

Hillsborough County SWMM4.31B

User's Manual

Stormwater Management Section
Public Works Department
Hillsborough County

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Content

List of Tables

List of Figures

1. Introduction	4
2. Runoff Calculation	6
2.1 SCS-CN Method	
2.2 SCS Dimensionless Hydrograph	
2.3 Model Implementation	
2.4 Discussion on Hydrograph Shape Factor, K	
2.5 Input Format	
3. Modifications of Extran Block	26
3.1 Minor Losses	
3.2 Pipe Extension	
3.3 Pipe Shape	
3.4 Input Format	
4. Modifications of Combine Block	30
5. Input of EXTRAN and COMBINE Blocks	31
Appendix A Overland Flow Manning's n	
Appendix B Minor Loss Coefficient	

List of Tables

Table 2.1a	Runoff Curve Numbers for Urban Areas	5
Table 2.1b	Runoff Curve Numbers for Cultivated Agricultural Lands	7
Table 2.1c	Runoff Curve Numbers for Other Agriculture Lands	9
Table 2.1d	Runoff Curve Numbers for Arid and Semiarid Rangeland	11
Table 3.1	Pipe Type Classification	24
Table 3.2	Changes of Input Format	25
Table 4.1	List of A1 Card Options	26

List of Figures

Figure 2.1	Definition of Unit Hydrograph	13
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1. Introduction

The Storm Water Management Model (SWMM) was developed for the Environmental Protection Agency in 1969-1971 as a single-event model for simulation of quantity processes in combined sewer systems (Metcalf and Eddy et al., 1971). It has since been applied to virtually every aspect of urban drainage, from routine drainage design to sophisticated hydraulic analysis to non-point source runoff quality studies, using both single event and continuous simulation. Through subdividing large catchments and flow routing down the drainage system, SWMM can be applied to catchments of almost any size, from parking lots to subdivisions to cities.

The current version of SWMM4.31 is segmented into several computational “Blocks”:

- The Runoff block generates runoff from rainfall using a nonlinear reservoir method and does simple flow routing by the same method. Subsurface flow routing of water infiltrated through the soil surface is optional.
- The Transport block performs flow routing using a kinematic wave technique.
- The Extran block performs flow routing by an explicit finite-difference solution of the complete St. Venant equations.
- The Storage/Treatment block routes through storage units using the Puls (storage indication) method.
- The Statistics block separates continuous simulation hydrographs and pollutographs (concentration vs. time) into independent storm events, calculates statistical moments, and performs elementary frequency analyses.

Water quality may also be simulated in all blocks except Extran, and the output from continuous simulation may be analyzed by the statistics block.

Hillsborough County of Florida has been using SWMM model for many years. Mostly only Runoff and Extran blocks were used. While using this model, the storm water modeling group of Hillsborough County made many modifications based on the watershed conditions of the county. All the modifications will be summarized in the following sections.

2. Runoff Calculation

In the Hillsborough County version of SWMM model, the SCS-CN method, rather than the nonlinear reservoir method, was used to calculate the runoff discharge used in Extran Block.

2.1 SCS-CN method

The Soil Conservation Service-curve number (SCS-CN) method is one of the most popular methods for computing the volume of surface runoff for a given rainfall event from small watersheds. Kent (1973) described and examined this method in detail. The SCS-CN method is based on the water balance equation and two fundamental hypotheses. The first hypothesis states that the ratio of the actual amount of direct runoff to the maximum potential runoff is equal to the ratio of the amount of actual infiltration to the amount of the potential maximum retention. The second hypothesis states that the amount of initial abstraction is some fraction of the potential maximum retention. Expressed mathematically, the water balance equation and the two hypotheses, respectively, are

$$P = I_a + F + P_E \quad (2-1)$$

$$\frac{P_E}{P - I_a} = \frac{F}{S} \quad (2-2)$$

$$I_a = IS \quad (2-3)$$

where P = total precipitation, inch;

I_a = initial abstraction, inch;

F = cumulative infiltration excluding I_a , inch;

I = non-dimensional parameter;

P_E = direct runoff, inch; and

S = potential maximum retention or infiltration, inch

The current version of the SCS-CN method assumes I equal to 0.2 for usual practical application. As the initial abstraction component accounts for surface storage, interception, and infiltration before runoff begins, I can take any value ranging from 0 to 1. Combining (2-1) and (2-2), we can write an equation for P_E as follows:

$$P_E = \frac{(P - I_a)^2}{P - I_a + S} \quad (2-4)$$

If $I = 0.2$, then

$$P_E = \frac{(P - 0.2S)^2}{P + 0.8S} \quad (2-5)$$

By studying the relationships of many different watersheds, the SCS further introduced a dimensionless number, CN , called curve number. The curve number and S are related by

$$S = \frac{1000}{CN} - 10 \quad (2-6)$$

The curve number is a function of land use, cover, soil classification, hydrologic conditions, and antecedent runoff conditions. The variation in infiltration rates of different soils is incorporated in curve number selection through the classification of soils into four hydrologic soil groups: A, B, C, and D. These groups, representing soils having high, moderate, low, and very low infiltration rates, are as follows:

Group A: soils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission (greater than 0.30 in/h).

Group B: soils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well drained to well drained soils with moderately fine to moderately coarse texture. These soils have a moderate rate of water transmission (0.15-0.30 in/h).

Group C: soils have low infiltration rates when thoroughly wetted and consist mainly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/h).

Group D: soils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/h)

Runoff curve numbers for urban areas, cultivated and other agricultural lands, and arid and semiarid rangelands are shown in Table 2.1

Table 2.1a Runoff Curve Numbers for Urban Areas*

Cover type and hydrologic condition	Average percentage of impervious area **	Curve numbers for hydrologic soil group			
		A	B	C	D
Fully developed urban areas (vegetation established) Open space (lawns, parks, golf courses, cemeteries, etc.) ***					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding Right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch, and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town house)	65	77	85	90	92
1/4 acre	38	61	75	83	87

1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acre	12	46	65	77	82
Developing urban areas:					
Newly graded areas (pervious areas only, no Vegetation)		77	86	91	94
Idle lands (CNs are determined through the use of cover types similar to those for other agricultural lands.)					

* Average runoff condition, and $I_a = 0.2S$.

** The average percentage of impervious area shown was used to develop the composite CNs. Other assumptions are as follows: Impervious areas are directly connected to the drainage system; impervious areas have a CN of 98; and pervious areas are considered equivalent to open space in good hydrologic condition.

*** CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space cover type.

Table 2.1b Runoff Curve Numbers for Cultivated Agricultural Lands *

Cover type	Treatment**	Hydrologic Condition***	Curve numbers for hydrologic soil group				
			A	B	C	D	
Fallow	Bare soil		77	86	91	94	
	Crop residue cover (CR)	Poor	76	85	90	93	
		Good	74	83	88	90	
Row crops	Straight row (SR)	Poor	72	81	88	91	
		Good	67	78	85	89	
	SR+CR	Poor	71	80	87	90	
		Good	64	75	82	85	
	Contoured (C)	Poor	70	79	84	88	
		Good	64	74	81	85	
	C+CR	Poor	69	78	83	87	
		Good	64	74	81	85	
	Contoured and terraced (C&T)	Poor	66	74	80	82	
		Good	62	71	78	81	
	C&T+CR	Poor	65	73	79	81	
		Good	61	70	77	80	
	Small grain	SR	Poor	65	76	84	88
			Good	63	75	83	87
		SR+CR	Poor	64	75	83	86
Good			60	72	80	84	
C		Poor	63	74	82	85	
		Good	61	73	81	84	
C+CR		Poor	62	73	81	84	
		Good	60	72	80	83	
C&T		Poor	61	72	79	82	
		Good	59	70	78	81	
C&T+CR		Poor	60	71	78	81	
			Good	58	69	77	80

Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

* Average runoff condition, and $I_a = 0.2S$.

** Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

*** Hydrologic condition is based on a combination of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes in rotations, (d) percentage of residue cover on the land surface (good $\geq 20\%$), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better-than-average infiltration and tend to decrease runoff.

Table 2.1c Runoff Curve Numbers for Other Agriculture Lands ¹

Cover type	Hydrologic condition	Curve numbers for hydrologic soil group			
		A	B	C	D
Pasture, grassland, or range-continuous forage for grazing ²	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay		30	58	71	78
Brush—brush-weed-grass mixture with brush the major element ³	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 ⁴	48	65	73
Woods—grass combination (orchard or tree farm) ⁵	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods ⁶	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 ⁴	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots		59	74	82	86

¹ Average runoff condition, and $I_a = 0.2S$.

² Poor: <50% ground cover or heavily grazed with no mulch.

Fair: 50% to 75% ground cover and not heavily grazed.

Good: >75% ground cover and lightly or only occasionally grazed.

³ Poor: <50% ground cover.

Fair: 50% to 75% ground cover.

Good: > 75% ground cover.

⁴ Actual curve number is less than 30; use CN=30 for runoff computations.

⁵ CNs shown were computed for areas with 50% woods and 50% grass(pasture) cover.

Other combinations of conditions may be computed from the CNs for woods and pasture.

⁶ Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.

Fair: Woods are grazed but not burned, and some forest litter covers the soil.

Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2.1d Runoff Curve Numbers for Arid and Semiarid Rangeland*

Cover Type	Hydrologic condition**	Curve numbers for hydrologic soil group			
		A***	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosote bush, blackbrush, bursage, paloverde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

* Average runoff condition, and $I_a = 0.2S$. For range in humid regions, use the table for other agriculture lands.

** Poor: <30% ground cover (litter, grass, and brush overstory).

Fair: 30% to 70% ground cover.

Good: > 70% ground cover.

*** Curve numbers for group A have been developed for desert shrub only.

2.2 SCS Dimensionless Hydrograph

The SCS dimensionless hydrograph is a synthetic unit hydrograph in which the discharge is expressed by the ratio of discharge Q to peak discharge Q_p and the time by the ratio of time t to the time of rise of the unit hydrograph, T_p . The unit peak discharge is calculated by

$$U_p = \frac{KA}{T_p} \quad (2-7)$$

where U_p = unit peak discharge, cfs/inch;

A = drainage are, mile²;

K = hydrograph shape factor, ranging from 300 for flat swampy areas to 600 in steep terrain. SCS standard K value = 484.

T_p = time to peak, in hours.

$$T_p = \frac{t_r}{2} + t_p \quad (2-8)$$

where t_r = storm duration, hours;

t_p = drainage area lag, hours.

$$t_p = 0.6T_c \quad (2-9)$$

where T_c = time of concentration, hours.

Figure 2.1 shows the definition of U_p , T_p , for a triangular unit hydrograph used in Hillsborough County version of SWMM model.

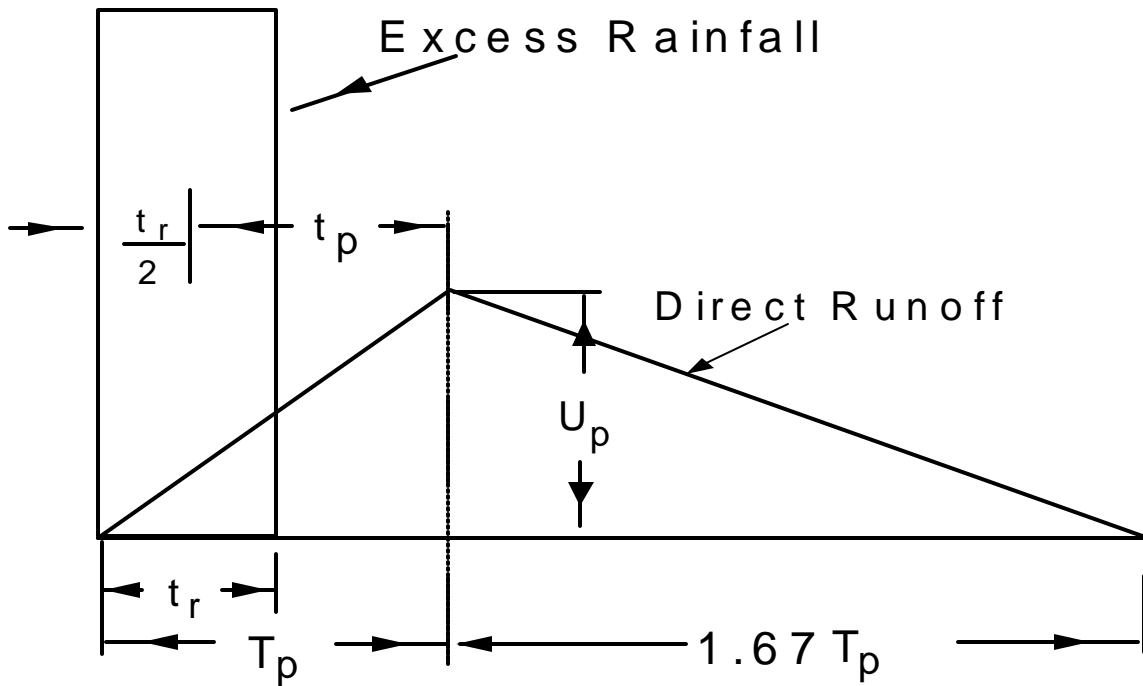


Figure 2.1 Definition of Unit Hydrograph

The peak discharge for a given rainfall is calculated by

$$Q_p = U_p P_E \quad (2-10)$$

where Q_p = peak discharge, cfs. P_E is calculated with Eq. (2-5).

2.3 Model implementation

The convolution method is used to yield the direct runoff hydrograph. The convolution equation is

$$Q_n = \sum_{m=1}^{n \leq M} P_{Em} U_{n-m+1} \quad (2-11)$$

where P_{Em} = excess rainfall of m th pulse, inch;

U_{n-m+1} = unit direct runoff at time $n\mathbf{D}$ of m th rainfall pulse, interpolated from

Fig. 2.1, cfs/inch;

$\mathbf{D}t$ = time step, minutes;

Q_n = total runoff at time $n\mathbf{D}$, cfs;

M = total pulses of excess rainfall.

Following are detail procedures to calculate the direct runoff at each time step: One thing needs to be pointed out is that, compared with original SWMM model, a new input file was introduced. The extension of this file is .WPX. This file contains all the information of rainfall and each sub-basin's area, CN number, T_c , I_a , and K . The detail of this file will be discussed in Appendix B.

- 1) Read rainfall information from file *.WPX ;
- 2) Read sub-basin information, i.e. base ID , area (in acres), T_c (in minutes.), CN number, I_a , and K , from file *.WPX ;
- 3) convert T_c into hour, i.e., $T_c = T_c/60$ (the model input is in minutes for convenience);
- 4) Determine time step $\mathbf{D} = 0.24T_c$; If $\mathbf{D} > 0.5$, $\mathbf{D} = 0.11T_c$;
- 5) Determine excess rainfall based on Eq. (2-5), and interpolated to \mathbf{D} time series ;
- 6) Calculate the direct runoffs $Q(t)$ at each time step based on Eq. (2-11);
- 7) Double check model accuracy with

$$e = 100 \bullet \frac{|P_{ESCS} - \frac{\int Q(t)dt}{A}|}{P_{ESCS}} \quad (2-12)$$

where

$$P_{ESCS} = \frac{(P_{total} - 0.2S)^2}{P_{total} + 0.8S} \quad (2-13)$$

- 8) Interpolate $Q(t)$ to SWMM model time step $Q_{yn}(t)$;

9) Write out $Q_{yn}(t)$ to a interface file (if required).

2.4 Discussion on hydrograph shape factor, K

Theoretically speaking, the hydrograph shape factor, K, only affects the peak runoff, and should not affect the total runoff volume. In other words, no matter what the shape factor we use, the total runoff volume should be the same – mass conservative. However, based on the conventional way, this mass conservative can not guarantee. Refer to Fig. 2.1, the conventional way is,

$$Q_p = \frac{KAP_E}{T_p} \quad (2-13),$$

and

$$T_b = T_p + 1.67T_p = 2.67T_p \quad (2-14)$$

where T_b = base time;

Q_p = peak runoff due to excess rainfall P_E .

The direct runoff at each time step can be calculated by

$$Q(t) = \begin{cases} \frac{Q_p}{T_p} t & t \leq T_p \\ Q_p \frac{2.67T_p - t}{1.67T_p} & T_p < t \leq T_b \end{cases} \quad (2-15)$$

The total direct runoff volume is

$$V_t = \int_0^{T_b} Q(t) dt = 1.335KAP_E \quad (2-16)$$

That means V_i is changed with K , mass are not conservative.

To avoid this, a parameter, R , was introduced.

$$R = \frac{2.67K_0}{K} - 1.0 \quad (2-17)$$

where K_0 = standard shape factor. Here use SCS standard value of 483.4.

Redefine T_b as

$$T_b = (1 + R)T_p \quad (2-18)$$

Then the direct runoff is

$$Q(t) = \begin{cases} \frac{Q_p}{T_p} t & t \leq T_p \\ Q_p \frac{T_b - t}{T_b - T_p} & T_p < t \leq T_b \end{cases} \quad (2-19)$$

The total volume of direct runoff is

$$\begin{aligned} V_i &= \int_0^{T_b} Q(t) dt = Q_p T_b / 2 \\ &= 2.67 K_0 A P_E / 2 \\ &= 646.14 A P_E \end{aligned} \quad (2-20)$$

That means the total direct runoff volume has nothing to do with the shape factor. The shape factor only affects the peak runoff. Mass is conservative. If $K=K_0$, Eq. (2-16) is identical to Eq. (2-20).

2.5 Input Format

The input format is identical to that of EXTRAN. That is, the first two columns are group identifier, and 3 to 232 columns are data line (See SWMM User's Manual and EXTRAN User's Manual).

Variable	Description	Default
ID	Group Identifier	None
ALPHA	Description of computer run (2 lines maximum of 80 Columns per line).	Blank

IT	Group Identifier	None
NMIN	Increment for runoff hydrograph storage	0.0 minutes
DATE	Rainfall date	Blank
ITIME	Rainfall start time	Blank
NQ	Number of sub-basins	Blank

(note, DATE, ITIME, and NQ are not used in the model yet, and can be blank.)

IO	Group Identifier	None
IPRT	Print controller (see description below)	0
IPLT	Plot controller (see description below)	0

IPRT =

- 0,1,2 All
- 3 Input Data and Intermediate and Master Summaries
- 4 Input Data and Master Summary
- 5 Job specification and Master Summary Only

IPLT =

- 0,1 No Printer Plots--Can be overridden on KO record
- 2 Plot All

(note, the IPRT and IPLT functions are not implemented yet.)

JR	Group Identifier	None
PRCARD	Card Name	PREC
PTOTAL	Total Rainfall (inch)	0.0

(note, PRCARD is not used in the model yet.)

PG	Group Identifier	None
GAGEN	Rainfall Gage name	Blank
PRAIN	Total Rainfall at this gage (inch)	0.0

(note, 1. PRAIN is not used in the model; 2. Total gages should be less than 11.)

IN	Group Identifier	None
DTRAINX	Time step of rainfall at this gage, minutes.	0.0
RDATE	Rainfall date	None
DUMMY	Dummy parameter	0

(note, DUMMY is not used in the model.)

PC	Group Identifier	None
----	------------------	------

RAIN(i,1) The first rainfall distribution value None

RAIN(i,2) The second rainfall distribution value None

.
. .
.

(Input the unit hydrograph for this gage. 10 numbers each line. Every new line should begin with PC identifier. See the following example.)

PR Group Identifier None

GAGEN Gage name to be used in this run. None

(note, GAGEN should be identical to one of the names in PG cards.)

WP Group Identifier None

IBASIN Sub-basin ID, integer None

JCTID Junction ID in the sub-basin None

TCMIN Time of concentration, minutes 0.0

ACRES Areas of the sub-basin, acres 0.0

CN CN curve number of the sub-basin 0

CIA Initial abstraction of the sub-basin 0.2

(note, this value has been fixed in the model. Don't try to change it.)

K Shape factor of the sub-basin 0.0

IWPPRT Print control parameter 0

(note, IWPPRT is not used in model.)

Following is a example.

```

* =====
*                               EAST LAKE AREA
*                               Rainfall Distributions
*                               JULY 13-19 1990 STORM EVENT
* =====
*THE FOLLOWING WPX HAS BEEN UPDATED WITH NEW CN's 3/19/99 - JG
*=====
ID                               East Lake Area
ID                               Hillsborough County BOCC--Dept of Public Works
*
*
* This is a standard HEC-1 file. RDHEC copies the ID, *, IT, IO, JR,
* PG, IN, PC, and PR records from this file. It ignores other records.
*
*FREE
*DIAGRAM
* NMIN    DATE    ITIME    NQ
IT      10 21JAN98      0      601
*
*NOLIST
* IPRT    IPLT
* 0,1,2
*      3      Input Data and Intermediate and Master Summaries
*      4      Input Data and Master Summary
*      5      Job specification and Master Summary Only
*
*      0,1    No Printer Plots--Can be overriden on KO record
*      2      Plot All
*
IO      3      0
*
* MULTIRATION ANALYSIS--DO NOT USE
* Use Only one ratio per run for SWMM.
* #####
* TIA RF JULY 13-19 1990 STORM EVENT
JR  PREC      8.0
* #####
* #####
* SCS 24-HR, TYPE II FLORIDA MODIFIED DISTRIBUTION (30 MIN INCREMENTS)
PGFLMOD      1.0
* SCS 24-HR, TYPE II FLORIDA MODIFIED DISTRIBUTION (30 MIN INCREMENTS)
IN      30 14JAN98      0
PC .000      .006      .012      .019      .025      .032      .039      .047      .054      .062
PC .071      .080      .089      .099      .110      .122      .134      .148      .164      .181
PC .201      .226      .258      .308      .607      .719      .757      .785      .807      .826
PC .842      .857      .870      .882      .893      .904      .913      .923      .931      .940
PC .948      .955      .962      .969      .976      .983      .989      .995      1.00      1.00
*
PGEL790
IN      60 13JUL90      0
*This is Accumulative Rain fall for July 13-19 1990 Storm event (60min Increment)
PC 0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000      0.000

```

PC	0.002	0.002	0.048	0.053	0.053	0.053	0.053	0.053	0.053	0.053
PC	0.053	0.053	0.053	0.053	0.096	0.096	0.096	0.096	0.096	0.096
PC	0.096	0.248	0.254	0.257	0.257	0.265	0.520	0.649	0.664	0.684
PC	0.693	0.693	0.693	0.693	0.693	0.693	0.693	0.693	0.693	0.693
PC	0.693	0.693	0.693	0.693	0.693	0.693	0.693	0.693	0.693	0.693
PC	0.693	0.695	0.708	0.713	0.713	0.713	0.713	0.713	0.713	0.713
PC	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713
PC	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713
PC	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713
PC	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713
PC	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713
PC	0.713	0.713	0.811	0.822	0.822	0.822	0.822	0.822	0.822	0.822
PC	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822	0.822
PC	0.822	0.822	0.822	0.822	0.822	0.993	0.998	1.000	1.000	1.000

* =====
 * THE FOLLOWING RECORD (PR) DETERMINES WHICH OF THE ABOVE DISTRIBUTIONS
 * WILL BE USED FOR THE CURRENT RUN.
 *

PREL790

* =====

ZZ

*	NODE#	BASIN		25AREA	OLD			
*	NUMBER				CN	Ia	FC	KI
WP	100999	100999	62	17.8	73	0.2	256	0
WP	104007	104007	24	11.7	64	0.2	256	0
WP	104020	104020	22	25.2	74	0.2	256	0
WP	104023	104023	15	17.6	76	0.2	256	0
WP	104025	104025	15	4	76	0.2	256	0
WP	104030	104030	15	3	76	0.2	256	0
WP	104045	104045	15	29	78	0.2	256	0
WP	104050	104050	15	9.6	77	0.2	256	0
WP	104060	104060	15	6.9	82	0.2	256	0
WP	104063	104063	15	2.1	65	0.2	256	0
WP	104075	104075	30	34	64	0.2	256	0
WP	104080	104080	15	11.8	87	0.2	256	0
WP	104085	104085	24	15.6	90	0.2	256	0
WP	104090	104090	15	10.6	81	0.2	256	0
WP	104095	104095	15	3.4	91	0.2	256	0
WP	104100	104100	15	9.5	85	0.2	256	0
WP	104130	104130	34	17.5	74	0.2	256	0
WP	104145	104145	21	14.9	71	0.2	256	0
WP	104165	104165	33	12.4	73	0.2	256	0
WP	104205	104205	19	15.4	83	0.2	256	0
WP	104208	104208	15	4.9	83	0.2	256	0
WP	104215	104215	15	3.1	85	0.2	256	0
WP	104400	104400	15	12.9	73	0.2	256	0
WP	104407	104407	38	9	65	0.2	256	0
WP	104416	104416	34	8.1	70	0.2	256	0
WP	104424	104424	15	4.1	93	0.2	256	0
WP	104428	104428	22	11.8	78	0.2	256	0
WP	104432	104432	15	10.3	91	0.2	256	0

3. Modifications of Extran Block

Several minor modifications have been carried out in Extran Block. These minor modifications are: minor losses, pipe extension, pipe shape, and input format.

3.1 Minor Losses

Minor head losses have been included in the model (subroutine HEADLOSS). In B0 card, another input flag, *KMFLAG*, was added (the third one). If *KMFLAG* = 1, the minor losses will automatically be taken into account. In this case, three minor loss coefficients, $K_{entrance}$, K_{extent} , and K_{others} , for each pipe are required (C1 card). If *KMFLAG*=0, minor losses are not calculated.

Assume the minor losses are uniformly distributed along the pipe, based on Chezy's Law, the minor losses can be converted into an equivalent Manning's coefficient, which is

$$n_1 = \sqrt{n_0^2 + K_t \frac{C^2 R^{4/3}}{2gL}} \quad (3-1)$$

where n_0 = the natural Manning's of the pipe;

$K_t = K_{entrance} + K_{extent} + K_{others}$, total minor loss coefficient;

R = hydraulic radius;

g = gravity;

L = pipe length;

C = Unit conversion factor, = 1 for metric system, and = 1.486 for US custom system;

n_1 = equivalent Manning's coefficient including minor losses.

3.2 Pipe extension (subroutine STRETCH)

In order to avoid the stability problem, an equivalent longer pipe can be developed for an extremely short pipe. Assuming that the equivalent pipe will have the same discharge, same area, and same hydraulic radius, based on Checy's Law, an equivalent Manning's coefficient for the longer pipe can be derived as

$$n_e = n_0 \sqrt{\frac{L_0}{L_e}} \quad (3-2)$$

where n_0 = natural Manning's coefficient of the pipe;

L_0 = initial pipe length;

L_e = extended pipe length;

n_e = equivalent Manning's coefficient.

The *KMFLAG* was also applied to pipe extension. That is, if *KMFLAG* = 1, pipe extension will automatically be considered in the model. In this case, a parameter, *SFACTOR*, is required in the C1 card. $SFACTOR = L_e/L_0$.

3.3 Pipe shape

In this version, the pipe types are classified as

Table 3.1 Pipe Type Classification

Type	Pipe Shape	Comments
1	Circle	
2	Rectangle	
3	Elliptical	Horizontal. The lookup tables for hydraulic radius and cross-section area are derived analytically.
4	Arch	
5	Basket Handler	
6	Trapezoidal	
7	Parabolic	
8	Natural Channel	
9		

3.4 Input format

All the original input formats for vertical distances, for example, ZP(1) (distance of conduit invert above junction invert at NJUNC(1)) and ZP(2) (distance of conduit invert above junction invert at NJUNC(2)), have been changed to real elevation. Table 3.2 lists all these changes.

Table 3.2 Changes of input format

Variable	Card	Original	Change to	Comments
ZP(1)	C1	Distance of conduit invert above junction invert at NJUNC(1)	Conduit invert at upstream	
ZP(2)	C1	Distance of conduit invert above junction invert at NJUNC(2)	Conduit invert at downstream	
QCURVE	E2	Depth above junction at point 1	Elevation at point 1	
ZP	F1	Distance of orifice invert above junction floor	Orifice invert	
YCREST	G1	Height of weir crest above invert	Elevation of weir crest	
YTOP	G1	Height of top of weir opening above invert (surcharge level)	Elevation of top of weir opening (surcharge level)	

4. Modifications of Combine Block

Because of the modifications of runoff calculation, the COMBINE block was also modified accordingly. The A1 card in COMBINE block now has 10 options as listed in Table 4.1.

Table 4.1 List of A1 Card Options

ICOMB	Option	Comments
0	Collate Option	
1	Combine Option	
2	Extract (and optionally renumber) nodes from a single input file.	
3	Read file header.	
4	Create ASCII file from binary interface file	
5	Calculate the simple statistics of an interface file.	
6	Calculate the simple statistics of a rain block interface file.	
7	Calculate the simple statistics of a TEMP block interface file.	Not implemented yet.
10	Read a hec-1 Tape21 file to interface file.	New
11	Generate SCS hydrograph to interface file.	New

5. Input of EXTRAN and COMBINE BLOCK

EXTRAN INPUT GUIDELINES

There have been many changes made to the input format of EXTRAN. Following is a short list of the major changes along with explanations and guidelines.

1. Free format input. Input is no longer restricted to fixed columns. Free format has the requirement, however, that at least one space separate each data field. Free format input also has the following strictures on real, integer, and character data.
 - a. No decimal points are allowed in integer fields. A variable is integer if it has a 0 in the default column. A variable is real if it has a 0.0 in the default column.
 - b. Character data must be enclosed by single quotation marks, including both of the two title lines. Use a double single-quote (") to represent an apostrophe within a character field, e.g., USER"S MANUAL.
2. Data group identifiers are a requirement and must be entered in columns 1 and 2. The program uses these for line and input error identification, and they are an aid to the EXTRAN user. 99999 lines no longer are required to signal the end of sets of data group lines; the data group identifiers are used to distinguish one data group from another.
3. The data lines may be up to 230 columns long.
4. Input lines can wrap around. For example, a line that requires 10 numbers may have 6 on the first line and 4 on the second line. The FORTRAN READ statement will continue reading until it finds 10 numbers, e.g.,

```
ZI 1 2 3 4 5 6  
   7 8 9 10
```

Notice that the line identifier is not used on the second line.

5. In most cases an entry must be made for every parameter in a data group, even if-it is not used or zero and even if it is the last required field on a line. Trailing blanks are not assumed to be zero. Rather, the program will continue to search on subsequent lines for the "last" required parameter. Zeros can be used to enter and "mark" unused parameters on a line. This requirement also applies to character data. A set of quotes must be found for each character entry field. E.g., if the two run title lines (data group A1) are to consist of one line followed by a blank line, the entry would be:

```
A1 'This is line 1.'
A1 ' '
```

6. See Section 2 of the SWMM User's Manual for use of comment lines (indicated by an asterisk in column 1) and additional information.

VARIABLE	DESCRIPTION	DEFAULT
Executive Block Input Data		
I/O File Assignments (Unit Numbers)		
SW	Group identifier	None
NBLOCK	Number of blocks to be run (max of 25).	1
JIN(1)	Input file (logical unit number) for the first block.	0
JOUT(1)	Output file for the first block.	0
.		
.		
.		
JIN(NBLOCK)	Input file for the last block.	0
JOUT(NBLOCK)	Output file for the last block.	0
Scratch File Assignments (Unit Numbers)		
MM	Group identifier	None
NITCH	Number of scratch files to be opened (max of 6). EXTRAN requires at least one scratch file.	0

NSCRAT(1)	First scratch file assignment.	0
.		
.		
.		
NSCRAT(NITCH)	Last scratch file assignment.	0

VARIABLE	DESCRIPTION	DEFAULT
----------	-------------	---------

Control Data Indicating Files To Be Opened and/or Permanently Saved.
 Note that different from EPA SWMM, the runoff block input file has to be opened here.

REPEAT THE @ LINE FOR EACH FILE TO BE SAVED.

@	Group identifier	None
FILENUM	Unit number of the JIN, JOUT, or NSCRAT file to be permanently saved (or used) by the SWMM program.	None
FILENAM	Name for permanently saved file. Enclose in single quotes, e.g. 'SAVE.OUT'.	None

Enter \$ANUM in columns 1-5 in order to use alphanumeric conduit/junction names in this (and all following) block(s).

Enter \$COMBINE in columns 1-7 to call the COMBINE block

COMBINE Block Controller

A1 Group Identifier None

ICOMB COMBINE block switch 0

- = 0, COLLATE OPTION
- = 1, COMBINE OPTION
- = 2, EXTRACT (AND OPTIONALLY RENUMBER) NODES FROM A SINGLE INPUT FILE.
- = 3, READ FILE HEADER
- = 4, CREATE ASCII FILE FROM BINARY INTERFACE FILE
- = 5, CALCULATE THE SIMPLE STATISTICS (SUMS) OF AN INTERFACE FILE
- = 6, CALCULATE THE SIMPLE STATISTICS (SUMS) OF A RAIN BLOCK INTERFACE FILE
- = 7, CALCULATE THE SIMPLE STATISTICS OF

VARIABLE	DESCRIPTION	DEFAULT
----------	-------------	---------

- A TEMP BLOCK INTERFACE FILE (Not implemented)
- = 10, READ A HEC-1 TAPE21 FILE TO INTERFACE FILE
- = 11, GENERATE SCS HYD TO INTERFACE FILE

B1 Comment line (2 lines). maximum of 80 columns per line). Both lines must be enclosed in quotes. Blank

Enter \$EXTRAN in columns 1-7 to call the EXTRAN Block.

Run Title

AI	Group identifier	None
ALPHA	Description of computer run (2 lines, maximum of 80 columns per line). Both lines must be enclosed in quotes. Will be printed on output (2 lines).	Blank

Optional Routing Solution Control Parameters
This data group is not a requirement and may be omitted.

B0	Group identifier	None
ISOL	Solution technique parameter (see Appendix C). = 0, Explicit solution of Section 5 (default), = 1, Enhanced explicit solution, = 2, Iterative explicit solution using variable time-steps < DELT (group B1). Iteration limit is ITMAX and convergence criterion is SURTOL (group B2).	0
KSUPER	= 0, Use <u>minimum</u> of normal flow and dynamic flow when water surface slope < conduit slope (default), = 1, Normal flow always used when flow is supercritical.	0

VARIABLE	DESCRIPTION	DEFAULT
KMFLAG	= 0, No minor loss and pipe extension = 1, With minor loss and pipe extension.	0

Input and Run Control Parameters (optional)

BB	Group identifier	None
JELEV	Conduit inverts input option = 0, input upstream(ZD) and downstream(ZU) inverts as offsets of junction inverts; = 1, input upstream(ZD) and downstream(ZU) inverts as elevation (suggested)	0
JDOWN	Outfall water depth option = 0, HD = minimum(normal depth, critical depth);	0

= 1, HD = critical depth;

= 2, HD = normal depth.

Where HD = down steam water depth of free outfall conduit.

First Group of Run Control Parameters

BI	Group identifier	None
NTCYC	Number of time-steps desired.	1
DELT	Length of time-step, seconds.	1.0
TZERO	Start time of simulation, decimal hours. Time zero is midnight (beginning) of first simulation day.	0.00
NSTART	First time-step to begin print cycle.	1
INTER	Interval between intermediate print cycles during simulation. Number of cycles printed is (NTCYC - NSTART)/INTER.	1

VARIABLE	DESCRIPTION	DEFAULT
JNTER	Interval between time-history summary print cycles at end of simulation. Number of cycles printed is NTCYC/JNTER.	1
JREDO	Hot-start file manipulation parameter. = 0, No hot-start file is created or used, = 1, Read NSCRAT(2) for initial flows, heads, areas, and velocities, = 2, Create a new hot-start file on NSCRAT(2), = 3, Create a new hot-start file but use the old file as the initial conditions. The old file is subsequently erased and a new file created.	0
IDATZ	Initial date (optional)	0

Second Group of Run Control Parameters

B2	Group identifier	None
METRIC	U.S. customary or metric units for input/output. = 0, U.S. customary units, = 1, Metric units.	0
NEQUAL	Modify short pipe lengths using an equivalent pipe to ease time step limitations. = 0, Do not modify, Please always use 0, = 1, Modify short pipe lengths.	0
AMEN	Default surface area for all manholes ft ² (m ²) Used for surcharge calculations in Extran. Manhole default diameter is 4 ft (1.22 m).	12.566
ITMAX	Maximum number of iterations to be used in surcharge and iterative calculations (30 recommended).	None
SURTOL	Fraction of average flow in surcharged areas to be used as convergence criterion for surcharge iterations (0.05 recommended). Also, convergence	None

VARIABLE	DESCRIPTION	DEFAULT
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criterion during flow iterations, ISOL - 2.

Third Group of Run Control Parameters

B3	Group identifier	None
NHPRT	Number of junctions for detailed printing of head output (30 nodes max.).	0
NQPRT	Number of conduits for detailed printing of discharge output (30 conduits max.).	0
NPLT	Number of junction heads to be plotted (30 max.).	0

LPLT	Number of conduits for flows to be plotted (30 max.).	0
NB8	Number of conduits for flows to be both printed and plotted Not implemented yet. Just input 0.	0
NB9	Number of junctions for water levels to be both printed and plotted Not implemented yet. Just input 0.	0
NJSW	Number of input junctions (data group K2), if user input hydrographs are used (65 max).	0

Note: For groups B4 - B8, enter each name in single quotes
if alphanumeric option is being used.

Printed Heads

Enter 10 junction numbers per line. Data group B4 is
required only if NHPRT > 0 on data group B3.

B4	Group identifier	None
----	------------------	------

VARIABLE	DESCRIPTION	DEFAULT
JPRT(1)	First junction number/name for detailed printing.	0
JPRT(2)	Second junction number/name, etc., up to number of nodes defined by NHPRT.	0

Printed Flows

Enter 10 conduit numbers per line. Data group B5 is
required only if NQPRT > 0 on data group B3.

B5	Group identifier	None
CPRT(1)	First conduit number/name for detailed printing.	0

CPRT(2)	Second conduit number/name, etc., up to number of nodes defined by NQPRT.	0
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Plotted Heads

Enter 10 junction numbers per line. Data group B6 is required only if NPLT > 0 on data group B3.

B6	Group identifier	None
JPLT(1)	First junction number/name for plotting.	0
JPLT(2)	Second junction number/name, etc., up to number of nodes defined by NPLT.	0

Plotted Flows

VARIABLE	DESCRIPTION	DEFAULT
	Enter 10 conduit numbers per line. Data group B7 is required only if LPT > 0 on data group B3.	
B7	Group identifier	None
KPLT(1)	First conduit number/name for plotting.	0
KPLT(2)	Second conduit number/name for plotting, etc., up to the number of nodes defined by LPLT. This option is for the conduit flow rate.	0

Upstream/Downstream Heads Plotted on Same Graph for Conduits

Enter 30 conduit numbers per line. Data group B8 is optional and may be omitted.

B8	Group identifier	None
----	------------------	------

NSURF	Number of conduit upstream/downstream plots.	1
JSURF(1)	First conduit number/name for plotting.	0
JSURF(2)	Second conduit number/name for plotting, etc., up to the number of conduits defined by NSURF.	0

Conduit Data (1 line/conduit)

C1	Group identifier	None
NCOND(N)	Conduit number (any valid integer), or conduit name (enclose in single quotes).	1 'Name'
NJUNC(N,1)	Junction number at upstream end of conduit, or Junction name (enclose in single quotes).	0
NJUNC(N,2)	Junction number at downstream end of conduit, or junction name (enclose in single quotes).	0
Q0 (N)	Initial flow, cfs [cms].	0.0

VARIABLE	DESCRIPTION	DEFAULT
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NKCLASS(N)	Type of conduit shape.	
	1 - circular	
	2 - rectangular	
	3 - elliptical	
	4 - arch	
	5 - baskethandle.	
	6 - trapezoidal channel	
	7 - parabolic/power function channel	
	8 - irregular (natural) channel	

(Types 9 and 10 are used internally for orifice and weir connections.)

Note: A negative NKCLASS(N) creates a flap gate that will only let water move from the downstream (lower elevation) node to the upstream node.

AFULL(N)	Cross sectional area of conduit, ft ² [m ²] enter only for types 4 and 5. (Geometric properties for types 4 and 5 may be found in Section 6 of the main SWMM User's Manual.)	0.0
DEEP(N)	Vertical depth (diameter for type 1) of conduit, ft [m]. Not required for type 8.	0.0
WIDE(N)	Maximum width of conduit, ft [m] Bottom width for trapezoid, ft [m] Top width for parabolic, ft [m] Not required (N.R.) for types 1 and 8.	0.0
LEN(N)	Length of conduit, ft [m] for type 8, enter it here for reference and also enter in data group C3.	0.0

Note: A negative LEN(N) creates a flap gate that will only let water move from the upstream (higher elevation) node to the downstream node.

ZP (N, 1)	Invert of conduit at NJUNC(N,1), ft [m]	0.0
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VARIABLE	DESCRIPTION	DEFAULT
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ZP(N, 2)	Invert of conduit at NJUNC(N,2), ft [m]	0.0
ROUGH(N)	Manning coefficient (not includes entrance, exit, expansion, and contraction losses). N.R. for type 8. Uses XNCH in data group C2.	0.014
STHETA(N)	Slope of one side of trapezoid. Required only for type - 6, (horizontal/vertical; 0 - vertical walls). For type 7, the channel exponent(2.0, 3.0, etc.). For type 8, the cross-section identification number (SECNO, group C3) of the cross section used for this EXTRAN channel. Unlike HEC-2, EXTRAN uses only a single cross section to represent a natural channel reach for type 8 channels. A negative STHETA(N) will eliminate the printing of the dimensionless curves associated with each natural channel or	0.0

power-function channel.

SPHI(N)	Slope of other side of trapezoid. Required only for type - 6, (horizontal/vertical; 0 - vertical walls). The average channel slope for type 8. This slope is used only for developing a rating curve for the channel. Routing calculations use invert elevation differences divided by length.	0.0
---------	--	-----

(Following three fields only needed when KMLAG = 1 in B0 card.)

ENTRANCE	Entrance loss coefficient	0.0
EXIT	Exit loss coefficient	0.0
OTHER	Other minor loss coefficient	0.0
SFACTOR	Pipe extension factor	1.0

The C2 (NC) or NH, C3 (XI), and C4 (GR) data lines for any type 8 conduits follow as a group after all C1 lines have been entered. The sequence for channels must be in the same order as the earlier sequence of type-8 C1-lines.

VARIABLE	DESCRIPTION	DEFAULT
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Data groups C2, C3 and C4 correspond to HEC-2 lines NC, XI and GR. HEC-2 input may be used directly if desired. Lines may be identified either by EXTRAN identifiers (C2, C3, C4) or HEC-2 identifiers (NC, XI, GR). NH line is for multi-Manning's n option. When more than three Manning's n are required for a given cross-section, NH line, rather than C2 line, should be prepared.

Channel Roughness

This is an optional data line that permanently modifies the Manning's roughness coefficients (n) for the remaining natural channels. This data group may be repeated for later channels. It must be included for the first natural channel-modeled.

C2 or NC	Group identifier	None
XNL	n for the left overbank. = 0.0, No change,	0.0

	> 0.0, New Manning's n.	
XNR	n for the right overbank. = 0.0, No change, > 0.0, New Manning's n.	0.0
XNCH	n for the channel. = 0.0, No change, > 0.0, New Manning's n.	0.0

Note, XNCH is used to develop normalized flow routing curves.

Or

NH	Group identifier for more than three Manning's n channel	none
NXNL	left bank number of Manning's n	1
NXNR	right bank number of Manning's n	1
XNL1(1)	the first Manning's n on left bank	0.0
XNL1(2)	the second Manning's n on left bank	0.0
.		
.		
XNL1(NXNL)	the NXNL Manning's n on left bank	0.0
XNR1(1)	the first Manning's n on right bank	0.0
XNR1(2)	the second Manning's n on right bank	0.0
.		
.		
.		

XNR1(NXNR)	the NXNR Manning's n on right bank	0.0
XNCH	Main channel Manning's n	0.0

Cross Section Data

Required for each type 8 conduit in earlier CI data lines.
Enter pairs of C3 and C4 lines in same sequence as appearance
of corresponding type 8 conduit in earlier CI lines.

C3 or XI	Group identifier	None
SECNO	Cross section identification number.	1
NUMST	Total number of stations on the following C4 (GR) data group lines. NUMST must be < 99.	0

VARIABLE	DESCRIPTION	DEFAULT
STCHL	The station of the left bank of the channel, ft [m]. Must be equal to one of the STA(N) on the C4 (GR) data lines.	0.0
(enter NXNL coordinates sequentially here if NH line prepared)		
STCHR	The station of the right bank of the channel, ft [m]. Must be equal to one of the STA(N) on the C4 (GR) data lines.	0.0
(enter NXNR coordinates sequentially here if NH line prepared)		
XLOBL	Not required for EXTRAN (enter 0.0).	0.0
XLOBR	Not required for EXTRAN (enter 0.0).	0.0
LEN(N)	Length of channel reach represented by this cross section, ft [m].	0.0

PXSECR	Factor to modify the horizontal dimensions for a cross section. The distances between adjacent C4 (GR) stations (STA) are multiplied by this factor to expand or narrow a cross section. The STA of the first C4 (GR) point remains the same. The factor can apply to a repeated cross section or a current one. A factor of 1.1 will increase the horizontal distance between the C4 (GR) stations by 10 percent. Enter 0.0 for no modification.	0.0
PSXECE	Constant to be added (+ or -) to C4 (GR) elevation data on next C4 (GR) line. Enter 0.0 to use C4 (GR) values as entered.	0.0

Cross-Section Profile

Required for type 8 conduits in data group C1.
Enter C3 and C4 lines in pairs.

C4 or GR	Group identifier	None
EL(1)	Elevation of cross section at STA(1). May be positive or negative, ft [m].	0.0
STA(1)	Station of cross section 1, ft [m].	0.0
EL(2)	Elevation of cross section at STA(2), ft [m].	0.0
STA(2)	Station of cross section 2, ft [m].	0.0

Enter NUMST elevations and stations to describe the cross section. Enter 5 pairs of elevations and stations per data line. (Include group identifier, C4 or GR, on each line.) Stations should be in increasing order progressing from left to right across the section. Cross section data are traditionally oriented looking downstream (HEC, 1982).

Junction Data (1 line/junction.)

VARIABLE	DESCRIPTION	DEFAULT
D1	Group identifier	None

JUN(J)	Junction number (any valid integer), or junction name (enclose in single quotes).	0
GRELEV(J)	Ground elevation, ft [m].	0.0
Z(J)	Invert elevation, ft [m].	0.0
QINST(J)	Net constant flow into junction, cfs [m ³ /s] Positive indicates inflow. Negative indicates withdrawal or loss.	0.0
Y0(J)	Initial water elevation, ft [m]	Z(J)

Storage Junctions

Note: Each storage junction must also have been entered in the junction data (Group DI).

EI	Group identifier	None
JSTORE(I)	Junction number containing storage facility, or junction name (enter in single quotes).	0
ZTOP(I)	Junction crown elevation (must be higher than	0.0

VARIABLE	DESCRIPTION	DEFAULT
	crown of highest pipe connected to the storage junction), ft [m].	
ASTORE(J)	Storage volume per foot (or meter) of depth (i.e., constant surface area) ft ³ /ft [m ³ /m]. Set ASTORE(J) < 0 to indicate a variable-area storage junction. NUMST required only if ASTORE < 0.	0.0
NUMST	Total number of stage/storage area points on following E2 data lines. NUMST < 99. Enter a value of -2 for NUMST to generate area vs. stage using a power function, A = a depth ^b .	0

Follow E1 line with E2 line(s) only if ASTORE < 0,
or NUMST equals -2 on line E1.

Variable-Area Storage Junction, Stage vs. Surface Area Points

E2	Group identifier	None
QCURVE(N,1,1)	Surface area of storage junction at depth point 1, acres [hectares]. If NUMST equals -2 this is the coefficient of the power function.	0.0
QCURVE(N,2,1)	Elevation at point 1, ft [m]. If NUMST equals -2 this is the exponent of the power function. This is the last value entered if NUMST equals -2.	0.0
QCURVE(N,1,2)	Surface area of storage junction at depth point 2, acres [hectares].	0.0
QCURVE(N,2,2)	Elevation at point 2, ft [m].	0.0
.		
.		
.		
.		

VARIABLE	DESCRIPTION	DEFAULT
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Continue entering total of NUMST (data group E1) area-stage points.
Use only one E2 group identifier for the E2 data group. If more than one line is required leave the first two columns blank.

Orifice Data (60 Max.)

E1	Group identifier	None
NJUNC(N,1)	Junction number containing orifice, or junction name (enter in single quotes).	None
NJUNC(N,2)	Junction number to which orifice discharges, or junction name (enter in single quotes).	None

NKIASS(N)	Type of orifice. 1 - side outlet, 2 - bottom outlet, -1 - time-history side outlet orifice, with data entered on data group F2. -2 - time-history bottom outlet orifice, with data entered on data group F2.	1
AORIF(I)	Orifice area, ft ² [m ²].	0.0
CORIF(I)	Orifice discharge coefficient.	1.0
ZP(I)	Orifice invert (define only for side outlet orifices), ft [m].	0.0

Time-History Orifice Data

Each F2 line follows the appropriate F1 line.

F2	Group identifier	None
NTIME	Number of data points to describe the time	1

VARIABLE	DESCRIPTION	DEFAULT
----------	-------------	---------

history of the orifice (50 max.).

VORIF(I,1,1)	First time, hours, that the orifice discharge coefficient and area change values from initial settings of group F1 above. Time zero refers to beginning (midnight) of beginning day of simulation. E.g., VORIF(I,1,1) = 22.0 means first change in orifice setting occurs at 10:00 p.m. on first day of simulation. Increase hours past 24 (e.g., 25, 26) for multi-day simulations.	0.0
VORIF(I,1,2)	First new value of orifice discharge coefficient.	0.0

VORIF(I,1,3)	First new value of orifice area.	0.0
.		
.		
.		

Enter NTIME values of time/coefficient/area. Only one F2 group identifier is required, on the first data line. Subsequent lines (if required) should not include F2 identifier.

Weir Data (1 line/weir, 60 Max.)

GI	Group identifier	None
NJUNC(N,1)	Junction number at which weir is located, or Junction name (enter in single quotes).	0
NJUNC(N,2)	Junction number to which weir discharges, or Junction name (enter in single quotes). Note: To designate outfall weir, set NJUNC(N,2) equal to zero or (one space between quotes).	0
KWEIR(I)	Type of weir. 1 = transverse	1

VARIABLE	DESCRIPTION	DEFAULT
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	2 = transverse with tide gate, 3 = side flow, 4 = side flow with tide gate.	
YCREST(I)	Elevation of weir crest, ft [m].	0.0
YTOP(I)	Elevation of top of weir opening (surcharge level) ft [m].	
WLEN(I)	Weir length, ft [m].	0.0
COEF(I)	Coefficient of discharge for weir.	1.0

Pump Data (1 line/pump, 20 Max.)

Note: ONLY ONE PIPE CAN BE CONNECTED TO A TYPE 1 PUMP NODE.

HI	Group identifier	None
IPTYP(I)	Type of pump. 1 = off-line pump with wet well (program will set pump junction invert to -100), 2 = in-line lift pump, 3 = three-point head-discharge pump curve.	1
NJUNC(N,1)	Junction number being pumped, or Junction name (enter in single quotes).	0
NJUNC(N,2)	Pump discharge goes to this junction number, or junction name (enter in single quotes).	0
PRATE(I,1)	Lower pumping rate, ft ³ /s [m ³ /s].	0.0

VARIABLE	DESCRIPTION	DEFAULT
PRATE(I,2)	Mid-pumping rate, ft ³ /s [m ³ /s].	0.0
PRATE(I,3)	High pumping rate, ft ³ /s [m ³ /s].	0.0
VRATE (I, 1)	If IPTYP = 1 enter the wet well volume for mid-rate pumps to start, ft ³ [m ³]. If IPTYP = 2 enter the junction depth for mid-rate pumps to start, ft [m]. If IPTYP = 3 enter the head difference (head at junction downstream of pump minus and head at junction upstream of pump) associated with the lowest pumping rate, ft [m]. (This will be the highest head difference.)	0.0

VRATE (I, 2) If IPTYP = 1 enter the wet well volume for high-rate pumps to start, ft³ [m³]. 0.0
 If IPTYP = 2 enter the junction depth for high-rate pumps to start, ft [m].
 If IPTYP = 3 enter the head difference associated with the mid-pumping rate, ft [m]

Non-zero VRATE(I,3) and VWELL(I) required only if IPTYP = 1 or 3.

VRATE(I,3) If IPTYP = 1 enter total wet well capacity, ft³ [m³] 0.0
 If IPTYP = 3 then enter the head difference associated with highest pumping rate, ft [m].
 (This will be the lowest head difference.)

VWELL(I) If IPTYP = 1 then enter initial wet well volume, ft³ [m³] 0.0
 If IPTYP = 3 then enter the initial depth in pump inflow Junction, ft [m]

Enter PON(I) and POFF(I) if IPTYP = 3

PON(I) Depth in pump inflow junction to turn pump on, ft [m]. 0.0

VARIABLE	DESCRIPTION	DEFAULT
POFF(I)	Depth in pump inflow junction to turn pump off, ft [m].	0.0

Note: for groups II and I2, enter junction name in single quotes if alphanumeric option is being used.

Outfalls Without Tide Gates (1 line/outfall, 25 Max.)

Note: ONLY ONE CONNECTING CONDUIT IS PERMITTED TO AN OUTFALL NODE.

I1	Group identifier	None
JFREE(I)	Number/name of outfall junction without tide gate (no back-flow restriction).	0
NBCF(I)	Type of boundary condition, from sequence of data group J1 - J4.	1

Outfalls with Tide Gates (1 line/outfall, 25 max.)

Note: ONLY ONE CONNECTING CONDUIT IS PERMITTED TO AN OUTFALL NODE.

I2	Group identifier	None
JGATE(I)	Number/name of outfall junction with tide gate (back-flow not allowed).	0
NBCG(I)	Type of boundary condition, from sequence of data groups J1 - J4.	1

VARIABLE	DESCRIPTION	DEFAULT
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Boundary Condition Information

Note: Repeat sequence of data groups J1-J4 for up to 20 different boundary conditions. Appearance in sequence (e.g., first, second... fifth...) determines value for NBCF and NBCG in data groups I1 and I2.

J1	Group identifier	None
NTIDE(I)	Boundary condition index. 1 = No water surface at outfalls (elevated discharge), 2 = Controlling water surface at outfall at constant elevation A1 (group J2), ft [m],	1

Types 3, 4 and possibly 5 are used for tidal variations at outfall.

- 3 = Tide coefficients (Group J2) provided by user,
 - 4 = Program will compute tide coefficients,
 - 5 = Stage-history of water surface elevations input by user.
- Program uses linear interpolation between data points.
-

Stage and/or Tidal Coefficients

Note: NOT REQUIRED (OMIT) IF NTIDE(I) = 1 OR 5 ON DATA GROUP JI.

J2	Group identifier	None
A1(I)	First tide coefficient, ft [m].	0.0
W(I)	Tidal period, hours. Required only if NTIDE(I) = 3 or 4.	0.0

Note: NEXT SIX FIELDS NOT REQUIRED UNLESS NTIDE(I) = 3

VARIABLE	DESCRIPTION	DEFAULT
A2(I)	Second tide coefficient, ft [m].	0.0
A3(I)	Third tide coefficient, ft [m].	0.0
A4(I)	Fourth tide coefficient, ft [m].	0.0
A5(I)	Fifth tide coefficient, ft [m].	0.0
A6(I)	Sixth tide coefficient, ft [m].	0.0
A7(I)	Seventh tide coefficient, ft [m].	0.0

Tidal/Stage Information

REQUIRED ONLY IF NTIDE = 4 OR 5

J3	Group identifier	None
K0	Type of tidal input. = 0, Input is in the form of a time series of NI tidal heights. This parameter is not used if NTIDE equals 5. =1, Input is in the form of the high and low water values found in the tide tables, (HHW, LLW, LHW, and HLW). NI must be 4.	0
NI	Number of information points.	4
NCHTID	Tide information print control. = 0, Do not print information, = 1, Print information on tide coefficients or stage history.	1
DELTA	Convergence criterion for fitting of tidal function, ft [m]. Not required for NTIDE = 5.	0.005

VARIABLE	DESCRIPTION	DEFAULT
----------	-------------	---------

Time and stage information

REQUIRED IF NTIDE = 4 OR 5

J4	Group identifier	None
TT(1) -	Time of day, first information point, hours. (Increase hours past 24 if necessary.)	0.0
YY(1)	Tide/stage at time above, ft [m].	0.0
TT(2)	Time of day, second information points, hours.	0.0
YY(2)	Tide/stage, at time above, up to number	0.0

of points as defined by NI, ft [m].

Note: Enter 5 pairs of time and stage information per data line.
(Repeat group identifier on each line.)

User Input Hydrographs

IF NJSW = 0 (GROUP B3), SKIP DATA GROUPS K1, K2 AND K3

K1	Group identifier	None
NINC	Number of input nodes and flows per line in group K3.	1

VARIABLE	DESCRIPTION	DEFAULT
Hydrograph Nodes		
K2	Group identifier	None
JSW(1)	First input node number for line hydrograph, or node name (enter in single quotes).	0
JSW(2)	Second input node number for line hydrograph, or node name (enter in single quotes).	0
Enter NINC nodes per line until NJSW nodes are entered. (Repeat group identifier on each line.)		

User Input Hydrographs		
K3	Group identifier	None
TEO	Time of day, decimal hours.	0.0
QCARD(1,1)	F13w ratq for first input node, JSW(1), ft ³ [m ³].	0.0
QCARD(2,1)	F1sw rat I for second input node, JSW(2), ft ³ [m ³].	0.0

Enter TEO plus NINC flows per line until NJSW flows are entered. Enter TEO only on first of multiple ("wrapped around") lines and do not include group identifier K3 on lines that are "wrapped around." Repeat the sequence for each TEO time. Times do not have to be evenly spaced; linear interpolation is used to interpolate between entries. The last K3 line will signal the end of the user hydrograph input. The last TEO value should be \geq length of simulation. Increase TEO past 24 for multi-day simulations.

END OF EXTRAN DATA INPUT

Control now returns to the Executive Block of SWMM.

If no more SWMM blocks are to be called, end input with \$ENDPROGRAM in columns 1-11.

Example:

```

* =====
*                               EXAMPLE OF SWMM INPUT
*                               =====
*   NBLOCKS   INBLK1  OUTBLK1  INBLK2  OUTBLK2
SW      2       8       12       12       0
MM      6      10      13      14      15      16
@       8      'EXAMPL.WPX'
@      11      'EXAMPL.HOT'
@      12      'EXAMPL.INT'
@      15      'EXAMPL.SMX'
@      16      'EXAMPL.PLT'
$COMBINE
A1 11
B1 ' A1=11 GENERATE HYDROGRAPH FROM WPX FILE '
B1 ' MAKE SWMM INTERFACE FILE '
*
$EXTRAN
*   ALPHA
A1 ' EXISTING CONDITION '
A1 ' DESIGN STORM EVENT '
*   ISOL      KSUPER
B0  2         0       1
BB  1         0
B1  86400     1.00    0.0    1    3600    3600    0
B2         0       0    12.6   30   0.05
*   H-prnt Q-prnt H-plot Q-plot
B3  3         2       3       2       0       0       1
B4  101005   100022  101007
B5  1101005  1101015
B6  101005   100022  101007
B7  1101005  1101015
*
*=====
*   1. ORIENT PARK SYSTEM
K_ent K_exit K_orther Stretch
*=====
*   TW
C1 1101005 0101005 0100022 0.0 1 0.0 5.00 0.00 80.0 4.95 4.85 0.024 0.0 0.0 0.5 1.0 0.0 1.0
C1 2101005 0101005 0100022 0.0 1 0.0 5.00 0.00 80.0 4.95 4.85 0.024 0.0 0.0 0.5 1.0 0.0 1.0
*   WEIR      0101007 0101005
C1 9101010 0101010 0101007 0.0 8 0.0 0.00 0.00 400.0 8.95 6.95 0.0 -9101010 0.0030 0.0
0.0 0.0 1.0
*----BROADWAY
C1 1101015 0101015 0101010 0.0 1 0.0 7.50 0.00 150.0 9.05 8.95 0.00960
0.0000 0.0000 0.5 1.0 0.0 1.0
*   UPGRADE
C1 1101025 0101025 0101015 0.0 1 0.0 7.00 0.00 450.0 9.15 9.05 0.01200
0.0000 0.0000 0.5 1.0 0.0 1.0
*   UPGRADE
C1 1101030 0101030 0101025 0.0 1 0.0 6.50 0.00 50.0 9.20 9.15 0.01200
0.0000 0.0000 0.5 1.0 0.0 1.0
C1 9101035 0101035 0101030 0.0 8 0.0 0.00 0.00 400.0 14.80 9.20 0.00000 -
9101035 0.0110 0.0 0.0 0.0 1.0
*----76TH ST.      PICTURE ERCP
*
C1 1101040 0101040 0101035 0.0 2 0.0 4.00 8.00 40.0 15.30 14.80 0.01200
0.0000 0.0000 0.5 1.0 0.0 1.0
C1 9101045 0101045 0101040 0.0 8 0.0 0.00 0.00 200.0 16.36 15.30 0.00000 -
9101045 0.0080 0.0 0.0 0.0 1.0
*----75TH ST.
C1 1101050 0101050 0101045 0.0 2 0.0 4.00 8.00 40.0 16.57 16.36 0.01200
0.0000 0.0000 0.5 1.0 0.0 1.0
C1 9101055 0101055 0101050 0.0 8 0.0 0.00 0.00 190.0 17.73 16.57 0.00000 -
9101055 0.0010 0.0 0.0 0.0 1.0
*----MISSOURI ST.  L=? 115 OR 40
C1 1101060 0101060 0101055 0.0 2 0.0 4.00 8.00 40.0 18.23 17.73 0.01200
0.0000 0.0000 0.5 1.0 0.0 1.0

```

C1	9101065	0101065	0101060	0.0	8	0.0	0.00	0.00	160.0	19.70	18.23	0.00000	-
	9101065	0.0030	0.0	0.0	0.0	1.0							
*----ORIENT RD.													
C1	1101070	0101070	0101065	0.0	2	0.0	4.00	8.00	50.0	19.75	19.70	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	9101075	0101075	0101070	0.0	8	0.0	0.00	0.00	150.0	20.25	19.75	0.00000	-
	9101075	0.0050	0.0	0.0	0.0	1.0							
*----FIRST ASSEMBLY OF GOD													
C1	1101080	0101080	0101075	0.0	1	0.0	3.00	0.00	37.0	20.43	20.25	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	1101090	0101090	0101080	0.0	1	0.0	3.00	0.00	62.0	20.51	19.89	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	1101095	0101095	0101090	0.0	3	0.0	4.00	2.50	112.0	20.90	20.43	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	1101105	0101105	0101095	0.0	1	0.0	3.00	0.00	285.0	23.69	20.94	0.01800	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
*----21ST ST. NEW SURVEY													
C1	1101115	0101115	0101105	0.0	3	0.0	2.50	4.42	64.5	25.09	25.00	0.03400	
	0.0000	0.0000	0.5	1.0	0.0	10.0							
C1	2101115	0101115	0101105	0.0	3	0.0	2.67	4.33	64.5	25.60	25.48	0.03400	
	0.0000	0.0000	0.5	1.0	0.0	10.0							
C1	9101120	0101120	0101115	0.0	6	0.0	13.90	6.20	1000.0	24.89	24.50	0.04000	
	1.1300	1.1300	0.0	0.0	0.0	1.0							
* PROPOSED DETENTION PONDS													
* WEIR		120	117										
* WEIR		117	115										
*----RHODE ISLAND 48" CMP L=230'													
C1	1101127	0101127	0101120	0.0	1	0.0	4.00	0.00	230.0	26.12	24.89	0.02400	
	0.0000	0.0000	0.5	1.0	0.0	10.0							
*----VERMONT DRIVE													
C1	1101140	0101140	0101127	0.0	1	0.0	2.50	0.00	36.7	27.12	27.11	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	2.0							
C1	9101145	0101145	0101140	0.0	6	0.0	13.10	3.00	500.0	28.30	27.12	0.04000	
	2.3300	2.3300	0.0	0.0	0.0	1.0							
C1	9101150	0101150	0101145	0.0	8	0.0	0.00	0.00	550.0	29.63	28.30	0.00000	-
	9101150	0.0270	0.0	0.0	0.0	1.0							
*----CORPOREX PARK DRIVE													
C1	1101160	0101160	0101150	0.0	3	0.0	4.00	6.33	100.0	29.93	29.63	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	2101160	0101160	0101150	0.0	3	0.0	4.00	6.33	100.0	29.93	29.63	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
*----CITICORP BLVD													
C1	1101170	0101170	0101160	0.0	1	0.0	4.00	0.00	120.0	30.10	30.00	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
*----BRANCH													
C1	1101146	0101146	0101150	0.0	1	0.0	2.50	0.00	45.0	30.90	30.64	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	1101148	0101148	0101150	0.0	3	0.0	1.58	2.50	36.0	30.90	30.68	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	1101161	0101161	0101160	0.0	1	0.0	2.00	0.00	24.0	31.50	31.40	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	1101163	0101163	0101160	0.0	1	0.0	1.50	0.00	24.0	31.50	31.40	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	1101171	0101171	0101160	0.0	1	0.0	2.50	0.00	24.0	30.70	30.60	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	10.0							
*----BRANCH (Tributary O2)													
C1	1101210	0101210	0101120	0.0	1	0.0	2.00	0.00	72.0	28.84	28.15	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	1101220	0101220	0101210	0.0	1	0.0	1.25	0.00	70.0	29.36	28.84	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	2101220	0101220	0101210	0.0	1	0.0	1.25	0.00	66.0	29.74	29.64	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	1101235	0101235	0101220	0.0	1	0.0	1.25	0.00	140.0	30.08	29.49	0.02400	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
C1	1101245	0101245	0101235	0.0	1	0.0	2.00	0.00	130.0	31.85	31.21	0.01200	
	0.0000	0.0000	0.5	1.0	0.0	1.0							
*----BRANCH													
C1	9101430	0101430	0101425	0.0	6	0.0	12.00	1.50	687.0	29.93	29.63	0.04000	
	1.4000	1.4000	0.0	0.0	0.0	1.0							
C1	9101435	0101435	0101430	0.0	6	0.0	13.00	6.00	250.0	30.55	29.33	0.04000	
	1.2000	1.2000	0.0	0.0	0.0	1.0							

```

C1 1101445 0101445 0101435 0.0 1 0.0 1.50 0.00 38.0 30.99 30.22 0.02400
0.0000 0.0000 0.5 1.0 0.0 1.0
C1 1101450 0101450 0101445 0.0 1 0.0 1.50 0.00 38.0 30.86 30.75 0.01200
0.0000 0.0000 0.5 1.0 0.0 1.0
*----BRANCH-BETWEEN ORIENT PARK & JUDSON CREEK
* TW
C1 1101505 0101505 0100025 0.0 1 0.0 4.00 0.00 50.0 22.86 22.76 0.01200
0.0000 0.0000 0.5 1.0 0.0 1.0
C1 1101520 0101520 0101505 0.0 1 0.0 5.00 0.00 120.0 21.08 21.21 0.02400
0.0000 0.0000 0.5 1.0 0.0 1.0
*- WEIR 0101535 0101520
*
*
* CHANNEL IMPROVEMENTS UP TP 1070
* --- Natural Channel Da 1005
C2 0.040 0.040 0.035
C3 9101010 6 100.00 130.00 0.00 0.00 400.00 0.00 0.00
C4 21.500 99.900
15.500 100.000
10.300 110.000
10.300 120.000
15.500 130.000
C4 21.500 130.100
* ---- Natural Channel Da 1030
C2 0.040 0.040 0.035
C3 9101035 7 100.00 130.10 0.00 0.00 400.00 0.00 0.00
C4 29.500 99.900
19.500 100.000
14.400 107.600
13.900 112.600
14.600 117.100
C4 19.200 130.100
29.200 130.200
* ---- Natural Channel Da 1040
C2 0.040 0.040 0.035
C3 9101045 7 100.00 128.00 0.00 0.00 200.00 0.00 0.00
C4 31.400 99.900
21.400 100.000
17.300 105.000
17.100 113.000
18.200 121.000
C4 22.500 128.000
32.500 128.100
* ---*-- Natural Channel Da 1050
C2 0.040 0.040 0.035
C3 9101055 7 100.00 120.00 0.00 0.00 190.00 0.00 0.00
C4 31.700 99.900
21.700 100.000
18.500 108.600
18.200 112.300
18.500 116.000
C4 22.000 120.000
32.000 120.100
* ----Natural Channel Da 1060
C2 0.040 0.040 0.035
C3 9101065 7 100.00 123.80 0.00 0.00 160.00 0.00 0.00
C4 32.100 99.900
22.100 100.000
18.900 105.700
18.600 113.050
18.900 120.400
C4 21.900 123.800
31.900 123.900
* CHANNEL IMPROVEMENTS UP TO D/S OF ORIENT ROAD
* ---- Natural Channel Da 1070
C2 0.040 0.040 0.040
C3 9101075 7 100.00 122.00 0.00 0.00 150.00 0.00 0.00
C4 33.500 99.900
23.500 100.000
20.000 103.000
19.700 110.000

```

	19.700	117.000							
C4	23.600	122.000							
	33.600	122.100							
* ---- Natural Channel Da 1145									
C2	0.040	0.040	0.040						
C3	9101150		7	100.00	115.50	0.00	0.00	550.00	0.00 0.00
C4	40.600	99.900							
	30.600	100.000							
	28.800	103.700							
	28.200	107.900							
	28.700	112.100							
C4	30.500	115.500							
	40.500	115.600							
=====									
*									
D1	0100025	99		22.76	0	27.00			
D1	0100026	99		24.45	0	28.00			
D1	0100027	99		24.45	0	28.00			

* SOUTH SYSTEM									
* Orient Park Outfall									

D1	0101005	99		4.95	0	9.70			
D1	0101007	99		6.95	0	9.70			
D1	0101010	99		8.95	0	9.70			
D1	0101015	99		9.05	0	9.70			
*D	0101020	99		9.15	0	9.70			
D1	0101025	99		9.15	0	9.70			
D1	0101030	99		9.20	0	9.70			
D1	0101035	99		14.80	0	14.80			
D1	0101040	99		15.30	0	15.40			
D1	0101045	99		16.36	0	16.46			
D1	0101050	99		16.57	0	16.57			
D1	0101055	99		17.73	0	17.73			
D1	0101060	99		18.23	0	18.39			
D1	0101065	99		19.70	0	19.70			
D1	0101070	99		19.75	0	19.85			
D1	0101075	99		20.25	0	20.25			
D1	0101080	99		20.43	0	20.53			
D1	0101090	99		20.43	0	20.53			
D1	0101095	99		20.90	0	21.00			
D1	0101105	99		23.69	0	23.79			
D1	0101115	99		24.50	0	24.50			
*									
* PROPOSED POND LOCATION									
D1	0101117	99		24.50	0	24.50			
*									
D1	0101120	99		24.89	0	24.99			
D1	0101127	99		26.12	0	26.12			
D1	0101140	99		27.12	0	27.12			
D1	0101145	99		28.30	0	28.40			
D1	0101146	99		30.90	0	32.30			
D1	0101147	99		31.99	0	32.30			
D1	0101148	99		30.90	0	32.30			
D1	0101149	99		31.54	0	32.30			
D1	0101150	99		29.63	0	32.30			
D1	0101151	99		32.40	0	32.50			
D1	0101160	99		29.93	0	32.30			
D1	0101161	99		31.50	0	32.30			
D1	0101162	99		31.50	0	32.30			
D1	0101163	99		31.50	0	32.30			
D1	0101164	99		31.50	0	32.30			
*D	0101165	99		27.90	0	32.30			
D1	0101170	99		30.10	0	32.30			
D1	0101171	99		30.70	0	32.30			
D1	0101172	99		32.76	0	32.86			
* Trib. O2									
D1	0101210	99		28.84	0	28.94			
D1	0101215	99		29.36	0	29.46			
D1	0101220	99		29.36	0	29.34			
D1	0101235	99		30.08	0	30.18			

D1	0101245	99	31.85	0	31.95
D1	0101305	99	20.75	0	20.85
* Trib. East of Orient Rd.					
D1	0101425	99	29.63	0	29.73
D1	0101430	99	29.33	0	29.43
D1	0101435	99	30.22	0	30.32
D1	0101445	99	30.75	0	30.85
D1	0101450	99	28.98	0	29.08
* TL TAKEOFF					
D1	0101505	99	21.21	0	27.00
D1	0101520	99	21.08	0	27.00
D1	0101535	99	25.69	0	25.79

SOUTH SYSTEM

E1	0101007	99	5000	0
E1	0101025	99	2000	0
E1	0101065	99	2000	0
E1	0101080	99	2000	0
E1	0101090	99	2000	0
E1	0101095	99	2000	0
E1	0101145	99	2000	0
E1	0101146	99	2000	0
E1	0101148	99	2000	0
E1	0101150	99	5000	0
E1	0101161	99	2000	0
E1	0101163	99	2000	0
E1	0101171	99	2000	0
E1	0101210	99	2000	0
E1	0101215	99	2000	0
E1	0101220	99	2000	0
E1	0101235	99	6000	0
E1	0101425	99	2000	0
E1	0101505	99	2000	0

=====

E1	0101005	99	-1	6
E2	0.10	4.95		
	0.15	10.11		
	0.20	10.12		
	1.20	13.12		
	3.19	15.12		
	6.69	17.12		

E1	0101015	99	-1	5
E2	0.10	9.05		
	0.15	18.99		
	3.47	19.00		
	4.42	20.00		
	5.23	21.00		

E1	0101030	99	-1	5
E2	0.10	9.20		
	0.15	18.99		
	1.99	19.00		
	3.07	20.00		
	6.63	21.00		

E1	0101040	99	-1	4
E2	0.10	15.30		
	0.15	20.00		
	0.20	22.00		
	0.91	23.00		

E1	0101050	99	-1	5
E2	0.10	16.57		
	0.15	20.00		
	0.68	22.00		
	1.65	23.00		
	2.17	24.00		

E1	0101060	99	-1	5
E2	0.10	18.23		
	0.15	20.00		
	0.35	22.00		
	1.24	23.00		
	2.02	24.00		
E1	0101075	99	-1	7
E2	0.10	20.25		
	0.15	21.99		
	0.20	22.00		
	0.90	23.00		
	4.88	24.00		
	8.86	25.00		
	11.44	26.00		
*				
E1	0101105	99	-1	6
E2	0.10	23.69		
	0.20	25.99		
	1.00	26.00		
	1.50	28.00		
	2.00	30.00		
	2.50	32.00		
*				
	REVISED FOR PROPOSED DETENTION POND			
E1	0101115	99	-1	6
E2	0.10	24.50		
	0.15	28.99		
	0.29	29.00		
	0.93	30.00		
	1.67	31.00		
	1.72	32.00		
*				
	PROPOSED DETENTION POND BETWEEN RHODE ISLAND & 21ST AVE.			
E1	0101117	99	-1	6
E2	3.70	24.50		
	4.00	26.50		
	4.30	28.50		
	5.93	30.00		
	8.67	31.00		
	11.72	32.00		
E1	0101120	99	-1	6
E2	0.10	24.89		
	0.15	28.99		
	0.16	29.00		
	0.83	30.00		
	1.73	31.00		
	2.46	32.00		
E1	0101127	99	-1	5
E2	0.10	26.12		
	0.15	29.99		
	0.20	30.00		
	0.91	31.00		
	1.95	32.00		
E1	0101140	99	-1	4
E2	0.10	27.12		
	0.15	30.99		
	0.30	31.00		
	1.37	32.00		
E1	0101147	99	-1	4
E2	0.51	31.99		
	0.81	33.00		
	0.91	36.00		
	0.91	38.00		
E1	0101149	99	-1	4
E2	1.05	31.54		
	1.05	33.00		
	1.10	34.23		

		1.32	35.00		
E1	0101151	99		-1	4
E2		0.10	32.40		
		3.22	33.00		
		6.04	34.00		
		8.74	35.00		
E1	0101160	99		-1	4
E2		0.10	29.93		
		25.22	31.00		
		36.95	33.00		
		50.22	35.00		
E1	0101162	99		-1	5
E2		1.30	31.5		
		1.59	33.00		
		2.67	34.00		
		3.37	35.00		
		3.50	36.00		
E1	0101164	99		-1	4
E2		1.00	31.50		
		1.34	33.00		
		1.88	34.00		
		2.00	36.00		
E1	0101170	99		-1	4
E2		0.10	30.10		
		0.51	32.00		
		2.19	34.00		
		9.81	35.00		
E1	0101172	99		-1	3
E2		0.50	32.76		
		0.98	34.00		
		1.00	37.00		
E1	0101245	99		-1	5
E2		0.10	31.85		
		0.15	32.50		
		0.63	34.00		
		2.11	35.00		
		4.16	36.00		
E1	0101305	99		-1	4
E2		0.10	20.75		
		0.17	24.00		
		1.43	25.00		
		3.87	26.00		
E1	0101450	99		-1	4
E2		0.10	28.98		
		0.49	30.00		
		0.82	31.00		
		3.85	32.00		
E1	0101520	99		-1	7
E2		0.10	21.08		
		0.15	24.90		
		0.20	25.00		
		0.52	26.00		
		2.50	27.00		
		4.81	28.00		
		11.25	29.00		
E1	0101535	99		-1	4
E2		0.10	25.69		
		0.15	28.00		
		0.22	29.00		

```

0.30    30.00
*-----*
*  South system Orifice
*-----*
*
F1    0101147  0101147  0101146    1    2.40  0.6  0.00
F1    0101149  0101149  0101148    1    1.69  0.6  0.00
*-----*
*    ORIENT PARK
*-----*
G1    8101007  0101007  0101005    1    9.20  99  14  3.1  1
G1    7101015  0101015  0101010    1   19.00  99  18  2.6  1
G1    7101025  0101025  0101015    1   19.00  99  24  2.6  1
G1    7101030  0101030  0101025    1   19.00  99  22  2.6  1
G1    7101040  0101040  0101035    1   21.99  99  28  2.6  1
G1    7101050  0101050  0101045    1   22.42  99  24  2.6  1
G1    7101060  0101060  0101055    1   22.35  99  24  2.6  1
G1    7101070  0101070  0101065    1   24.20  99  24  2.6  1
*-----*
*    CHURCH SITE ROAD OVERTOPPING WEIR
*    BASED ON SITE OBSERVATION  RULE*3
*-----*
G1    7101080  0101080  0101075    1   24.23  99  36  2.6  1
G1    7101090  0101090  0101080    1   24.80  99  36  2.6  1
G1    7101095  0101095  0101090    1   25.40  99  48  2.6  1
G1    7101105  0101105  0101095    1   28.52  99  36  2.6  1
G1    7101115  0101115  0101105    1   31.44  99  35  2.6  1
*    PROPOSED DETENTION & CONTROL STRUCTURE
G1    8101120  0101120  0101117    1   26.00  99  20  3.1  1
G1    8101117  0101117  0101115    1   28.00  99  20  3.1  1
*
G1    7101127  0101127  0101120    1   30.08  99  16  2.6  1
G1    7101140  0101140  0101127    1   31.10  99  10  2.6  1
G1    7101160  0101160  0101150    1   37.26  99  51  2.6  1
G1    7101170  0101170  0101160    1   36.35  99  16  2.6  1
*
G1    6101147  0101147  0101150    1   36.00  99  50  2.6  1
G1    6101149  0101149  0101150    1   34.23  99  50  2.6  1
G1    7101151  0101151  0101145    1   32.50  99  50  2.6  1
G1    7101162  0101162  0101160    1   35.00  99  50  2.6  1
G1    7101164  0101164  0101160    1   35.00  99  50  2.6  1
G1    7101172  0101172  0101160    1   36.45  99  50  2.6  1
G1    7101235  0101235  0101120    1   34.00  99  50  2.6  1
G1    6101245  0101245  0101151    1   35.30  99  50  2.6  1
G1    8101305  0101305  0101075    1   20.75  22.75  1.4  3.31  1
G1    7101305  0101305  0101075    1   24.29  99  50  2.6  1
G1    7101127  0101127  0101425    1   31.00  99  50  2.6  1
G1    8101127  0101127  0101425    1   29.74  99  0.8  3.1  2
G1    6101535  0101535  0101520    1   29.50  99  50  2.6  1
*-----*
I1    0100024    1
I1    0100025    2
I1    0100026    3
I1    0100027    4
* J-CARD GROUP 1
J1    5
J3    0  3  1
J4    0  2.5  15  2.5  240  2.5
* J-CARD GROUP 2
J1    5
J3    0  3  1
J4    0  27.0  15  27.0  240  27.0
* J-CARD GROUP 3
J1    5
J3    0  3  1
J4    0  27.0  15  27.0  240  27.0
* J-CARD GROUP 4
J1    5
J3    0  3  1
J4    0  28.0  15  28.0  240  28.0
$ENDPROGRAM

```

**APPENDIX A, OVERLAND FLOW
MANNING'S N VALUES**

Basin Type	Recommended value	Range of values
Concrete	0.011	0.01 - 0.013
Asphalt	0.012	0.01 - 0.015
Bare Sand	0.010	0.010 -- 0.016
Graveled Surface	0.012	0.012 - 0.030
Bare Clay-loam (eroded)	0.012	0.012 - 0.033
Fallow (no residue)	0.05	0.006 - 0.16
Chisel Plow (<1/4 tons/acre residue)	0.07	0.006 - 0.17
Chisel Plow (1/4 - 1 tons/acre residue)	0.18	0.07 -- 0.34
Chisel Plow (1 - 3 tons/acre residue)	0.30	0.19 -- 0.47
Chisel Plow (>3 tons/acre residue)	0.40	0.34 -- 0.46
Disk/Harrow (<1/4 tons/acre residue)	0.08	0.008 - 0.41
Disk/Harrow (1/4 - 1 tons/acre residue)	0.16	0.10 -- 0.25
Disk/Harrow (1 - 3 tons/acre residue)	0.25	0.14 -- 0.53
Disk/Harrow (>3 tons/acre residue)	0.30	N/A
No Till (<1/4 tons/acre residue)	0.04	0.03 -- 0.07
No Till (1/4 - 1 tons/acre residue)	0.07	0.01 -- 0.13
No Till (1 - 3 tons/acre residue)	0.30	0.16 -- 0.47
Plow (fall)	0.06	0.02 -- 0.10
Coulter	0.10	0.05 -- 0.13
Range (natural)	0.13	0.01 -- 0.32
Range (clipped)	0.08	0.02 -- 0.24
Grass (bluegrass sod)	0.45	0.39 -- 0.63
Short grass prairie	0.15	0.10 -- 0.20
Dense grass	0.24	0.17 -- 0.30
Bermudagrass	0.41	0.30 -- 0.48
Woods	0.45	N/A

APPENDIX B

CULVERT ENTRANCE LOSS COEFFICIENTS OUTLET CONTROL, FULL OR PARTIALLY FULL

<u>Type of Structure and Design of Entrance</u>	<u>Coefficient k_e</u>
<u>Pipe, Concrete</u>	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, square cut end	0.5
Straight headwall	
Socket end of pipe (groove-end)	0.2
Square-edge	0.5
Rounded (radius = 1/12D) (Indexes 250, 251, 252, 253, 255)	0.2
Mitered to conform to fill slope (Indexes 272, 273, 274)	0.7
End section conforming to fill slope ¹	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
Straight sand-cement (Index 258)	0.3
U-type with grate (Index 260)	0.7
U-type (Index 261)	0.5
Winged concrete (Index 266)	0.3
U-type sand-cement (Index 268)	0.5
Flared end concrete (Index 270)	0.5
Side drain, mitered with grate (Index 273)	1.0
 <u>Pipe or Pipe-Arch, Corrugated Metal</u>	
Straight endwall--rounded (Radius=1/12 D) (Index 250)	0.2
Projecting from fill (no headwall)	0.9
Headwall or headwall and wingwalls, square-edge	0.5
Mitered to conform to fill slope (Indexes 272, 273, 271)	0.7
End section conforming to fill slope, paved or unpaved*	0.5
Beveled edges, 33.7° or 45° bevels	0.2
Side- or slope-tapered inlet	0.2
 <u>Box, Reinforced Concrete</u>	
Headwall parallel to embankment (no wingwalls)	
Square-edged on three edges	0.5
Rounded on three edges to radius of 1/12 barrel dimension, or beveled edges on three sides (Index 290)	0.2

APPENDIX B (continue)

CULVERT ENTRANCE LOSS COEFFICIENTS OUTLET CONTROL, FULL OR PARTIALLY FULL

Type of Structure and Design of Entrance	Coefficient k_e
Wingwalls at 30° to 75° to barrel	
Square-edged at crown	0.4
Crown edge rounded to radius of 1/12 barrel dimension, or beveled top edge	0.2
Wingwalls at 10° to 25° to barrel, square-edged at crown	0.5
Wingwalls parallel (extension of sides)	
Square edged at crown	0.7
Side- or slope-tapered inlet	0.2

*End sections conforming to fill slope, made of either metal or concrete, are the sections commonly available from manufacturers. From limited hydraulic tests, they are equivalent in operation to a headwall in both inlet and outlet control. Some end sections incorporating a closed taper in their design have a superior hydraulic performance.

Note: Entrance head loss, $H_e = K_e \frac{V^2}{2g}$

Reference : USDOT, FHWA, HEC-5 (1965).