	90	0.305	0.338	0.0030	0.0238	0.163	0.001	1.351	0.093	0.152	0.141	Level	0.070	0.002	15.42		
			4	90	0.610	0.338	0.0089	0.0238	0.667	0.023	1.351	0.093	0.105	0.141	Level	0.000	0.002	64.46		
	J213233	8/ 6/90	2	180	0.000	0.443	0.0158	0.0316	0.866	0.038	1.745	0.155	0.152	0.149	Level	0.324	0.006	79.77	96.16	0.504
			3	90	0.305	0.443	0.0040	0.0316	0.217	0.002	1.745	0.155	0.152	0.149	Level	0.127	0.006	22.81		
			4	90	0.610	0.443	0.0119	0.0316	0.773	0.030	1.745	0.155	0.119	0.149	Level	0.000	0.006	88.35		
	J131231	8/ 7/90	2	180	0.000	0.170	0.0024	0.0095	0.132	0.001	0.997	0.051	0.152	0.079	Level	0.021	0.000	4.11	12.10	0.328
			3	90	0.305	0.170	0.0054	0.0095	0.548	0.015	0.997	0.051	0.080	0.079	Level	0.000	0.000	21.02		
			4	90	0.610	0.170	0.0018	0.0095	0.293	0.004	0.997	0.051	0.056	0.079	Level	0.000	0.000	11.72		
	J131232	8/ 7/90	2	180	0.000	0.345	0.0063	0.0253	0.347	0.006	1.443	0.106	0.152	0.140	Level	0.190	0.000	21.58	60.86	0.506
			3	90	0.305	0.345	0.0142	0.0253	0.817	0.034	1.443	0.106	0.138	0.140	Level	0.000	0.000	66.32		
			4	90	0.610	0.345	0.0047	0.0253	0.501	0.013	1.443	0.106	0.078	0.140	Level	0.000	0.000	32.49		
	J131233	8/ 7/90	2	180	0.000	0.403	0.0075	0.0300	0.411	0.009	1.658	0.140	0.152	0.148	Level	0.275	0.006	32.05	86.40	0.543
			3	90	0.305	0.403	0.0169	0.0300	0.925	0.044	1.658	0.140	0.152	0.148	Level	0.032	0.006	88.11		
			4	90	0.610	0.403	0.0056	0.0300	0.550	0.015	1.658	0.140	0.083	0.148	Level	0.000	0.006	38.93		
	J122231	8/ 8/90	2	180	0.000	0.162	0.0027	0.0106	0.149	0.001	1.124	0.064	0.152	0.078	Level	0.005	0.000	4.21	14.86	0.323
			3	90	0.305	0.162	0.0040	0.0106	0.504	0.013	1.124	0.064	0.068	0.078	Level	0.000	0.000	14.99		
			4	90	0.610	0.162	0.0040	0.0106	0.489	0.012	1.124	0.064	0.069	0.078	Level	0.000	0.000	26.87		
	J122233	8/ 8/90	2	180	0.000	0.455	0.0082	0.0328	0.450	0.010	1.809	0.167	0.152	0.149	Level	0.329	0.011	39.63	105.19	0.493
			3	90	0.305	0.455	0.0123	0.0328	0.675	0.023	1.809	0.167	0.152	0.149	Level	0.196	0.011	81.65		
			4	90	0.610	0.455	0.0123	0.0328	0.815	0.034	1.809	0.167	0.118	0.149	Level	0.000	0.011	91.91		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	J113331	8/ 9/90	2	180	0.000	0.183	0.0031	0.0123	0.168	0.001	1.261	0.081	0.152	0.080	Level	0.049	0.000	6.08	19.51	0.299
			3	90	0.305	0.183	0.0023	0.0123	0.127	0.001	1.261	0.081	0.148	0.080	Level	0.000	0.000	10.19		
			4	90	0.610	0.183	0.0069	0.0123	0.617	0.019	1.261	0.081	0.090	0.080	Level	0.000	0.000	48.92		
	J113332	8/ 9/90	2	180	0.000	0.414	0.0065	0.0260	0.355	0.006	1.485	0.112	0.152	0.140	Level	0.295	0.002	28.87	64.62	0.386
			3	90	0.305	0.414	0.0049	0.0260	0.267	0.004	1.486	0.113	0.152	0.140	Level	0.106	0.002	27.05		
			4	90	0.610	0.414	0.0146	0.0260	0.890	0.040	1.485	0.112	0.129	0.140	Level	0.000	0.002	111.53		
	J013231	8/10/90	3	90	0.305	0.222	0.0029	0.0114	0.232	0.003	1.191	0.072	0.098	0.079	Level	0.000	0.000	11.36	16.95	0.230
			4	90	0.610	0.222	0.0086	0.0114	1.184	0.071	1.191	0.072	0.064	0.079	Level	0.000	0.000	62.44		
	J013232	8/10/90	3	90	0.305	0.342	0.0055	0.0220	0.301	0.005	1.309	0.087	0.152	0.132	Level	0.037	0.000	26.87	47.33	0.298
			4	90	0.610	0.342	0.0165	0.0220	1.528	0.119	1.309	0.087	0.087	0.132	Level	0.000	0.000	131.81		
	J031231	8/10/90	3	90	0.305	0.162	0.0089	0.0118	0.719	0.026	1.425	0.103	0.098	0.071	Level	0.000	0.000	37.25	20.18	0.354
			4	90	0.610	0.162	0.0029	0.0118	0.408	0.008	1.425	0.103	0.064	0.071	Level	0.000	0.000	19.68		
	J031232	8/10/90	3	90	0.305	0.360	0.0184	0.0246	1.011	0.052	1.410	0.101	0.152	0.139	Level	0.037	0.000	98.76	58.06	0.409
			4	90	0.610	0.360	0.0062	0.0246	0.572	0.017	1.410	0.101	0.087	0.139	Level	0.000	0.000	43.18		
1	J031111	4/ 6/90	3	90	0.000	0.075	0.0032	0.0042	0.320	0.005	0.951	0.046	0.081	0.037	Level	0.000	0.000	2.69	3.46	0.998
			4	90	0.000	0.075	0.0010	0.0042	0.118	0.001	0.951	0.046	0.074	0.037	Level	0.000	0.000	0.77		
1	J031112	4/ 6/90	3	90	0.000	0.137	0.0098	0.0130	0.546	0.015	1.298	0.086	0.144	0.070	Level	0.000	0.000	15.30	19.89	0.999
			4	90	0.000	0.137	0.0033	0.0132	0.186	0.002	1.298	0.086	0.141	0.070	Level	0.000	0.000	4.61		
1	J022111	4/ 9/90	3	90	0.000	0.081	0.0021	0.0042	0.204	0.002	0.975	0.048	0.085	0.035	Level	0.000	0.000	1.81	3.47	0.997
			4	90	0.000	0.081	0.0021	0.0042	0.220	0.002	0.975	0.048	0.079	0.035	Level	0.000	0.000	1.67		
1	J022112	4/ 9/90	3	90	0.000	0.139	0.0066	0.0132	0.374	0.007	1.280	0.083	0.141	0.062	Level	0.000	0.000	9.59	18.82	0.999
			4	90	0.000	0.139	0.0066	0.0132	0.385	0.008	1.280	0.083	0.135	0.062	Level	0.000	0.000	9.24		
	J022113	4/ 6/90	3	90	0.000	0.414	0.0144	0.0287	0.787	0.032	1.574	0.126	0.152	0.152	Level	0.271	0.118	63.99	111.76	0.881
			4	90	0.000	0.414	0.0144	0.0287	0.787	0.032	1.574	0.126	0.152	0.152	Level	0.263	0.118	62.88		
1	J013111	4/ 9/90	3	90	0.000	0.082	0.0010	0.0040	0.096	0.000	0.981	0.049	0.086	0.036	Level	0.000	0.000	0.86	3.34	1.000
			4	90	0.000	0.082	0.0030	0.0040	0.313	0.005	0.981	0.049	0.079	0.036	Level	0.000	0.000	2.48		
1	J013112	4/ 9/90	3	90	0.000	0.156	0.0031	0.0123	0.169	0.001	1.274	0.083	0.152	0.075	Level	0.002	0.000	4.70	19.10	0.999
			4	90	0.000	0.156	0.0093	0.0123	0.517	0.014	1.274	0.083	0.145	0.075	Level	0.000	0.000	14.41		
	J031311	4/11/90	3	90	0.610	0.088	0.0044	0.0059	0.611	0.019	1.481	0.112	0.064	0.041	Level	0.000	0.000	30.19	8.94	0.277
			4	90	0.000	0.088	0.0015	0.0059	0.086	0.000	1.481	0.112	0.140	0.041	Level	0.000	0.000	2.06		
	J031312	4/11/90	3	90	0.610	0.180	0.0095	0.0127	0.833	0.035	1.470	0.110	0.091	0.073	Level	0.000	0.000	68.46	22.72	0.299
			4	90	0.000	0.180	0.0032	0.0127	0.174	0.002	1.470	0.110	0.152	0.073	Level	0.088	0.000	7.52		
	J031313	4/13/90	3	90	0.610	0.524	0.0188	0.0251	1.174	0.070	1.377	0.097	0.125	0.152	Level	0.000	0.128	148.63	92.86	0.521
			4	90	0.000	0.524	0.0063	0.0251	0.345	0.006	1.377	0.097	0.152	0.152	Level	0.324	0.128	29.75		
	J022311	4/13/90	3	90	0.610	0.112	0.0039	0.0077	0.547	0.015	1.354	0.093	0.062	0.053	Level	0.000	0.000	25.95	11.08	0.347
			4	90	0.000	0.112	0.0039	0.0077	0.211	0.002	1.354	0.093	0.152	0.053	Level	0.004	0.000	5.98		
	J022312	4/13/90	3	90	0.610	0.190	0.0063	0.0124	0.659	0.022	1.135	0.066	0.079	0.088	Level	0.000	0.000	43.58	18.70	0.326
			4	90	0.000	0.190	0.0061	0.0124	0.337	0.006	1.135	0.066	0.152	0.088	Level	0.072	0.000	13.84		
	J022313	4/18/90	3	90	0.610	0.543	0.0141	0.0274	0.936	0.045	1.501	0.115	0.117	0.152	Level	0.000	0.183	106.42	120.85	0.681
			4	90	0.000	0.543	0.0133	0.0274	0.730	0.027	1.501	0.115	0.152	0.152	Level	0.365	0.183	71.03		
	J013311	4/18/90	3	90	0.610	0.102	0.0012	0.0045	0.232	0.003	0.728	0.027	0.049	0.057	Level	0.000	0.000	7.72	3.70	0.331
			4	90	0.000	0.102	0.0033	0.0045	0.252	0.003	0.728	0.027	0.103	0.057	Level	0.000	0.000	3.45		
	J013312	4/13/90	3	90	0.610	0.159	0.0029	0.0116	0.481	0.012	1.328	0.090	0.055	0.073	Level	0.000	0.000	19.17	18.50	0.529
			4	90	0.000	0.159	0.0087	0.0116	0.475	0.011	1.328	0.090	0.152	0.073	Level	0.022	0.000	15.79		
	J013313	4/18/90	3	90	0.610	0.429	0.0060	0.0230	0.603	0.019	1.260	0.081	0.081	0.152	Level	0.000	0.094	41.56	73.78	0.625
			4	90	0.000	0.429	0.0170	0.0230	0.933	0.044	1.260	0.081	0.152	0.152	Level	0.261	0.094	76.41		
	J331311	4/20/90	2	180	0.000	0.088	0.0027	0.0036	0.251	0.003	0.876	0.039	0.087	0.042	Level	0.000	0.000	2.42	2.89	0.419
			3	90	0.610	0.088	0.0007	0.0036	0.234	0.003	0.876	0.039	0.033	0.042	Level	0.000	0.000	4.30		
			4	90	0.000	0.088	0.0002	0.0036	0.022	0.000	0.876	0.039	0.085	0.042	Level	0.000	0.000	0.19		
	J331312	4/23/90	2	180	0.000	0.160	0.0106	0.0139	0.579	0.017	1.393	0.099	0.152	0.082	Level	0.028	0.000	20.49	24.71	0.639
			3	90	0.610	0.160	0.0025	0.0139	0.481	0.012	1.393	0.099	0.051	0.082	Level	0.000	0.000	16.79		
			4	90	0.000	0.160	0.0008	0.0139	0.047	0.000	1.393	0.099	0.152	0.082	Level	0.014	0.000	1.39		
	J331313	4/23/90	2	180	0.000	0.483	0.0220	0.0294	1.206	0.074	1.611	0.132	0.152	0.152	Level	0.313	0.196	116.46	138.46	0.849
			3	90	0.610	0.483	0.0055	0.0294	0.659	0.022	1.611	0.132	0.071	0.152	Level	0.000	0.196	38.06		
			4	90	0.000	0.483	0.0019	0.0294	0.102	0.001	1.611	0.132	0.152	0.152	Level	0.318	0.196	8.62		
	J322311	4/24/90	2	180	0.000	0.077	0.0041	0.0055	0.360	0.007	1.321	0.089	0.092	0.043	Level	0.000	0.000	3.99	7.13	0.805
			3	90	0.610	0.077	0.0007	0.0055	0.374	0.007	1.321	0.089	0.024	0.043	Level	0.000	0.000	4.27		
			4	90	0.000	0.077	0.0007	0.0055	0.061	0.000	1.321	0.089	0.090	0.043	Level	0.000	0.000	0.60		
	J322312	4/24/90	2	180	0.000	0.180	0.0112	0.0150	0.616	0.019	1.416	0.102	0.152	0.086	Level	0.025	0.000	21.65	27.55	0.753
			3	90	0.610	0.180	0.0018	0.0150	0.497	0.013	1.416	0.102	0.039	0.086	Level	0.000	0.000	11.74		
			4	90	0.000	0.180	0.0019	0.0150	0.104	0.001	1.416	0.102	0.152	0.086	Level	0.018	0.000	3.18		
	J322313	4/24/90	2	180	0.000	0.447	0.0208	0.0278	1.141	0.066	1.524	0.118	0.152	0.152	Level	0.282	0.202	102.17	128.94	0.917
			3	90	0.610	0.447	0.0035	0.0278	0.537	0.015	1.524	0.118	0.059	0.152	Level	0.000	0.202	23.53		
			4	90	0.000	0.447	0.0035	0.0278	0.192	0.002	1.524	0.118	0.152	0.152	Level	0.277	0.202	14.85		
	J313311	4/25/90	2	180	0.000	0.085	0.0033	0.0043	0.268	0.004	0.980	0.049	0.096	0.044	Level	0.000	0.000	3.19	3.93	0.707
			3	90	0.610	0.085	0.0003	0.0043	0.086	0.000	0.980	0.049	0.034	0.044	Level	0.000	0.000	1.61		
			4	90	0.000	0.085	0.0008	0.0043	0.069	0.000	0.980	0.049	0.094	0.044	Level	0.000	0.000	0.76		
	J313311R	5/ 3/90	2	180	0.000	0.085	0.0041	0.0055	0.398	0.008	1.111	0.063	0.084	0.048	Level	0.000	0.000	3.71	5.98	0.899
			3	90	0.610	0.085	0.0003	0.0055	0.632	0.020	1.111	0.063	0.010	0.048	Level	0.000	0.000	2.13		
			4	90	0.000	0.085	0.0010	0.0055	0.104	0.001	1.111	0.063	0.080	0.048	Level	0.000	0.000	0.81		
	J313312	4/25/90	2	180	0.000	0.157	0.0119	0.0158	0.650	0.022	1.612	0.132	0.152	0.081	Level	0.017	0.000	22.19	33.11	0.986
			3	90	0.610	0.157	0.0010	0.0158	0.278	0.004	1.612	0.132	0.038	0.081	Level	0.000	0.000	6.33		
			4	90	0.000	0.157	0.0030	0.0158	0.163	0.001	1.612	0.132	0.152	0.081	Level	0.020	0.000	5.05		
	J313313	4/25/90	2	180	0.000	0.245	0.0213	0.0284	1.167	0.069	1.557	0.124	0.152	0.152	Level	0.305	0.180	110.08	127.10	0.875
			3	90	0.610	0.245	0.0018	0.0284	0.374	0.007	1.557	0.124	0.047	0.152	Level	0.000	0.180	11.61		
			4	90	0.000	0.245	0.0053	0.0284	0.292	0.004	1.557	0.124	0.152	0.152	Level	0.295	0.180	23.59		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	J231311	4/26/90	2	180	0.000	0.070	0.0021	0.0042	0.199	0.002	1.084	0.060	0.087	0.041	Level	0.000	0.000	1.84	4.16	0.333
			3	90	0.610	0.070	0.0016	0.0042	0.421	0.009	1.084	0.060	0.040	0.041	Level	0.000	0.000	10.23		
			4	90	0.000	0.070	0.0005	0.0042	0.056	0.000	1.084	0.060	0.080	0.041	Level	0.000	0.000	0.42		
	J231312	4/26/90	2	180	0.000	0.198	0.0073	0.0146	0.401	0.008	1.125	0.064	0.152	0.102	Level	0.046	0.000	14.80	23.87	0.423
			3	90	0.610	0.198	0.0055	0.0146	0.638	0.021	1.125	0.064	0.073	0.102	Level	0.000	0.000	37.87		
			4	90	0.000	0.198	0.0018	0.0146	0.099	0.001	1.125	0.064	0.152	0.102	Level	0.061	0.000	3.80		
	J231313	4/26/90	2	180	0.000	0.455	0.0142	0.0284	0.778	0.031	1.555	0.123	0.152	0.152	Level	0.330	0.173	71.44	124.70	0.749
			3	90	0.610	0.455	0.0106	0.0284	0.822	0.034	1.555	0.123	0.102	0.152	Level	0.000	0.173	77.86		
			4	90	0.000	0.455	0.0035	0.0284	0.194	0.002	1.555	0.123	0.152	0.152	Level	0.340	0.173	17.14		
	J222311	4/30/90	2	180	0.000	0.082	0.0017	0.0034	0.168	0.001	1.013	0.052	0.083	0.036	Level	0.000	0.000	1.40	2.93	0.402
			3	90	0.610	0.082	0.0008	0.0034	0.266	0.004	1.013	0.052	0.034	0.036	Level	0.000	0.000	5.21		
			4	90	0.000	0.082	0.0008	0.0034	0.088	0.000	1.013	0.052	0.080	0.036	Level	0.000	0.000	0.67		
	J222312	4/27/90	2	180	0.000	0.166	0.0067	0.0134	0.366	0.007	1.394	0.099	0.152	0.079	Level	0.030	0.000	12.37	23.38	0.569
			3	90	0.610	0.166	0.0033	0.0134	0.522	0.014	1.394	0.099	0.058	0.079	Level	0.000	0.000	22.33		
			4	90	0.000	0.166	0.0033	0.0134	0.183	0.002	1.394	0.099	0.152	0.079	Level	0.041	0.000	6.40		
	J222313	4/27/90	2	180	0.000	0.486	0.0138	0.0276	0.756	0.029	1.512	0.116	0.152	0.152	Level	0.322	0.176	68.10	120.20	0.802
			3	90	0.610	0.486	0.0071	0.0276	0.697	0.025	1.512	0.116	0.084	0.152	Level	0.000	0.176	50.22		
			4	90	0.000	0.486	0.0067	0.0276	0.366	0.007	1.512	0.116	0.152	0.152	Level	0.321	0.176	31.48		
	J213311	4/30/90	2	180	0.000	0.082	0.0020	0.0039	0.189	0.002	1.072	0.058	0.084	0.039	Level	0.000	0.000	1.65	3.73	0.637
			3	90	0.610	0.082	0.0005	0.0039	0.256	0.003	1.072	0.058	0.024	0.039	Level	0.000	0.000	3.01		
			4	90	0.000	0.082	0.0015	0.0039	0.148	0.001	1.072	0.058	0.082	0.039	Level	0.000	0.000	1.20		
	J213312	4/30/90	2	180	0.000	0.166	0.0068	0.0136	0.373	0.007	1.446	0.107	0.152	0.078	Level	0.016	0.000	11.68	24.61	0.786
			3	90	0.610	0.166	0.0017	0.0136	0.432	0.010	1.446	0.107	0.041	0.078	Level	0.000	0.000	10.99		
			4	90	0.000	0.166	0.0051	0.0136	0.279	0.004	1.446	0.107	0.152	0.078	Level	0.016	0.000	8.64		
	J213313	5/ 1/90	2	180	0.000	0.462	0.0133	0.0263	0.731	0.027	1.441	0.106	0.152	0.152	Level	0.293	0.151	61.83	105.32	0.830
			3	90	0.610	0.462	0.0032	0.0263	0.518	0.014	1.441	0.106	0.057	0.152	Level	0.000	0.151	21.33		
			4	90	0.000	0.462	0.0097	0.0263	0.532	0.014	1.441	0.106	0.152	0.152	Level	0.293	0.151	43.75		
	J131311	5/ 2/90	2	180	0.000	0.084	0.0012	0.0045	0.090	0.000	1.092	0.061	0.101	0.042	Level	0.000	0.000	1.16	4.51	0.246
			3	90	0.610	0.084	0.0025	0.0045	0.487	0.012	1.092	0.061	0.049	0.042	Level	0.000	0.000	16.39		
			4	90	0.000	0.084	0.0008	0.0045	0.066	0.000	1.092	0.061	0.098	0.042	Level	0.000	0.000	0.79		
	J131312	5/ 2/90	2	180	0.000	0.169	0.0031	0.0122	0.168	0.001	1.209	0.074	0.152	0.083	Level	0.030	0.000	5.52	18.80	0.322
			3	90	0.610	0.169	0.0069	0.0122	0.721	0.027	1.209	0.074	0.079	0.083	Level	0.000	0.000	48.24		
			4	90	0.000	0.169	0.0023	0.0122	0.126	0.001	1.209	0.074	0.152	0.083	Level	0.054	0.000	4.66		
	J131313	5/ 1/90	2	180	0.000	0.518	0.0060	0.0241	0.328	0.005	1.319	0.089	0.152	0.152	Level	0.271	0.119	25.14	85.03	0.576
			3	90	0.610	0.518	0.0135	0.0241	0.925	0.044	1.319	0.089	0.114	0.152	Level	0.000	0.119	101.56		
			4	90	0.000	0.518	0.0046	0.0241	0.251	0.003	1.319	0.089	0.152	0.152	Level	0.312	0.119	21.01		
	J113311	5/ 4/90	2	180	0.000	0.080	0.0007	0.0027	0.064	0.000	0.788	0.032	0.086	0.037	Level	0.000	0.000	0.57	1.86	0.355
			3	90	0.610	0.080	0.0005	0.0027	0.220	0.002	0.788	0.032	0.029	0.037	Level	0.000	0.000	3.38		
			4	90	0.000	0.080	0.0016	0.0027	0.151	0.001	0.788	0.032	0.084	0.037	Level	0.000	0.000	1.30		
	J113312	5/ 4/90	2	180	0.000	0.157	0.0031	0.0126	0.172	0.002	1.533	0.120	0.152	0.070	Level	0.007	0.000	4.97	23.55	0.726
			3	90	0.610	0.157	0.0024	0.0126	0.473	0.011	1.533	0.120	0.049	0.070	Level	0.000	0.000	15.62		
			4	90	0.000	0.157	0.0071	0.0126	0.390	0.008	1.533	0.120	0.152	0.070	Level	0.010	0.000	11.84		
	J113313	5/ 9/90	2	180	0.000	0.469	0.0067	0.0265	0.368	0.007	1.455	0.108	0.152	0.152	Level	0.304	0.158	30.47	108.94	0.801
			3	90	0.610	0.469	0.0049	0.0265	0.585	0.017	1.455	0.108	0.072	0.152	Level	0.000	0.158	33.75		
			4	90	0.000	0.469	0.0149	0.0265	0.815	0.034	1.455	0.108	0.152	0.152	Level	0.306	0.158	71.70		
	J122311	5/ 8/90	2	180	0.000	0.080	0.0011	0.0045	0.126	0.001	1.353	0.093	0.075	0.036	Level	0.000	0.000	0.84	5.72	0.443
			3	90	0.610	0.080	0.0017	0.0045	0.425	0.009	1.353	0.093	0.041	0.036	Level	0.000	0.000	10.80		
			4	90	0.000	0.080	0.0017	0.0045	0.185	0.002	1.353	0.093	0.076	0.036	Level	0.000	0.000	1.27		
	J122311R	5/ 9/90	2	180	0.000	0.086	0.0012	0.0048	0.109	0.001	1.147	0.067	0.091	0.043	Level	0.000	0.000	1.12	5.22	0.361
			3	90	0.610	0.086	0.0018	0.0048	0.417	0.009	1.147	0.067	0.044	0.043	Level	0.000	0.000	11.77		
			4	90	0.000	0.086	0.0018	0.0048	0.161	0.001	1.147	0.067	0.089	0.043	Level	0.000	0.000	1.58		
	J122312	5/ 8/90	2	180	0.000	0.204	0.0035	0.0138	0.189	0.002	1.188	0.072	0.152	0.093	Level	0.033	0.000	6.35	22.39	0.414
			3	90	0.610	0.204	0.0052	0.0138	0.589	0.018	1.188	0.072	0.074	0.093	Level	0.000	0.000	35.84		
			4	90	0.000	0.204	0.0052	0.0138	0.284	0.004	1.188	0.072	0.152	0.093	Level	0.078	0.000	11.92		
	J31031	5/10/90	2	180	0.000	0.089	0.0043	0.0058	0.392	0.008	1.454	0.108	0.089	0.041	Level	0.000	0.000	4.11	8.43	0.630
			3	90	0.610	0.089	0.0014	0.0058	0.414	0.009	1.454	0.108	0.037	0.041	Level	0.000	0.000	9.29		
	J31031R	6/ 4/90	2	180	0.000	0.185	0.0108	0.0144	0.590	0.018	1.505	0.115	0.152	0.079	Level	0.027	0.000	20.84	27.37	0.609
			3	90	0.610	0.185	0.0036	0.0144	0.565	0.016	1.505	0.115	0.058	0.079	Level	0.000	0.000	24.11		
	J31032	5/10/90	2	180	0.000	0.159	0.0097	0.0129	0.531	0.014	1.471	0.110	0.152	0.074	Level	0.012	0.000	16.96	23.40	0.609
			3	90	0.610	0.159	0.0032	0.0129	0.595	0.018	1.471	0.110	0.052	0.074	Level	0.000	0.000	21.49		
	J31033	5/11/90	2	180	0.000	0.500	0.0216	0.0288	1.186	0.072	1.580	0.127	0.152	0.152	Level	0.364	0.194	124.66	134.02	0.763
			3	90	0.610	0.500	0.0072	0.0288	0.653	0.022	1.580	0.127	0.089	0.152	Level	0.000	0.194	50.99		
	J22031	5/14/90	2	180	0.000	0.103	0.0031	0.0063	0.233	0.003	1.418	0.102	0.106	0.045	Level	0.000	0.000	3.34	9.06	0.373
			3	90	0.610	0.103	0.0031	0.0063	0.509	0.013	1.418	0.102	0.057	0.045	Level	0.000	0.000	20.94		
	J22033	5/11/90	2	180	0.000	0.542	0.0138	0.0276	0.758	0.029	1.515	0.117	0.152	0.152	Level	0.361	0.192	73.46	125.04	0.699
			3	90	0.610	0.542	0.0138	0.0276	0.810	0.033	1.515	0.117	0.135	0.152	Level	0.000	0.192	105.37		
	J13031	5/14/90	2	180	0.000	0.130	0.0018	0.0071	0.125	0.001	1.383	0.097	0.110	0.049	Level	0.000	0.000	1.90	10.20	0.266
			3	90	0.610	0.130	0.0053	0.0071	0.581	0.017	1.383	0.097	0.076	0.049	Level	0.000	0.000	36.49		
	J13032	5/14/90	2	180	0.000	0.250	0.0032	0.0129	0.177	0.002	0.957	0.047	0.152	0.105	Level	0.031	0.000	5.85	19.22	0.253
			3	90	0.610	0.250	0.0097	0.0129	0.751	0.029	0.957	0.047	0.101	0.105	Level	0.000	0.000	70.01		
	J13033	5/15/90	2	180	0.000	0.486	0.0192	0.0255	1.051	0.056	1.400	0.100	0.152	0.152	Level	0.267	0.115	89.47	91.97	0.676
			3	90	0.610	0.486	0.0064	0.0255	0.391	0.008	1.400	0.100	0.127	0.152	Level	0.000	0.115	46.52		
	J222313R1	5/16/90	2	180	0.000	0.472	0.0158	0.0315	0.865	0.038	1.729	0.152	0.152	0.152	Level	0.301	0.162	75.98	144.54	0.858
			3	90	0.610	0.472	0.0080	0.0315	0.790	0.032	1.729	0.152	0.083	0.152	Level	0.000	0.162	56.91		
			4	90	0.000	0.472	0.0078	0.0315	0.425	0.009	1.729	0.152	0.152	0.152	Level	0.305	0.162	35.48		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	J222313R2	5/16/90	2	180	0.000	0.478	0.0158	0.0317	0.865	0.038	1.737	0.154	0.152	0.152	Level	0.300	0.161	75.79	145.04	0.859
			3	90	0.610	0.478	0.0080	0.0317	0.797	0.032	1.737	0.154	0.082	0.152	Level	0.000	0.161	56.91		
			4	90	0.000	0.478	0.0079	0.0317	0.433	0.010	1.737	0.154	0.152	0.152	Lovel	0.305	0.161	36.20		
	J222313R3	5/16/90	2	180	0.000	0.210	0.0158	0.0316	0.866	0.038	1.732	0.153	0.152	0.152	Level	0.305	0.166	76.80	145.91	0.862
			3	90	0.610	0.210	0.0080	0.0316	0.783	0.031	1.732	0.153	0.084	0.152	Level	0.000	0.166	56.91		
			4	90	0.000	0.210	0.0078	0.0316	0.425	0.009	1.732	0.153	0.152	0.152	Level	0.306	0.166	35.57		

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Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	A400001RR	8/16/91	2	180	0.000	0.159	0.0157	0.0157	0.876	0.039	0.876	0.039	0.145	0.145	level	0.000	0.000	28.42	28.42	1.000
	A040202	11/26/90	3	135	0.288	0.305	0.0193	0.0193	1.205	0.074	1.510	0.116	0.125	0.101	level	0.000	0.000	92.05	40.97	0.445
	A040201R	11/28/90	3	135	0.288	0.183	0.0131	0.0131	0.881	0.040	1.622	0.134	0.116	0.069	level	0.000	0.000	57.15	26.22	0.459
	A220202	11/21/90	2	180	0.000	0.302	0.0138	0.0274	0.756	0.029	1.611	0.132	0.152	0.134	level	0.162	0.000	46.38	71.48	0.661
			3	135	0.305	0.302	0.0136	0.0274	0.890	0.040	1.611	0.132	0.119	0.134	level	0.000	0.000	61.84		
	A220203	11/21/90	2	180	0.000	0.415	0.0164	0.0322	0.900	0.041	1.792	0.164	0.152	0.146	level	0.244	0.000	70.45	97.83	0.673
			3	135	0.305	0.415	0.0158	0.0322	0.921	0.043	1.792	0.164	0.136	0.146	level	0.000	0.000	74.92		
	A220201	11/21/90	2	180	0.000	0.145	0.0055	0.0113	0.303	0.005	1.217	0.075	0.152	0.077	level	0.018	0.000	9.49	16.86	0.524
			3	135	0.305	0.145	0.0057	0.0113	0.603	0.019	1.217	0.075	0.079	0.077	level	0.000	0.000	22.67		
	A310202	12/21/90	2	180	0.000	0.268	0.0196	0.0262	1.076	0.059	1.608	0.132	0.152	0.127	level	0.092	0.000	58.43	66.54	0.784
			3	135	0.305	0.268	0.0066	0.0262	0.648	0.021	1.608	0.132	0.083	0.127	level	0.000	0.000	26.48		
	A310201	12/20/90	2	180	0.000	0.145	0.0100	0.0134	0.546	0.015	1.283	0.084	0.152	0.085	level	0.005	0.000	16.86	22.09	0.747
			3	135	0.305	0.145	0.0034	0.0134	0.496	0.013	1.283	0.084	0.062	0.085	level	0.000	0.000	12.73		
	A130202	12/26/91	2	180	0.000	0.332	0.0056	0.0232	0.307	0.005	1.385	0.098	0.152	0.131	level	0.137	0.000	16.18	52.03	0.515
			3	135	0.305	0.332	0.0176	0.0232	1.033	0.054	1.385	0.098	0.134	0.131	level	0.000	0.000	84.89		
	A130201R	1/9/91	2	180	0.000	0.168	0.0033	0.0127	0.180	0.002	1.486	0.113	0.152	0.072	level	0.021	0.000	5.65	22.93	0.506
			3	135	0.305	0.168	0.0094	0.0127	0.760	0.029	1.486	0.113	0.098	0.072	level	0.000	0.000	39.68		
	A130302	12/28/90	2	180	0.000	0.408	0.0056	0.0216	0.307	0.005	1.338	0.091	0.152	0.126	level	0.195	0.000	19.36	46.04	0.323
			3	135	0.610	0.408	0.0160	0.0216	0.978	0.049	1.338	0.091	0.128	0.126	level	0.000	0.000	123.34		
	A130301	12/28/90	2	180	0.000	0.206	0.0032	0.0116	0.175	0.002	1.223	0.076	0.152	0.079	level	0.046	0.000	6.26	17.62	0.265
			3	135	0.610	0.206	0.0084	0.0116	0.719	0.026	1.223	0.076	0.093	0.079	level	0.000	0.000	60.12		
	A220303	1/3/91	2	180	0.000	0.396	0.0147	0.0294	0.807	0.033	1.614	0.133	0.152	0.152	level	0.259	0.004	64.19	83.39	0.472
			3	135	0.610	0.396	0.0147	0.0294	0.910	0.042	1.614	0.133	0.126	0.152	level	0.000	0.004	112.35		
	A220302	1/3/91	2	180	0.000	0.405	0.0119	0.0242	0.654	0.022	1.383	0.097	0.152	0.140	level	0.207	0.000	44.58	56.26	0.413
			3	135	0.610	0.405	0.0123	0.0242	0.876	0.039	1.383	0.097	0.110	0.140	level	0.000	0.000	91.59		
	A220301	1/3/91	2	180	0.000	0.189	0.0064	0.0126	0.352	0.006	1.483	0.112	0.152	0.072	level	0.041	0.000	12.60	22.81	0.409
			3	135	0.610	0.189	0.0062	0.0126	0.632	0.020	1.483	0.112	0.081	0.072	level	0.000	0.000	43.21		
	A310301	1/4/91	2	180	0.000	0.158	0.0093	0.0122	0.512	0.013	1.282	0.084	0.152	0.079	level	0.018	0.000	16.86	19.52	0.537
			3	135	0.610	0.158	0.0029	0.0122	0.414	0.009	1.282	0.084	0.062	0.079	level	0.000	0.000	19.47		
	A040302	1/8/91	3	135	0.610	0.424	0.0171	0.0171	1.043	0.055	1.346	0.092	0.129	0.100	level	0.000	0.000	133.29	32.34	0.243
	A040301	1/8/91	3	135	0.610	0.201	0.0115	0.0115	0.832	0.035	1.509	0.116	0.108	0.066	level	0.000	0.000	85.09	20.61	0.242
	A222211	11/27/90	2	180	0.000	0.157	0.0062	0.0125	0.340	0.006	1.257	0.081	0.152	0.081	level	0.008	0.000	10.09	19.78	0.746
			3	135	0.305	0.157	0.0032	0.0125	0.502	0.013	1.257	0.081	0.058	0.081	level	0.000	0.000	11.67		
			4	90	0.000	0.157	0.0031	0.0125	0.169	0.001	1.257	0.081	0.152	0.081	level	0.003	0.000	4.75		
	A222212	11/27/90	2	180	0.000	0.323	0.0140	0.0278	0.767	0.030	1.593	0.129	0.152	0.139	level	0.171	0.000	48.42	73.14	0.747
			3	135	0.305	0.323	0.0070	0.0278	0.663	0.022	1.593	0.129	0.085	0.139	level	0.000	0.000	28.17		
			4	90	0.000	0.323	0.0068	0.0278	0.374	0.007	1.593	0.129	0.152	0.139	level	0.158	0.000	21.28		
	A222213	11/27/90	2	180	0.000	0.418	0.0172	0.0345	0.945	0.046	1.892	0.182	0.152	0.152	level	0.294	0.005	83.19	115.06	0.729
			3	135	0.305	0.418	0.0088	0.0345	0.512	0.013	1.892	0.182	0.136	0.152	level	0.000	0.005	39.05		
			4	90	0.000	0.418	0.0085	0.0345	0.466	0.011	1.892	0.182	0.152	0.152	level	0.265	0.005	35.70		
	A331211R	3/14/91	2	180	0.000	0.152	0.0098	0.0133	0.539	0.015	1.307	0.087	0.152	0.083	level	0.009	0.000	16.99	22.07	0.804
			3	135	0.305	0.152	0.0026	0.0133	0.426	0.009	1.307	0.087	0.056	0.083	level	0.000	0.000	9.34		
			4	90	0.000	0.152	0.0008	0.0133	0.050	0.000	1.307	0.087	0.135	0.083	level	0.000	0.000	1.12		
	A331212	3/14/91	2	180	0.000	0.250	0.0222	0.0295	1.219	0.076	1.817	0.168	0.152	0.127	level	0.152	0.000	82.91	85.50	0.782
			3	135	0.305	0.250	0.0056	0.0295	0.565	0.016	1.817	0.168	0.081	0.127	level	0.000	0.000	21.87		
			4	90	0.000	0.250	0.0018	0.0295	0.096	0.000	1.817	0.168	0.152	0.127	level	0.111	0.000	4.55		
	A131211	3/15/91	2	180	0.000	0.152	0.0022	0.0089	0.126	0.001	1.110	0.063	0.140	0.069	level	0.000	0.000	3.05	11.48	0.465
			3	135	0.305	0.152	0.0050	0.0089	0.543	0.015	1.110	0.063	0.076	0.069	level	0.000	0.000	19.24		
			4	90	0.000	0.152	0.0017	0.0089	0.096	0.000	1.110	0.063	0.142	0.069	level	0.000	0.000	2.37		
	A131212	3/15/91	2	180	0.000	0.305	0.0060	0.0241	0.328	0.005	1.365	0.095	0.152	0.141	level	0.158	0.000	18.53	55.83	0.592
			3	135	0.305	0.305	0.0134	0.0241	0.856	0.037	1.365	0.095	0.122	0.141	level	0.000	0.000	60.93		
			4	90	0.000	0.305	0.0047	0.0241	0.258	0.003	1.365	0.095	0.152	0.141	level	0.168	0.000	14.90		
	A131213	3/18/91	2	180	0.000	0.384	0.0076	0.0303	0.418	0.009	1.725	0.152	0.152	0.141	level	0.232	0.000	29.34	86.84	0.652
			3	135	0.305	0.384	0.0172	0.0303	0.992	0.050	1.725	0.152	0.137	0.141	level	0.000	0.000	82.79		
			4	90	0.000	0.384	0.0056	0.0303	0.304	0.005	1.725	0.152	0.152	0.141	level	0.229	0.000	20.99		
	A313211	3/18/91	2	180	0.000	0.152	0.0104	0.0142	0.571	0.017	1.379	0.097	0.152	0.084	level	0.014	0.000	18.67	25.28	0.976
			3	135	0.305	0.152	0.0009	0.0142	0.286	0.004	1.379	0.097	0.035	0.084	level	0.000	0.000	3.06		
			4	90	0.000	0.152	0.0029	0.0142	0.160	0.001	1.379	0.097	0.146	0.084	level	0.000	0.000	4.18		
	A313212	3/19/91	2	180	0.000	0.241	0.0224	0.0300	1.226	0.077	1.892	0.182	0.152	0.124	level	0.140	0.000	80.97	90.08	0.887
			3	135	0.305	0.241	0.0020	0.0300	0.343	0.006	1.892	0.182	0.053	0.124	level	0.000	0.000	6.98		
			4	90	0.000	0.241	0.0057	0.0300	0.314	0.005	1.892	0.182	0.152	0.124	level	0.085	0.000	13.61		
	A322211	3/21/91	2	180	0.000	0.165	0.0121	0.0163	0.666	0.023	1.488	0.113	0.152	0.088	level	0.034	0.000	24.83	32.00	0.900
			3	135	0.305	0.165	0.0022	0.0163	0.439	0.010	1.488	0.113	0.048	0.088	level	0.000	0.000	7.65		
			4	90	0.000	0.165	0.0020	0.0163	0.109	0.001	1.488	0.113	0.152	0.088	level	0.005	0.000	3.06		
	A322212	3/21/91	2	180	0.000	0.241	0.0219	0.0291	1.200	0.073	1.875	0.179	0.152	0.121	level	0.137	0.000	77.88	85.39	0.854
			3	135	0.305	0.241	0.0036	0.0291	0.515	0.013	1.875	0.179	0.062	0.121	level	0.000	0.000	13.53		
			4	90	0.000	0.241	0.0035	0.0291	0.194	0.002	1.875	0.179	0.152	0.121	level	0.091	0.000	8.53		
	A231211	3/25/91	2	180	0.000	0.141	0.0057	0.0118	0.315	0.005	1.253	0.080	0.148	0.078	level	0.000	0.000	8.53	18.25	0.653
			3	135	0.305	0.141	0.0045	0.0118	0.562	0.016	1.253	0.080	0.069	0.078	level	0.000	0.000	17.08		
			4	90	0.000	0.141	0.0016	0.0118	0.089	0.000	1.253	0.080	0.148	0.078	level	0.000	0.000	2.35		
	A231212	3/26/91	2	180	0.000	0.308	0.0132	0.0266	0.723	0.027	1.609	0.132	0.152	0.130	level	0.149	0.000	42.48	68.38	0.720
			3	135	0.305	0.308	0.0099	0.0266	0.778	0.031	1.609	0.132	0.101	0.130	level	0.000	0.000	42.51		
			4	90	0.000	0.308	0.0035	0.0266	0.192	0.002	1.609	0.132	0.152	0.130	level	0.134	0.000	9.93		
	A231213	3/26/91	2	180	0.000	0.405	0.0174	0.0349	0.955	0.046	1.916	0.187	0.152	0.152	level	0.299	0.000	84.94	116.25	0.713
			3	135	0.305	0.405	0.0131	0.0349	0.747	0.028	1.916	0.187	0.140	0.152	level	0.000	0.000	60.85		
			4	90	0.000	0.405	0.0044	0.0349	0.242	0.003	1.916	0.187	0.152	0.152	level	0.244	0.000	17.29		

Notes	Run ID	Dato	Inflow Pipe	Thota	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	A122211	3/29/91	2	180	0.000	0.183	0.0038	0.0151	0.206	0.002	1.285	0.084	0.152	0.094	level	0.037	0.000	7.06	26.43	0.665
			3	135	0.305	0.183	0.0056	0.0151	0.785	0.031	1.285	0.084	0.063	0.094	level	0.000	0.000	22.07		
			4	90	0.000	0.183	0.0057	0.0151	0.315	0.005	1.285	0.084	0.152	0.094	level	0.030	0.000	10.59		
	A122212	4/1/91	2	180	0.000	0.269	0.0062	0.0248	0.342	0.006	1.593	0.129	0.152	0.121	level	0.107	0.000	16.19	60.95	0.773
			3	135	0.305	0.269	0.0093	0.0248	0.751	0.029	1.593	0.129	0.098	0.121	level	0.000	0.000	39.13		
			4	90	0.000	0.269	0.0093	0.0248	0.512	0.013	1.593	0.129	0.152	0.121	level	0.091	0.000	23.56		
	A122213R	4/2/91	2	180	0.000	0.396	0.0079	0.0319	0.435	0.010	1.779	0.161	0.152	0.145	level	0.244	0.000	31.55	95.92	0.726
			3	135	0.305	0.396	0.0118	0.0319	0.828	0.035	1.779	0.161	0.111	0.145	level	0.000	0.000	52.20		
			4	90	0.000	0.396	0.0121	0.0319	0.666	0.023	1.779	0.161	0.152	0.145	level	0.232	0.000	48.43		
	A113211	4/3/91	2	180	0.000	0.167	0.0024	0.0096	0.130	0.001	0.989	0.050	0.152	0.080	level	0.008	0.000	3.76	12.17	0.666
			3	135	0.305	0.167	0.0019	0.0096	0.294	0.004	0.989	0.050	0.058	0.080	level	0.000	0.000	6.73		
			4	90	0.000	0.167	0.0053	0.0096	0.297	0.005	0.989	0.050	0.145	0.080	level	0.000	0.000	7.79		
	A113212	4/3/91	2	180	0.000	0.271	0.0061	0.0244	0.332	0.006	1.537	0.120	0.152	0.124	level	0.128	0.000	16.99	58.34	0.786
			3	135	0.305	0.271	0.0046	0.0244	0.548	0.015	1.537	0.120	0.072	0.124	level	0.000	0.000	17.73		
			4	90	0.000	0.271	0.0137	0.0244	0.751	0.029	1.537	0.120	0.152	0.124	level	0.113	0.000	39.49		
	A031211B	4/16/91	3	135	0.305	0.189	0.0097	0.0127	0.731	0.027	0.886	0.040	0.104	0.112	level	0.000	0.000	41.24	18.93	0.400
			4	90	0.021	0.189	0.0031	0.0127	0.168	0.001	0.886	0.040	0.152	0.112	level	0.027	0.000	6.07		
	A031212	4/8/91	3	135	0.305	0.326	0.0178	0.0236	1.046	0.056	1.296	0.086	0.134	0.151	level	0.000	0.000	86.24	54.61	0.510
			4	90	0.021	0.326	0.0058	0.0236	0.318	0.005	1.296	0.086	0.152	0.151	level	0.186	0.000	20.76		
	A022211	4/9/91	3	135	0.305	0.158	0.0053	0.0104	0.608	0.019	1.529	0.119	0.073	0.061	level	0.000	0.000	20.49	18.40	0.623
			4	90	0.021	0.158	0.0052	0.0104	0.283	0.004	1.529	0.119	0.152	0.061	level	0.001	0.000	9.04		
	A022212	4/9/91	3	135	0.305	0.372	0.0131	0.0265	0.866	0.038	1.453	0.108	0.117	0.152	level	0.000	0.012	58.92	70.71	0.627
			4	90	0.021	0.372	0.0135	0.0265	0.737	0.028	1.453	0.108	0.152	0.152	level	0.207	0.012	53.89		
	A013211	4/10/91	3	135	0.305	0.180	0.0033	0.0132	0.413	0.009	1.370	0.096	0.069	0.080	level	0.000	0.000	12.30	22.66	0.722
			4	90	0.021	0.180	0.0099	0.0132	0.543	0.015	1.370	0.096	0.152	0.080	level	0.008	0.000	19.08		
	A013212	4/10/91	3	135	0.305	0.289	0.0054	0.0223	0.558	0.016	1.252	0.080	0.079	0.143	level	0.000	0.000	20.98	48.75	0.561
			4	90	0.021	0.289	0.0169	0.0223	0.928	0.044	1.252	0.080	0.152	0.143	level	0.180	0.000	65.98		
	A031311	4/17/91	3	135	0.610	0.219	0.0093	0.0124	0.740	0.028	0.787	0.032	0.099	0.123	level	0.000	0.000	67.07	18.77	0.257
			4	90	0.021	0.219	0.0031	0.0124	0.171	0.001	0.787	0.032	0.152	0.123	level	0.017	0.000	5.86		
	A031312	5/6/91	3	135	0.610	0.390	0.0146	0.0194	0.884	0.040	1.096	0.061	0.130	0.142	level	0.000	0.000	111.58	38.76	0.302
			4	90	0.021	0.390	0.0048	0.0194	0.262	0.004	1.096	0.061	0.152	0.142	level	0.183	0.000	16.90		
	A031313	5/7/91	3	135	0.610	0.372	0.0145	0.0191	0.886	0.040	1.090	0.061	0.128	0.140	level	0.000	0.000	110.53	37.45	0.295
			4	90	0.021	0.372	0.0046	0.0191	0.253	0.003	1.090	0.061	0.152	0.140	level	0.183	0.000	16.28		
	A022311	5/7/91	3	135	0.610	0.176	0.0060	0.0126	0.690	0.024	0.791	0.032	0.073	0.124	level	0.000	0.000	41.41	19.22	0.354
			4	90	0.021	0.176	0.0066	0.0126	0.363	0.007	0.791	0.032	0.152	0.124	level	0.018	0.000	12.91		
	A022312	5/8/91	3	135	0.610	0.384	0.0084	0.0169	0.733	0.027	0.950	0.046	0.091	0.143	level	0.000	0.000	59.86	31.36	0.351
			4	90	0.021	0.384	0.0085	0.0169	0.467	0.011	0.950	0.046	0.152	0.143	level	0.168	0.000	29.45		
	A022313	5/8/91	3	135	0.610	0.354	0.0132	0.0263	0.910	0.042	1.442	0.106	0.113	0.152	level	0.000	0.047	98.69	78.81	0.484
			4	90	0.021	0.354	0.0131	0.0263	0.720	0.026	1.442	0.106	0.152	0.152	level	0.299	0.047	64.26		
	A013311	5/8/91	3	135	0.610	0.204	0.0032	0.0131	0.436	0.010	0.785	0.031	0.064	0.130	level	0.000	0.000	21.25	20.72	0.481
			4	90	0.021	0.204	0.0099	0.0131	0.542	0.015	0.785	0.031	0.152	0.130	level	0.037	0.000	21.82		
	A013312	5/9/91	3	135	0.610	0.338	0.0044	0.0170	0.600	0.018	0.957	0.047	0.064	0.142	level	0.000	0.000	29.58	31.43	0.425
			4	90	0.021	0.338	0.0126	0.0170	0.691	0.024	0.957	0.047	0.152	0.142	level	0.162	0.000	44.42		
	A013313	5/9/91	3	135	0.610	0.372	0.0056	0.0227	0.684	0.024	1.245	0.079	0.070	0.152	level	0.000	0.005	38.67	52.60	0.461
			4	90	0.021	0.372	0.0171	0.0227	0.938	0.045	1.245	0.079	0.152	0.152	level	0.232	0.005	75.48		
	A331311	5/10/91	2	180	0.000	0.176	0.0101	0.0136	0.583	0.017	0.800	0.033	0.137	0.134	level	0.000	0.000	15.27	22.30	0.647
			3	135	0.610	0.176	0.0027	0.0136	0.395	0.008	0.800	0.033	0.061	0.134	level	0.000	0.000	17.89		
			4	90	0.000	0.176	0.0008	0.0136	0.047	0.000	0.800	0.033	0.152	0.134	level	0.001	0.000	1.28		
	A331312	5/13/91	2	180	0.000	0.292	0.0185	0.0253	1.015	0.053	1.491	0.113	0.152	0.134	level	0.137	0.000	62.10	61.45	0.599
			3	135	0.610	0.292	0.0053	0.0253	0.608	0.019	1.491	0.113	0.073	0.134	level	0.000	0.000	36.23		
			4	90	0.000	0.292	0.0016	0.0253	0.087	0.000	1.491	0.113	0.152	0.134	level	0.122	0.000	4.27		
	A331313	5/13/91	2	180	0.000	0.344	0.0217	0.0292	1.188	0.072	1.660	0.140	0.152	0.141	level	0.183	0.000	86.46	80.55	0.609
			3	135	0.610	0.344	0.0059	0.0292	0.646	0.021	1.660	0.140	0.076	0.141	level	0.000	0.000	40.83		
			4	90	0.000	0.344	0.0017	0.0292	0.092	0.000	1.660	0.140	0.152	0.141	level	0.148	0.000	4.92		
	A222311	5/14/91	2	180	0.000	0.180	0.0061	0.0123	0.332	0.006	0.726	0.027	0.152	0.134	level	0.043	0.000	11.92	19.48	0.502
			3	135	0.610	0.180	0.0032	0.0123	0.490	0.012	0.726	0.027	0.059	0.134	level	0.000	0.000	21.56		
			4	90	0.000	0.180	0.0031	0.0123	0.168	0.001	0.726	0.027	0.152	0.134	level	0.023	0.000	5.30		
	A222312	5/14/91	2	180	0.000	0.347	0.0119	0.0243	0.652	0.022	1.374	0.096	0.152	0.141	level	0.183	0.000	41.62	56.54	0.540
			3	135	0.610	0.347	0.0063	0.0243	0.686	0.024	1.374	0.096	0.076	0.141	level	0.000	0.000	43.55		
			4	90	0.000	0.347	0.0061	0.0243	0.335	0.006	1.374	0.096	0.152	0.141	level	0.168	0.000	19.53		
	A222313	5/14/91	2	180	0.000	0.381	0.0168	0.0335	0.921	0.043	1.890	0.182	0.152	0.142	level	0.314	0.000	83.88	106.49	0.584
			3	135	0.610	0.381	0.0083	0.0335	0.792	0.032	1.890	0.182	0.085	0.142	level	0.000	0.000	59.33		
			4	90	0.000	0.381	0.0084	0.0335	0.459	0.011	1.890	0.182	0.152	0.142	level	0.314	0.000	39.20		
	A131311	5/15/91	2	180	0.000	0.181	0.0029	0.0111	0.160	0.001	0.738	0.028	0.152	0.117	level	0.047	0.000	5.75	15.83	0.305
			3	135	0.610	0.181	0.0061	0.0111	0.729	0.027	0.738	0.028	0.072	0.117	level	0.000	0.000	42.67		
			4	90	0.000	0.181	0.0021	0.0111	0.113	0.001	0.738	0.028	0.152	0.117	level	0.021	0.000	3.53		
	A131312	5/15/91	2	180	0.000	0.390	0.0053	0.0208	0.292	0.004	1.154	0.068	0.152	0.147	level	0.183	0.000	17.72	43.82	0.372
			3	135	0.610	0.390	0.0120	0.0208	0.878	0.039	1.154	0.068	0.107	0.147	level	0.000	0.000	88.73		
			4	90	0.000	0.390	0.0035	0.0208	0.194	0.002	1.154	0.068	0.152	0.147	level	0.174	0.000	11.38		
	A131313	5/15/91	2	180	0.000	0.402	0.0071	0.0284	0.390	0.008	1.557	0.124	0.152	0.152	level	0.305	0.021	32.40	82.68	0.454
			3	135	0.610	0.402	0.0163	0.0284	0.961	0.047	1.557	0.124	0.134	0.152	level	0.000	0.021	126.66		
			4	90	0.000	0.402	0.0050	0.0284	0.272	0.004	1.557	0.124	0.152	0.152	level	0.320	0.021	23.13		
	A313311	5/16/91	2	180	0.000	0.145	0.0096	0.0129	0.528	0.014	0.826	0.035	0.152	0.122	level	0.010	0.000	16.70	19.75	0.784
			3	135	0.610	0.145	0.0008	0.0129	0.368	0.007	0.826	0.035	0.027	0.122	level	0.000	0.000	5.18		
			4	90	0.000	0.145	0.0024	0.0129	0.141	0.001	0.826	0.035	0.137	0.122	level	0.000	0.000	3.30		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	A313312	5/16/91	2	180	0.000	0.282	0.0225	0.0297	1.234	0.078	1.753	0.157	0.152	0.134	level	0.174	0.000	89.10	84.49	0.725
			3	135	0.610	0.282	0.0020	0.0297	0.335	0.006	1.753	0.157	0.055	0.134	level	0.000	0.000	13.02		
			4	90	0.000	0.282	0.0052	0.0297	0.286	0.004	1.753	0.157	0.152	0.134	level	0.125	0.000	14.38		
	A313313	5/20/91	2	180	0.000	0.304	0.0230	0.0301	1.260	0.081	1.962	0.196	0.152	0.119	level	0.174	0.000	91.76	93.12	0.785
			3	135	0.610	0.304	0.0018	0.0301	0.394	0.008	1.962	0.196	0.046	0.119	level	0.000	0.000	11.78		
			4	90	0.000	0.304	0.0053	0.0301	0.290	0.004	1.962	0.196	0.152	0.119	level	0.133	0.000	15.02		
	A322311	5/21/91	2	180	0.000	0.189	0.0117	0.0156	0.643	0.021	0.902	0.041	0.152	0.137	level	0.049	0.000	25.54	27.23	0.659
			3	135	0.610	0.189	0.0019	0.0156	0.511	0.013	0.902	0.041	0.040	0.137	level	0.000	0.000	12.51		
			4	90	0.000	0.189	0.0019	0.0156	0.104	0.001	0.902	0.041	0.152	0.137	level	0.024	0.000	3.30		
	A322312	5/21/91	2	180	0.000	0.326	0.0230	0.0305	1.262	0.081	1.851	0.175	0.152	0.129	level	0.198	0.000	97.42	90.66	0.677
			3	135	0.610	0.326	0.0039	0.0305	0.559	0.016	1.851	0.175	0.062	0.129	level	0.000	0.000	26.55		
			4	90	0.000	0.326	0.0035	0.0305	0.192	0.002	1.851	0.175	0.152	0.129	level	0.137	0.000	10.03		
	A322313	5/21/91	2	180	0.000	0.329	0.0231	0.0307	1.268	0.082	1.855	0.175	0.152	0.130	level	0.198	0.000	98.08	91.94	0.677
			3	135	0.610	0.329	0.0040	0.0307	0.590	0.018	1.855	0.175	0.061	0.130	level	0.000	0.000	27.13		
			4	90	0.000	0.329	0.0036	0.0307	0.196	0.002	1.855	0.175	0.152	0.130	level	0.149	0.000	10.62		
	A231311	5/22/91	2	180	0.000	0.157	0.0061	0.0123	0.332	0.006	0.773	0.030	0.152	0.125	level	0.030	0.000	11.20	18.77	0.413
			3	135	0.610	0.157	0.0047	0.0123	0.627	0.020	0.773	0.030	0.066	0.125	level	0.000	0.000	32.03		
			4	90	0.000	0.157	0.0016	0.0123	0.088	0.000	0.773	0.030	0.143	0.125	level	0.000	0.000	2.19		
	A231312	5/23/91	2	180	0.000	0.384	0.0128	0.0259	0.700	0.025	1.472	0.110	0.152	0.140	level	0.198	0.000	47.01	63.53	0.498
			3	135	0.610	0.384	0.0096	0.0259	0.840	0.036	1.472	0.110	0.091	0.140	level	0.000	0.000	69.36		
			4	90	0.000	0.384	0.0035	0.0259	0.191	0.002	1.472	0.110	0.152	0.140	level	0.174	0.000	11.20		
	A231313	5/23/91	2	180	0.000	0.482	0.0161	0.0330	0.885	0.040	1.807	0.166	0.152	0.152	level	0.311	0.025	79.62	111.17	0.582
			3	135	0.610	0.482	0.0123	0.0330	0.962	0.047	1.807	0.166	0.101	0.152	level	0.000	0.025	91.25		
			4	90	0.000	0.482	0.0045	0.0330	0.248	0.003	1.807	0.166	0.152	0.152	level	0.299	0.025	20.18		
	A213311	5/24/91	2	180	0.000	0.152	0.0068	0.0129	0.371	0.007	0.810	0.033	0.152	0.125	level	0.000	0.000	10.58	20.06	0.739
			3	135	0.610	0.152	0.0015	0.0129	0.823	0.035	0.810	0.033	0.024	0.125	level	0.000	0.000	9.65		
			4	90	0.000	0.152	0.0047	0.0129	0.262	0.004	0.810	0.033	0.146	0.125	level	0.000	0.000	6.90		
	A213312	5/24/91	2	180	0.000	0.289	0.0140	0.0289	0.768	0.030	1.641	0.137	0.152	0.141	level	0.137	0.000	43.92	78.98	0.782
			3	135	0.610	0.289	0.0037	0.0289	0.640	0.021	1.641	0.137	0.053	0.141	level	0.000	0.000	24.49		
			4	90	0.000	0.289	0.0113	0.0289	0.619	0.020	1.641	0.137	0.152	0.141	level	0.122	0.000	32.55		
	A213313	5/28/91	2	180	0.000	0.494	0.0172	0.0335	0.942	0.045	1.836	0.172	0.152	0.152	level	0.335	0.018	89.79	112.48	0.629
			3	135	0.610	0.494	0.0042	0.0335	0.518	0.014	1.836	0.172	0.152	0.152	level	0.000	0.018	31.65		
			4	90	0.000	0.494	0.0121	0.0335	0.664	0.022	1.836	0.172	0.152	0.152	level	0.308	0.018	57.36		
	A122311	5/28/91	2	180	0.000	0.152	0.0024	0.0098	0.131	0.001	0.712	0.026	0.152	0.108	level	0.009	0.000	3.83	12.88	0.380
			3	135	0.610	0.152	0.0037	0.0098	0.518	0.014	0.712	0.026	0.062	0.108	level	0.000	0.000	24.75		
			4	90	0.000	0.152	0.0037	0.0098	0.210	0.002	0.712	0.026	0.142	0.108	level	0.000	0.000	5.28		
	A122312	5/29/91	2	180	0.000	0.381	0.0049	0.0200	0.271	0.004	1.094	0.061	0.152	0.152	level	0.183	0.007	16.38	43.08	0.447
			3	135	0.610	0.381	0.0080	0.0200	0.762	0.030	1.094	0.061	0.082	0.152	level	0.000	0.007	56.28		
			4	90	0.000	0.381	0.0071	0.0200	0.387	0.008	1.094	0.061	0.152	0.152	level	0.183	0.007	23.80		
	A122313	5/29/91	2	180	0.000	0.399	0.0058	0.0222	0.317	0.005	1.217	0.075	0.152	0.152	level	0.213	0.005	21.00	50.65	0.458
			3	135	0.610	0.399	0.0087	0.0222	0.762	0.030	1.217	0.075	0.091	0.152	level	0.000	0.005	62.47		
			4	90	0.000	0.399	0.0077	0.0222	0.424	0.009	1.217	0.075	0.152	0.152	level	0.198	0.005	27.16		
	A113311	5/30/91	2	180	0.000	0.148	0.0027	0.0114	0.149	0.001	0.753	0.029	0.152	0.118	level	0.003	0.000	4.17	16.36	0.614
			3	135	0.610	0.148	0.0020	0.0114	0.518	0.014	0.753	0.029	0.040	0.118	level	0.000	0.000	12.70		
			4	90	0.000	0.148	0.0067	0.0114	0.381	0.007	0.753	0.029	0.140	0.118	level	0.000	0.000	9.75		
	A113312	5/30/91	2	180	0.000	0.303	0.0053	0.0206	0.290	0.004	1.132	0.065	0.152	0.152	level	0.122	0.008	14.46	45.59	0.631
			3	135	0.610	0.303	0.0036	0.0206	0.579	0.017	1.132	0.065	0.055	0.152	level	0.000	0.008	24.22		
			4	90	0.000	0.303	0.0117	0.0206	0.643	0.021	1.132	0.065	0.152	0.152	level	0.119	0.008	33.60		
	A113313	5/31/91	2	180	0.000	0.351	0.0054	0.0230	0.293	0.004	1.259	0.081	0.152	0.152	level	0.201	0.014	18.78	55.72	0.576
			3	135	0.610	0.351	0.0042	0.0230	0.671	0.023	1.259	0.081	0.061	0.152	level	0.000	0.014	28.68		
			4	90	0.000	0.351	0.0134	0.0230	0.735	0.027	1.259	0.081	0.152	0.152	level	0.195	0.014	49.24		
	A331331	6/6/91	2	180	0.000	0.162	0.0101	0.0133	0.552	0.016	0.902	0.041	0.152	0.115	level	0.012	0.000	17.80	20.32	0.526
			3	135	0.610	0.162	0.0024	0.0133	0.396	0.008	0.902	0.041	0.052	0.115	level	0.000	0.000	15.42		
			4	90	0.610	0.162	0.0008	0.0133	0.213	0.002	0.902	0.041	0.037	0.115	level	0.000	0.000	5.40		
	A331332	6/12/91	2	180	0.000	0.311	0.0193	0.0255	1.061	0.057	1.399	0.100	0.152	0.152	level	0.183	0.012	74.44	65.94	0.568
			3	135	0.610	0.311	0.0047	0.0255	0.549	0.015	1.399	0.100	0.070	0.152	level	0.000	0.012	31.84		
			4	90	0.610	0.311	0.0015	0.0255	0.229	0.003	1.399	0.100	0.058	0.152	level	0.000	0.012	9.86		
	A331333	6/13/91	2	180	0.000	0.369	0.0211	0.0283	1.158	0.068	1.552	0.123	0.152	0.152	level	0.219	0.016	91.16	80.87	0.577
			3	135	0.610	0.369	0.0054	0.0283	0.549	0.015	1.552	0.123	0.079	0.152	level	0.000	0.016	36.95		
			4	90	0.610	0.369	0.0018	0.0283	0.274	0.004	1.552	0.123	0.059	0.152	level	0.000	0.016	11.95		
	A222331	6/13/91	2	180	0.000	0.183	0.0046	0.0094	0.250	0.003	0.624	0.020	0.152	0.117	level	0.017	0.000	7.75	12.64	0.317
			3	135	0.610	0.183	0.0025	0.0094	0.579	0.017	0.624	0.020	0.043	0.117	level	0.000	0.000	16.17		
			4	90	0.610	0.183	0.0024	0.0094	0.244	0.003	0.624	0.020	0.079	0.117	level	0.000	0.000	15.94		
	A222332	6/14/91	2	180	0.000	0.335	0.0119	0.0234	0.652	0.022	1.726	0.152	0.152	0.106	level	0.177	0.000	40.91	59.11	0.491
			3	135	0.610	0.335	0.0059	0.0234	0.640	0.021	1.726	0.152	0.076	0.106	level	0.000	0.000	41.20		
			4	90	0.610	0.335	0.0055	0.0234	0.610	0.019	1.726	0.152	0.079	0.106	level	0.000	0.000	38.31		
	A222333	6/14/91	2	180	0.000	0.372	0.0124	0.0248	0.680	0.024	1.888	0.182	0.152	0.103	level	0.206	0.000	46.30	69.14	0.521
			3	135	0.610	0.372	0.0063	0.0248	0.610	0.019	1.888	0.182	0.084	0.103	level	0.000	0.000	43.70		
			4	90	0.610	0.372	0.0061	0.0248	0.579	0.017	1.888	0.182	0.082	0.103	level	0.000	0.000	42.71		
	A131331	6/17/91	2	180	0.000	0.215	0.0035	0.0141	0.189	0.002	1.632	0.136	0.152	0.073	level	0.041	0.000	6.62	28.94	0.356
			3	135	0.610	0.215	0.0078	0.0141	0.762	0.030	1.632	0.136	0.085	0.073	level	0.000	0.000	55.51		
			4	90	0.610	0.215	0.0029	0.0141	0.366	0.007	1.632	0.136	0.069	0.073	level	0.000	0.000	19.21		
	A131332	6/17/91	2	180	0.000	0.269	0.0037	0.0152	0.201	0.002	1.537	0.120	0.152	0.081	level	0.076	0.000	8.26	30.14	0.334
			3	135	0.610	0.269	0.0087	0.0152	0.762	0.030	1.537	0.120	0.091	0.081	level	0.000	0.000	62.67		
			4	90	0.610	0.269	0.0028	0.0152	0.305	0.005	1.537	0.120	0.076	0.081	level	0.000	0.000	19.17		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	A131333	6/18/91	2	180	0.000	0.204	0.0033	0.0144	0.183	0.002	2.043	0.213	0.152	0.062	level	0.040	0.000	6.35	38.79	0.463
			3	135	0.610	0.204	0.0083	0.0144	0.762	0.030	2.043	0.213	0.088	0.062	level	0.000	0.000	58.98		
			4	90	0.610	0.204	0.0027	0.0144	0.396	0.008	2.043	0.213	0.066	0.062	level	0.000	0.000	18.40		
	A313331	6/18/91	2	180	0.000	0.194	0.0102	0.0136	0.558	0.016	0.888	0.040	0.152	0.119	level	0.015	0.000	18.29	21.23	0.521
			3	135	0.610	0.194	0.0009	0.0136	0.457	0.011	0.888	0.040	0.026	0.119	level	0.000	0.000	5.74		
			4	90	0.610	0.194	0.0025	0.0136	0.366	0.007	0.888	0.040	0.061	0.119	level	0.000	0.000	16.74		
	A313332	6/19/91	2	180	0.000	0.341	0.0189	0.0251	1.033	0.054	1.378	0.097	0.152	0.152	level	0.183	0.023	72.04	67.14	0.585
			3	135	0.610	0.341	0.0017	0.0251	0.259	0.003	1.378	0.097	0.061	0.152	level	0.000	0.023	11.04		
			4	90	0.610	0.341	0.0046	0.0251	0.427	0.009	1.370	0.097	0.087	0.152	level	0.000	0.023	31.74		
	A313333	6/19/91	2	180	0.000	0.363	0.0209	0.0281	1.146	0.067	1.538	0.121	0.152	0.152	level	0.213	0.023	88.76	81.38	0.591
			3	135	0.610	0.363	0.0019	0.0281	0.305	0.005	1.538	0.121	0.058	0.152	level	0.000	0.023	12.50		
			4	90	0.610	0.363	0.0052	0.0281	0.457	0.011	1.538	0.121	0.091	0.152	level	0.000	0.023	36.55		
	A322331	6/20/91	2	180	0.000	0.200	0.0097	0.0131	0.530	0.014	0.848	0.037	0.152	0.120	level	0.024	0.000	18.09	20.11	0.500
			3	135	0.610	0.200	0.0018	0.0131	0.396	0.008	0.048	0.037	0.046	0.120	level	0.000	0.000	11.79		
			4	90	0.610	0.200	0.0016	0.0131	0.305	0.005	0.848	0.037	0.050	0.120	level	0.000	0.000	10.33		
	A322332	6/20/91	2	180	0.000	0.341	0.0186	0.0247	1.021	0.053	1.354	0.093	0.152	0.152	level	0.163	0.005	67.33	60.74	0.563
			3	135	0.610	0.341	0.0029	0.0247	0.488	0.012	1.354	0.093	0.050	0.152	level	0.000	0.005	18.84		
			4	90	0.610	0.341	0.0032	0.0247	0.351	0.006	1.354	0.093	0.076	0.152	level	0.000	0.005	21.71		
	A322333	6/21/91	2	180	0.000	0.347	0.0202	0.0270	1.109	0.063	1.482	0.112	0.152	0.152	level	0.183	0.003	79.00	70.89	0.568
			3	135	0.610	0.347	0.0033	0.0270	0.518	0.014	1.482	0.112	0.058	0.152	level	0.000	0.003	22.13		
			4	90	0.610	0.347	0.0035	0.0270	0.396	0.008	1.482	0.112	0.073	0.152	level	0.000	0.003	23.59		
	A231331	6/24/91	2	180	0.000	0.190	0.0057	0.0117	0.314	0.005	0.996	0.051	0.152	0.094	level	0.021	0.000	10.02	16.52	0.328
			3	135	0.610	0.190	0.0044	0.0117	0.610	0.019	0.996	0.051	0.070	0.094	level	0.000	0.000	30.45		
			4	90	0.610	0.190	0.0015	0.0117	0.305	0.005	0.996	0.051	0.049	0.094	level	0.000	0.000	9.94		
	A231332	6/24/91	2	180	0.000	0.251	0.0086	0.0169	0.469	0.011	1.524	0.118	0.152	0.089	level	0.107	0.000	22.66	34.48	0.429
			3	135	0.610	0.251	0.0062	0.0169	0.640	0.021	1.524	0.118	0.079	0.089	level	0.000	0.000	42.95		
			4	90	0.610	0.251	0.0022	0.0169	0.259	0.003	1.524	0.118	0.072	0.089	level	0.000	0.000	14.82		
	A231333	6/25/91	2	180	0.000	0.223	0.0079	0.0158	0.433	0.010	1.402	0.100	0.152	0.091	level	0.067	0.000	17.67	29.59	0.412
			3	135	0.610	0.223	0.0059	0.0158	0.671	0.023	1.402	0.100	0.073	0.091	level	0.000	0.000	40.94		
			4	90	0.610	0.223	0.0020	0.0158	0.335	0.006	1.402	0.100	0.055	0.091	level	0.000	0.000	13.21		
	A213331	6/25/91	2	180	0.000	0.216	0.0057	0.0122	0.311	0.005	0.746	0.028	0.152	0.128	level	0.030	0.000	10.48	18.71	0.342
			3	135	0.610	0.216	0.0016	0.0122	0.396	0.008	0.746	0.028	0.041	0.128	level	0.000	0.000	10.24		
			4	90	0.610	0.216	0.0049	0.0122	0.457	0.011	0.746	0.028	0.084	0.128	level	0.000	0.000	34.01		
	A213332	6/26/91	2	180	0.000	0.286	0.0090	0.0178	0.494	0.012	1.032	0.054	0.152	0.137	level	0.098	0.000	23.09	33.47	0.398
			3	135	0.610	0.286	0.0024	0.0178	0.610	0.019	1.032	0.054	0.041	0.137	level	0.000	0.000	15.80		
			4	90	0.610	0.286	0.0064	0.0178	0.579	0.017	1.032	0.054	0.091	0.137	level	0.000	0.000	45.25		
	A213333	6/26/91	2	180	0.000	0.296	0.0081	0.0170	0.445	0.010	0.989	0.050	0.152	0.136	level	0.104	0.000	21.20	30.94	0.375
			3	135	0.610	0.296	0.0021	0.0170	0.549	0.015	0.989	0.050	0.040	0.136	level	0.000	0.000	13.84		
			4	90	0.610	0.296	0.0067	0.0170	0.610	0.019	0.989	0.050	0.091	0.136	level	0.000	0.000	47.57		
	A122331	6/27/91	2	180	0.000	0.174	0.0022	0.0095	0.122	0.001	0.702	0.025	0.152	0.106	level	0.006	0.000	3.49	12.24	0.233
			3	135	0.610	0.174	0.0038	0.0095	0.549	0.015	0.702	0.025	0.061	0.106	level	0.000	0.000	25.71		
			4	90	0.610	0.174	0.0035	0.0095	0.396	0.008	0.702	0.025	0.070	0.106	level	0.000	0.000	23.29		
	A122332	6/27/91	2	180	0.000	0.375	0.0056	0.0226	0.305	0.005	1.582	0.127	0.152	0.111	level	0.213	0.000	20.26	52.82	0.371
			3	135	0.610	0.375	0.0085	0.0226	0.732	0.027	1.582	0.127	0.091	0.111	level	0.000	0.000	60.65		
			4	90	0.610	0.375	0.0085	0.0226	0.640	0.021	1.582	0.127	0.104	0.111	level	0.000	0.000	61.34		
	A122333	6/28/91	2	180	0.000	0.408	0.0059	0.0241	0.320	0.005	1.321	0.089	0.152	0.152	level	0.229	0.014	22.19	60.32	0.392
			3	135	0.610	0.408	0.0089	0.0241	0.762	0.030	1.321	0.089	0.094	0.152	level	0.000	0.014	64.36		
			4	90	0.610	0.408	0.0093	0.0241	0.655	0.022	1.321	0.089	0.107	0.152	level	0.000	0.014	67.21		
	A113331	6/28/91	2	180	0.000	0.207	0.0027	0.0101	0.152	0.001	0.658	0.022	0.152	0.119	level	0.021	0.000	4.71	13.89	0.254
			3	135	0.610	0.207	0.0020	0.0101	0.457	0.011	0.658	0.022	0.046	0.119	level	0.000	0.000	12.94		
			4	90	0.610	0.207	0.0053	0.0101	0.472	0.011	0.658	0.022	0.088	0.119	level	0.000	0.000	37.02		
	A113332	7/1/91	2	180	0.000	0.329	0.0046	0.0175	0.250	0.003	0.993	0.050	0.152	0.141	level	0.137	0.000	13.08	32.93	0.312
			3	135	0.610	0.329	0.0032	0.0175	0.549	0.015	0.993	0.050	0.055	0.141	level	0.000	0.000	21.51		
			4	90	0.610	0.329	0.0097	0.0175	0.701	0.025	0.993	0.050	0.110	0.141	level	0.000	0.000	71.08		
	A113333	7/1/91	2	180	0.000	0.393	0.0065	0.0264	0.357	0.006	1.448	0.107	0.152	0.152	level	0.277	0.021	27.85	72.60	0.413
			3	135	0.610	0.393	0.0045	0.0264	0.610	0.019	1.448	0.107	0.064	0.152	level	0.000	0.021	30.76		
			4	90	0.610	0.393	0.0153	0.0264	0.975	0.048	1.448	0.107	0.122	0.152	level	0.000	0.021	117.36		
	A331231	7/9/91	2	180	0.000	0.178	0.0105	0.0142	0.576	0.017	0.839	0.036	0.152	0.133	level	0.021	0.000	19.69	23.42	0.540
			3	135	0.610	0.178	0.0026	0.0142	0.503	0.013	0.839	0.036	0.050	0.133	level	0.000	0.000	17.37		
			4	90	0.610	0.178	0.0010	0.0142	0.305	0.005	0.839	0.036	0.035	0.133	level	0.000	0.000	6.31		
	A331232	7/9/91	2	180	0.000	0.267	0.0218	0.0294	1.195	0.073	1.855	0.175	0.152	0.123	level	0.143	0.000	78.74	86.01	0.661
			3	135	0.610	0.267	0.0057	0.0294	0.792	0.032	1.855	0.175	0.064	0.123	level	0.000	0.000	39.76		
			4	90	0.610	0.267	0.0018	0.0294	0.305	0.005	1.855	0.175	0.055	0.123	level	0.000	0.000	11.70		
	A331233	7/10/91	2	180	0.000	0.335	0.0224	0.0307	1.228	0.077	1.884	0.181	0.152	0.127	level	0.198	0.000	93.97	92.78	0.615
			3	135	0.610	0.335	0.0063	0.0307	0.610	0.019	1.884	0.181	0.084	0.127	level	0.000	0.000	43.70		
			4	90	0.610	0.335	0.0020	0.0307	0.305	0.005	1.884	0.181	0.061	0.127	level	0.000	0.000	13.31		
	A222231	7/10/91	2	180	0.000	0.219	0.0068	0.0140	0.372	0.007	0.812	0.034	0.152	0.137	level	0.021	0.000	12.04	23.51	0.468
			3	135	0.305	0.219	0.0036	0.0140	0.610	0.019	0.012	0.034	0.055	0.137	level	0.000	0.000	13.24		
			4	90	0.610	0.219	0.0037	0.0140	0.427	0.009	0.812	0.034	0.073	0.137	level	0.000	0.000	24.97		
	A222233R	7/12/91	2	180	0.000	0.411	0.0170	0.0336	0.933	0.044	2.011	0.206	0.152	0.131	level	0.290	0.000	81.13	110.86	0.628
			3	135	0.305	0.411	0.0086	0.0336	0.488	0.012	2.011	0.206	0.139	0.131	level	0.000	0.000	38.20		
			4	90	0.610	0.411	0.0080	0.0336	0.610	0.019	2.011	0.206	0.104	0.131	level	0.000	0.000	57.32		
	A131231	7/15/91	2	180	0.000	0.205	0.0032	0.0130	0.177	0.002	0.770	0.030	0.152	0.133	level	0.018	0.000	5.45	20.87	0.403
			3	135	0.305	0.205	0.0073	0.0130	0.701	0.025	0.770	0.030	0.085	0.133	level	0.000	0.000	29.62		
			4	90	0.610	0.205	0.0025	0.0130	0.335	0.006	0.770	0.030	0.067	0.133	level	0.000	0.000	16.67		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	A131232	7/15/91	2	180	0.000	0.288	0.0048	0.0198	0.259	0.003	1.084	0.060	0.152	0.152	level	0.110	0.001	12.38	41.24	0.473
			3	135	0.305	0.288	0.0112	0.0198	0.823	0.035	1.084	0.060	0.105	0.152	level	0.000	0.001	48.61		
			4	90	0.610	0.288	0.0039	0.0198	0.427	0.009	1.084	0.060	0.073	0.152	level	0.000	0.001	26.13		
	A131233	7/16/91	2	180	0.000	0.402	0.0075	0.0313	0.415	0.009	1.776	0.161	0.152	0.141	level	0.268	0.000	31.71	92.68	0.565
			3	135	0.305	0.402	0.0174	0.0313	0.951	0.046	1.776	0.161	0.152	0.141	level	0.009	0.000	87.20		
			4	90	0.610	0.402	0.0064	0.0313	0.518	0.014	1.776	0.161	0.098	0.141	level	0.000	0.000	45.22		
	A313231	7/16/91	2	180	0.000	0.195	0.0084	0.0112	0.463	0.011	0.663	0.022	0.152	0.133	level	0.018	0.000	15.03	17.11	0.549
			3	135	0.305	0.195	0.0007	0.0112	0.244	0.003	0.663	0.022	0.035	0.133	level	0.000	0.000	2.47		
			4	90	0.610	0.195	0.0021	0.0112	0.305	0.005	0.663	0.022	0.061	0.133	level	0.000	0.000	13.68		
	A313232	7/17/91	2	180	0.000	0.308	0.0181	0.0246	0.994	0.050	1.349	0.093	0.152	0.152	level	0.149	0.085	62.55	79.72	0.784
			3	135	0.305	0.308	0.0017	0.0246	0.914	0.043	1.349	0.093	0.027	0.152	level	0.000	0.085	6.14		
			4	90	0.610	0.308	0.0048	0.0246	0.427	0.009	1.349	0.093	0.085	0.152	level	0.000	0.085	33.04		
	A313233	7/17/91	2	180	0.000	0.390	0.0227	0.0310	1.244	0.079	1.819	0.169	0.152	0.135	level	0.241	0.000	104.95	92.28	0.585
			3	135	0.305	0.390	0.0020	0.0310	0.195	0.002	1.819	0.169	0.085	0.135	level	0.000	0.000	7.73		
			4	90	0.610	0.390	0.0063	0.0310	0.518	0.014	1.819	0.169	0.101	0.135	level	0.000	0.000	45.01		
	A322231	7/18/91	2	180	0.000	0.195	0.0101	0.0135	0.555	0.016	0.777	0.031	0.152	0.138	level	0.015	0.000	18.22	22.27	0.632
			3	135	0.305	0.195	0.0016	0.0135	0.457	0.011	0.777	0.031	0.038	0.138	level	0.000	0.000	5.49		
			4	90	0.610	0.195	0.0018	0.0135	0.280	0.004	0.777	0.031	0.056	0.138	level	0.000	0.000	11.53		
	A322232	7/18/91	2	180	0.000	0.311	0.0213	0.0282	1.170	0.070	1.758	0.157	0.152	0.125	level	0.146	0.000	77.03	78.16	0.695
			3	135	0.305	0.311	0.0037	0.0282	0.579	0.017	1.758	0.157	0.058	0.125	level	0.000	0.000	13.60		
			4	90	0.610	0.320	0.0032	0.0282	0.366	0.007	1.758	0.157	0.075	0.125	level	0.000	0.000	21.87		
	A322233	7/19/91	2	180	0.000	0.329	0.0230	0.0308	1.262	0.081	1.945	0.193	0.152	0.123	level	0.183	0.000	93.98	95.39	0.707
			3	135	0.305	0.329	0.0040	0.0308	0.564	0.016	1.945	0.193	0.062	0.123	level	0.000	0.000	14.87		
			4	90	0.610	0.329	0.0038	0.0308	0.396	0.008	1.945	0.193	0.076	0.123	level	0.000	0.000	26.00		
	A231231	7/19/91	2	180	0.000	0.206	0.0071	0.0140	0.387	0.008	0.808	0.033	0.152	0.138	level	0.034	0.000	13.43	23.50	0.521
			3	135	0.305	0.206	0.0052	0.0140	0.549	0.015	0.808	0.033	0.076	0.138	level	0.000	0.000	20.02		
			4	90	0.610	0.206	0.0018	0.0140	0.335	0.006	0.808	0.033	0.049	0.138	level	0.000	0.000	11.61		
	A231232	7/22/91	2	180	0.000	0.276	0.0108	0.0215	0.588	0.018	1.180	0.071	0.152	0.152	level	0.122	0.004	30.80	47.89	0.586
			3	135	0.305	0.276	0.0082	0.0215	0.732	0.027	1.180	0.071	0.091	0.152	level	0.000	0.004	34.21		
			4	90	0.610	0.276	0.0025	0.0215	0.351	0.006	1.180	0.071	0.062	0.152	level	0.000	0.004	16.76		
	A231233	7/22/91	2	180	0.000	0.390	0.0188	0.0376	1.030	0.054	2.176	0.241	0.152	0.137	level	0.332	0.000	99.15	139.63	0.684
			3	135	0.305	0.390	0.0141	0.0376	0.771	0.030	2.176	0.241	0.152	0.137	level	0.034	0.000	72.03		
			4	90	0.610	0.390	0.0048	0.0376	0.442	0.010	2.176	0.241	0.085	0.137	level	0.000	0.000	33.07		
	A213231	7/23/91	2	180	0.000	0.207	0.0060	0.0121	0.332	0.006	0.733	0.027	0.152	0.129	level	0.012	0.000	10.06	18.48	0.399
			3	135	0.305	0.207	0.0015	0.0121	0.396	0.008	0.733	0.027	0.041	0.129	level	0.000	0.000	5.20		
			4	90	0.610	0.207	0.0045	0.0121	0.457	0.011	0.733	0.027	0.079	0.129	level	0.000	0.000	31.07		
	A213232	7/23/91	2	180	0.000	0.332	0.0112	0.0221	0.613	0.019	1.212	0.075	0.152	0.152	level	0.158	0.005	36.19	50.33	0.477
			3	135	0.305	0.332	0.0029	0.0221	0.219	0.002	1.212	0.075	0.105	0.152	level	0.000	0.005	11.91		
			4	90	0.610	0.332	0.0080	0.0221	0.573	0.017	1.212	0.075	0.107	0.152	level	0.000	0.005	57.38		
	A213233	7/24/91	2	180	0.000	0.396	0.0180	0.0340	0.991	0.050	1.934	0.190	0.152	0.140	level	0.326	0.000	93.46	110.07	0.547
			3	135	0.305	0.396	0.0044	0.0340	0.238	0.003	1.934	0.190	0.152	0.140	level	0.043	0.000	21.49		
			4	90	0.610	0.396	0.0116	0.0340	0.792	0.032	1.934	0.190	0.119	0.140	level	0.000	0.000	86.13		
	A122231	7/24/91	2	180	0.000	0.186	0.0031	0.0119	0.177	0.002	0.741	0.028	0.148	0.125	level	0.000	0.000	4.60	17.87	0.354
			3	135	0.305	0.186	0.0047	0.0119	0.472	0.011	0.741	0.028	0.082	0.125	level	0.000	0.000	18.36		
			4	90	0.610	0.186	0.0040	0.0119	0.427	0.009	0.741	0.028	0.079	0.125	level	0.000	0.000	27.52		
	A122232	7/25/91	2	180	0.000	0.320	0.0053	0.0214	0.290	0.004	1.188	0.072	0.152	0.146	level	0.168	0.000	16.84	45.73	0.418
			3	135	0.305	0.320	0.0079	0.0214	0.518	0.014	1.188	0.072	0.117	0.146	level	0.000	0.000	33.76		
			4	90	0.610	0.320	0.0082	0.0214	0.610	0.019	1.188	0.072	0.104	0.146	level	0.000	0.000	58.74		
	A122233	7/25/91	2	180	0.000	0.323	0.0086	0.0347	0.472	0.011	1.988	0.201	0.152	0.139	level	0.351	0.000	43.40	116.00	0.542
			3	135	0.305	0.323	0.0140	0.0347	0.768	0.030	1.988	0.201	0.152	0.139	level	0.094	0.000	79.78		
			4	90	0.610	0.323	0.0121	0.0347	0.777	0.031	1.988	0.201	0.123	0.139	level	0.000	0.000	90.97		
	A113231	7/26/91	2	180	0.000	0.180	0.0023	0.0088	0.131	0.001	0.599	0.018	0.143	0.115	level	0.000	0.000	3.24	11.53	0.271
			3	135	0.305	0.180	0.0017	0.0088	0.351	0.006	0.599	0.018	0.047	0.115	level	0.000	0.000	5.86		
			4	90	0.610	0.180	0.0049	0.0088	0.518	0.014	0.599	0.018	0.076	0.115	level	0.000	0.000	33.40		
	A113232	7/26/91	2	180	0.000	0.329	0.0049	0.0192	0.271	0.004	1.070	0.058	0.152	0.145	level	0.113	0.000	12.99	38.22	0.357
			3	135	0.305	0.329	0.0034	0.0192	0.223	0.003	1.070	0.058	0.119	0.145	level	0.000	0.000	14.20		
			4	90	0.610	0.329	0.0108	0.0192	0.732	0.027	1.070	0.058	0.114	0.145	level	0.000	0.000	79.87		
	A113233	7/29/91	2	180	0.000	0.415	0.0077	0.0284	0.421	0.009	1.557	0.124	0.152	0.152	level	0.268	0.016	32.32	81.23	0.468
			3	135	0.305	0.415	0.0057	0.0284	0.305	0.005	1.557	0.124	0.152	0.152	level	0.014	0.016	26.54		
			4	90	0.610	0.415	0.0150	0.0284	0.945	0.045	1.557	0.124	0.125	0.152	level	0.000	0.016	114.77		
	A031231	7/30/91	3	135	0.305	0.207	0.0091	0.0118	0.732	0.027	0.736	0.028	0.098	0.125	level	0.000	0.000	38.16	17.62	0.313
			4	90	0.610	0.207	0.0027	0.0118	0.366	0.007	0.736	0.028	0.065	0.125	level	0.000	0.000	18.15		
	A031232	7/30/91	3	135	0.305	0.305	0.0148	0.0202	0.914	0.043	1.134	0.065	0.128	0.144	level	0.000	0.000	69.02	41.61	0.388
			4	90	0.610	0.305	0.0055	0.0202	0.457	0.011	1.134	0.065	0.094	0.144	level	0.000	0.000	38.29		
	A031233	7/31/91	3	135	0.305	0.366	0.0184	0.0244	1.097	0.061	1.338	0.091	0.134	0.152	level	0.000	0.002	90.41	58.66	0.442
			4	90	0.610	0.366	0.0060	0.0244	0.472	0.011	1.338	0.091	0.101	0.152	level	0.000	0.002	42.27		
	A022231	7/31/91	3	135	0.305	0.165	0.0051	0.0102	0.671	0.023	0.708	0.026	0.067	0.112	level	0.000	0.000	19.62	13.83	0.250
			4	90	0.610	0.165	0.0052	0.0102	0.488	0.012	0.708	0.026	0.082	0.112	level	0.000	0.000	35.77		
	A022232	8/1/91	3	135	0.305	0.357	0.0112	0.0220	0.610	0.019	1.206	0.074	0.151	0.152	level	0.000	0.004	51.91	49.78	0.379
			4	90	0.610	0.357	0.0109	0.0220	0.914	0.043	1.206	0.074	0.091	0.152	level	0.000	0.004	79.27		
	A022233	8/1/91	3	135	0.305	0.436	0.0148	0.0292	0.814	0.034	1.599	0.130	0.152	0.152	level	0.000	0.017	71.42	85.78	0.476
			4	90	0.610	0.436	0.0143	0.0292	1.219	0.076	1.599	0.130	0.088	0.152	level	0.000	0.017	108.68		
	A013231	8/2/91	3	135	0.305	0.195	0.0019	0.0080	0.305	0.005	0.548	0.015	0.056	0.113	level	0.000	0.000	6.91	10.02	0.206
			4	90	0.610	0.195	0.0060	0.0080	0.853	0.037	0.548	0.015	0.061	0.113	level	0.000	0.000	41.65		
	A013232	8/2/91	3	135	0.305	0.314	0.0042	0.0178	0.244	0.003	1.025	0.054	0.137	0.138	level	0.000	0.000	18.53	33.57	0.277
			4	90	0.610	0.314	0.0136	0.0178	0.853	0.037	1.025	0.054	0.125	0.138	level	0.000	0.000	102.83		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	A013233	8/5/91	3	135	0.305	0.314	0.0056	0.0223	0.320	0.005	1.289	0.085	0.137	0.137	level	0.000	0.000	24.58	48.45	0.315
			4	90	0.610	0.314	0.0167	0.0223	1.036	0.055	1.289	0.085	0.123	0.137	level	0.000	0.000	129.02		
	A013331	8/6/91	3	135	0.610	0.146	0.0017	0.0066	0.610	0.019	0.594	0.018	0.034	0.090	level	0.000	0.000	11.21	6.99	0.157
			4	90	0.610	0.146	0.0049	0.0066	0.762	0.030	0.594	0.018	0.055	0.090	level	0.000	0.000	33.33		
	A013332	8/6/91	3	135	0.610	0.366	0.0043	0.0171	0.549	0.015	0.991	0.050	0.069	0.137	level	0.000	0.000	29.26	31.23	0.249
			4	90	0.610	0.366	0.0128	0.0171	1.128	0.065	0.991	0.050	0.094	0.137	level	0.000	0.000	96.26		
	A013333	8/6/91	3	135	0.610	0.421	0.0059	0.0229	0.549	0.015	1.254	0.080	0.087	0.152	level	0.000	0.001	41.10	52.44	0.303
			4	90	0.610	0.421	0.0170	0.0229	1.067	0.058	1.254	0.080	0.123	0.152	level	0.000	0.001	131.76		
	A031331	8/7/91	3	135	0.610	0.171	0.0069	0.0090	0.640	0.021	1.416	0.102	0.085	0.058	level	0.000	0.000	48.49	14.13	0.226
			4	90	0.610	0.171	0.0021	0.0090	0.792	0.032	1.416	0.102	0.035	0.058	level	0.000	0.000	13.90		
	A031332	8/7/91	3	135	0.610	0.323	0.0132	0.0176	0.914	0.043	2.060	0.216	0.113	0.073	level	0.000	0.000	99.17	49.94	0.386
			4	90	0.610	0.323	0.0044	0.0176	0.853	0.037	2.060	0.216	0.050	0.073	level	0.000	0.000	30.18		
	A031333	8/8/91	3	135	0.610	0.408	0.0186	0.0250	1.128	0.065	1.369	0.096	0.128	0.152	level	0.000	0.009	146.13	62.94	0.329
			4	90	0.610	0.408	0.0064	0.0250	0.823	0.035	1.369	0.096	0.076	0.152	level	0.000	0.009	45.19		
	A022331	8/8/91	3	135	0.610	0.198	0.0048	0.0094	0.610	0.019	0.667	0.023	0.066	0.110	level	0.000	0.000	32.37	12.16	0.190
			4	90	0.610	0.198	0.0046	0.0094	0.762	0.030	0.667	0.023	0.055	0.110	level	0.000	0.000	31.60		
	A022332	8/9/91	3	135	0.610	0.344	0.0096	0.0192	0.747	0.028	1.174	0.070	0.102	0.128	level	0.000	0.000	69.65	37.30	0.268
			4	90	0.610	0.344	0.0096	0.0192	1.036	0.055	1.174	0.070	0.076	0.128	level	0.000	0.000	69.69		
	A022333	8/9/91	3	135	0.610	0.366	0.0154	0.0306	0.914	0.043	1.680	0.144	0.128	0.152	level	0.000	0.021	117.61	95.26	0.405
			4	90	0.610	0.366	0.0153	0.0306	0.975	0.048	1.680	0.144	0.125	0.152	level	0.000	0.021	117.38		

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Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	W040201	9/25/91	3	45	0.305	0.201	0.0099	0.0099	1.196	0.073	0.741	0.028	0.071	0.105	level	0.000	0.000	43.58	12.91	0.296
	W040202	9/25/91	3	45	0.305	0.347	0.0180	0.0180	1.124	0.064	1.035	0.055	0.125	0.138	level	0.000	0.000	86.93	33.86	0.390
	W040203	9/25/91	3	45	0.305	0.387	0.0203	0.0203	1.239	0.078	1.116	0.063	0.128	0.150	level	0.000	0.000	101.60	42.37	0.417
	W130201	9/27/91	2	180	0.000	0.148	0.0019	0.0090	0.106	0.001	0.658	0.022	0.151	0.107	level	0.000	0.000	2.86	11.33	0.340
			3	45	0.305	0.148	0.0071	0.0090	1.289	0.085	0.658	0.022	0.052	0.107	level	0.000	0.000	30.51		
	W130202	9/30/91	2	180	0.000	0.375	0.0055	0.0215	0.301	0.005	1.177	0.071	0.152	0.152	level	0.195	0.005	18.96	47.89	0.506
			3	45	0.305	0.375	0.0160	0.0215	1.205	0.074	1.177	0.071	0.104	0.152	level	0.000	0.005	75.59		
	W130203	9/30/91	2	180	0.000	0.378	0.0062	0.0253	0.340	0.006	1.445	0.106	0.152	0.139	level	0.235	0.000	23.89	60.86	0.516
			3	45	0.305	0.378	0.0191	0.0253	1.131	0.065	1.445	0.106	0.133	0.139	level	0.000	0.000	94.10		
	W220201	10/1/91	2	180	0.000	0.152	0.0061	0.0119	0.334	0.006	0.745	0.028	0.152	0.125	level	0.013	0.000	10.20	17.83	0.535
			3	45	0.305	0.152	0.0058	0.0119	0.977	0.049	0.745	0.028	0.055	0.125	level	0.000	0.000	23.13		
	W220202	10/2/91	2	180	0.000	0.344	0.0130	0.0252	0.711	0.026	1.446	0.107	0.152	0.139	level	0.195	0.000	47.46	60.61	0.585
			3	45	0.305	0.344	0.0122	0.0252	1.295	0.085	1.446	0.107	0.078	0.139	level	0.000	0.000	56.21		
	W220203	10/2/91	2	180	0.000	0.408	0.0161	0.0330	0.885	0.040	2.018	0.208	0.152	0.128	level	0.259	0.000	71.43	108.70	0.714
			3	45	0.305	0.408	0.0169	0.0330	1.011	0.052	2.018	0.208	0.131	0.128	level	0.000	0.000	80.74		
	W310201	10/3/91	2	180	0.000	0.162	0.0102	0.0134	0.560	0.016	0.801	0.033	0.152	0.131	level	0.011	0.000	18.01	21.46	0.723
			3	45	0.305	0.162	0.0031	0.0134	0.825	0.035	0.801	0.033	0.040	0.131	level	0.000	0.000	11.69		
	W310202	10/3/91	2	180	0.000	0.280	0.0183	0.0257	1.004	0.051	1.642	0.137	0.152	0.122	level	0.131	0.000	60.15	65.31	0.716
			3	45	0.305	0.280	0.0074	0.0257	1.114	0.063	1.642	0.137	0.060	0.122	level	0.000	0.000	31.00		
	W310203	10/3/91	2	180	0.000	0.317	0.0206	0.0284	1.127	0.065	1.814	0.168	0.152	0.122	level	0.149	0.000	73.87	80.58	0.755
			3	45	0.305	0.317	0.0078	0.0284	1.082	0.060	1.814	0.168	0.064	0.122	level	0.000	0.000	32.81		
	W040301	10/8/91	3	45	0.610	0.300	0.0095	0.0095	1.000	0.051	0.656	0.022	0.079	0.113	level	0.000	0.000	69.19	12.66	0.183
	W040302	10/8/91	3	45	0.610	0.451	0.0178	0.0178	1.070	0.058	1.020	0.053	0.130	0.139	level	0.000	0.000	139.19	33.43	0.240
	W040303	10/8/91	3	45	0.610	0.469	0.0206	0.0206	1.340	0.091	1.142	0.066	0.119	0.146	level	0.000	0.000	165.40	42.90	0.259
	W130301	10/9/91	2	180	0.000	0.258	0.0028	0.0112	0.152	0.001	0.683	0.024	0.152	0.129	level	0.015	0.000	4.59	16.75	0.252
			3	45	0.610	0.258	0.0084	0.0112	1.238	0.078	0.683	0.024	0.061	0.129	level	0.000	0.000	61.94		
	W130302	10/9/91	2	180	0.000	0.437	0.0049	0.0195	0.267	0.004	1.066	0.058	0.152	0.152	level	0.204	0.002	17.20	40.42	0.308
			3	45	0.610	0.437	0.0146	0.0195	1.421	0.103	1.066	0.058	0.084	0.152	level	0.000	0.002	114.09		
	W130303	10/9/91	2	180	0.000	0.460	0.0053	0.0233	0.289	0.004	1.276	0.083	0.152	0.152	level	0.247	0.009	20.84	55.74	0.344
			3	45	0.610	0.460	0.0180	0.0233	1.101	0.062	1.276	0.083	0.128	0.152	level	0.000	0.009	141.15		
	W220301	10/9/91	2	180	0.000	0.224	0.0052	0.0105	0.284	0.004	0.637	0.021	0.152	0.129	level	0.006	0.000	8.26	15.44	0.337
			3	45	0.610	0.224	0.0054	0.0105	1.064	0.058	0.637	0.021	0.049	0.129	level	0.000	0.000	37.57		
	W220302	10/9/91	2	180	0.000	0.393	0.0094	0.0192	0.514	0.013	1.054	0.057	0.152	0.152	level	0.168	0.007	30.64	40.67	0.390
			3	45	0.610	0.393	0.0099	0.0192	1.278	0.083	1.054	0.057	0.067	0.152	level	0.000	0.007	73.63		
	W220303	10/10/91	2	180	0.000	0.476	0.0149	0.0307	0.817	0.034	1.683	0.144	0.152	0.152	level	0.293	0.000	69.95	89.32	0.465
			3	45	0.610	0.476	0.0158	0.0307	1.237	0.078	1.683	0.144	0.101	0.152	level	0.000	0.000	122.10		
	W310301	10/10/91	2	180	0.000	0.202	0.0099	0.0131	0.540	0.015	0.805	0.033	0.152	0.127	level	0.000	0.000	16.16	20.54	0.539
			3	45	0.610	0.202	0.0032	0.0131	0.959	0.047	0.805	0.033	0.037	0.127	level	0.000	0.000	21.93		
	W310302	10/10/91	2	180	0.000	0.322	0.0161	0.0224	0.880	0.039	1.226	0.077	0.152	0.152	level	0.126	0.004	50.12	51.11	0.551
			3	45	0.610	0.322	0.0061	0.0224	1.025	0.054	1.226	0.077	0.055	0.152	level	0.000	0.004	42.66		
	W310303R	10/18/91	2	180	0.000	0.442	0.0249	0.0332	1.363	0.095	1.918	0.187	0.152	0.137	level	0.265	0.000	124.87	105.55	0.569
			3	45	0.610	0.442	0.0083	0.0332	1.218	0.076	1.918	0.187	0.061	0.137	level	0.000	0.000	60.69		
	W231331	10/11/91	2	180	0.000	0.155	0.0064	0.0124	0.349	0.006	0.791	0.032	0.152	0.122	level	0.003	0.000	10.10	18.66	0.368
			3	45	0.610	0.155	0.0043	0.0124	1.036	0.055	0.791	0.032	0.043	0.122	level	0.000	0.000	30.03		
			4	90	0.610	0.155	0.0016	0.0124	0.632	0.020	0.791	0.032	0.030	0.122	level	0.000	0.000	10.63		
1	W231332	10/11/91	2	180	0.000	0.347	0.0116	0.0234	0.636	0.021	1.316	0.088	0.152	0.143	level	0.186	0.000	40.86	53.17	0.426
			3	45	0.610	0.347	0.0087	0.0234	1.125	0.064	1.316	0.088	0.067	0.143	level	0.000	0.000	63.16		
			4	90	0.610	0.347	0.0031	0.0234	0.745	0.028	1.316	0.088	0.043	0.143	level	0.000	0.000	20.78		
	W231333	10/15/91	2	180	0.000	0.491	0.0182	0.0364	0.995	0.050	2.022	0.208	0.152	0.146	level	0.366	0.000	101.19	126.56	0.532
			3	45	0.610	0.491	0.0136	0.0364	1.355	0.094	2.022	0.208	0.082	0.146	level	0.000	0.000	104.90		
			4	90	0.610	0.491	0.0046	0.0364	0.682	0.024	2.022	0.208	0.061	0.146	level	0.000	0.000	31.61		
	W131331	10/15/91	2	180	0.000	0.177	0.0028	0.0107	0.155	0.001	0.669	0.023	0.152	0.125	level	0.015	0.000	4.69	15.51	0.262
			3	45	0.610	0.177	0.0060	0.0107	1.020	0.053	0.669	0.023	0.055	0.125	level	0.000	0.000	42.43		
			4	90	0.610	0.177	0.0019	0.0107	0.628	0.020	0.669	0.023	0.034	0.125	level	0.000	0.000	12.15		
	W131332R	10/18/91	2	180	0.000	0.341	0.0050	0.0203	0.275	0.004	1.174	0.070	0.152	0.137	level	0.158	0.000	15.47	41.30	0.322
			3	45	0.610	0.341	0.0117	0.0203	1.285	0.084	1.174	0.070	0.076	0.137	level	0.000	0.000	88.50		
			4	90	0.610	0.341	0.0036	0.0203	0.781	0.031	1.174	0.070	0.046	0.137	level	0.000	0.000	24.20		
	W131333	10/16/91	2	180	0.000	0.457	0.0079	0.0303	0.432	0.009	1.661	0.141	0.152	0.152	level	0.305	0.016	36.02	91.86	0.442
			3	45	0.610	0.457	0.0165	0.0303	1.442	0.106	1.661	0.141	0.091	0.152	level	0.000	0.016	130.40		
			4	90	0.610	0.457	0.0059	0.0303	0.873	0.039	1.661	0.141	0.061	0.152	level	0.000	0.016	41.36		
	W113331	10/17/91	2	180	0.000	0.177	0.0024	0.0096	0.130	0.001	0.645	0.021	0.152	0.116	level	0.012	0.000	3.86	12.90	0.243
			3	45	0.610	0.177	0.0020	0.0096	0.774	0.031	0.645	0.021	0.030	0.116	level	0.000	0.000	13.22		
			4	90	0.610	0.177	0.0052	0.0096	0.769	0.030	0.645	0.021	0.061	0.116	level	0.000	0.000	35.99		
	W113332	10/17/91	2	180	0.000	0.335	0.0046	0.0197	0.251	0.003	1.097	0.061	0.152	0.146	level	0.174	0.000	14.81	40.18	0.321
			3	45	0.610	0.335	0.0035	0.0197	0.917	0.043	1.097	0.061	0.040	0.146	level	0.000	0.000	23.44		
			4	90	0.610	0.335	0.0117	0.0197	1.026	0.054	1.097	0.061	0.091	0.146	level	0.000	0.000	86.74		
	W113333	10/17/91	2	180	0.000	0.427	0.0066	0.0260	0.363	0.007	1.427	0.104	0.152	0.152	level	0.290	0.015	29.15	69.25	0.398
			3	45	0.610	0.427	0.0044	0.0260	0.917	0.043	1.427	0.104	0.047	0.152	level	0.000	0.015	30.30		
			4	90	0.610	0.427	0.0150	0.0260	0.896	0.041	1.427	0.104	0.131	0.152	level	0.000	0.015	114.56		
	W113311	10/21/91	2	180	0.000	0.195	0.0039	0.0152	0.215	0.002	0.994	0.050	0.151	0.119	level	0.000	0.000	5.87	25.19	0.648
			3	45	0.610	0.195	0.0029	0.0152	1.134	0.066	0.994	0.050	0.030	0.119	level	0.000	0.000	20.37		
			4	90	0.000	0.195	0.0083	0.0152	0.468	0.011	0.994	0.050	0.143	0.119	level	0.000	0.000	12.60		
	W113312	10/21/91	2	180	0.000	0.335	0.0057	0.0221	0.310	0.005	1.224	0.076	0.152	0.148	level	0.152	0.000	17.20	48.73	0.576
			3	45	0.610	0.335	0.0042	0.0221	1.236	0.078	1.224	0.076	0.037	0.148	level	0.000	0.000	29.55		
			4	90	0.000	0.335	0.0123	0.0221	0.677	0.023	1.224	0.076	0.152	0.148	level	0.137	0.000	37.87		

Notes	Run ID	Date	Inflow Pipe	Theta	Zi (m)	d (m)	Qi (cms)	Qo (cms)	Vi (m/s)	Vi^2/2g (m)	Vo (m/s)	Vo^2/2g (m)	di (m)	do (m)	Floor Config.	Pi (m H2O)	Po (m H2O)	PWRi (Watts)	PWRo (Watts)	EFF
	W113313R	10/29/91	2	180	0.000	0.451	0.0071	0.0302	0.390	0.008	1.714	0.150	0.152	0.141	level	0.290	0.000	31.33	86.03	0.584
			3	45	0.610	0.451	0.0063	0.0302	1.068	0.058	1.714	0.150	0.055	0.141	level	0.000	0.000	44.74		
			4	90	0.000	0.451	0.0168	0.0302	0.919	0.043	1.714	0.150	0.152	0.141	level	0.238	0.000	71.20		
	W231311	10/22/91	2	180	0.000	0.192	0.0066	0.0131	0.365	0.007	0.840	0.036	0.149	0.122	level	0.000	0.000	10.14	20.34	0.445
			3	45	0.610	0.192	0.0048	0.0131	0.851	0.037	0.840	0.036	0.053	0.122	level	0.000	0.000	33.22		
			4	90	0.000	0.192	0.0017	0.0131	0.095	0.000	0.840	0.036	0.140	0.122	level	0.000	0.000	2.30		
	W231312	10/22/91	2	180	0.000	0.366	0.0107	0.0208	0.587	0.018	1.138	0.066	0.152	0.152	level	0.177	0.004	36.39	45.19	0.371
			3	45	0.610	0.366	0.0101	0.0208	1.475	0.111	1.138	0.066	0.061	0.152	level	0.000	0.004	77.02		
			4	90	0.000	0.366	0.0028	0.0208	0.155	0.001	1.138	0.066	0.152	0.152	level	0.149	0.004	8.39		
	W231313	10/22/91	2	180	0.000	0.497	0.0178	0.0351	0.973	0.048	2.018	0.207	0.152	0.138	level	0.357	0.000	97.01	118.81	0.558
			3	45	0.610	0.497	0.0131	0.0351	1.145	0.067	2.018	0.207	0.091	0.138	level	0.000	0.000	98.48		
			4	90	0.000	0.497	0.0042	0.0351	0.231	0.003	2.018	0.207	0.152	0.138	level	0.262	0.000	17.26		
	W131311	10/28/91	2	180	0.000	0.189	0.0023	0.0090	0.128	0.001	0.622	0.020	0.143	0.113	level	0.000	0.000	3.19	11.70	0.281
			3	45	0.610	0.189	0.0051	0.0090	1.156	0.068	0.622	0.020	0.045	0.113	level	0.000	0.000	36.29		
			4	90	0.000	0.189	0.0016	0.0090	0.093	0.000	0.622	0.020	0.138	0.113	level	0.000	0.000	2.19		
	W131312	10/28/91	2	180	0.000	0.427	0.0058	0.0222	0.317	0.005	1.217	0.075	0.152	0.152	level	0.232	0.002	22.04	50.14	0.384
			3	45	0.610	0.427	0.0125	0.0222	1.394	0.099	1.217	0.075	0.075	0.152	level	0.000	0.002	96.19		
			4	90	0.000	0.427	0.0039	0.0222	0.214	0.002	1.217	0.075	0.152	0.152	level	0.165	0.002	12.23		
	W131313	10/28/91	2	180	0.000	0.479	0.0076	0.0294	0.415	0.009	1.614	0.133	0.152	0.152	level	0.312	0.000	35.18	82.38	0.440
			3	45	0.610	0.479	0.0164	0.0294	1.542	0.121	1.614	0.133	0.086	0.152	level	0.000	0.000	130.96		
			4	90	0.000	0.479	0.0055	0.0294	0.304	0.005	1.614	0.133	0.152	0.152	level	0.228	0.000	20.94		
	W231211	10/30/91	2	180	0.000	0.143	0.0058	0.0119	0.320	0.005	0.771	0.030	0.152	0.120	level	0.011	0.000	9.64	17.62	0.614
			3	45	0.305	0.143	0.0044	0.0119	0.771	0.030	0.771	0.030	0.053	0.120	level	0.000	0.000	16.72		
			4	90	0.000	0.143	0.0017	0.0119	0.095	0.000	0.771	0.030	0.141	0.120	level	0.000	0.000	2.32		
	W231212	10/30/91	2	180	0.000	0.329	0.0108	0.0226	0.593	0.018	1.305	0.087	0.152	0.137	level	0.157	0.000	34.68	49.57	0.613
			3	45	0.305	0.329	0.0091	0.0226	1.064	0.058	1.305	0.087	0.072	0.137	level	0.000	0.000	38.62		
			4	90	0.000	0.329	0.0027	0.0226	0.149	0.001	1.305	0.087	0.152	0.137	level	0.131	0.000	7.58		
	W231213R	11/6/91	2	180	0.000	0.411	0.0175	0.0356	0.961	0.047	2.011	0.206	0.152	0.142	level	0.287	0.000	83.51	121.50	0.738
			3	45	0.305	0.411	0.0134	0.0356	0.801	0.033	2.011	0.206	0.131	0.142	level	0.000	0.000	61.57		
			4	90	0.000	0.411	0.0047	0.0356	0.256	0.003	2.011	0.206	0.152	0.142	level	0.269	0.000	19.45		
	W131211	10/31/91	2	180	0.000	0.162	0.0031	0.0109	0.169	0.001	0.697	0.025	0.152	0.122	level	0.017	0.000	5.18	15.68	0.513
			3	45	0.305	0.162	0.0057	0.0109	0.923	0.043	0.697	0.025	0.056	0.122	level	0.000	0.000	22.47		
			4	90	0.000	0.162	0.0022	0.0109	0.124	0.001	0.697	0.025	0.138	0.122	level	0.000	0.000	2.94		
	W131212	11/1/91	2	180	0.000	0.357	0.0057	0.0236	0.315	0.005	1.366	0.095	0.152	0.137	level	0.177	0.000	18.84	53.78	0.574
			3	45	0.305	0.357	0.0134	0.0236	1.152	0.068	1.366	0.095	0.093	0.137	level	0.000	0.000	61.24		
			4	90	0.000	0.357	0.0045	0.0236	0.245	0.003	1.366	0.095	0.152	0.137	level	0.154	0.000	13.57		
	W131213	11/4/91	2	180	0.000	0.415	0.0082	0.0325	0.452	0.010	1.831	0.171	0.152	0.142	level	0.280	0.000	35.81	99.66	0.665
			3	45	0.305	0.415	0.0187	0.0325	1.116	0.063	1.831	0.171	0.132	0.142	level	0.000	0.000	91.60		
			4	90	0.000	0.415	0.0055	0.0325	0.303	0.005	1.831	0.171	0.152	0.142	level	0.256	0.000	22.36		
	W113211	11/4/91	2	180	0.000	0.155	0.0022	0.0086	0.123	0.001	0.532	0.014	0.152	0.126	level	0.017	0.000	3.74	11.80	0.703
			3	45	0.305	0.155	0.0016	0.0086	0.413	0.009	0.532	0.014	0.040	0.126	level	0.000	0.000	5.39		
			4	90	0.000	0.155	0.0048	0.0086	0.262	0.004	0.532	0.014	0.152	0.126	level	0.007	0.000	7.66		
	W113212	11/4/91	2	180	0.000	0.274	0.0050	0.0201	0.272	0.004	1.229	0.077	0.152	0.128	level	0.132	0.000	14.01	40.42	0.662
			3	45	0.305	0.274	0.0039	0.0201	0.739	0.028	1.229	0.077	0.050	0.128	level	0.000	0.000	14.56		
			4	90	0.000	0.274	0.0113	0.0201	0.619	0.020	1.229	0.077	0.152	0.128	level	0.121	0.000	32.45		
	W113213	11/5/91	2	180	0.000	0.457	0.0080	0.0345	0.436	0.010	1.894	0.183	0.152	0.152	level	0.308	0.002	36.66	114.39	0.696
			3	45	0.305	0.457	0.0067	0.0345	0.366	0.007	1.894	0.183	0.152	0.152	level	0.009	0.002	31.02		
			4	90	0.000	0.457	0.0199	0.0345	1.090	0.060	1.894	0.183	0.152	0.152	level	0.283	0.002	96.74		

Notes: Outflow velocity adjusted so efficiency = 0.999.

APPENDIX C. DESIGN GUIDE

This appendix presents design guidelines for applying the energy grade line and the power-loss approaches. The computational procedures for calculating energy losses are outlined, along with the methodologies developed to calculate the junction manhole depth.

ENERGY GRADE LINE METHODOLOGY

The energy grade line methodology starts with equation (30) that describes the energy loss for an inflow pipe:

$$\Delta E_i = K_i \frac{V_o^2}{2g} \tag{30}$$

The methodology is completed by using the determining factors identified in the dimensional analysis to predict K_i for a given physical configuration and hydraulic loading as given in the following equation:

$$K_i = (C_1 \; C_2 \; C_3 + C_4)\omega \tag{31}$$

where:

K_i	=	Composite energy-loss coefficient for the main inflow pipe.
C_1	=	Coefficient related to relative manhole size.
C_2	=	Coefficient related to water depth in the manhole.
C_3	=	Coefficient related to lateral flow, lateral angle, and plunging flow.
C_4	=	Coefficient related to relative pipe diameters.
ω	=	Coefficient related to floor configuration.

Equations (30) and (31) are combined to yield the following equation:

$$\Delta E_i = (C_1 \; C_2 \; C_3 + C_4)\, \omega \, \frac{V_o^2}{2g} \tag{32}$$

Equation (32) provides an energy-loss estimate for a straight (θ_i = 180 degrees) inflow pipe with an invert at the same elevation as the outlet pipe. The calculation of C_1, C_2, C_3, and C_4 is accomplished with respect to the main inflow pipe.

The determining factor C_1 is computed as follows:

$$C_1 = \frac{0.9\left[\frac{b}{D_o}\right]}{\left[6 + \frac{b}{D_o}\right]} \tag{33}$$

where:

b = Manhole diameter, m.

D_o = Outflow pipe diameter, m.

The determining factor C_2 is computed as follows:

$$C_2 = 0.24\left(\frac{d_{mH}}{D_o}\right)^2 - 0.05\left(\frac{d_{mH}}{D_o}\right)^3 \tag{34}$$

where:

d_{mH} = Depth in the manhole relative to the outlet pipe invert, m.

The determining factor C_3 is computed as follows:

$$C_3 = 1 + \sum_{i=2}^{3}\left(\frac{Q_i}{Q_0}\right)^{.75}\left[1 + 2\left(\frac{Z_i}{D_0} - \frac{d_{mH}}{D_0}\right)^{.3}\left(\frac{Z_i}{D_0}\right)^{.3}\right]$$

$$+ \; 4\sum_{i=2}^{3}\frac{\left\{\mathrm{Cos}\theta_i\left[0.85 - \left(\frac{Z_i}{D_0}\right)\left(\frac{Q_i}{Q_0}\right)^{.75}\right]\right\}}{\left(\frac{d_{mH}}{D_0}\right)^{.3}}$$

$$+ \left|\left(\frac{Q_2}{Q_0}\right)^{.75}\mathrm{Sin}\theta_2 + \left(\frac{Q_3}{Q_0}\right)^{.75}\mathrm{Sin}\theta_3\right| + 0.8\left|\frac{Z_2}{D_0} - \frac{Z_3}{D_0}\right| \tag{35}$$

where:

Q_0 = Total discharge in the outlet pipe, m^3/s.

Q_2, Q_3 = Pipe discharge in lateral pipes 2 and 3, m^3/s.

Z_2, Z_3 = Invert elevation of lateral pipes 2 and 3 relative to the outlet pipe invert, m.

D_0 = Outlet pipe diameter, m.

b = Manhole diameter, m.

d_{mH} = Depth in the manhole relative to the outlet pipe invert, m.

θ_2, θ_3 = Angle between the outlet main and lateral pipes 2 and 3, degrees.

The determining factor C_4 is computed as follows:

$$C_4 = \left[1 - \left(\frac{D_o}{D_i}\right)^2\right]^2 \tag{36}$$

where:

D_o = Outlet pipe diameter, m.

D_i = Inlet pipe diameter, m.

Correction factors for floor configuration are presented in table 2.

Table 2. Correction factors (ω) for benching (repeated).

	Bench Submerged*	Bench Unsubmerged**
Flat Floor	1.0	1.0
Benched one-half pipe diameter high	0.95	0.15
Benched one pipe diameter high	0.75	0.07
Improved	0.40	0.02

* Pressure flow, $d_{mH}/D_o > 3.2$

** Free-surface flow, $d_{mH}/D_o < 1.0$

The methodology developed can be applied by determining the estimated energy loss through a junction manhole given a set of physical and hydraulic parameters. Computation of the energy loss allows for the determination of the energy grade line (EGL) upstream of the manhole analyzed. First, an estimated depth in the manhole is determined, from which the EGL of the upstream main is estimated. The EGL for the lateral inflow pipes are then computed.

Solving for Manhole Depth

To determine the depth in the manhole, an iterative procedure must be applied in computing the energy loss because the energy-loss coefficient (K) is a function of C_2 and C_3, which, in turn, are functions of d_{mH} (which is unknown). Therefore, an initial estimation must be made for d_{mH}.

For mild flows through a junction manhole where the energy loss is small, a realistic assumption is that losses are divided equally between the expansion and contraction losses. The following applies:

$$d_{mH} = EGL_o + 0.5\left(K\frac{V_o^2}{2g}\right) - Z_o \tag{37}$$

where:

K	=	Energy-loss coefficient.
EGL_o	=	Energy grade line in the outlet pipe.

For a high flow, where turbulence in the manhole is vigorous, the velocity head of the incoming main flow may be considered to be totally lost. The following equation applies:

$$d_{mH} = EGL_o + K\frac{V_o^2}{2g} - \frac{V_i^2}{2g} - Z_o \tag{38}$$

The initial application of equations (37) and (38) also requires an assumption about the magnitude of K. Use of C_1 as that initial estimate is reasonable since it is independent of d_{mH}. Then, d_{mH} can be estimated using either equations (37) or (38). Once the initial estimate is made for d_{mH}, calculation of C_2, C_3, C_4, ω, K, and ΔE proceed according to the appropriate equations. Equations (37) and (38) are again applied to determine a manhole depth. The computed d_{mH} value is compared to the prior estimate, and the procedure is repeated until these two values converge. If the junction manhole configuration has only one inflow pipe that is not plunging, d_{mH} may be solved for directly.

Once the iterative procedure is complete, the computed energy loss (ΔE) is applied so that the energy grade line in the main inflow pipe can be computed. It is recommended that the process be performed using both equations (37) and (38) to select the conservative result for the design. The following equation is used to compute the EGL in the main inflow pipe:

$$EGL_m = \frac{V_o^2}{2g} + Z_o + d_o + \frac{P_o}{\gamma} + \Delta E \qquad (39)$$

where:

EGL_m = Energy grade line of the 180-degree main inflow pipe.

Computation of the EGL for Laterals

Upon finding the water depth in the manhole, the energy grade line in the lateral pipe(s) can be computed. For submerged or partially submerged inflow pipes, it may be assumed that the incoming velocity head is lost as the junction manhole is entered. Therefore, the EGL is estimated by:

$$EGL_i = d_{mH} + \frac{V_i^2}{2g} \qquad (40)$$

For pipes with plunging flow ($d_{mH} + Z_o < d_n + Z_i$), the hydraulic grade line is interrupted by the plunge. Therefore, the EGL is estimated by computing the normal flow conditions in the inflow pipe such that:

$$EGL_i = Z_i + d_n + \frac{V_i^2}{2g} \qquad (41)$$

where:

EGL_i = Energy grade line at the outlet of lateral pipe, i.

Z_i = Invert elevation at the outlet of the lateral pipe, i.

d_n = Normal depth of the plunging pipe.

For a physical pipe configuration where there is no main inflow pipe, i.e., a pipe at 180 degrees from the outlet pipe, the methodology is applied as follows: a hypothetical 180-degree inflow with zero flow is assumed and calculations for d_{mH} proceeding as described earlier through application of equations (37) and (38). The inflow pipe(s) in the configuration would be treated as laterals, and the EGL for these pipes is computed by applying equations (40) or (41).

POWER-LOSS METHODOLOGY

Under the power-loss approach, the following equation was developed which provides for an estimation of the losses through the manhole:

$$\Delta E = \alpha_1 \frac{V_o^2}{2g} + \sum_{i=1}^{n} \alpha_{2,i} \frac{Q_i}{Q_o} \frac{V_i^2}{2g} + \sum_{j=1}^{m} \alpha_{3,j} \frac{Q_j}{Q_o} (Z_j + d_j - d_{mH}) + \sum_{j=1}^{m} \alpha_{4,j} \frac{Q_j}{Q_o} \frac{V_j^2}{2g} \qquad (42)$$

where:

ΔE	=	Total energy lost, m.
α_1	=	Contraction-loss coefficient.
$\alpha_{2,i}$	=	Expansion-loss coefficient for each submerged inflow pipe, i.
$\alpha_{3,j}$	=	Plunging-loss coefficient for each plunging inflow pipe, j.
$\alpha_{4,j}$	=	Expansion-loss coefficient for each plunging inflow pipe, j.

The α_1 equation is formulated as follows:

$$\alpha_1 = a_1 C_1 C_2 C_3 f \qquad (43)$$

where:

a_1	=	Adjustment coefficient.
C_1, C_2, C_3	=	Empirically derived coefficients which quantify portions of the energy loss based on the determining factors.[1]
f	=	Floor-configuration coefficient.

The equation representing the C_1 coefficient is related to the relative diameter of the manhole and is expressed as follows:

$$C_1 = \left(\frac{b}{D_o}\right)^{0.55} \qquad (44)$$

[1]The definition of these coefficients differs from their use in the energy grade line methodology.

The C_2 coefficient is related to the outlet hydraulic gradeline and is represented as follows:

$$C_2 = 4.5 - 2\left(\frac{HGL_o}{D_o}\right)^{0.25} \tag{45}$$

The C_3 coefficient represents a loss term that accounts for manhole size relative to the outflow velocity head:

$$C_3 = \left(\frac{b}{\left(\frac{V_o^2}{2g}\right)}\right)^{0.5} \tag{46}$$

Table 3 gives values for *f* for the various floor configurations tested in this study.

Table 3. Floor configuration adjustment coefficients (*f*) (repeated).

Floor Configuration	*f*
Level	1.0
Depressed	1.12
Benched	1.0*

*No significant difference between level and benched floor configuration was observed in the analysis of the data collected in this study.

The second term in the loss estimation equation (equation 42) accounts for the expansion loss into a manhole for a submerged inflow pipe.[2] The form of the equation is as follows:

$$\alpha_{2,I} = a_2 C_1 C_2 C_3 f \beta \tag{47}$$

where:

a_2 = Adjustment coefficient.

C_1, C_2, C_3 = Empirically derived coefficient that quantifies portions of the energy loss based on the determining factors.

β = Inflow-angle adjustment coefficient.

[2] A pipe is considered submerged if the elevation of water in the junction manhole is equal to or greater than the elevation of the water surface in the pipe assuming normal flow depth.

The C_1 coefficient equation is identical to the one formulated for α_1, and is represented in equation (44). The C_2 coefficient has the same form as equation (45), but uses manhole depth relative to the inflow pipe diameter as the determining variable:

$$C_2 = 4.5 - 2\left(\frac{d_{mH}}{D_i}\right)^{0.25} \tag{48}$$

The equation representing C_3 assumes a similar form to equation (46) and is expressed as follows:

$$C_3 = \left(\frac{b}{\left(\frac{V_i^2}{2g}\right)}\right)^{0.5} \tag{49}$$

Equation (50) represents the adjustment coefficient for varying inflow angles:

$$\beta = \frac{(360 - \theta_i)}{180} \tag{50}$$

where:

θ_i = Lateral angle relative to the outflow pipe.

The $\alpha_{3,j}$ and $\alpha_{4,j}$ coefficients were determined to be 1.1 and 1.2, respectively.

The power-loss methodology can be applied to a variety of physical and hydraulic parameters to predict the depth of water in a manhole. An iterative procedure is required to calculate manhole depth (d_{mH}) by balancing the calculated inflow power with the sum of the outflow power and the energy lost. The inflow power, calculated as the summation of power for each inflow line, is computed through application of the following equation:

$$\sum_{i=1}^{n} PWR_i = \gamma \sum_{i=1}^{n} Q_i \left(Z_i + d_i + \frac{P_i}{\gamma} + \frac{V_i^2}{2g}\right) \tag{51}$$

where:

i = Index representing an inflow pipe, submerged or plunging.

Outflow power is computed as follows:

$$PWR_o = \gamma Q_o \left(Z_o + d_o + \frac{P_o}{\gamma} + \frac{V_o^2}{2g} \right). \tag{52}$$

An initial value of d_{mH} is selected, and computations for inflow power, outflow power, and the energy lost proceed until the equality represented in equation (53) is achieved. A reasonable initial estimate for d_{mH} is the outflow energy grade line.

$$\sum_{i=1}^{n} PWR_i = PWR_o + \Delta E \gamma Q_o \tag{53}$$

In order for the methodology to be properly applied, the status of the inflow pipes must be determined in terms of whether they are submerged or plunging. Computation of the loss components presented in equation (42) are dependent upon knowledge of the physical and hydraulic condition of the inflow pipes. For example, a manhole configuration with all inflow pipes plunging into the manhole would not require computation of the $\alpha_{2,i}$ expansion-loss coefficient, which applies only to submerged inflow pipes. Similarly, for conditions where all inflow pipes are submerged, computation of $\alpha_{4,j}$ (the expansion-flow coefficient for plunging inflows) is not necessary.

Computations of the losses are dependent upon the initial value of d_{mH} selected, and the adjusted d_{mH} values during the iterative process. During this process, it is possible for inflow pipes to fluctuate from being submerged to plunging and vice versa, based on the current value of d_{mH}. Thus, this fluctuation alters the computation procedure of the energy lost, because components of the energy loss are dependent on the submerged or plunging status of the pipes.

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