ROADS, HIGHWAYS AND BRIDGES BMP's COST ANALYSIS

MAY 15, 1992

Prepared For:

Environmental Protection Agency 401 M Street, SW Washington, D.C. 20460

Prepared by:

WOODWARD-CLYDE FEDERAL SERVICES

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Library Region IV US Environmental Protection Agency 345 Couriland Street Atlanta, Georgia 30365

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1.0 INTRODUCTION

This report describes cost analyses of best management practices (BMPs) that could be used to achieve the roads, highways and bridges' management measures presented in the "Management Measures for Sources of Nonpoint Pollution in Coastal Waters." There are six management measures for roads, highways, and bridges. The measures address the following:

- Planning and design of roads and highways (including treatment of stormwater runoff from highways and roads);
- Siting and design of bridges (including excluding the use of scupper drains on certain bridges);
- Erosion and sediment control during construction;
- Control and toxic and hazardous materials loadings during construction.
- Operation and maintenance of roads, highways and bridges; and
- Redraft programs.

This report addresses the costs of implementing certain BMPs under all of the management measures except for management measure number 4; control of toxic and hazardous materials loadings during construction.

The purpose of the cost analyses is to provide data to compare to current baseline roads, highways and bridges' costs for various locations throughout the coastal region. These comparisons will serve as a basis for judging the economic achievability of the management measures.

2.0 TECHNICAL APPROACH

Twenty-one hypothetical scenarios were developed for the cost analysis. The scenarios are organized according to the various management measures and examined control of nonpoint pollution sources (NPS) from: road and highway stormwater runoff; bridge stormwater runoff; erosion and sediments generated during road, highway and bridge construction; and general operation and maintenance of roads, highways and bridges. The following sections outline the specific scenarios used to determine the cost of implementing BMPs for the roads, highways and bridges' management measures.

2.1 Planning and Design of Roads and Highways

This management measure involves planning and design of roads and highways to minimize NPS pollution to coastal waters. During the planning phase roads and highways should be located to avoid wetlands, areas requiring excessive cut and fill, highly erodible soils, rock outcroppings and environmentally sensitive areas.

The cost of achieving the planning part of this management measure should be minimal because most of the practices are currently necessary under the Clean Water Act, the National Environmental Policy Act NEPA, and Federal Highway Administration (FHWA) guidelines. The primary cost associated with achieving this management measure would be in the design and construction of stormwater runoff treatment and control structures.

Most highways are currently designed with grass swales and vegetative buffer strips that provide treatment of stormwater runoff. Consequently, treatment facilities around highway interchanges were the only BMP scenarios examined for this management measure.

The scenario considered was for one clover-leaf highway interchange, constructed in each of the four coastal regions. It was assumed that the construction area was a lightly wooded 50 acre site. Extended Detention Dry Pond was the only BMP considered.

For design, varying site conditions were examined based on the coastal region and rainfall type. To represent various region's rainfall in the United States, the Soil Conservation Service (SCS) developed four synthetic 24-hour rainfall distributions (I, IA, II, III) from available National Weather Service duration-frequency data or local storm data (Soil Conservation Service, 1986). These rainfall types were used in the development of the different scenarios. The following is a list of the coastal regions and rainfall types:

Coastal Regions and Rainfall Types:

- GL Great Lakes and Northeast (Type II rainfall);
- SE Gulf Coast, Southeast and Mid-Atlantic Coast (Type III rainfall);
- NW Pacific Northwest (Type IA rainfall); and
- SW Pacific Southwest (Type I rainfall).

The requirements to satisfy the road and highway management measure for runoff control were assumed to be the same as those for runoff control from developed areas, such that: the practice must reduce post-development peak runoff rates ranging from the 2-year, 24-hour rainfall to predevelopment levels and remove 80% of total suspended solids (TSS) from the average storm runoff. In order to determine the total size of the detention or retention basin required, separate designs were prepared to determine the storage volume required for peak runoff rate control and removal of TSS. The two storage volumes were then added together to obtain the total storage volume required. This is a conservative approach to determining the total volume required, but the approach is used by some agencies to provide a factor of safety in their designs.

A summary of the design analyses results and costs are presented in Table 1. Detailed design calculations and computer simulation results are presented in Appendix A.

The following sections discuss the methods that were used in sizing the ED dry ponds. In general, the SCS's method presented in TR-55 (SCS, 1986) was used to determine the storage for controlling the peak runoff rate and the P-8 Model (or Urban Catchment Model) (Palmstrom and Walker, 1990) was used to determine the storage for 80% removal of TSS.

A. Design for Control of 2-year, 24-hour Rainfall Peak Runoff

The SCS TR-55 graphical method (SCS, 1986) was used to determine the required volume to control the peak discharge generated from a 2-year, 24-hour rainfall because it provides simplified procedures to calculate the effects of changed land use on runoff volume in the different coastal regions. It calculates the approximate storage volume required to contain post-construction peak discharge, such that it does not exceed the pre-construction peak discharge rate.

The peak discharge rate for the 2-year, 24-hour rainfall was calculated based on the following assumptions:

- (i) Dimensions of Site: 1500 feet x 1500 feet
- (ii) Slope, S: 3% for GL, SE and SW Region 5% for NW Region
- (iii) Curve Number, CN:

Existing Conditions - Light underbrush woods with good hydrologic conditions:

Pervious soil (SCS Soil Type B) CN=60

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Proposed Conditions - Impervious Cover, CN=98

- (iv) Time of Concentration:
- Existing Conditions All pre-construction sites were assumed to have light underbrush cover with Manning's roughness coefficient, n=0.40 for 300 feet of sheet flow. For flow lengths that exceed 300 feet, flows will be unpaved shallow concentrated flow.
- Proposed Conditions Using TR-55, the time of concentration was calculated assuming the runoff sheet flowed over a light underbrush cover (Manning's roughness coefficient n=0.40) before entering the pipe system. The assumed length of sheet flow and pipe velocity are shown below.

Shee	et Flow Distance	Pipe Velocity
Highway Interchange (50 acres)	100 feet	7 ft/sec

- (v) Pond Depth = 3.5 feet
- (vi) 2-year, 24-hour Rainfall, i
 - $\begin{array}{lll} GL & i=3.0 \text{ inches} \\ SE & i=4.5 \text{ inches} \\ SW & i=2.5 \text{ inches} \\ NW & i=3.0 \text{ inches} \end{array}$

B. Design for Removal of 80% TSS

The P-8 model (Palmstrom and Walker, 1990) was used to predict the generation and transport of stormwater runoff pollutants in the urban catchments. The P-8 model input parameters for this analysis included:

- 1. Average storm rainfall (i.e. inches of rainfall for each hour throughout the duration of the storm) for each of the 4 coastal regions;
- 2. Type of BMP (ED Dry Pond); and
- 3. Average pollutant loads of TSS (taken from NURP 50).

The following is a list of the rainfall parameters used for each region based on <u>Analysis of</u> <u>Storm Event Characteristics for Selected Rainfall Gages Throughout the United States</u> (Woodward-Clyde, 1989):

	Average Storm Duration	Average Storm Rainfall	Average Interval
GL	12 hours	0.59 inches	Between Storms 144 hours
SW	12 hours	0.54 inches	476 hours
SE	8 hours	0.78 inches	133 hours
NW	16 hours	0.54 inches	123 hours

In order to distribute the rainfall over the storm duration, the SCS Type I, IA, II, and III curves were used and the rainfall was distributed over the appropriate storm duration. For example, in the GL region, 0.59 inches of rainfall was distributed over 12 hours using a Type II storm distribution.

The ED dry ponds were designed to have a 48-hour drawdown time. All designs were optimized to achieve 80% removal of TSS.

C. Cost Determination

Cost data were taken from Woodward-Clyde's "Urban BMPs Cost and Effectiveness Summary Data for 6217(g) Guidance- Roads, Highways and Bridges" (Woodward-Clyde, 1992). Figure 1 shows the unit construction costs per storage volume for dry ponds. Costs were based on 1988 dollars.



The cost of the different scenarios was based on the size of the "Control Volume." The "Control Volume" will provide sufficient volume to meet the management measure performance criteria. Table 1 summarizes for each scenario the cost of the required ED dry pond. The table includes the costs to control only the 2-year, 24-hour peak rainfall and the costs to control both the 2-year, 24-hour peak rainfall and 80% TSS removal.

Planning and design costs were assumed to be 10% of the construction costs. Annual maintenance costs were also based on a percentage of the construction costs. The following is a list of how the maintenance costs were computed for each scenario.

Extended Detention Dry Pond

- 2-year, 24-hour only = 3% of construction cost
- 2-year, 24-hour + 80% TSS removal = 5% of construction cost

2.2 Siting and Design of Bridges

This management measure is designed to protect domestic water supplies, wetlands, shellfish beds, and other sensitive ecosystems from receiving contaminated runoff waters from bridge decks. Practices that could be used to achieve the management measure include:

- Coordinate designs with FHWA, USCG, USACB, and other Federal and state agencies as appropriate;
- Review NEPA requirements to ensure that environmental concerns are met;
- Avoid highway locations that require numerous river or stream crossings;
- Divert pollutant loadings away from bridge decks by diverting runoff water to land for treatment;
- Site bridges to avoid sensitive ecosystems; and
- Restrict the use of scupper drains on bridges less than 400 feet in length and on bridges crossing sensitive ecosystems.

Of the above BMPs, only the elimination of scupper drains should have a significant cost over current bridge siting and design practices. Consequently, this was the only BMP scenario examined for this management measure.

Table 1 - Highway Interchange Runoff Treatment

No.	Type of	2ут. 24 Нг.		Control of 2 yr 24 hour Peak Only					Control of 2 yr. 24 hour Peak & 80% TSS Removal							
	Rainfall:	Rainfall, (in) ⁽¹⁾														
-	Туре І	SW, i=2.5	Control	Unit Cost	Construction	Planning &	Total	Area Lost	Maint.	Control	Unit Cost	Construction	Planning &	Total	Area Lost	Maint.
	Type IA	NW, i=3.0	Volume	(\$¢1)	Cost	Design Cost	Cost	(acres)	Cost (\$/yr)	Vol.	(\$¢f)	Cost	Design Cost	Cost	(ac res)	Cost
ļ	Type II	GL, i=3.0	(ac−ft)							(ac−ft)		1				(\$/ут)
1	Type III	SE, i=4.5	(2)	(3)	1	(4)		(5)	(6)	(2)	(3)		(4)		(5)	(7)
	I													I		
1	Type II	GL	6.9	0.14	\$42,079	\$4,208	\$46,287	1.97	\$1,262	9.42	0.12	\$49,240	\$4,924	\$54,164	2.69	\$2,462
2	Type II	SE	9.6	0.12	\$50,181	\$5,018	\$55,199	2.74	\$1,505	12.89	0.1	\$56,149	\$5,615	\$61,764	3.68	\$2,807
3	Туре І	SW	5.4	0.17	\$39,988	\$3,999	\$43,987	1.54	\$1,200	7.52	0.13	\$42,584	\$4,258	\$46,843	2.15	\$2,129
4	Type IA	NW	6.3	0.15	\$41,164	\$4,116	\$45,281	1.80	\$1,235	8.18	0.13	\$46,322	\$4,632	\$50,954	2.34	\$2,316

 GL=Great Lakes and Northeast Coast SE=Gulf, Southeast and Mid-Atlantic Coasts NW=Pacific Northwest (North of San Francisco) SW=Southwest Coast (South of San Francisco) (2) Control volume is based on 2 ponds

(3) Unit cost based on construction of 1 pond

(4) Planning and Design Cost = 10% of Construction Cost

(5) Control Volume/Avg. Depth of 3.5

(6) Annual Maintenance Cost = 3% of Construction Cost

(7) Annual Maintenance Cost = 5% of Construction Cost

Four hypothetical scenarios were developed for this BMP implementation. One newly constructed bridge with a connecting roadway on each side was examined in four coastal regions. The bridge was assumed to be 400-foot by 60-foot and would not have scupper drains, however, it did have drainage pipes to capture the bridge runoff. Each roadway segment draining to the bridge was assumed to be 0.25 mile long and 60 feet wide with a 20 foot right-of-way along each shoulder. The construction area was assumed to be lightly wooded and encompassing approximately 7 acres. Extended Detention Dry Pond was the only BMP considered.

For design, varying site conditions were examined based on the coastal region and rainfall type. To represent various region's rainfall in the United States, the SCS developed four synthetic 24hour rainfall distributions (I, IA, II, III) from available National Weather Service durationfrequency data or local storm data (1986). These rainfall types were used in the development of the different scenarios. The following is a list of the coastal regions used for the analysis and the associated rainfall types:

Coastal Regions and Rainfall Types:

- GL Great Lakes and Northeast (Type II rainfall);
- SE Gulf Coast, Southeast and Mid-Atlantic Coast (Type III rainfall);
- NW Pacific Northwest (Type IA rainfall); and
- SW Pacific Southwest (Type I rainfall).

The requirements to satisfy the bridge management measure for runoff control were assumed to be the same as those for runoff control from developed areas, such that: the practice must reduce post-development peak runoff rates ranging from the 2-year, 24-hour rainfall to pre-development levels and remove 80% of TSS from the average storm runoff. In order to determine the total size of the detention or retention basin required, separate designs were prepared to determine the storage volume required for peak runoff rate control and removal of TSS. The two storage volumes were then added together to obtain the total storage volume required. This is a conservative approach to determining the total volume required, but the approach is used by some agencies to provide a factor of safety in their designs.

A summary of the design analyses results and cost are presented in Table 2. Detailed design calculations and computer simulation results are presented in Appendix B.

The following sections discuss the methods that were used in sizing the ED dry ponds. In general, the SCS's method presented in TR-55 (SCS, 1986) was used to determine the storage for controlling the peak runoff rate and the P-8 Model (or Urban Catchment Model) (Palmstrom and Walker, 1990) was used to determine the storage for 80% removal of TSS.

A. Design for Control of 2-year, 24-hour Rainfall Peak Runoff from Roadway Segment

The SCS TR-55 graphical method (SCS, 1986) was used to determine the required volume to control the peak discharge generated from a 2-year, 24-hour rainfall because it provides simplified procedures to calculate the effects of changed land use on runoff volume in the different coastal regions. It calculates the approximate storage volume required to contain post-construction peak discharge, such that it does not exceed the pre-construction peak discharge rate.

The peak discharge rate for the 2-year, 24-hour rainfall was calculated based on the following assumptions:

- (i) Dimensions of site 3000 feet x 100 feet
- (ii) Slope, S: 3% for GL, SE and SW Region 5% for NW Region
- (iii) Curve Number, CN:

Existing Conditions - Light underbrush woods with good hydrologic conditions:

Pervious soil (SCS Soil Type B) CN=60

Proposed Conditions - Impervious Cover, CN=89

- (iv) Time of Concentration:
- Existing Conditions All pre-construction sites were assumed to have light underbrush cover with Manning's roughness coefficient, n=0.40 for 200 feet of sheet flow. For flow lengths that exceed 200 feet, flows will be unpaved shallow concentrated flow.

- Proposed Conditions Using TR-55, the time of concentration was calculated assuming the runoff sheet flowed over a smooth cover (Manning's roughness coefficient n=0.011) before entering a drainage ditch adjacent to the roadway leading to the bridge.
- (v) Pond Depth = 3.5 feet
- (vi) 2-year, 24-hour Rainfall, i

GL i=3.0 inches SE i=4.5 inches SW i=2.5 inches NW i=3.0 inches

B. Design for Removal of 80% TSS

The P-8 model (Palmstrom and Walker, 1990) was used to predict the generation and transport of stormwater runoff pollutants in the urban catchments. The P-8 model input parameters for this analysis included:

- 1. Average storm rainfall (i.e. inches of rainfall for each hour throughout the duration of the storm) for each of the 4 coastal regions;
- 2. Type of BMP (ED Dry Pond); and
- 3. Average pollutant loads of TSS (taken from NURP 50).

The following is a list of the rainfall parameters used for each region based on <u>Analysis of</u> <u>Storm Event Characteristics for Selected Rainfall Gages Throughout the United States</u> (Woodward-Clyde, 1989):

	Average Storm Duration	Average Storm Rainfall	<u>Average Interval</u> Between Storms
GL	12 hours	0.59 inches	144 hours
SW	12 hours	0.54 inches	476 hours
SE	8 hours	0.78 inches	133 hours
NW	16 hours	0.54 inches	123 hours

In order to distribute the rainfall over the storm duration, the SCS Type I, IA, II, and III curves were used and the rainfall was distributed over the appropriate storm duration. For example, in the GL region, 0.59 inches of rainfall was distributed over 12 hours using a Type II storm distribution.

The ED dry ponds were designed to have a 48-hour drawdown time. All designs were optimized to achieve 80% removal of TSS.

C. Design for Pipe Collection System

A pipe collection system will be necessary in order to collect the runoff on the bridge and to prevent excessive surface flows that would pose a hazard to motorists.

Pipe Sizing:

For each of the design scenarios, a reinforced steel pipe was assumed to be used to convey the stormwater runoff from the bridge surface to an ED Dry Pond. TR-55 was used to compute the 10-year, 24-hour peak discharge generated from an average storm in each coastal region. A 10-year storm was used for design to minimize the hazards to motorists from frequent and excessive surface flows.

The peak discharge from the bridge runoff was calculated based on the following assumptions:

- bridge size: 200 x 60 (half of bridge);
- slope = 2% for all regions
- CN = 98
- Tc was calculated to be less than 6 minutes, however, 6 minutes was used for TR-55 analyses.

The following assumptions were made for the pipe design:

- pipe is half full for design storm; and
- ground slope of bridge = slope of pipe (2%)

For the pipe design, a pipe diameter was assumed, and a peak discharge for the pipe was calculated based on Manning's equation.

According to the means "Building construction Cost Data" dated 1991, a 6-inch pipe was the smallest pipe diameter available. Using Manning's equation, a 6-inch diameter pipe was large enough to control the peak discharge for all coastal zones except the southeast, the southeast coastal zone needed an 8-inch diameter to meet the design criteria.

2.3 Cost Determination

Cost data were taken from Woodward-Clyde's "Urban BMPs Cost and Effectiveness Summary Data for 6217(g) Guidance- Roads, Highways and Bridges" (Woodward-Clyde, 1992) and means "Building Construction Cost data (means, 1991). Costs were based on 1988 dollars.

The cost of the different scenarios was based on the size of the "Control Volume" and the pipe collection system. The "Control Volume" will provide sufficient volume to meet the management measure performance criteria. Table 2 summarizes for each scenario the cost of the required ED dry pond and piping system. The table includes the costs to control only the 2-year, 24-hour peak rainfall and the costs to control both the 2-year, 24-hour peak rainfall and 80% TSS removal.

Planning and design costs were assumed to be 10% of the construction costs. Annual maintenance costs were also based on a percentage of the construction costs. The following is a list of how the maintenance costs were computed for each scenario.

Extended Detention Dry Pond and Piping System

- 2-year, 24-hour only= 3% of construction cost
- 2-year, 24-hour + 80% TSS removal = 5% of construction cost

The estimated useful life of ED dry Pond and piping system is 50 years.

Table 2 – Bridge Runoff Treatment

No.	Type of Rainfall:	2yr. 24 Hr. Rainfall, (in) ⁽¹⁾			Control of 2 yr 24 bour Peak Only						Control of 2 yr. 24 hour Peak & 80% TSS Removal						
	Type I Type IA Type II Type II	SW, i=2.5 NW, i=3.0 GL, i=3.0 SE, i=4.5	Construction Cost of Pipe	Control Volume (ac-ft) (2)	Unit Cost (\$/cf) (3)	Construction Cost of Dry Pond	Planning & Design Cost (4)	Total Cost	Area Los (acres) (S)	Maint. Cost (\$/yr) (6)	Control Vol. (ac-t) (2)	Unit Cost (\$/cf) (3)	Construction Cost of Dry Pond	Pianning & Design Cost (4)	Totai Cost	Area Los (acres) (5)	Maint. Cost (\$/yr) (7)
1	Type II	GL	\$2,860	0.64	0.77	\$21,466	\$2,433	\$26,759	0.18	\$730	0.98	0.63	\$26,894	\$2,975	\$32,729	0.28	\$1,488
2	Type III	SE	\$3,160	0.90	0.65	\$25,483	\$2,864	\$31,507	0.26	\$859	1.34	0.54	\$31,599	\$3,476	\$38,234	0.38	\$1,738
3	Type I	sw	\$2,860	0.48	0.91	\$19,027	\$2,189	\$24,076	0.14	\$657	0.76	0.7	\$23,174	\$2,603	\$28,637	0.22	\$1,302
4	Type IA	NW	\$2,860	0.60	0.8	\$20,909	\$2,377	\$26,146	0.17	\$713	0.88	0.65	\$24,916	\$2,778	\$30,554	0.25	\$1,389

(1) GL=Great Lakes and Northeast Coast SE=Gulf,Southeast and Mid-Atlantic Coasts (2)Control volume is based on 2 ponds

(3) Unit cost based on construction of 1 pond

(4) Planning and Design Cost = 10% of Construction Cost of Pipe and Dry Pond

SW=Southwest Coast (South of San Francisco)

NW=Pacific Northwest (North of San Francisco)

(5) Control Volume/Avg. Depth of 35

(6) Annual Maintenance Cost = 3% of Construction Cost of Pipe and Dry Pond
(7) Annual Maintenance Cost = 5% of Construction Cost of Pipe and Dry Pond

2.3 Erosion and Sediment Control

Erosion must be minimized and retention of sediment onsite during and after construction for this management measure. NPDES permit are required for construction projects over 5 acres in size. Consequently, only road and bridge construction projects of less than 5 acres were considered.

Erosion and sediment control were examined for bridge to be constructed on a 0.5 acre site, and an interstate exit ramp to be constructed on a 5 acre site. Four hypothetical scenarios were developed for this section. The following varying site conditions were examined:

- Two different site topographic slopes:
 - For exit ramp- Low (0% 10%)
 - For bridge- Medium (10% 30%)
- Non-erodible soils; and
- High and low rainfall.

For each scenario, uncontrolled erosion was calculated using the Universal Soil Loss Equation (USLE). This amount of erosion was based on clearing the entire site for a one-year construction project and not using any erosion or sediment controls. The effectiveness of erosion controls was determined based on a modified C Factor (cover factor) in the USLE. Details of how this factor was calculated are given for each scenario. The method was based on the method presented by R. Beasley in Erosion and Sediment Control (1972).

The effectiveness of various sediment control devices was based on the summary data presented in Woodward-Clyde's "Urban BMPs Cost and Effectiveness Summary Data for 6217(g) Guidance- Erosion and Sediment Control During Construction" (1992) and "Urban BMPs Cost and Effectiveness Summary Data for 6217(g) Guidance- Roads, Highways and Bridges" (1992). The effectiveness of the various structures was used as the **P** Factor (practice factor) in the USLE. The controlled erosion after implementing best management practices (BMPs) was calculated using the USLE and the revised **C** and **P** Factors.

The following is a list of criteria and associated values used in the calculations: Criteria Values

-Rainfall Intensity (I) Low

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I = 150

High	I=400
-Soils	
Non-erodible	K=0.2
-Slopes	
Low	3%
Medium	15%

In the completion of these analyses, general and specific assumptions have been made for the four design scenarios. The specific assumptions are listed in the discussion for each scenario. The following is a list of the general assumptions that were consistent for each of the four design scenarios:

- Non-erodible soils are silt-loams;
- All on-site drainage will flow in one direction; and
- The design life of each BMP is 1 year (4 quarters).

Cost data for the various erosion and sediment controls were obtained from Woodward-Clyde's "Urban BMPs Cost and Effectiveness Summary Data for 6217(g) Guidance- Erosion and Sediment Control During Construction" (1992) and "Urban BMPs Cost and Effectiveness Summary Data for 6217(g) Guidance- Roads, Highways and Bridges" (1992). Specific costs of the controls used in the various scenarios are as follows:

Temporary Sediment Trap	\$1,100/Drainage Acre
Filter Fabric Fence	\$700/Drainage Acre
Seed	\$600/Acre
Seed and Mulch	\$1,700/Acre
Construction Entrance	\$1,300/each

Planning and design costs were assumed to be 10% of the erosion and sediment control capital costs. The costs do not include cost of land, permits, and agency review fees.

The summary of the effectiveness and costs for all four scenarios is presented in Table 3. The following are the specific assumptions and management practices used in each of the scenarios.

TABLE 3

		ERO	SIONAL	ND SEDIME	NT CONTRO	OL COST SO	CENARIO'S										
A APRIL	0.7		<u> </u>	-													
SCEN			EAI	1000	SOIL	RAINFALL	LS	UNCONT.	ERO CONT	SED CONT	EROSION	ERO CNIL	SED CNIL	PLN & DSN	TOTAL	MAINT	DSN UFE
NO	SIZI	<u>ST</u>	<u>END</u>		ERODIB	INDEX	FACTOR	EROSION	CFACT	P FACT	WT BMPs	· cost	COST	COST	COST	COST	OF BMPs
	ACRES	6) (80	0%) ((3 OR 15%)	(K= 0 2)	(1= 150	(500 FT	(C = 1)								(\$/YR)	(YRS)
li i						OR 400)	LENGTH)	(TONS/YR)			(TONS/YR)						
	1	05	80	15	0.2	150	5 78	87	0 495	03	13	\$850	\$350	\$180	\$1,380	\$170	1
	2	5	80	3	0 2	1 50	0 68	102	0 585	0 12	7	\$3,000	\$9,000	\$1,800	\$13,800	\$1,700	1
	3	0.5	80	15	02	400	5 78	231	0 665	0 35	54	\$850	\$750	\$240	\$1,840	\$170	1
	4	5	80	3	0 2	-400	0 68	272	0 705	0 16	31	\$3,000	\$10,300	\$1,995	\$15,295	\$2,800	1

Scenario #1:

- Bridge construction on a 0.5 acre site.
- Site has a 15% slope.
- Soil is non-erodible.
- Rainfall intensity is low.

• Sediment controls implemented immediately after construction begins. Erosion controls implemented in third quarter.

Erosion controls used - Seed and mulch on 0.5 acre site.

Sediment controls used - Filter fabric fence (0.5 acre drainage area).

DERIVATIO	N OF C VAL	UE FOR SC	ENARIO #	1		- <u>-</u>
ITEM	AREA	RAIN	EROS	SOIL	COLUMN	C
	AFFECT.	QUARTER	INDEXIN	LOSS	(1)*(2)	FACTOR
	BYITEM		PERIOD	RATIO		
	(ACRES)		(1)	(2)		
BARE	05	1	0 05	1	0 05	0 05
BARE	05	2	03	1	03	0.3
SD/MULC	05	3	0 4 5	0.3	0 135	0 135
NEW VEG	0 5	4	02	0 05	0 01	0.01
					0	0
					0	0
					0	0
					0	0
					0	0
					0	0
					0	0
					0	0
		ll			0	0
TOTAL						0 495

Scenario #2:

- Interstate exist ramp construction on a 5 acre site.
- Site has a 3% slope.
- Soil is non-erodible.
- Rainfall intensity is low.

• Sediment controls implemented immediately after construction begins. Erosion controls implemented in third quarter.

Erosion controls used - Seed with minimal straw mulch on 5 acre site.

Sediment controls used - Filter fabric fence (5 acre drainage area) and sediment trap (5 acre drainage area).

DERIVATION OF C VALUE FOR SCENARIO # 2											
				د							
ITEM	AREA AFFECT BY ITEM (ACRES)	RAIN OUARTER	EROS. INDEX IN PERIOD	SOIL LOSS RATIO	COLUMN (1)*(2)	C FACTOR					
BARE	5	1	0.05		0.05						
BARE	5	2	0.3		0.05	0 05					
SEED	5	3	0.45		03	03					
NEW VEG	5	4	0.2	0.0	0.225	0.225					
			0.2	005	001	0.01					
					0	0					
					0	0					
					0	0					
					0	0					
					0	0					
					0	0					
					0	0					
					0	0					
TOTAL					0	0					
						0.585					

Scenario #3:

Bridge construction on a 0.5 acre site.

- Site has a 15% slope.
- Soil is non-erodible.
- Rainfall intensity is high.

• Sediment controls implemented immediately after construction begins. Erosion controls implemented in third quarter.

Erosion controls used - Seed and mulch on 0.5 acre site.

Sediment controls used - Filter fabric fence (0.5 acre drainage area) and construction entrance.

DERIVATIO	DERIVATION OF C VALUE FOR SCENARIO # 3											
ITEM	AREA	RAIN	EROS.	SOIL	COLUMN	С						
ļ	AFFECT	QUARTER	INDEXIN	LOSS	(1)*(2)	FACTOR						
	BYITEM		PERIOD	RATIO								
	(ACRES)		(1)	(2)								
BARE	05	1	0 15	1	0.15	0 15						
BARE	0.5	2	0 35	1	0 35	0.35						
SD/MULC	05	3	04	04	0 16	0.16						
NEW VEG	0 5	4	01	0 05	0 005	0 005						
			_		0	0						
					0	0						
					0	0						
					0	0						
					0.	0						
					0	0						
					0	0						
					0	0						
					0	0						
TOTAL]			0 665						

Scenario #4:

- Interstate exit ramp construction on a 5 acre site.
- Site has a 3% slope.
- Soil is non-erodible.
- Rainfall intensity is high.

• Sediment controls implemented immediately after construction begins. Erosion controls implemented in third quarter.

Erosion controls used - Seed with minimal straw mulch on 5 acre site.

Sediment controls used - Filter fabric fence (5 acre drainage area), sediment trap (5 acre drainage area) and a construction entrance.

DERIVATIO	N OF C VAL	UE FOR SC	ENARIO #	4		
			2.0.1110 //	•		
ITEM	AREA	RAIN	EROS	SOIL	COLUMN	С
	AFFECT	QUARTER	INDEXIN	LOSS	(1)*(2)	FACTOR
	BYITEM	i i	PERIOD	RATIO		
	(ACRES)		(1)	(2)		
BARE	5	1	0.15	1	0 15	0 15
BARE	5	2	0 35	1	0.35	0 35
SEED	5	3	04	05	0 2	02
NEW VEG	5	4	0 1	0 05	0 005	0 005
					0	0
					0	0
					0	0
					0	0
					0	0
					ō	0
					0	0
					0	0
					0	0
TOTAL			_			0 705

2.4 Operation and Maintenance of Roads, Highways and Bridges

Many of the operation and maintenance BMPs that could be used to achieve this management measure (e.g., pothole repair, bank stabilization, and revegetation) are generally applied by most state transportation agencies. Three practices that are not routinely applied are street sweeping/vacuuming, road salt minimization and containment of paint chips and debris during bridge maintenance. Consequently, the costs of implementing these practices were examined. The following sections discuss the implementation scenarios examined and the associated costs.

2.4.1 Street Sweeping

Six scenarios were developed for this analysis. The scenarios considered: rainfall in the northeast and southwest; and sweeping frequencies of 1, 2, and 4 times per month. The following is a list of the general assumptions made for the calculation of the street sweeping cost analysis:

- Watershed is 100 acres with 1/4 acre single family homes.
- Watershed is 25% impervious.
- Streets make up 70% of total impervious area.
- There are 10 curb-miles of street in a residential 100-acre watershed.

• Costs include financing of the street sweeper machine over its design life and labor (assumes a vacuum sweeper is used).

The effectiveness of the various street sweeping scenarios was examined using the P-8 model. The model has an option for examining the effects of street sweeping on pollutant concentrations in stormwater runoff. Simulations were completed for the impacts on the runoff from a 2-year, 24-hour rainfall event. For the simulations, varying site conditions were examined based on the coastal region and rainfall type. To represent various region's rainfall in the United States, the Soil Conservation Service (SCS) developed four synthetic 24-hour rainfall distributions (I, IA, II, III) from available National Weather Service duration-frequency data or local storm data (Soil Conservation Service, 1986). Two of the four coastal zones were examined for these scenarios. The following is a list of the coastal regions and rainfall types:

Coastal Regions and Rainfall Types:

- GL Great Lakes and Northeast (Type II rainfall); and
- SW Pacific Southwest (Type I rainfall).

The follwing are the specific assumptions used in each of the scenarios:

Scenario #1:

- Rainfall zone is northeast
- Streets are swept 4 times per month

Scenario #2:

- Rainfall zone is southwest
- Streets are swept 4 times per month

Scenario #3:

- Rainfall zone is northeast
- Streets are swept twice per month

Scenario #4:

- Rainfall zone is southwest
- Streets are swept twice per month

Scenario #5:

- Rainfall zone is northeast
- Streets are swept once per month

Scenario #6:

- Rainfall zone is southwest
- Streets are swept once per month

Cost data were taken from Woodward-Clyde's "Urban BMPs Cost and Effectiveness Summary Data for 6217(g) Guidance- Roads, Highways and Bridges" (Woodward-Clyde, 1992). Costs were based on 1988 dollars.

The summary of the scenario results are presented in Table 4. The computer simulation results are presented in Appendix C.

TABLE 4

		STREET SW	/EEPING CC	ST SCENAR	RIO'S					
SCEN.	FREQ.	RAIN.	TSS	TP	TKN	ZN	HC	CURB	COST	TOTAL
NO.		ZONE						MILE		COST
	(SWEEPS	(NE OR	(% REM.)	(% REM.)	(% REM.)	(% REM.)	(% REM.)	(MILES)	(\$/MILE)	(\$/YR)
	/MON.)	SW)								
	1 4	NE	3.9	2.5	2.1	2.7	3.7	10	20	9600
	2 4	SW	5.8	3.6	3	1.6	5.4	10	20	9600
	3 2	NE	2	1.2	1	1.3	1.9	10	20	4800
	4 2	SW	3	2.2	1.5	1.6	2.8	10	20	4800
	5 1	NE	1	0.6	0.6	1.3	1	10	20	2400
	6 1	SW	1.5	0.7	0.8	0	1.3	10	20	2400

2.4.2 Road Salt

Two hypothetical scenarios were developed for this analysis. The first scenario examined the cost of containing road salt in a properly designed salt storage facility. The second scenario examined the costs incurred when fitting salt spreading vehicles with special equipment to minimize the amount of salt applied. The equipment is calibrated yearly.

For this cost analysis, the use of Calcium Magnesium Acetate (CMA) and other salt alternatives was not considered. However, it has been documented that many coastal states, i.e. Massachusetts, recommend using salt alternatives.

Scenario #1: Salt Storage Facility

The salt storage facility was located in the northeast coastal region. The following is a list of the assumptions made for this design scenario:

- The storage facility design was for half of the annual salt use;
- Eight storms requiring salt application occured in a given year;
- The amount of salt needed was based on 4 applications per storm per 2-lane mile; and
- The salt storage facility was needed for 400 miles of a two-lane highway on bare pavement.

From information presented in the Salt Institute's "Salt Storage Handbook" dated 1987, the minimum salt storage requirement for this design scenario was 3200 tons of salt.

The following table outlines the cost of the salt storage facility based on the above design criteria.

Storage Facility Type	Amount of Salt Needed for Year (tons)	Capacity of Salt Storage Facility (tons)	Cost (\$/ton of salt storage capacity)	Total Cost of Salt Storage Facility (\$)	
Wood and Concrete	3200	1750	22	38,500	

Cost data were taken from Woodward-Clyde's "Urban BMPs Cost and Effectiveness Summary Data for 6217(g) Guidance- Roads, Highways and Bridges" (Woodward-Clyde, 1992).

It was assumed that this salt storage facility was properly designed and met the general guidelines outlined in Salt Institute's "Salt Storage Handbook." Some of these guidelines include:

- Selecting a safe, accessible site for the facility;
- Building a strong and sturdy structure; and
- Keeping the salt covered in a roofed facility.

These costs do not include the cost of land, access drive, or surrounding fences/walls used to keep persons away from the facility. The design life of the structure should be about 30 years.

Scenario #2: Salt Spreading Equipment

For this design scenario, it was assumed that a truck capable of carrying specialized salt spreading equipment was already purchased. The equipment was designed to spread salt based on the traveling speed of the truck; therefore, the slower the truck traveled the slower the salt was applied, and the same was true for higher traveling speeds. This minimizes the amount of salt applied to the roads, highways and bridges. The design scenario also assumed the equipment was calibrated on a yearly basis to insure the amount of NPS pollution caused by road salt application was minimal. The following is a list of the costs incurred when 1 truck is equipped with calibrated salt spreading equipment.

- The cost of salt spreading equipment = \$6,000;
- The annual calibration cost (10% of equipment cost) = \$600; and
- The total cost = \$6,600.

Cost data were taken from Woodward-Clyde's "Urban BMPs Cost and Effectiveness Summary Data for 6217(g) Guidance- Roads, Highways and Bridges" (Woodward-Clyde, 1992).

The depreciation cost of the truck was not included in this cost analysis.

2.4.3 Bridge Maintenance

One hypothetical scenario was developed for this analysis. A bridge was assumed to be repainted and cleaned to remove rust. The maintenance costs consist of containing the paint chips with tarpaulin and then disposing the paint chips in a properly designed landfill. The following is a list of the specific assumptions made for this cost analysis:

- Bridge size was 400 feet by 60 feet.
- Maintenance was only done on half the bridge at one time.
- Polyvinyl coated nylon tarpaulin was used to collect paint chips.
- It took a three man crew working for three days to complete the work (72 total man-hours).
- The tarpaulin was not revised on other projects.
- Protective equipment was worn by the crew.

The following table summarizes the costs involved in the bridge maintenance scenario. Only the cost of the tarpaulin and labor are included in the table. Costs for newly purchased protective equipment and landfill disposal fees are not included.

Item	Maintenance Area (sq. ft.)	Cost of Tarpaulin (\$/sq. ft.)	Labor Costs [•] (\$/hour)	Labor (hours)	Total Cost (\$)
Install and Remove Tarpaulin	12,000	0.45	20	60	6,600
Dispose of Paint Chips	NA	NA	25	12	300

NA: not applicable

* Cost data were taken from "Means Building and Construction Cost Data" dated 1991.

2.5 Retrofit Programs

In meeting the requirements of this management measure, the most common practices would probably be providing stormwater treatment around large highway interchanges near receiving and elimination of scupper drains on bridges over sensitive ecosystems. The costs for implementing these BMPs as retrofit projects would be very similar to the costs presented in Sections 2.1 and 2.2 of this report.

Additional costs would be imposed on communities and states to prioritized the areas in the need of retrofit projects to protect coastal waters. Computer models such as the FHWA PC-based model for evaluating pollutant loadings and impacts from highway stormwater runoff.

3.0 SUMMARY

This report addressed the costs of limited use BMPs that would be needed to achieve the management measures. The BMPs considered are not all inclusive but represent the minimum actions that would be need to be taken. Costs were not developed for BMPs that are generally being widely applied by most highway departments.

4.0 REFERENCES

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APPENDIX A

Road and Highway Stormwater Treatment Design and Computer Simulation Results number of storms = 1 interval = 133. hrs, storm duration = 8. hrs, precip = .78 inches device = 1 dry pond, type = pond , variable = tss flow load conc lbs mass-balance term acre-ft ppm807.32 01 watershed inflows 1.99 149.2786 161.56 645.76 06 normál outlet 1.99 29.8701 .0000 08 sedimen + decay .00 807.32 161.56 161.56 149.2786 09 total inflow 1.99 29.8701 10 surface outflow 1.99 12 total outflow 1.99 29.8701 13 total trapped .00 645.76 14 storage increase .00 .00 15 mass balance check .00 .00 load removal efficiency = 79.99 %, adjusted = 79.99 % continuity errors: volume = -.01 %, load = .00 % case title = Coastal Zone Study(SE) case data file = sehi50d.inp storm data file = czmsest.stm particle file = czm_nurp.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 3 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Coastal zone management one watershed one device one particle class = NURP 50% southeast rainfall zone 50 acres, highway interchange ED dry pond watershed = 1 watersh surface runoff device = 1 dry pond percolation device = 0 acres = 50.000 watershed area impervious fraction = .020 impervious depression storage inches = .020 scs curve number (pervious portion) = 60.000 sweeping frequency times/week = .000 1.000 watershed area device = 1 dry pond, type = 1 pond bottom elevation feet = .000 bottom area acres = .705

permanene peer area	acres	=	.000				
permanent pool volume	ac-ft	-	.000				
perm. pool infiltration rate	in/hr	= .00	0000				
flood pool area	acres	=	.941				
flood pool volume	ac-ft	= 3	.292				
flood pool infiltration rate	in/hr	= .00	0000				
flood pool drain time	hours	= 48	.000				
outlet orifice diameter	inches	=	.000				
orifice discharge coefficien	t	=	.600				
outlet weir length	feet	=	.000				
weir discharge coefficient		= 3	.300				
perforated riser height	feet	=	.000				
number of holes in riser		=	.000				
hole diameter	inches	=	.000				
particle removal scale facto	r	= 1	.000				
exfiltrate routed to device	0	OUT					
normal outlet routed to devi spillway outlet routed to de	ce 0 vice 0	OUT OUT					
normal outlet routed to devi spillway outlet routed to de Coastal Zone Study(SE)	ce 0 vice 0	OUT OUT					
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normal outlet routed to devi spillway outlet routed to devi Coastal Zone Study(SE) watershed areas contributing total impe device acres acre 1 dry pond 50.00 31.5 24 OVERALL 50.00 31.5 normalized device areas and device areas and device areas and device areas and device areas and	ce 0 vice 0 surface rvious s % 0 63.0 0 63.0 volumes storage ab/at	OUT OUT e runoff dead acres .71 .71 .71	to each I-storage ac-ft .00 .00 total ab/at	device zmean feet .00 .00 -storage vb/at	total-s acres .94 .94 flood v	torage ac-ft 3.29 3.29 -storage b/at	zmea feer 3.5° 3.5
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number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 dry pond, type = pond , variable = tss load flow conc mass-balance term lbs acre-ft ppm597.89 160.8434 01 watershed inflows 1.37 119.52 478.37 06 normal outlet 1.37 32.1495 08 sedimen + decay.00 .0000 597.89 119.52 119.52 09 total inflow 1.37 160.8434 32.1495 10 surface outflow 1.37 12 total outflow 1.37 32.1495 13 total trapped .00 478.37 .00 14 storage increase .00 .00 .00 15 mass balance check load removal efficiency = 80.01 %, adjusted = 80.01 % continuity errors: volume = -.01 %, load = .00 % extreme values over all storms base minimum maximum maximum maximum wet elev elev elev inflow outflow velocity period ftftftcfscfsft/sec.00.001.883.94.75.0012. device ft % 1 dry pond .00 .00 1.88 case title = Coastal Zone Study(SW) 12.4 case data file = swhi50d.inp storm data file = czmswst.stm particle file = czm_nurp.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 3 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Coastal zone management one watershed one device one particle class = NURP 50% southwest rainfall zone 50 acres, highway interchange ED dry pond watershed = 1 watersh surface runoff device = 1 dry pond percolation device = 0 watershed area acres = 50.000 impervious fraction = .630 impervious depression storage inches = .020 scs curve number (pervious portion) = 60.000 sweeping frequency times/week = .000 = 1.000 water quality load factor

device = 1 dry pond, type = 1 pond

bottom elevation bottom area permanent pool area permanent pool volume perm. pool infiltration rate flood pool area flood pool volume flood pool infiltration rate flood pool drain time outlet orifice diameter orifice discharge coefficies outlet weir length weir discharge coefficient perforated riser height number of holes in riser hole diameter particle removal scale fact exfiltrate routed to device normal outlet routed to dev	= = = = = 2 = .000 = 48 = = = 3 = = = 1 OUT OUT	.000 .454 .000 .000 .000 .605 .119 .000 .000 .000 .000 .000 .000 .000					
Coastal Zone Study(SW) watershed areas contributin	g surfac	e runoff	to each	device			
douido acros acr	ervious	dead	-storage	zmean	total-s	storage	zmean
device acres acr	25 3 50 62 0	acres	ac-rt	reet	acres	ac-rt	
24 OVERALL 50.00 31.	50 63.0	.45	-00-	.00	.01	2.12 2.12	3.50
	50 05.0		.00	.00	•01	2.12	5.50
normalized device areas and	volumes						
dead	-storage		total	-storage	flood	l-storaç	je
ab/ai vb/ai	ab/at	vb/at	ab/at	vb/at	V	rb/at	
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1 dry pond 1.44 .00	.91	.00	1.21	.51		.51	
25 OVERALL 1.44 .00	.91	.00	1.21	.51		.51	
number of storms = 1 interval = 123. hrs, storm duration = 16. hrs, precip = .54 inches device = 1 dry pond, type = pond , variable = tss flow load conc mass-balance term acre-ft lbs ppm 378.05 75.57 302.49 01 watershed inflows 1.37 101.8991 1.37 06 normal outlet 20.3666 .00 08 sedimen + decay .0000 378.05 09 total inflow 1.37 101.8991 75.57 10 surface outflow 1.37 20.3666 1.37 75.57 12 total outflow 20.3666 .00 13 total trapped 302.49 14 storage increase .00 .00 15 mass balance check .00 .00 load removal efficiency = 80.01 %, adjusted = 80.01 % continuity errors: volume = -.01 %, load = .00 % extreme values over all storms base minimum maximum maximum maximum wet elev elev elev inflow outflow velocity period ft ft ft ft cfs cfs ft/sec % .00 .00 1.85 3.43 .65 .00 52.0 deviceftftft1 dry pond.00.001.85case title= Coastal Zone Study(NW) device case data file = nwhi50d.inp storm data file = czmnwst.stm particle file = czm nurp.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 3 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Coastal zone management one watershed one device one particle class = NURP 50% northwest rainfall zone 50 acres, highway interchange ED dry pond watershed = 1 watersh surface runoff device = 1 dry pond percolation device = 0watershed area impervious fraction acres = 50.000 = .630 impervious depression storage inches = .020
scs curve number (pervious portion) = 60.000
sweeping frequency times/week = .000
water quality load factor - = 1.000

device = 1 dry pond, type = 1 pond

Doccom crevuer	on	feet	= .	000												
bottom area		acres	-	403												
permanent pool	area	acres		000												
permanent pool	. volume	ac-ft		000												
perm. pool inf	iltration rate	in/hr	= .000	000												
flood pool are	ea	acres		537												
flood pool vol	ume	ac-ft	= 1.	880												
flood pool inf	iltration rate	in/hr	= .000	000												
flood pool dra	in time	hours	= 48.	000												
outlet orifice	e diameter	inches		000												
orifice discha	arge coefficien	it		600												
outlet weir le	ength	feet		000												
weir discharge	e coefficient		= 3.	300												
perforated ris	ser height	feet		000												
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hole diameter		inches	= .	000												
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device 1 dry pond 24 OVERALL normalized dev	Study(NW) as contributing acres acre 50.00 31. 50.00 31. vice areas and dead	y surfac rvious s % 50 63.0 50 63.0 volumes -storage	e runoff dead- acres .40 .40	to each storage ac-ft .00 .00 total	device zmean feet .00 .00	total-s acres .54 .54 flood	torage ac-ft 1.88 1.88 -storag	zmean fe: 3.5 3.5u								
device 1 dry pond 24 OVERALL normalized dev	Study(NW) as contributing acres acre 50.00 31. 50.00 31. vice areas and dead ab/ai vb/ai	g surfac ervious 50 63.0 50 63.0 volumes -storage ab/at	e runoff dead- acres .40 .40 .40	to each storage ac-ft .00 .00 total ab/at	device zmean feet .00 .00 -storage vb/at	total-s acres .54 .54 flood	torage ac-ft 1.88 1.88 -storag	zmean feເ 3.ເ 3.5ບ ge								
device 1 dry pond 24 OVERALL normalized device	Study(NW) as contributing acres acro 50.00 31. 50.00 31. vice areas and dead ab/ai vb/ai % inches	g surfac ervious 50 63.0 50 63.0 volumes -storage ab/at %	e runoff dead- acres .40 .40 .40 vb/at inches	to each storage ac-ft .00 .00 total- ab/at %	device zmean feet .00 .00 -storage vb/at inches	total-s acres .54 .54 flood v in	torage ac-ft 1.88 1.88 -storage b/at ches	zmean fe 3.5 3.50 ge								
device 1 dry pond 24 OVERALL normalized dev device 1 dry pond	Study(NW) as contributing total impo acres acro 50.00 31.5 50.00 31.5 vice areas and dead ab/ai vb/ai % inches 1.28 .00	g surfac ervious 50 63.0 50 63.0 volumes -storage ab/at % .81	e runoff dead- acres .40 .40 .40 .vb/at inches .00	to each storage ac-ft .00 .00 total ab/at % 1.07	device zmean feet .00 .00 -storage vb/at inches .45	total-s acres .54 .54 flood v in	torage ac-ft 1.88 1.88 -storage b/at ches .45	zmean fe 3.5 3.50 ge								

number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 dry pond, type = pond , variable = tss = pond , Variable - ... flow load conc acre-ft lbs ppm 1.50 709.02 174.3422 1.50 141.71 34.8415 .00 567.31 .0000 mass-balance term 01 watershed inflows 06 normal outlet 08 sedimen + decay 709.02174.3422141.7134.8415141.7134.8415567.31 09 total inflow 1.50 1.50 10 surface outflow 1.50 .00 12 total outflow 13 total trapped 14 storage increase .00 .00 .00 15 mass balance check .00 load removal efficiency = 80.01 %, adjusted = 80.01 % continuity errors: volume = -.01 %, load = .00 % extreme values over all storms base minimum maximum maximum maximum wet elev elev inflow outflow velocity period deviceftftftcfscfs/ft/sec1 dry pond.00.001.936.54.91.0040.case title= Coastal Zone Study(NE)case data file= nehi50d.inp % 40.3 storm data file = czmnest.stm particle file = czm_nurp.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 3 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Coastal zone management one watershed one device one particle class = NURP 50% northeast rainfall zone 50 acres, highway interchange ED dry pond watershed = 1 watersh surface runoff device = 1 dry pond percolation device = 0 acres = watershed area 50.000 impervious fraction .630 = Impervious fraction=.630impervious depression storageinches=.020scs curve number (pervious portion)=60.000sweeping frequencytimes/week=.000water quality load factor-=1.000

device = 1 dry pond, type = 1 pond

bottom elevati	on	feet	=	.00	0				
bottom area		acres	=	.54	0				
permanent pool	area	acres	=	.00	0				
permanent pool	volume	ac-ft	=	.00	0				
perm. pool inf	iltration rat	e in/hr	=	.00000	0				
flood pool are	a	acres	=	.71	.9				
flood pool vol	ume	ac-ft	=	2.51	.8				
flood pool inf	iltration rat	e in/hr	=	.00000	0				
flood pool dra	in time	hours	=	48.00	0				
outlet orifice	e diameter	inches	=	.00	00				
orifice discha	rge coefficie	nt	=	.60	0				
outlet weir le	ength	feet	=	.00	00				
weir discharge	coefficient		=	3.30	00				
perforated ris	er height	feet	=	.00	00				
number of hole	s in riser		=	.00	00				
hole diameter		inches	=	.00	00				
particle remov	al scale fact	or	=	1.00	00				
exfiltrate rou normal outlet spillway outle	nted to device routed to dev et routed to d	0 ice 0 evice 0	01 01	UT UT UT					
Coastal Zone S	Study(NE)								
watershed area	s contributin	g surfac	e r	unoff to	o each	device			
	total imp	ervious		dead-st	corage	zmean	total-s	torage	zmean
device	acres acr	es %		acres	ac-ft	feet	acres	ac-ft	fe
1 dry pond	50.00 31.	50 63.0		.54	.00	.00	.72	2.52	3.!
24 OVERALL	50.00 31.	50 63.0		.54	.00	.00	.72	2.52	3.50
normalized dev	vice areas and	volumes							
	dead	-storage			total-	-storage	t100d	l-storad	je
	ab/ai vb/ai	ab/at		vø/at	ab/at	vb/at	. v	p/at	
device	% inches	š 1 0 0	1	ncnes	*	inches	ln	cnes	
1 dry pond	1.71 .00	1.08		.00	1.44	.60		.60	
25 OVERALL	1.71 .00	1.08		.00	1.44	.60		.60	

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Highway Interchange	By <u>B</u>	JD I	Date <u>5/8</u>	192
Location Southwest	Check	ed 1	Date	
Circle one: Present Developed				
Circle one: T _c T _t through subarea				
NOTES: Space for as many as two segments per flow worksheet.	type (can be used	for each	
Include a map, schematic, or description of	of flow	segments.	DEVELOPO	D
Sheet flow (Applicable to T only) Segment	ID			
Surface description (table 3-1)		Lightly	Smooth	
2. Manufactor market and for a (table 3-1)		0.40	0.011	
2. Manning & roughness coeff., n (lable 5-1)	<i>c</i> .	300	100	
3. Flow length, L (total L \leq 300 ft)	IL	25	25	
4. Two-yr 24-hr rainfall, P ₂	in	6,5		
5. Land slope, s	ft/ft	103	0.03	\nearrow
6. $T_t = \frac{0.007 (nL)}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	0.83	0.02	-
Shallow concentrated flow Segment	ID		L	
7. Surface description (paved or unpaved)		Unpaved	Paved	
8. Flow length, L	ft	1200	1400	
9. Watercourse slope, s	ft/ft	. 03	.03	
10. Average velocity, V (figure 3-1)	ft/s	2.B	3.6	
11. $T_{a} = \frac{L}{2(20, 3)}$ Compute T	hr	0.12.	0.10	- X
£ 3600 V			·	$\rightarrow \rightarrow$
Channel flow Segment	ID.	/		
12. Cross sectional flow area, a	ft ²	/	<u> </u>	
13. Wetted perimeter, p _w	ft	/_		
14. Hydraulic radius, $r = \frac{a}{p}$ Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s			
18. Plow length, L	ft			<u> </u>
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr			-
20. Watershed or subarea T_c or T_t (add T_t in step	os 6, 11	1, and 19)	••••• hi	
Τ	Tr-		0:95 hr	
	T	X157 -		
(210-VI-TR-55, Second Ed.	, June 1	.986)	2.12 hr	·

Pro Loca	ject <u>Highway Interchange</u> stion Southwest	By Chec	BJD	Date $5/8$	192
Ciro	cle one: Present Developed	_		. <u> </u>	
1.	Data: Drainage area A $= 0.078$ m Runoff curve number CN $= 60$ (Time of concentration T _c $= 0.95$ h Rainfall distribution type $= 1$ (Pond and swamp areas spread	di ² (acres From work or (From w [I, IA, I]	s/640) ksheet 2) worksheet 3 [, III)	DEN Amo CND TCD	$\frac{120PED}{.078mi^2}$ = 98 = 0.12 hr
	throughout watershed = F	percent of	EXISTING	acres or mi ⁻ -Storm #2-	covered) DEVELOPED Storm_#3
2. 3.	Frequency Rainfall, P (24-hour)	yr in	2.5		2.5
4.	Initial abstraction, I _a (Use CN with table 4-1.)	in	1.33		.041
5.	Compute I _a /P		0.53		0.02
6.	Unit peak discharge, q_u (Use T_c and I_a/P with exhibit 4- <u></u>)	csm/in	48		470
7.	Runoff, Q (From worksheet 2).	in	.17		2.27
8.	Pond and swamp adjustment factor, F _p (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		1.0
9.	Peak discharge, q _p (Where q _p = q _u A _m QF _p)	cfs	0.64		83.22

Worksheet 6a: Detention basin storage, peak outflow discharge (q_0) known



 $\frac{1}{2}$ 2nd stage q_0 includes 1st stage q_0 .

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Highway Interchange	By BJD Date 5/8/92
Location Great Lakes	Checked Date
Circle one: Present Developed	
Circle one: T I through subarea	
NOTES: Space for as many as two segments per flow worksheet.	type can be used for each
Include a map, schematic, or description o	EXISTING DEVELOPED
Sheet flow (Applicable to T, only) Segment	ID
1. Surface description (table 3-1)	Lightly Smooth
2. Manning's roughness coeff., n (table 3-1)	0.40 0.011
3. Flow length, L (total L \leq 300 ft)	ft 300 100
4. Two-yr 24-hr rainfall, P ₂	in 3.0 3.0
5. Land slope, s	ft/ft 0.03 0.03
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr 0.76 0.02 - X
Shallow concentrated flow Segment	ID
7. Surface description (paved or unpaved)	Unpaved Paved
8. Flow length, L	st 1200 1400
9. Watercourse slope, s	ft/ft .03 103
10. Average velocity, V (figure 3-1)	fr/s 2.8 3.6
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr 0,12 0,10 -
Channel flow Segment	ID //
12. Cross sectional flow area, a	ft ²
13. Wetted perimeter, p _w	ft
14. Hydraulic radius, $r = \frac{a}{P_{constraint}}$ Compute r	ft
15. Channel slope, s	ft/ft
16. Manning's roughness coeff., n	
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s
18. Flow length, L	
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	
20. Watershed or subarea T_c or T_t (add T_t in step	os 6, 11, and 19) hr
	CEX15 = 0.88 hr.
	CDEY = 0,12 hr.)
(210-VI-TR-55, Second, Ed.	, June 1986)

Worksheet 4: Graphical Peak Discharge method

Pro	ject Highway Interchange	By <u></u>	BID	Date 58	92			
LOC		Chec	, KEU					
Cir	Circle one: Present Developed							
1.	Data: EXISTING			DEVE	LOPED			
	Drainage area A_ = _0.078_ =	ni ² (acres	s/640)	$A_m = 0_n$	078 mi -			
	Runoff curve number CN =	(From work	(sheet 2)	CN = 1	98			
	Time of concentration $T_c = 0.88$	hr (From v	worksheet 3	$T_{c} = 0$	0.12hr			
	Rainfall distribution type =	(I, IA, I)	I, III)	U				
	Pond and swamp areas spread throughout watershed =	percent of		acres or mi ²	covered)			
			EXISTIN	4	DEVELOPET			
			Storm #1	-Storm #2	-Storm-#3-			
2.	Frequency	уг	2		2			
3.	Rainfall, P (24-hour)	ĺn	3.0		3.0			
4.	Initial abstraction, I _a (Use CN with table 4-1.)	in	1, 33		0.041			
5.	Compute I _a /P		01443		0.014			
6.	Unit peak discharge, q_u	csm/in	220		950			
7.	Runoff, Q	ín	0.33		2.77			
8.	Pond and swamp adjustment factor, F _p (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1. 0		1.0			
9.	Peak discharge, q_p (Where $q_p = q_u A_m QF_p$)	cfs	5.66		205.3			



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Highway Interchange	By B	JD	Date 5/8	192
Location Southeast	Checke	ed	Date	_
Circle one: Present Developed			·	
Circle one: Tc Tt through subarea				
NOTES: Space for as many as two segments per flow worksheet.	v type o	an be use	d for each	
Include a map, schematic, or description of	of flow	segments. EXISTING	DEVELOPI	εD
Sheet flow (Applicable to T _c only) Segment	: ID			
1. Surface description (table 3-1)		Lightly Wood a	Smooth	
2. Manning's roughness coeff., n (table 3-1)		0.40	0.011	
3. Flow length, L (total L \leq 300 ft)	ft	300	100	
4. Two-yr 24-hr rainfall, P ₂	in	4.5	4.5	
5. Land slope, s	ft/ft	0.03	0.03	- \ -
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr	0.62	+ 0.01	-[X]
Shallow concentrated flow Segment	ID			
7. Surface description (paved or unpaved)		Unpaved	Paved	
8. Flow length, L	ft	1200	1400	
9. Watercourse slope, s	ft/ft	.03	.03	
10. Average velocity, V (figure 3-1)	ft/s	2.8	3.6	
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr	0,12	+ 0.10	-LAI
Channel flow Segment	: ID	<i>,</i>		
12. Cross sectional flow area, a	ft ²	/		
13. Wetted perimeter, P _w	ft	└──/ ──	 	
14. Hydraulic radius, $r = \frac{a}{p_0}$ Compute r	ft			
15. Channel slope, s	ft/ft	- <i> </i>	↓	
16. Manning's roughness coeff., n		<i>- </i> -	<u> </u>	
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s	┞┦────		
18. Plow length, L	ft	ļ ļ	Ⅰ	
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr		+	
20. Watershed or subarea T_c or T_t (add T_t in step	05 6, 11	, and 19)	••••• hi	
	TC EX	5 = 0.	74 hr	
	Tep	EV = C).11 hr	
(210-VI-TR-55, Second Ed.	, June 1	986)		لمسم

Pro Loca	iece <u>Highway</u> Interchange Southeast	By Chec	<u>BTD</u>	Date <u>5/8/4</u> Date	
Ciro	ele oner Present Developed				
1.	Data: Drainage area $A_m = 0.078$ Runoff curve number $CN = 60$ Time of concentration $T_c = 0.74$ Rainfall distribution type = III Pond and swamp areas spread	ni ² (acres (From work hr (From w (I, IA, I)	s/640) ksheet 2) worksheet 3) I, (II)	$\frac{\text{DEVELOF}}{\text{Am}_{D}^{-1}}$ CN_{D}^{-1} $T_{C}O^{-1}$	<u>ED</u> 078 mi ² 18 - 0.11 hr
	throughout watershed = $- \varphi_{-}$	percent of	$E A_{m} (\underline{\psi} a$ $E K 5T NC$ $\underline{Storm \# 1}$	cres or mi ² Z Storw #2	covered) Develof5D Storm #37
2.	Frequency	yr	2		2
3.	Rainfall, P (24-hour)	in	4.5		4,5
4.	Initial abstraction, I _a (Use CN with table 4-1.)	in	1.33		0.041
5.	Compute I _a /P		0.30		0.01
6.	Unit peak discharge, q_u	csm/in	290	1	650
7.	Runoff, Q	in	1.02		4.26
8.	Pond and swamp adjustment factor, F _p (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		(.0
9.	Peak discharge, q_p (Where $q_p = q_u A_m QF_p$)	cfs	23.1		216.0



 $\frac{1}{2}$ 2nd stage q_0 includes lst stage q_0 .

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Highway Interchange	By BID Date 5/8/4	2
Location NNthwest	Checked Date	-
Circle one: Present Developed		_
Circle one: T _c I through subarea		-
NOTES: Space for as many as two segments per flow worksheet.	type can be used for each	
Include a map, schematic, or description o	f flow segments. EXIST. DEVELOPE	>
Sheet flow (Applicable to T _c only) Segment	ID	
1. Surface description (table 3-1)	Woodest Smooth	
2. Manning's roughness coeff., n (table 3-1)	0.40 0.011	
3. Flow length, L (total L \leq 300 ft)	ft 300 100	
4. Two-yr 24-hr rainfall, P ₂	in 3.0 3.0	
5. Land slope, s	ft/ft 0.05 0.05	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr $0.62 + 0.01 =$	
Shallow concentrated flow Segment	ID	
7. Surface description (paved or unpaved)	Unpaved Paved	
8. Flow length, L	ft 1200 1400	
9. Watercourse slope, s	ft/ft .05 .05	
10. Average velocity, V (figure 3-1)	ft/s 3.6 4.6	>
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr $0.09 + 0.08 =$	\square
Channel flow Segment	ID	•
12. Cross sectional flow area, a	ft ²	
13. Wetted perimeter, p _w	ft	
14. Hydraulic radius, $r = \frac{a}{P_{res}}$ Compute r	ft	
15. Channel slope, s	it/ft	
16. Manning's roughness coeff., n		
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s	
18. Plow length, L	ft ///	\rightarrow
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr+	X
20. Watershed or subarea T_c or T_t (add T_t in step	s 6, 11, and 19) hr	
	Ex= 0.71.hr	
	[coiv= .09 hr ≥ 0.1	Ohr
(210-V1-TK-55, Second Ed.,	Julie 1990)	

Pro	ject Highway Interchange	By	<u>Th</u>	Date <u>5/8/</u>	92
Loca	ation <u>Voithwest</u>	Chec	ked	Date	
Cir	cle one: Present Developed				
1.	Data: EXISTING			DEV	ELOPED
	Drainage area $\dots A_m = 0.018$	u ² (acres	/640)	Am = 0.	078 mi 2
	Runoff curve number $CN = 60$ (From work	sheet 2)	CNN=	98
	Time of concentration $T_c = 0.71$ b	ar (From w	orksheet 3)	T	10 6-
	Rainfall distribution type = (I, IA, II	, III)	10-0	
	Pond and swamp areas spread throughout watershed =	percent of		cres or mi ²	covered)
			EXISTING		DEVELOPED
			Storm # 1	Storm #2-	Storm #3
2.	Frequency	yr	2-yr		2-yr
3.	Rainfall, P (24-hour)	in	3.0		3.0
4.	Initial abstraction, I	in	1,33		0.041
	(Use CN with table 4-1.)		[
5.	Compute I _a /P		0,443		0,014
6.	Unit peak discharge, q_u (Use T_c and I_a/P with exhibit $4-IA$)	csm/in	47		165
7.	Runoff, Q	in	.33		2.77
8.	Pond and swamp adjustment factor, F (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		1.0
9.	Peak discharge, q_p	cfs	1.21		35.65
	''''' p 'u'm' p'				



APPENDIX B

Bridge Stormwater Treatment Design and Computer Simulation Results

80040000H:\wp\cost_ana\roads

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Bridge construction	By BJD Date 5/4/92
Location Great Lakes	Checked Date
Circle one: Present Developed	
Circle one: T_c T_t through subarea	
NOTES: Space for as many as two segments per flow worksheet.	type can be used for each
Include a map, schematic, or description of	f flow segments. Existing Developed
Sheet flow (Applicable to T_ only) Segment	ID III
1. Surface description (table 3-1)	Light Underbrush Smooth
2. Manning's roughness coeff., n (table 3-1)	0.40 0.011
3. Flow length, L (total L \leq 300 ft)	ft 200 100
4. Two-yr 24-hr rainfall, P ₂	in 3.0 3.0
5. Land slope, 8	ft/ft 03 .03
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr 0.55 0, 02 -
Shallow concentrated flow Segment	ID
7. Surface description (paved or unpaved)	Unpaved Unpaved
8. Flow length, L	ft 1120 1320
9. Watercourse slope, s	ft/ft .03 .03
10. Average velocity, V (figure 3-1)	ft/s 2.8 2.8
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr 0.11 0.13 •
Channel flow Segment	
12. Cross sectional flow area, a	ft ²
13. Wetted perimeter, p _w	ft
14. Hydraulic radius, $r = \frac{a}{P_{11}}$ Compute r	ft
15. Channel slope, s	ft/ft
<pre>16. Manning's roughness coeff., n</pre>	
17. $V = \frac{1.49 r^{-7} s^{-7}}{n}$ Compute V	ft/s
18. Flow length, L	
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	
20. Watershed or subarea T _c or T _t (add T _t in step:	s 6, 11, and 19) hr
Ta	-EXIT. = 0.66hr.
(210-VI-TR-55, Second Ed.,	2 dev. = 0.15 hr.

Pro	ject Bridge Construction	By _	BJD	Date 5/4	1/92
Loc	acion Great bakes	Chec	cked	Date	
Cir	cle one: Present Developed				
1.	Data: EXISTING			DEVELOT	ED HIZ
	Drainage area Ame <u>0.0052</u> m	i ² (acres	s/640)	IMDEV - 1	005 CM
	Runoff curve number $CN_g = 60$ (From work	ksheet 2)	CNDEY =	61
	Time of concentration $T_{c_e} = -0.66$ h	r (From v	worksheet	3) TEDEN =	0.15 hr.
	Rainfall distribution type = (I, IA,(I	j III)		
	Pond and swamp areas spread throughout watershed = P	ercent of	f A _m (acres or mi	² covered)
			Present Storm #1	- Store #2	Peveloped
2.	Frequency	yr	2		2
3.	Rainfall, P (24-hour)	in	3.0		3.0
4.	Initial abstraction, I	in	1.33		0.247
5.	Compute I _a /P		0.443		0.082
6.	Unit peak discharge, q_u	csm/in	260	I	920
7.	Runoff, Q (From worksheet 2).	in	0.33		1.90
8.	Pond and swamp adjustment factor, F (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1,0		1.0
9.	Peak discharge, q_p	cfs	0.45	<u> </u>	9.10



Worksheet 6a: Detention basin storage,

 $\frac{1}{2}$ 2nd stage q₀ includes 1st stage q₀.

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Proj	ect Bridge Construction	By <u></u>	TD :	Date <u>5</u> /5	192
Loca	cion Southwest	Check	ed 1	Date	- <u></u>
Circ	le one Present Developed				
Circ	le one: T _c T _t through subarea				
NOTE	S: Space for as many as two segments per f. worksheet.	low type	can be use	d for each	
	Include a map, schematic, or description	n of flow	segments. Extinu	l Develop	EŊ
Sheet	t flow (Applicable to T _c only) Segme	ent ID			
1.	Surface description (table 3-1)	••	Light Underbrus	Smooth	
2.	Manning's roughness coeff., n (table 3-1)	••	0.4	0.011	
3.	Flow length, L (total L \leq 300 ft)	ft	200	100	
4.	Two-yr 24-hr rainfall, P ₂	in	2.5	2.5	
5.	Land slope, s	. ft/ft	.03	.03	\rightarrow
6.	$T_{t} = \frac{0.007 (nL)^{0.6}}{\frac{P_{2}}{s} s^{0.4}} \qquad \text{Compute } T_{t} \dots$	hr	0.60	0.02	
<u>Shal</u>	low concentrated flow Segme	ent ID		ļ	
7.	Surface description (paved or unpaved)	••	Unpared	Unpaved	
8.	Flow length, L	ft	1120	1320	
9.	Watercourse slope, s	. ft/ft	,03	.03	
10.	Average velocity, V (figure 3-1)	ft/s	2.8	2.8	\rightarrow
11.	$T_t = \frac{L}{3600 V}$ Compute $T_t \dots$	hr	0.11	0.13	
Chan	nel flow Segme	ent ID		1	
12.	Cross sectional flow area, a	ft ²	L/	Į	
13.	Wetted perimeter, p	ft			
14.	Hydraulic radius, $r = \frac{a}{p_u}$ Compute r	. ft		<u> </u>	
15.	Channel slope, s	. ft/ft			
16.	Manning's roughness coeff., n	••			
17.	$V = \frac{1.49 r^{1/3} s^{1/2}}{n}$ Compute V	ft/s			
18.	Flow length, L	ft	<i> ↓−−−</i> _↓	h./	$ \rightarrow $
19.	$T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	. hr	الا		
20.	Watershed or subarea T_c or T_t (add T_t in st	teps 6, 1	1, and 19)	••••• h	r L
		7	CENS	= 0.71 h	- 1
	(210-VI-TR.55 Second F	Ed., June 1	TZ DEY =	0.154	-
	(MAN AT THE ON POCCOME A		,		

Pro	jectB	ridge Consti	ruction	By	BJD	Date 5/5	192
Loca	ation	Southwe	st	Chec	ked	Date	
Cir	cle one: Present	Developed					
1.	Data:	<u>=</u>	(ISTING	2		DEVELOP	ED .
	Drainage area	A =	mi	² (acres	/640)	Amp = ·	29 29
	Runoff curve num		$-\frac{40}{5}$ (r	(From work	sheet 2) orksheet 3) $T_{c} =$	0156
	Rainfall distrib	ution type =	<u> </u>		. III)	, i2D -	UID Nr.
	Pond and swamp a throughout water	reas spread shed =	(i	rcent of		acres or mi	covered)
			,		EXISTING		Developed
					Storm #1_	Storm #2-	Storm #3
2.	Frequency			yr	2-45		2-yr
3.	Rainfall, P (24-	hour)	• • • • • • • • • • • •	in	2.5	L	2.5
4.	Initial abstract (Use CN with tab	ion, I _a 1e 4-1.)	•••••	in	1.33		.247
5.	Compute I _a /P	•••••	• • • • • • • • • • • •		0.53		0.10
6.	Unit peak discha (Use T _c and I _a /P	rge, q _u with exhibit	4- <u>L</u>)	csm/in	49		450
7.	Runoff, Q (From worksheet	2).	••••	in	.17		1.46
8.	Pond and swamp a (Use percent pon with table 4-2. zero percent pon	djustment fact d and swamp ar Factor is 1.0 d and swamp ar	or, F rea for rea.)		1.0		1.0
9.	Peak discharge, (Where q _p = q _u A _m	۹ _p QF _p)	•••••	cfs	0.04		3.41



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Proj	ect Bridge Construction	By <u>R</u>	JD	Date <u>5/5/9</u>	72
Loca	rion Southeast	Check	ed	Date	
Circ	le one: Present Developed				
Circ	le one: T _c T _t through subarea				_
NOTE	S: Space for as many as two segments per flow worksheet.	type	can be use	d for each	
	Include a map, schematic, or description of	of flow	segments. Existing	Developer	1
Shee	t flow (Applicable to T only) Segment	ID			r
1.	Surface description (table 3-1)		Light Underbrugh	Smooth	
2.	Manning's roughness coeff., n (table 3-1)		0.4	.011	
3.	Flow length, L (total L \leq 300 ft)	ft	200	10.0	
4.	Two-yr 24-hr rainfall, P ₂	in	4.5	4.5	
5.	Land slope, s	ft/ft	.03	,03	
6.	$T_{t} = \frac{0.007 (nL)^{0.8}}{P_{0}^{0.5} s^{0.4}} \qquad \text{Compute } T_{t} \dots$	hr	0.45	. 01	•
Shal	2 low concentrated <u>flow</u> Segment	ID			
7.	Surface description (paved or unpaved)		Unpaved	Untraved	
8.	Flow length, L	ft	1120	1320	
9.	Watercourse slope, s	ft/ft	.03	. 03	
10.	Average velocity, V (figure 3-1)	ft/s	2.8	Z.8	<u> </u>
11.	$T_t = \frac{L}{3600 V}$ Compute T_t	hr	0.11	0.13	•LX1
Chan	nel flow Segment	ID	[_ /		
12.	Cross sectional flow area, a	ft ²	/	/	
13.	Wetted perimeter, p _w	ft		/	
14.	Hydraulic radius, $r = \frac{a}{P_{r_1}}$ Compute r	ft	/.	/	
15.	Channel slope, s	ft/ft		/	
16.	Manning's roughness coeff., n		-/	_/	
17.	$V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s		·/	
18.	Flow length, L	ft	-/	/	∇
19.	$T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr			
20.	Watershed or subarea T_c or T_t (add T_t in step	s 6, 11	l, and 19)	h	
		LEX	= 0	56 hr	
		TLO	V 0.1	4 hr	
	(210-VI-TR-55, Second Ed.)	, June 1	.986)		

Worksheet 4: Graphical Peak Discharge method

Pro	jectB	ridge Coustru	etim	By	BJD	Date <u>5/5/6</u>	12
Loca	ation	Southeas	t	Chec	ked	Date	
Cir	cle one: Pre	esent Developed	<u> </u>				
1.	Data: Drainage are Runoff curve Time of cone Rainfall dis Pond and swa throughout of	$E \times 15TING$ ea A me number CN centration T _c stribution type amp areas spread watershed	$= \frac{.0052}{60} \text{ m}$ $= \frac{.0052}{0.56} \text{ m}$ $= \frac{.0.56}{111} \text{ m}$ $= \frac{.0.56}{111} \text{ m}$	L ² (acres From work r (From w L, IA, II ercent of	$\frac{D}{A}$ (640) A (sheet 2) (porksheet 3) (, (1)) (A_m ()) (A_m ())	EVELOFED $m_{D} = 100$ ND = 89 $T_{CD} = 0.0$ acres or mi ²	52 14 hr covered) Developed
					Storm 41	Stormal 2	Stream #3
2.	Frequency .		• • • • • • • • • • • • • • •	yr	2-yr		2-4r
3.	Rainfall, P	(24-hour)	•••••	in	4.5		4,5
4.	Initial abs (Use CN wit	traction, I h table 4-1.)	•••••	ín	1.33		,247
5.	Compute I _a /	Ρ			0.30		,055
6.	Unit peak d (Use T _c and	ischarge, q _u I _a /P with exhib	it 4- <u>III</u>)	csm/in	325		620
7.	Runoff, Q . (From works	heet 2).	• • • • • • • • • • • • • • • •	in	1.02		3.3
8.	Pond and sw (Use percen with table zero percen	amp adjustment f t pond and swamp 4-2. Factor is t pond and swamp	factor, F area 1.0 for area.)		1.0		1.0
9.	Peak discha (Where q _p =	rge, q _p q _u A _m QF _p)	•••••	cfs	1.72		10.64



Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Bridge Construction	By BID	Date 5/5/92
Location Northwest	Checked	Date
Circle one: Present Developed		
Circle one: T _c T _t through subarea		
NOTES: Space for as many as two segments per flow worksheet.	type can be u	sed for each
Include a map, schematic, or description o	of flow segment	nol Developed
Sheet flow (Applicable to T _c only) Segment	ID	
1. Surface description (table 3-1)	Light Underbri	ush Smooth
2. Manning's roughness coeff., n (table 3-1)	0,4	0.011
3. Flow length, L (total L \leq 300 ft)	ft 200	100
4. Two-yr 24-hr rainfall, P ₂	in 3,0	3.0
5. Land slope, 8	ft/ft .03	.05
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2 0.5 0.4}$ Compute T_t	hr 0.45	0.01 - X
Shallow concentrated flow Segment	ID	
7. Surface description (paved or unpaved)	Umpau	el Unparco
8. Flow length, L	ft 1120	1320
9. Watercourse slope, в	ft/ft .05	.05
10. Average velocity, V (figure 3-1)	ft/s 3.6	3.6
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr 0.09	J- 0.10- X
Channel flow Segment	ID	
12. Cross sectional flow area, a	ft ²	
13. Wetted perimeter, p _w	ft	
14. Hydraulic radius, $r = \frac{a}{P_{11}}$ Compute r	ft	
15. Channel slope, s	ft/ft	
16. Manning's roughness coeff., n		
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s	
18. Flow length, L	ft	
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr	
20. Watershed or subarea T_c or T_t (add T_t in step	s 6, 11, and 1	9) hr
	TO EX =	0.54 hr.
(210-VI-TR-55, Second Ed.,	June 1986)	

Pro	ject Bridge Construction	By	BID	Date <u>5/5/</u>	192
Loc	ation Northwest	Che	cked	Date	
Cir	cle one: Present Developed		·····		
1.	Data: EXISTING			A DEVE	ELOPED 2
	Drainage area $A_m = 10057$	ni ² (acre:	s/640)	$m_{D} = 0$	052 MI
	Runoff curve number CN =60	(From world	ksheet 2)	CND = i	89
	Time of concentration $T_c = 0.54$	hr (From	worksheet 3	$T_{CD} =$	oild hr.
	Rainfall distribution type = \underline{TA}	(I, (IA) I	I, III)		
	Pond and swamp areas spread throughout watershed =	percent o	f A _m (acres or mi ²	covered)
			EXISTING		DEVELOPED
			Storm #1-	Storm #2-	Storm-#3
2.	Frequency	yr	2-yr		2-yr
3.	Rainfall, P (24-hour)	in	3.0		3.0
4.	Initial abstraction, I _a	in	1.33		0.247
5.	Compute I _a /P		0.443		0.082
6.	Unit peak discharge, q_u (Use T_c and I_a/P with exhibit 4- <u>IA</u>)	csm/in	47		160
7.	Runoff, Q	in	0.33		1.90
8.	Pond and swamp adjustment factor, F_p (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		1.0
9.	Peak discharge, q_p (Where $q_p = q_u^A QF_p$)	cfs	0.08		1.58



number of storms = 1 interval = 133. hrs, storm duration = 8. hrs, precip = .78 inches device = 1 dry pond, type = pond , variable = tss flow load load conc lbs ppm 53.28 149.2786 Ilow01 watershed inflows06 normal outline .13 .00 10.65 42.63 29.8390 08 sedimen + decay .0000 53.28149.278610.6529.839010.6529.8390 .13 09 total inflow 10 surface outflow 12 total outflow 13 total trapped 14 storage increase .13 .00 42.63 .00 .00 15 mass balance check .00 .00 load removal efficiency = 80.01 %, adjusted = 80.01 % continuity errors: volume = -.01 %, load = .00 % extreme values over all storms base minimum maximum maximum maximum wet elev elev elev inflow outflow velocity period deviceftftftcfscfsft/sec%1 dry pond.00.002.07.64.09.0042.9case title= Coastal Zone Study(SE) case data file = sebred.inp storm data file = czmsest.stm particle file = czm nurp.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 3 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Coastal zone management one watershed one device one particle class = NURP 50% southeast rainfall zone 3.3 acres, bridge construction ED dry pond watershed = 1 watersh surface runoff device = 1 dry pond percolation device = 0 impervious fraction watershed area 3.300 impervious fraction = .630
impervious depression storage inches = .020
scs curve number (pervious portion) = 60.000
sweeping frequency times/week = .000
water quality load factor - = 1.000

device = 1 dry por	nd, type	=	1	pond					
bottom elevation		feet	=	.0	00				
bottom area		acres	=	.0	47				
permanent pool area		açres	=	.0	00				
permanent pool volum	ne	ac-ft	=	.0	00				
perm. pool infiltrat	cion rate	in/hr	=	.0000	00				
flood pool area		acres	=	.0	62				
flood pool volume		ac-ft	=	. 2	18				
flood pool infiltrat	cion rate	in/hr	=	.0000	00				
flood pool drain tir	ne	hours	=	48.0	00				
outlet orifice diame	eter	inche	s =	.0	00				
orifice discharge co	pefficient		=	.6	00				
outlet weir length		feet	=	.0	00				
weir discharge coeff	ficient		=	3.3	00				
perforated riser he:	ight	feet	=	.0	00				
number of holes in a	riser		=	.0	00				
hole diameter		inche	s =	.0	00				
particle removal sca	ale factor		=	1.0	00				
exfiltrate routed to normal outlet routed spillway outlet rout	o device d to devic ted to dev	e ice	0	OUT OUT OUT					
Constal Zono Study (רסכ								
watershed areas cont	56) tributing	curfa	~ ~	runoff t	o oach	dovido			
watershed areas contact	al imner	vious		dead-s	torage	Zmean	totaled	torado	7moan
device acre	es acres	VIOUD	2	acres	ac-ft	feet	acres	ac-ft	for
1 dry pond 3.3	2.08	63.	ñ	.05	00	00	06	22	רבג זי
24 OVERALL 3.30	2.08	63.	õ	.05	.00	.00	.06	.22	3.50
21 01210122 010	2.00	05.	Ŭ		••••	.00	.00	• 2 2	5.50
normalized device as	reas and v	olume	s						
	dead-s	torage	e -		total	-storage	flood	-storag	re
ab/ai	vb/ai	ab/a	t	vb/at	ab/at	vb/at	VI	b/at ⁻	
device %	inches	-	\$	inches	%	inches	ind	ches	
1 dry pond 2.25	.00	1.4	2	.00	1.89	.79		.79	
25 OVERALL 2.25	.00	1.4	2	.00	1.89	.79		.79	

number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 dry pond, type = pond , variable = tss flow load re-ft lbs conc
 lbs
 ppm

 46.80
 174.3422

 9.35
 34.8337
 acre-ft .10 .10 mass-balance term 01 watershed inflows 06 normal outlet 08 sedimen + decay .00 37.44 .0000 .10 .10 09 total inflow 46.80 174.3422 9.35 9.35 10 surface outflow 34.8337 .10 34.8337 12 total outflow 13 total trapped 14 storage increase .00 37.44 .00 .00 15 mass balance check .00 .00 load removal efficiency = 80.02 %, adjusted = 80.02 % continuity errors: volume = -.01 %, load = .00 % extreme values over all storms base minimum maximum maximum maximum wet elev elev elev inflow outflow velocity period deviceftftftcfscfsft/sec%1 dry pond.00.001.93.43.06.0040.3case title= Coastal Zone Study(NE) case data file = nebrED.inp storm data file = czmnest.stm particle file = czm_nurp.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 3 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Coastal zone management one watershed one device one particle class = NURP 50% northeast rainfall zone 3.3 acres, bridge construction ED dry pond watershed = 1 watersh surface runoff device = 1 dry pond percolation device = 0impervious fraction impervious fraction=.630impervious depression storageinches=.020scs curve number (pervious portion)=60.000sweeping frequencytimes/week=.000water quality load factor-=1.000

device = 1 dr	y pond,	type	= :	1	pond					
bottom elevatio	n	fe	et	=	.00	0				
bottom area		ac	res	=	.03	6				
permanent pool	area	ac	res	=	.00	0				
permanent pool	volume	ac	-ft	=	.00	0				
perm. pool infi	ltration	rate in	/hr	=	.00000	0				
flood pool area		ac	res	=	.04	8				
flood pool volu	me	ac	-ft	=	.16	6				
flood pool infi	ltration	rate in	/hr	=	.00000	0				
flood pool drai	n time	ho	urs	=	48.00	0				
outlet orifice	diameter	in	ches	=	.00	0				
orifice dischar	ge coeffi	lcient		=	.60	0				
outlet weir len	gth	fe	et	=	.00	00				
weir discharge	coefficie	ent		=	3.30	0				
perforated rise	r height	fe	et	=	.00	0				
number of holes	in riser	5		=	.00	00				
hole diameter		in	ches	=	.00	00				
particle remova	l scale f	actor		=	1.00	00				
exfiltrate rout normal outlet r spillway outlet	ed to dev outed to routed t	vice device to devic	0 0 2e 0	(OUT OUT OUT					
Coastal Zone St	udy(NE)						Jarriga			
watersned areas	contribu	iting su	iriac	e	runoii to	b each	device	+-+-1		
a i	total	Impervi	Lous		dead-st	Lorage	zmean	total-s	torage	zmean
device	acres	acres	ة د ک		acres	ac-rt	reet	acres	ac-it	ie
1 ary pona	3.30	2.08	63.0		.04	.00	.00	.05	• 1 7	3.
24 OVERALL	3.30	2.08	63.0		.04	.00	.00	.05	• 1 /	3.00
normalized devi	Ce areas	and vol	lumes							
normarized devi	(lead-sto	rage	_		total-	-storage	flood	-storad	1e
2	ub/ai vi	b/ai a	ab/at		vb/at	ab/at	vb/at	v	b/at	, -
device	, v.	ches	,e %		inches	~~, ~~ %	inches	in	ches	
1 dry pond	1.72	.00	1.08		.00	1.44	. 61		.61	
25 OVERALL	1.72	.00	1.08		.00	1.44	.61		.61	

number of storms = 1 interval = 123. hrs, storm duration = 16. hrs, precip = .54 inches device = 1 dry pond, type = pond , variable = tss load conc flow e-ftlbsppm.0924.95101.8991.094.9920.3666.0019.96.0000 acre-ft mass-balance term .09 01 watershed inflows 06 normal outlet .09 08 sedimen + decay 24.95 101.8991 09 total inflow .09 4.99 10 surface outflow .09 20.3666 .09 12 total outflow 4.99 20.3666 .00 13 total trapped 19.96 14 storage increase .00 .00 15 mass balance check .00 .00 load removal efficiency = 80.01 %, adjusted = 80.01 % continuity errors: volume = -.01 %, load = .00 % extreme values over all storms base minimum maximum maximum maximum wet deviceft<</th>ft<</th>ft<</th>ft<</th>ft<</th>ft<</th>ft<</th>ft<</t case data file = nwbred.inp storm data file = czmnwst.stm particle file = czm nurp.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 3 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Coastal zone management one watershed one device one particle class = NURP 50% northwest rainfall zone 3.3 acres, bridge construction ED dry pond watershed = 1 watersh surface runoff device = 1 dry pond percolation device = 0 impervious fraction 3.300 .630 impervious depression storage inches = .020 scs curve number (pervious portion) = 60.000 sweeping frequency times/week = .000 water quality load factor - = 1.000

device = 1 dr	y pond,	type	=	1	pond					
bottom elevatio	n	fe	et	=	.00	0				
bottom area		ac	res	=	.02	7				
permanent pool	area	ac	res	=	.00	0				
permanent pool	volume	ac	-ft	=	.00	0				
perm. pool infi	ltration :	rate in	/hr	=	.00000	0				
flood pool area	L	ac	res	=	.03	5				
flood pool volu	ıme	ac	-ft	=	.12	4				
flood pool infi	ltration :	rate in	/hr	=	.00000	0				
flood pool drai	n time	ho	urs	=	48.00	0				
outlet orifice	diameter	in	ches	. =	.00	0				
orifice dischar	ge coeffi	cient		=	.60	0				
outlet weir ler	igth	fe	et	=	.00	0				
weir discharge	coefficie	nt		=	3.30	0				
perforated rise	rheight	fe	et	=	.00	0				
number of holes	; in riser		_	=	.00	0				
hole diameter		in	ches	. =	.00	0				
particle remova	il scale f	actor		=	1.00	0				
ovfiltrato rout	od to dov	ico	0	. ,	חידור					
pormal outlot	eu co uev	dovico	0							
spillway outlet	routed t	a dovia	0							
spillway ouclet	, routed t	U UEVIC	eu	, ,	501					
Coastal Zone St	udv(NW)									
watershed areas	contribu	ting su	rfac	e	runoff to	each	device			
	total	impervi	ous		dead-st	orage	zmean	total-s	torage	zmean
device	acres	acres	00	5	acres	ac-ft	feet	acres	ac-ft	fe
1 dry pond	3.30	2.08	63.0)	.03	.00	.00	.04	.12	3.
24 OVERALL	3.30	2.08	63.0)	.03	.00	.00	.04	.12	3.50
normalized devi	lce areas	and vol	umes	;						
	d	ead-sto	rage	<u> </u>		total.	-storage	flood	-storag	e
ć	ab/ai vb	/ai a	b/at		vb/at	ab/at	vb/at	V	b/at	
device	% inc	hes	00	5	inches	00	inches	in	ches	
1 dry pond	1.28	.00	.81	-	.00	1.08	.45		.45	
25 OVERALL	1.28	.00	.81	-	.00	1.08	.45		.45	

number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 dry pond, type = pond , variable = tss load flow conc mass-balance term acre-ft lbs ppm 39.46 160.8434 .09 01 watershed inflows .09 06 normal outlet 7.85 32.0065 08 sedimen + decay .00 31.61 .0000 09 total inflow .09 39.46 160.8434 10 surface outflow .09 7.85 32.0065 7.85 12 total outflow .09 32.0065 .00 13 total trapped 31.61 14 storage increase .00 .00 15 mass balance check .00 .00 load removal efficiency = 80.10 %, adjusted = 80.10 % continuity errors: volume = -.01 %, load = .00 % extreme values over all storms base minimum maximum maximum maximum wet elev elev inflow outflow velocity period ft cfs cfs ft/sec .26 .05 .00 device ft ft % .00 .00 1.86 1 dry pond .00 .00 1.86 case title = Coastal Zone Study(SW) 12.4 case data file = swbred.inp storm data file = czmswst.stm particle file = czm nurp.par air temp file = prov6988.tmp= 1.000 = 1.000 precipitation volume factor storm duration factor number of passes through storm file = 3 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Coastal zone management one watershed one device one particle class = NURP 50% southwest rainfall zone 3.3 acres, bridge construction ED dry pond watershed = 1 watersh surface runoff device = 1 dry pond percolation device = 0 watershed area acres = 3.300 impervious fraction .630 = impervious depression storage inches =
scs curve number (pervious portion) =
sweeping frequency times/week =
water quality load factor - = .020 60.000 .000 1.000
device = 1 d	ry pond,	type	= :	l pond					
bottom elevati	on	f	eet	= .	000				
bottom area		a	cres	= .	030				
permanent pool	area	a	cres		000				
permanent pool	volume	a	c-ft	= .	000				
perm. pool inf	iltration	rate i	n/hr	= .000	000				
flood pool are	a	a	cres		040				
flood pool vol	ume	a	c-ft	= .	142				
flood pool inf	iltration	rate i	n/hr	= .000	000				
flood pool dra	in time	h	ours	= 48.	000				
outlet orifice	diameter	i	nches	= .	000				
orifice discha	rge coeff	icient		= .	600				
outlet weir le	ngth	f	eet	= .	000				
weir discharge	coeffici	ent		= 3.	300				
perforated ris	er height	. f	eet	= ,	000				
number of hole	s in rise	r		= ,	000				
hole diameter		i	nches	= ,	000				
particle remov	al scale	factor		= 1.	000				
exfiltrate rou	ted to de	vice	0	OUT					
normal outlet	routed to	device	e 0	OUT					
spillway outle	t routed	to devi	.ce 0	OUT					
Coastal Zone S	tuay(Sw)				to soob	-]			
watersned area	s contrib	uting s	suriac	e runoii	to each	device	+ - + - 1 -	+	
3 ¹	total	Imperv	10US	dead	-storage	zmean	total-s	lorage	zmean
device	acres	acres	6	acres	ac-it	reet	acres	ac-it	ree
1 ary pona	3.30	2.08	63.0	.03	.00	.00	.04	.14	3.1
24 OVERALL	3.30	2.08	63.0	.03	.00	.00	.04	.14	3.50
normalized dev	vice areas	and vo	lumes						
		dead-st	corage		total	-storage	flood	l-storag	je
	ab/ai v	/b/ai	ab/at	vb/at	ab/at	vb/at	v	vb/at	
device	% ir	ches	%	inches	00	inches	in	ches	
1 dry pond	1.46	.00	.92	.00	1.23	.52		.52	
25 OVERALL	1.46	.00	.92	.00	1.23	.52		.52	

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Determine peak discharge from 1	oridge by BD	Date 5/12/92
Location Southwest	Checked	Date
Circle one: Present Developed	10-year, 24-	hour rainfall
Circle one: T_c T_t through subarea		
NOTES: Space for as many as two segments p worksheet.	er flow type can be u	used for each
Include a map, schematic, or descrip	ption of flow segment DEVEL	DPED
Sheet flow (Applicable to T only)	Segment ID	
<pre>1. Surface description (table 3-1)</pre>	5m00-	m /
2. Manning's roughness coeff., n (table 3	-1) 0.011	
3. Flow length, L (total $L \leq 300$ ft)	ft 60	
4 Duo-yr 24-hr rainfall, P ₂	in <u>3.5</u>	
5. Land slope, s	ft/ft 0,02	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr 0.01	+ [
Shallow concentrated flow	Segment ID	
7. Surface description (paved or unpaved)	Paved	
8. Flow length, L	ft 200	
9. Watercourse slope, в	ft/ft .02	
10. Average velocity, V (figure 3-1)	ft/s 2.9	
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr 0.02	
Channel flow	Segment ID	
12. Cross sectional flow area, a	ft ²	<u> </u>
13. Wetted perimeter, p _w	ft	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r.	ft	
15. Channel slope, s	ft/ft	
16. Manning's roughness coeff., n		
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V.	ft/s	
18. Plow length, L	ft	
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr]+[]•[]
20. Watershed or subarea T_c or T_t (add T_t :	in steps 6, 11, and 1 T_{r}	9) hr
		- 7
	ASSUME	c=0.1 hr
(210-V1-TK-55, Seco	un ru., 1mue 1986)	

Worksheet 4: Graphical Peak Discharge method

Pro	ject Sizing Pipe en bridge	By	BJD	Date 5/12	192
Loca	acion Southwest	Chec	:ked	Date	
Ciro	ele one: Present Developed				
1.	Data:				
	Drainage area $A_{m} = 0.000 43 mi^{2}$	2 (acres	;/640)		
	Runoff curve number $CN = \frac{98}{(Fr})$	com work	sheet 2)		
	Time of concentration $T_c = 0.1$ hr	(From v	vorksheet 3)	
	Rainfall distribution type = $\underline{\Box}$ (I,	, IA, II	(, III)		
	Pond and swamp areas spread throughout watershed = per	ccent of		acres or mi	covered)
			Storm #1	Storm #2	Storm #3
2.	Frequency	yr	10		
3.	Rainfall, P (24-hour)	in	3,5		
					······
4.	Initial abstraction, I	in	0.041		
5.	Compute I _a /P		0.01		
6.	Unit peak discharge, q_u	csm/in	500		
	c_{c} and c_{a} , where controls $\frac{2}{2}$,				[]
7.	Runoff, Q (From worksheet 2).	in	3.27		
8.	Pond and swamp adjustment factor, F (Use percent pond and swamp area with table 4-2. Factor is 1.0 for		1.0		
	zero percent pond and swamp area.)				[]
9.	Peak discharge, q _p (Where q _p = q,A_QF_)	cfs	0.70		

Worksheet 3: Time of concentration (T_c) or travel time (T_t)	
Project Determine peak discharge from By BTD Date 5/11/92	
Location Great Lakes Dridge Checked Date	
Circle one: Present Developed <u>10-year, 24-hour peat</u> rainfa	પી
NOTES: Space for as many as two segments per flow type can be used for each worksheet.	
Include a map, schematic, or description of flow segments. DEVELOPED	
Sheet flow (Applicable to T _c only) Segment ID	
1. Surface description (table 3-1) Smorth	
2. Manning's roughness coeff., n (table 3-1) 0.011	
3. Flow length, L (total L \leq 300 ft) ft 60	
4. Two-yr 24-hr rainfall, P_2 in 4.0	
5. Land slope, s	1
6. $T_t = \frac{0.007 \text{ (nL)}}{P_2 0.5 \text{ s}^{0.4}}$ Compute T_t hr $\frac{0.02}{P_2 0.5 \text{ s}^{0.4}}$	
Shallow concentrated flow Segment ID	
7. Surface description (paved or unpaved)	
8. Flow length, L ft 200	
9. Watercourse slope, 5 ft/ft	
10. Average velocity, V (figure 3-1) ft/s 2.9	\prec
11. $T_t = \frac{L}{3600 V}$ Compute T_t hr $[0.02]^+$	
Channel flow Segment ID	
12. Cross sectional flow area, a ft ²	
13. Wetted perimeter, p _w ft	
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r ft	
15. Channel slope, s	
16. Manning's roughness coeff., n	
17. $V = \frac{1.49 \text{ f}}{\text{n}}$ Compute V ft/s	
18. Plow length, L ft	カ
$\frac{17}{t} = \frac{1}{3600 \text{ V}}$	\neg
The second of Bubarea is the term of the second of the sec	J
1c=10411r = 0.10 11	

(210-VI-TR-55, Second Ed., June 1986)

Worksheet 4: Graphical Peak Discharge method

Proj	ject <u>Sizing pipe for bridge</u>	Ву _	3JD	Date <u>5/1</u>	1/92
Loca	action Great Lakes	Chec	ked	Date	
Circ	cle one: Present Developed	,	<u> </u>	<u></u>	
1.	Data:				
	Drainage area $A_m = .00043 \text{ mi}^2$ (a	acres	/640)		
	Runoff curve number $CN = -\frac{98}{1000}$ (From	work	sheet 2)		
	Time of concentration $T_c = 0.1$ hr (Fi	rom w	orksheet 3)	
	Rainfall distribution type = (I, IA	A, II	, III)		
	Pond and swamp areas spread throughout watershed = percent	nt of		acres or mi	² covered)
	,		DEVELOPED	•	
			Storu #1	Storu #2	Stora #3
2.	Frequency	yr	10		
3.	Rainfall, P (24-hour)	in	4.0		
4.	Initial abstraction, I _a (Use CN with table 4-1.)	in	0.041		·
5.	Compute I _a /P		0.01		
6.	Unit peak discharge, q_u csm, (Use T_c and I_a/P with exhibit 4- I_a)	/in	1000		
7.	Runoff, Q (From worksheet 2).	in	3.77		
8.	Pond and swamp adjustment factor, F _p (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1,0		
9.	Peak discharge, q _p (Where q _p = q _u A _m QF _p)	cfs	1.62	<u> </u>	<u> </u>

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

		-1 10
Project Determine peak discharge trom bridge	By BJD	Date 5/12/92
Location Northwest	Checked	Date
Circle one: Present Developed	lear, 24-hour	- rainfall
Circle one: Tc Tt through subarea		
NOTES: Space for as many as two segments per flow worksheet.	type can be us	ed for each
Include a map, schematic, or description o	of flow segments	•
Sheet flow (Applicable to T only) Segment	ID	
<pre>l. Surface description (table 3-1)</pre>	Smoot	h /
2. Manning's roughness coeff., n (table 3-1)	0.011	
3. Flow length, L (total L \leq 300 ft)	ft 60	
$\begin{array}{c} T_{a}n-\gamma r\\ 4. \overline{T_{a}0-\gamma r} 24-hr rainfall, P_2 \dots \end{array}$	in 4.0	<u></u>
5. Land slope, s	ft/ft 0,02	
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$ Compute T_t	hr 0.02]+[/]-[_/]
Shallow concentrated flow Segment	ID	
7. Surface description (paved or unpaved)	Paved	
8. Flow length, L	ft 200	
9. Watercourse slope, s	ft/ft 0.02	
10. Average velocity, V (figure 3-1)	ft/s 2.9	
11. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr 0.02	+
Channel flow Segment	ID	
12. Cross sectional flow area, a	ft ²	<u> </u>
13. Wetted perimeter, p _w	ft	
14. Hydraulic radius, $r = \frac{a}{P_{r_s}}$ Compute r	ft	
15. Channel slope, s	ft/ft	1
16. Manning's roughness coeff., n		
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V	ft/s	
18. Flow length, L	ft	
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t	hr	+[]
20. Watershed or subarea T_{c} or T_{t} (add T_{t} in step	s 6, 11, and 19) hr []
	Tc= 0.	04 hr.
	Assu	me: Te= 0.1 hr.

(210-VI-TR-55, Second Ed., June 1986)

Worksheet 4: Graphical Peak Discharge method

Pro Loc	ject <u>Sizing pipe on bridge</u> By action <u>Northwest</u> Cha	<u>BJD</u> ecked	Date <u>5/12</u> Date	<u> 92</u>
Cir	cle one: Present developed	<u></u>		
1.	Data:			
	Drainage area $A_m = 0.00043 mi^2 (acro$	es/640)		
	Runoff curve number $CN = 98$ (From wo	rksheet 2)		
	Time of concentration $T_c = O_i$ hr (From	worksheet 3)	
	Rainfall distribution type =A (I, IA,)	II, III)		
	Pond and swamp areas spread throughout watershed = percent	of $A_{\underline{m}}^{\prime}$ (acres or mi ²	covered)
		Sterm #1	Storm #2	Storm #3
2.	Frequency yr	10-yr		
3.	Rainfall, P (24-hour) in	4.0		
4.	Initial abstraction, I_a in (Use CN with table 4-1.)	0.041		
5.	Compute I _a /P	0.01		
6.	Unit peak discharge, q_u csm/in (Use T _c and I _a /P with exhibit 4- <u>IA</u>)	165		
7.	Runoff, Q in (From worksheet 2).	3.77		
8.	Pond and swamp adjustment factor, F (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)	1.0		
9.	Peak discharge, q_p cfs (Where $q_p = q_u A_m QF_p$)	0.27		

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project Determine peak discharge from bridge by BJD	Date 5/12/92
Location South east Checked	Date
Circle one: Present Developed 10-year, 24 h	our rainfall
Circle one: T _c T _t through subarea	······································
NOTES: Space for as many as two segments per flow type can be worksheet.	used for each
Include a map, schematic, or description of flow segme	nts.
DEV	ELOPED
Sheet flow (Applicable to T _c only) Segment ID	
1. Surface description (table 3-1)	poth
2. Manning's roughness coeff., n (table 3-1) 0.0	<u> </u>
3. Flow length, L (total L \leq 300 ft) ft 60	p /
4. Two-yr 24-hr rainfall, P_2 in 7.	0
5. Land slope, s ft/ft	2
6. $T_t = \frac{0.007 (nL)^{0.8}}{P_0^{0.5} s^{0.4}}$ Compute T_t hr o_t	.01]+
Shallow concentrated flow Segment ID	
7. Surface description (paved or unpaved) Pays	ed /
8. Flow length, L ft 20	0 / 0
9. Watercourse slope, B ft/ft ,0	2
10. Average velocity, V (figure 3-1) ft/s 2.	9 /
11. $T = \frac{L}{D_{10}}$ Compute T hr 0.0	2+
E 3600 V	
Channel flow Segment ID	
12. Cross sectional flow area, a ft ²	
13. Wetted perimeter, p ft	
14. Hydraulic radius, $r = \frac{a}{P_{r_1}}$ Compute r ft	
15. Channel slope, s ft/ft	
16. Manning's roughness coeff., n	
17. $V = \frac{1.49 r^{2/3} s^{1/2}}{n}$ Compute V ft/s	
18. Flow length, L ft	
19. $T_t = \frac{L}{3600 \text{ V}}$ Compute T_t hr	
20. Watershed or subarea T _c or T _t (add T _t in steps 6, 11, and	19) hr
$T_c = 0$,0.3 hr
(210-VI-TR-55, Second Ed., June 1986)	e Te = 0.1 hr

Worksheet 4: Graphical Peak Discharge method

Pro	ject Sizing Pipe on bridge	Ву		Date	
Loc	ation <u>Southeast</u>	Cheo		Date	
Cir	cle one: Present Developed				
1.	Data:				
	Drainage area A_ =000 43 r	mi ² (acres	s/640)		
	Runoff curve number $CN = -\frac{98}{6}$	(From worl	(sheet 2)		
	Time of concentration $T_c = 0.1$	nr (From v	worksheet 3)	
	Rainfall distribution type = ((I, IA, I	I, III)		
	Pond and swamp areas spread throughout watershed =	percent of	E A' (acres or mi	covered)
	·		DEVELOPEI	>	
			Storm #1	-Storm #2-	SEOLE #3
2.	Frequency	yr	10		
3.	Rainfall, P (24-hour)	in	7.0		
4.	Initial abstraction, Ia (Use CN with table 4-1.)	in	0.041		
5.	Compute I _a /P		0.01		
6.	Unit peak discharge, q_u	csm/in	650		
7.	Runoff, Q	ĺn	6.76-		
8.	Pond and swamp adjustment factor, F_p (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		
9.	Peak discharge, q_p (Where $q_p = q_A A_P QF_p$)	cfs	1.89		

Subject Pipe SIZING & COSt
By BRIAN DONOVAN Checked By
$$p/2$$

Date $5/14/92$ Date $5/14/92$ Sheet I of Z
Northeast Region: Break = 0.27 cfs
Southnesst Region: Break = 0.27 cfs
Southnesst Region: Break = 0.27 cfs
Southnesst Region: Break = 0.70 cfs
Ceneral Assumptions:
1) Fipe is only y_2 full
2) Pipe design based on 10-year, 24-hour rainfall
3) Pipe is vinde of reinforced steel
4) Means "Building Construction Cost Data " dated 1991
used for pipe pricing
Northeast
Area = $\pi d^2/4 = \pi \left(\frac{6}{12}\right)^2/4 = 0.20 \text{ ft}^2$
Hydrawlic Radius $R = \frac{Area}{Wetted Remoter} = \frac{0.20}{\pi r} = \frac{0.20}{\pi(25)} = 0.25$
 $n = 0.010$
Using Manning's eq: Slope = 0.02
 $R_{max} = Av = \frac{1.49}{0.01} (0.20) (0.25)^{2/3} (.02)^{V_2} = 1.67 cfs$
Cost of pipe five cach half of bridge = 200 ft 7.15 ft =
Total Cost of Pipe Fire = 1430 x Z = $\frac{42,860}{\pi}$

Woodward-Clyde Federal Services 😜

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APPENDIX C

Street Sweeping Computer Simulation Results

80040000H:\wp\cost_ana\roads

case title = Street Sweeping case case data file = Sweep.cas storm data file = czmswst.stm particle file = nurp50.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 storm duration factor = 1.000
number of passes through storm file = 5 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Street sweeping case one watershed one device one particle class=NURP 50% watershed = 1 watersh surface runoff device = 1 Pipe percolation device = 0 watershed area acres = 100.000 device = 1 Pipe , type = 5 pipe time of concentration = .000 hours normal outlet routed to device 0 OUT number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 Pipe , type = pipe , variable = tss load lbsconc1bsppm474.52160.8447474.52160.8447 flow conc mass-balance term acre-ft 01 watershed inflows 1.09 06 normal outlet 1.09 474.52160.8447474.52160.8447474.52160.8447 09 total inflow 1.09 10 surface outflow 1.09 12 total outflow 1.09 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 Pipe , type = pipe , variable = tp

flowloadacre-ftlbs1.091.391.091.39 conc mass-balance termacre-ft01 watershed inflows1.0906 normal outlet1.09 ppm 1.09 .4706 06 normal outlet .4706 09 total inflow1.091.39.470610 surface outflow1.091.39.470612 total outflow1.091.39.4706 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 Pipe type = pipe , variable = tkn flow load conc mass-balance term acre-ft lbs ppm 01 watershed inflows 1.09 6.04 2.0476 06 normal outlet 1.09 6.04 2.0476 09 total inflow1.096.042.047610 surface outflow1.096.042.047612 total outflow1.096.042.0476 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 Pipe , type = pipe , variable = cu flow load conc acre-ft lbs ppm 1.09 .14 .0464 1.09 .14 .0464 mass-balance term 01 watershed in Co 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 1.09.141.09.141.09.14 .0464 .0464 12 total outflow .0464 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches Interval =476. hrs, storm duration -12. hrs, precip -...device =1 Pipe, type = pipe, variable = pbflowloadconcmass-balance termacre-ftlbsppm01 watershed inflows1.09.09.031006 normal outlet1.09.09.0310 09 total inflow1.09.09.031010 surface outflow1.09.09.031012 total outflow1.09.09.0310 .0310 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 Pipe , type = pipe , variable = zn

	flow	load	conc	
mass-balance term	acre-ft	lbs	ppm	
01 watershed inflows	1.09	.64	.2184	
06 normal outlet	1.09	.64	.2184	
09 total inflow	1.09	.64	.2184	
10 surface outflow	1.09	.64	.2184	
12 total outflow	1.09	.64	.2184	
load removal efficiency =	.00 %,	adjusted = .	00 %	
continuity errors: volume =	.00 %,	load = .	00 %	
number of storms = 1 interval = 476. hrs, storm	duration =	12. hrs, pr	ecip = .54 :	inches
device = 1 Pipe , type =	pipe ,	variable = hc		
	flow	load	conc	
mass-balance term	acre-ft	lbs	ppm	
01 watershed inflows	1.09	11.41	3.8690	
06 normal outlet	1.09	11.41	3.8690	
09 total inflow	1.09	11.41	3.8690	
10 surface outflow	1.09	11.41	3.8690	
12 total outflow	1.09	11.41	3.8690	
<pre>load removal efficiency =</pre>	.00 %,	adjusted = .	.00 %	
continuity errors: volume =	.00 %,	load =	.00 %	

case title = Street Sweeping case case data file = Sweep.cas storm data file = czmswst.stm particle file = nurp50.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 5 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Street sweeping case one watershed one device one particle class=NURP 50% watershed = 1 watersh surface runoff device = 1 Pipe percolation device = 0 acres = 100.000 watershed area impervious fraction = .250 impervious fraction=.250impervious depression storageinches=.020scs curve number (pervious portion)=60.000sweeping frequencytimes/week1.000water quality load factor-=1.000 device = 1 Pipe , type = 5 pipe time of concentration = .000 hours normal outlet routed to device 0 OUT number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 Pipe , type = pipe , variable = tss load conc lbs ppm 446.88 151.4759 446.88 151.4759 flow mass-balance term acre-ft ppm1.09 1.09 01 watershed inflows 06 normal outlet 446.88151.4759446.88151.4759446.88151.4759 09 total inflow 1.09 1.09 10 surface outflow 12 total outflow .00 15 mass balance check .00 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches

device = 1 Pipe , type :	= pipe ,	variable = tp	
	flow	load	conc
mass-balance term	acre-ft	lbs	ppm
01 watershed inflows	1.09	1.34	.4548
06 normal outlet	1.09	1.34	.4548
09 total inflow	1.09	1.34	.4548
10 surface outflow	1.09	1.34	.4548
12 total outflow	1.09	1.34	.4548
15 mass balance check	.00	.00	
load removal efficiency =	00 %	adjusted =	00 %
continuity errors: volume =	.00 %,	load =	.00 %
-			
number of storms =	1 duration -	10 hrs n	regin - El inches
lnuerval = 4/6. mrs, storm	auration =	iz. nrs, p.	recip = .54 inches
device = 1 Pipe , type	= pipe ,	variable = tk	n
mage balance torm	LIUW Daro-ft	10au	conc
mass-parance term		au su s	
of watershed inflows	1.09	5.86	1.9862
U6 normal outlet	1.09	5.86	1.9862
09 total inflow	1.09	5.86	1.9862
10 surface outflow	1.09	5.86	1,9862
12 total outflow	1.09	5.86	1,9862
15 mass balance check	.00	.00	10000
load removal efficiency =	.00 %,	adjusted =	.00 %
continuity errors: volume =	.00 %,	load =	.00 %
number of storms =	1		
interval - 176 brs storm	~, , ,		
	duration =	12. hrs. p	recip = .54 inches
device = 1 Pipe . type	duration =	12. hrs, p variable = cu	recip = .54 inches
device = 1 Pipe , type	<pre>duration = = pipe , flow</pre>	12. hrs, p variable = cu load	recip = .54 inches
device = 1 Pipe , type	<pre>duration = = pipe , flow acre-ft</pre>	12. hrs, p variable = cu load lbs	conc
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows</pre>	<pre>duration = pipe , flow acre-ft 1 09</pre>	12. hrs, p variable = cu load lbs 13	recip = .54 inches conc ppm 0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet</pre>	<pre>duration = pipe , flow acre-ft 1.09 1.09</pre>	12. hrs, p variable = cu load lbs .13	conc ppm .0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet</pre>	<pre>duration = = pipe , flow acre-ft 1.09 1.09</pre>	12. hrs, p variable = cu load lbs .13 .13	recip = .54 inches conc ppm .0450 .0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow</pre>	<pre>duration = = pipe flow acre-ft 1.09 1.09 1.09</pre>	12. hrs, p variable = cu load lbs .13 .13 .13	recip = .54 inches conc ppm .0450 .0450 .0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow</pre>	<pre>duration = pipe , flow acre-ft 1.09</pre>	12. hrs, p variable = cu load lbs .13 .13 .13 .13	recip = .54 inches conc ppm .0450 .0450 .0450 .0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow</pre>	<pre>duration = pipe , flow acre-ft 1.09 1.09 1.09 1.09 1.09 1.09 </pre>	12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .13	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	<pre>duration = = pipe flow acre-ft 1.09 1.09 1.09 1.09 1.09 00</pre>	12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .13 .00	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency =</pre>	<pre>duration = pipe , flow acre-ft 1.09 1.09 1.09 1.09 1.09 00 </pre>	12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume =</pre>	<pre>duration = = pipe , flow acre-ft 1.09 1.09 1.09 1.09 1.09 .00 .00 %, .00 %</pre>	12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load =	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume =</pre>	<pre>duration = pipe flow acre-ft 1.09 1.09 1.09 1.09 1.09 1.09 1.09 .00 .00</pre>	12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load =	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450 .0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = .</pre>	<pre>duration = pipe , flow acre-ft 1.09 1.09 1.09 1.09 1.09</pre>	12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load =	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450 .0450
<pre>device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm</pre>	<pre>duration = pipe , flow acre-ft 1.09 1.09 1.09 1.09 1.09 .00 .00 %, .00 %, 1 duration = </pre>	<pre>12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load = 12. hrs, p</pre>	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450
<pre>interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm device = 1 Pipe , type</pre>	<pre>duration = pipe flow acre-ft 1.09 1.09 1.09 1.09 1.09</pre>	<pre>12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load = 12. hrs, p variable = pb</pre>	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450
<pre>interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = - interval = 476. hrs, storm device = 1 Pipe , type</pre>	<pre>duration = pipe , flow acre-ft 1.09 1.09 1.09 1.09 1.09 1.09 1.09 1.09 .00 .00 %, .00 %, 1 duration = pipe , flow</pre>	<pre>12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load = 12. hrs, p variable = pb load</pre>	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450
<pre>interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm device = 1 Pipe , type mass-balance term</pre>	<pre>duration = pipe , flow acre-ft 1.09 .00 *</pre>	<pre>12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load = 12. hrs, p variable = pb load lbs</pre>	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450
<pre>interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows</pre>	<pre>duration = pipe , flow acre-ft 1.09</pre>	<pre>12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load = load = load lbs .09</pre>	recip = .54 inches conc ppm .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450 .0450
<pre>interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet</pre>	<pre>duration = pipe , flow acre-ft 1.09 1.09 1.09 1.09 1.09 1.09 1.09 1.09 .00 .00 %, .00 %, 1 duration = pipe , flow acre-ft 1.09</pre>	<pre>12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load = 12. hrs, p variable = pb load lbs .09 .09</pre>	<pre>conc ppm .0450 .0293 .0293'</pre>
<pre>interval = 470. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow</pre>	<pre>duration = pipe flow acre-ft 1.09</pre>	12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load = 12. hrs, p variable = pb load lbs .09 .09	recip = .54 inches conc ppm .0450 .0293 .0293 .0293
<pre>interval = 470. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow</pre>	<pre>duration = pipe , flow acre-ft 1.09</pre>	<pre>12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .13 .00 adjusted = load = 12. hrs, p variable = pb load lbs .09 .09 .09 .09 .09</pre>	recip = .54 inches conc ppm .0450 .0293 .0293 .0293
<pre>interval = 470. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow</pre>	<pre>duration = pipe , flow acre-ft 1.09</pre>	<pre>12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .13 .00 adjusted = load = 12. hrs, p variable = pb load lbs .09 .09 .09 .09 .09 .09 .09 .09 .09 .09</pre>	recip = .54 inches conc ppm .0450 .0293 .0293 .0293 .0293
<pre>interval = 470. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	<pre>duration = pipe , flow acre-ft 1.09</pre>	12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load = 12. hrs, p variable = pb load lbs .09 .09 .09 .09	recip = .54 inches conc ppm .0450 .0293 .0293 .0293 .0293
<pre>interval = 470. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	<pre>duration = pipe flow acre-ft 1.09 1.09 1.09 1.09 1.09 1.09 1.09 .00 .00 %, .00 %, 1 duration = pipe flow acre-ft 1.09</pre>	12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .00 adjusted = load = load = 12. hrs, p variable = pb load lbs .09 .09 .09 .09 .09 .00	recip = .54 inches conc ppm .0450 .0293 .0293 .0293 .0293
<pre>interval = 470. mis, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = . interval = 476. hrs, storm device = 1 Pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency =</pre>	<pre>duration = pipe , flow acre-ft 1.09 1.009 1.009</pre>	<pre>12. hrs, p variable = cu load lbs .13 .13 .13 .13 .13 .13 .00 adjusted = load = 12. hrs, p variable = pb load lbs .09 .09 .09 .09 .09 .09 .09 .09 .00 adjusted =</pre>	recip = .54 inches conc ppm .0450 .0293 .0293 .0293 .0293 .0293 .0293

continuity errors: volume =	.00 %,	load =	.00 %		
number of storms = 1					
interval = 476. hrs, storm of	duration =	12. hrs,	precip	= .54	inches
device = 1 Pipe , type =	pipe ,	variable = z	zn		
waaa kalawaa taww	rlow	load		conc	
Mass-palance term	acre-it	ad I		ppm	
of watershed inflows	1.09	.63		.2119	
US NORMAL OUTLEL	1.09	.63		.2119	
09 total inflow	1.09	.63		.2119	
10 surface outflow	1.09	.63		.2119	
12 total outflow	1.09	.63		.2119	
15 mass balance check	.00	.00			
load removal efficiency =	00 %	= beteuchs	00 %		
continuity errors: volume =	.00 %,	load =	.00 %		
-					
number of storms = 1					
interval = 476. hrs, storm	duration =	12. hrs,	precip	= .54	inches
device = 1 Pipe , type =	pipe ,	variable = l	hc		
	flow	load		conc	
mass-balance term	acre-ft	lbs		ppm	
01 watershed inflows	1.09	10.79		3.6582	
06 normal outlet	1.09	10.79		3.6582	
09 total inflow	1.09	10.79		3.6582	
10 surface outflow	1.09	10.79		3.6582	
12 total outflow	1.09	10.79		3,6582	
15 mass balance check	.00	.00			
<pre>load removal efficiency =</pre>	.00 %,	adjusted =	.00 %		
continuity errors: volume =	.00 %,	load =	.00 %		

case title = Street Sweeping case case data file = sweep.cas storm data file = czmswst.stm particle file = nurp50.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 5 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Street sweeping case one watershed one device one particle class=NURP 50% watershed = 1 watersh surface runoff device = 1 pipe percolation device = 0watershed area acres = 100.000 impervious fraction = .250 impervious depression storage inches = .020 scs curve number (pervious portion) = 60.000 sweeping frequency times/week = .250 water quality load factor - = 1.000 device = 1 pipe , type = 5 pipe time of concentration = .000 hours normal outlet routed to device 0 OUT number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 pipe , type = pipe , variable = tss load flow conc acre-ft 1.09 lbs 467.25 mass-balance term ppm 01 watershed inflows 158.3796 467.25 06 normal outlet 1.09 158.3796 1.09 09 total inflow 467.25158.3796467.25158.3796 10 surface outflow 1.09 12 total outflow 1.09 467.25 158.3796 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 pipe , type = pipe , variable = tp

flow load conc I lowI loadmass-balance termacre-ftlbs01 watershed inflows1.091.3806 normal outlet1.091.38 թթա •4665 •4665 ppm 1.091.38.46651.091.38.46651.091.38.4665 09 total inflow 10 surface outflow 12 total outflow load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 pipe, type = pipe, variable = tknflowloadconcmass-balance termacre-ftlbsppm01 watershed inflows1.095.992.031706 normal outlet1.095.992.0317 09 total inflow1.095.992.031710 surface outflow1.095.992.031712 total outflow1.095.992.0317 load removal efficiency = .00 %, adjusted = .00 % continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 pipe , type = pipe , variable = cu mass-balance termacre-ftloadconc01 watershed inflows1.09.14.046106 normal outlet1.09.14.0461 09 total inflow 1.09 .14 1.09 .14 1.09 .14 .0461 10 surface outflow .0461 12 total outflow .0461 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches interval = 476. hrs, storm duration - 12. hrs, proof device = 1 pipe , type = pipe , variable = pb flow load conc mass-balance term acre-ft lbs ppm 01 watershed inflows 1.09 .09 .0305 06 normal outlet 1.09 .09 .0305 09 total inflow1.09.09.030510 surface outflow1.09.09.030512 total outflow1.09.09.0305 .0305 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 pipe , type = pipe , variable = zn

	flow	load	conc	
mass-balance term	acre-ft	lbs	mqq	
01 watershed inflows	1.09	.64	.2167	
06 normal outlet	1.09	.64	.2167	
09 total inflow	1 09	64	2167	
10 surface outflow	1.09	.04	2167	
12 total outflow	1.09	.04	2167	
12 COLAI OUCIIOW	1.09	• 04	.2107	
<pre>load removal efficiency =</pre>	.00 %,	adjusted =	.00 %	
continuity errors: volume =	.00 %,	load =	.00 %	
<pre>number of storms = 1 interval = 476. hrs, storm d device = 1 pipe , type =</pre>	luration = pipe ,	12. hrs, j variable = h	precip = .54 incl c	ies
	flow	load	conc	
mass-balance term	acre-ft	lbs	ppm	
01 watershed inflows	1.09	11.25	3.8135	
06 normal outlet	1.09	11.25	3.8135	
09 total inflow	1.09	11.25	3.8135	
10 surface outflow	1.09	11.25	3.8135	
12 total outflow	1.09	11.25	3.8135	
<pre>load removal efficiency =</pre>			00 8	
continuity errors: volume =	.00 %, .00 %.	adjusted = load =	.00 %	

case title = Street Sweeping case case data file = sweep.cas storm data file = czmswst.stm particle file = nurp50.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 5 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Street sweeping case one watershed one device one particle class=NURP 50% watershed = 1 watersh surface runoff device = 1 pipe percolation device = 0 watershed area acres = 100.000 .250 impervious fraction = impervious fraction=.250impervious depression storageinches=.020scs curve number (pervious portion)=60.000sweeping frequencytimes/week=.500water quality load factor-=1.000 device = 1 pipe , type = 5 pipe time of concentration = .000 hours normal outlet routed to device 0 OUT number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches device = 1 pipe , type = pipe , variable = tss flowloadconcre-ftlbsppm1.09460.22155.99951.09460.22155.9995 mass-balance term acre-ft 01 watershed inflows 1.09 06 normal outlet 460.22155.9995460.22155.9995460.22155.9995 09 total inflow 1.09 1.09 10 surface outflow 460.22 12 total outflow 155.9995. .00 15 mass balance check .00 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 476. hrs, storm duration = 12. hrs, precip = .54 inches

device = 1 pipe , type =	pipe ,	variable = tp	
	flow	load	conc
mass-balance term	acre-ft	lbs	ppm
01 watershed inflows	1.09	1.36	.4625
06 normal outlet	1.09	1.36	.4625
09 total inflow	1.09	1.36	.4625
10 surface outflow	1.09	1.36	.4625
12 total outflow	1.09	1.36	.4625
15 mass balance check	.00	.00	
<pre>load removal efficiency =</pre>	.00 %,	adjusted = $.0$	0 %
continuity errors: volume =	.00 %,	load = .0	0 %
number of storms - 1			
interval = 476, brs. storm d	luration =	12 hrs pre	cin = .54 inches
device = 1 pipe . type =	pipe .	variable = tkn	
	flow	load	conc
mass-balance term	acre-ft	lbs	maa
01 watershed inflows	1.09	5.95	2.0161
06 normal outlet	1.09	5.95	2.0161
09 total inflow	1 09	5 95	2 0161
10 surface outflow	1.09	5.95	2.0161
12 total outflow	1.09	5.95	2.0101
15 mass halance check	1.09	5.95	2.0101
15 mass barance check	.00	.00	
<pre>load removal efficiency =</pre>	.00 %,	adjusted = .0	0 %
continuity errors: volume =	.00 %,	load = $.0$)0 %
number of storms $=$ 1			
interval = 476 brs storm d	luration =	17 hrs pro	cin - 54 inches
device = 1 pipe $type =$	nine	variable = cu	ecip54 inches
device i pipe , cype -	flow		CODC
mass-balance term	acre-ft	lbs	maa
01 watershed inflows	1.09	.13	. 0457
06 normal outlet	1.09	.13	.0457
oo normar ouoroo	2.000	• 1 3	
09 total inflow	1.09	.13	.0457
10 surface outflow	1.09	.13	.0457
12 total outflow	1.09	.13	.0457
15 mass balance check	.00	.00	
<pre>load removal efficiency =</pre>	.00 %.	adiusted ≈ .(0 %
continuity errors: volume =	.00 %,	load = .(00 %
number of storms - 1			
[interval] = 476 brg storm (Juration -	10 hrs pr	ain - El inchos
dovice = 1 nine type =	nine	12. ms, pre	ectp = .54 inches
device - i pipe , cype -	flow	bed	aona
mass-halance term	acre-ft	lba	
01 watershed inflows		UQ TD2	2201 0301
06 normal outlet	1 19	.09 Na	0301
SS HOLMAL SAULES	1.05	• 0 9	• 0701
09 total inflow	1.09	.09	.0301
10 surface outflow	1.09	.09	.0301
12 total outflow	1.09	.09	.0301
15 mass balance check	.00	.00	
load removal efficiencv =	.00 %.	adjusted =	S0 %

continuity errors: volume =	.00 %,	load =	.00 %		
<pre>number of storms = 1 interval = 476. hrs, storm d device = 1 pipe , type =</pre>	uration = pipe ,	12. hrs, variable = 2	precip 2n	= .54	inches
	flow	load		conc	
mass-balance term	acre-ft	lbs		ppm	
01 watershed inflows	1.09	.63		.2151	
06 normal outlet	1.09	.63		.2151	
09 total inflow	1.09	.63		.2151	
10 surface outflow	1.09	. 63		.2151	
12 total outflow	1.09	.63		.2151	
15 mass balance check	.00	.00			
<pre>load removal efficiency = continuity errors: volume =</pre>	.00 %, .00 %,	adjusted = load =	00 % .00 %		
<pre>number of storms = 1 interval = 476. hrs, storm of device = 1 pipe , type =</pre>	luration = pipe ,	12. hrs, variable = 1	precip hc	= .54	inches
mass-balance term	acro-ft	lba		nnm	
01 watershed inflows	1.09	11.09		3.7600	
06 normal outlet	1.09	11.09		3.7600	
09 total inflow 10 surface outflow	1.09 1.09 1.09	11.09 11.09		3.7600 3.7600 3.7600	
15 mass balance check	.00	.00		5.7000	
<pre>load removal efficiency = continuity errors: volume =</pre>	.00 %, .00 %,	adjusted = load =	.00 % .00 %		

case title = Street Sweeping case case data file = sweep.cas storm data file = czmnest.stm particle file = nurp50.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 5 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Street sweeping case one watershed one device one particle class=NURP 50% Northeast rainfall watershed = 1 watersh surface runoff device = 1 pipe percolation device = 0acres = 100.000 watershed area impervious fraction = .250 impervious depression storage inches = .020 scs curve number (pervious portion) = 60.000 times/week = nes/week = .000 - = 1.000 sweeping frequency water quality load factor device = 1 pipe , type = 5 pipe time of concentration = .000 hours normal outlet routed to device 0 OUT number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe , type = pipe , variable = tss load flow conc lbs 563.54 acre-ft mass-balance term ppm 01 watershed inflows 1.19 174.5998 563.54 06 normal outlet 1.19 174.5998 563.54 563.54 09 total inflow 1.19 174.5998 10 surface outflow 1.19 174.5998 12 total outflow 1.19 563.54 174.5998 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % .00 % number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe , type = pipe , variable = tp

flow load flowloadconcmass-balance termacre-ftlbsppm01 watershed inflows1.191.62.502306 normal outlet1.191.62.5023 conc 09 total inflow1.191.62.502310 surface outflow1.191.62.502312 total outflow1.191.62.5023 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe, type = pipe, variable = tknflowloadconcmass-balance termacre-ftlbs01 watershed inflows1.197.0106 normal outlet1.197.01 09 total inflow1.197.012.171410 surface outflow1.197.012.171412 total outflow1.197.012.1714 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe , type = pipe , variable = cu definitionimplifyimplifyimplifyimplifyimplifyimplifyimplifyflowloadconcmass-balance termacre-ftlbsppm01 watershed inflows1.19.16.049206 normal outlet1.19.16.0492 09 total inflow 10 surface outflow $\begin{array}{ccc}
1.19 & .16 \\
1.19 & .16 \\
1.19 & .16
\end{array}$.0492 .0492 12 total outflow .0492 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches Interval =144. hrs, scorm duration -12. hrs, precip -device =1 pipe, type = pipe, variable = pbflowloadconcmass-balance termacre-ftlbsppm01 watershed inflows1.19.11.033406 normal outlet1.19.11.0334 09 total inflow1.19.11.033410 surface outflow1.19.11.033412 total outflow1.19.11.0334 .0334 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe , type = pipe , variable = zn

mass-balance term 01 watershed inflows 06 normal outlet	flow acre-ft 1.19 1.19	load 1bs .75 .75	conc ppm .2316 .2316
09 total inflow	1.19	.75	.2316
10 surface outflow	1.19	.75	.2316
12 total outflow	1.19	.75	.2316
<pre>load removal efficiency = continuity errors: volume =</pre>	.00 %,	adjusted = .00	8
	.00 %,	load = .00	8
number of storms = 1 interval = 144. hrs, storm d device = 1 pipe , type =	uration = pipe ,	12. hrs, preci variable = hc	p = .59 inches
mass-balance term 01 watershed inflows 06 normal outlet	acre-ft 1.19 1.19	1020 105 13.49 13.49	ppm 4.1785 4.1785
09 total inflow	1.19	13.49	4.1785
10 surface outflow	1.19	13.49	4.1785
12 total outflow	1.19	13.49	4.1785
<pre>load removal efficiency = continuity errors: volume =</pre>	.00 %,	adjusted = .00	१
	.00 %,	load = .00	१

case title = Street Sweeping case case data file = sweep.cas storm data file = czmnest.stm particle file = nurp50.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 5 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Street sweeping case one watershed one device one particle class=NURP 50% Northeast rainfall watershed = 1 watersh surface runoff device = 1 pipe percolation device = 0 watershed area acres = 100.000 impervious fraction = .250 impervious depression storage inches = .020 scs curve number (pervious portion)=.020sweeping frequencytimes/week =60.000water quality load factor-=1.000 device = 1 pipe , type = 5 pipe time of concentration = .000 hours normal outlet routed to device 0 OUT number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe, type = pipe, variable = tssflowloadconcmass-balance termacre-ftlbsppm01 watershed inflows1.19541.42167.744606 normal outlet1.19541.42167.7446 conc 1.19 541.42167.7446541.42167.7446541.42167.7446 09 total inflow 1.19 1.19 10 surface outflow 541.42 12 total outflow 15 mass balance check .00 .00 load removal efficiency = .00 %, adjusted = .00 % ·
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches

	pipe ,	variable = t	ç	
maga-balango torm	flow	load	conc	
01 watershed inflows	acre-11	1DS 1 58	vaua bbw	
06 normal outlet	1.19	1,58	.4909	
of normal outlet	1.12	1.00	. 4000	
09 total inflow	1.19	1.58	.4909	
10 surface outflow	1.19	1.58	.4909	
12 total outflow	1.19	1.58	.4909	
15 mass balance check	.00	.00		
load removal efficiency =	00 %	adjusted =	00 8	
continuity errors: volume =	.00 %,	load =	.00 %	
number of storms = 1				
interval = 144. hrs, storm (duration =	12. hrs, j	precip = .59	inches
device = 1 pipe , type =	pipe ,	variable = t	kn	
	flow	load	conc	
mass-balance term	acre-ft	lbs	ppm	
01 watershed inflows	1.19	6.86	2.1268	
06 normal outlet	1.19	6.86	2.1268	
09 total inflow	1 19	6 86	2 1268	
10 surface outflow	1,19	6.86	2,1268	
12 total outflow	1.19	6.86	2.1268	
15 mass balance check	.00	.00		
<pre>load removal efficiency =</pre>	.00 %,	adjusted =	.00 %	
continuity errors: volume =	.00 %,	load =	.00 %	
number of storms - 1				
interval = 144, hrs. storm	duration =	12. hrs.	precip = .59	inches
interval = 144. hrs, storm device = 1 pipe , type =	duration = pipe ,	12. hrs, variable = c	precip = .59 u	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type =</pre>	duration = pipe , flow	12. hrs, variable = c load	precip = .59 u conc	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term</pre>	duration = pipe , flow acre-ft	12. hrs, variable = c load lbs	precip = .59 u conc ppm	inches
<pre>interval = 144. hrs, storm { device = 1 pipe , type = mass-balance term 01 watershed inflows</pre>	duration = pipe , flow acre-ft 1.19	12. hrs, variable = c load lbs .16	precip = .59 u conc ppm .0482	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet</pre>	duration = pipe , flow acre-ft 1.19 1.19	12. hrs, variable = c load lbs .16 .16	precip = .59 u conc ppm .0482 .0482	inches
<pre>interval = 144. hrs, storm i device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet</pre>	duration = pipe , flow acre-ft 1.19 1.19	12. hrs, variable = c load lbs .16 .16	precip = .59 u conc ppm .0482 .0482	inches
<pre>interval = 144. hrs, storm i device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 symface symfaley</pre>	duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19	12. hrs, variable = c load lbs .16 .16 .16	precip = .59 u conc ppm .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm - device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow</pre>	<pre>duration = pipe , flow acre-ft 1.19</pre>	12. hrs, variable = c load lbs .16 .16 .16 .16	precip = .59 u conc ppm .0482 .0482 .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.00 </pre>	12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16	precip = .59 u conc ppm .0482 .0482 .0482 .0482 .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm i device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.0 </pre>	12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .00	precip = .59 u conc ppm .0482 .0482 .0482 .0482 .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm { device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency =</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 00 .00 %,</pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .00 adjusted =</pre>	precip = .59 u conc ppm .0482 .0482 .0482 .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume =</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 00 .00 %, .00 %,</pre>	12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .00 adjusted = load =	precip = .59 u .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume =</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 00 .00 %, .00 %,</pre>	12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .00 adjusted = load =	precip = .59 u conc ppm .0482 .0482 .0482 .0482 .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 00 .00 %, .00 %,</pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .00 adjusted = load =</pre>	precip = .59 u conc ppm .0482 .0482 .0482 .0482 .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1 interval = 144. hrs, storm</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 .00 .00 %, .00 %, duration = pipe</pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs,</pre>	precip = .59 u conc ppm .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm i device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1 interval = 144. hrs, storm device = 1 pipe , type =</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.0 .00 .00 %, .00 %, duration = pipe , flow</pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, variable = p</pre>	precip = .59 u conc ppm .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm { interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1 interval = 144. hrs, storm device = 1 pipe , type = mass-balance term</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 .00 .00 %, .00 %, duration = pipe , flow acre-ft</pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, variable = p load lbs</pre>	precip = .59 u conc ppm .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482 .0482	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1 interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.00 .00 %, .00 %, duration = pipe , flow acre-ft 1.19</pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .10 .00 adjusted = load = 12. hrs, variable = p load lbs .10</pre>	precip = .59 u conc ppm .0482 .008 .008 .008 .007 .007 .007 .007 .007	inches
<pre>interval = 144. hrs, storm i device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1 interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.0 .00 %, .00 %, duration = pipe , flow acre-ft 1.19</pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .10 adjusted = load = 12. hrs, variable = p load lbs .10 .10</pre>	precip = .59 u conc ppm .0482 .008 .008 .0032 .0032 .00322 .00322 .00322	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1 interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.00 .00 %, .00 %, duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 </pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, variable = p load lbs .10 .10</pre>	precip = .59 u conc ppm .0482 .008 .008 .0032 .0032 .0032 .0032 .0032 .00322 .00322	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1 interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface inflow 10 surface inflow</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.0 1.0 1.0 1.0 1.0 1.0 duration = pipe , flow acre-ft 1.19</pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .10 .10 adjusted = load = 12. hrs, variable = p load lbs .10 .10</pre>	precip = .59 u conc ppm .0482 .008 .008 .0032 .00322 .00322 .00322	inches
<pre>interval = 144. hrs, storm i device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1 interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total autflow</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.0 .00 %, .00 %, duration = pipe , flow acre-ft 1.19</pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .10 .10 adjusted = load = 12. hrs, variable = p load lbs .10 .10 .10</pre>	precip = .59 u conc ppm .0482 .0322 .0322 .0322	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1 interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 .00 .00 %, .00 %, duration = pipe , flow acre-ft 1.19</pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .10 .10 adjusted = load = 12. hrs, variable = p load lbs .10 .10 .10 .10</pre>	precip = .59 u .0482 .0322 .0322 .0322 .0322 .0322	inches
<pre>interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency = continuity errors: volume = number of storms = 1 interval = 144. hrs, storm device = 1 pipe , type = mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	<pre>duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.0 1.19 1.00 </pre>	<pre>12. hrs, variable = c load lbs .16 .16 .16 .16 .16 .16 .16 .10 .10 .10 .10 .10 .10 .10 .00</pre>	precip = .59 u .0482 .0322 .0322 .0322 .0322 .0322	inches

continuity errors: volume =	.00 %,	load =	.00 %		
number of storms =	L				
interval = 144. hrs, storm	duration =	12. hrs,	precip	= .59	inches
device = 1 pipe , type =	= pipe ,	variable = 2	zn		
	flow	load		conc	
mass-balance term	acre-ft	lbs		ppm	
01 watershed inflows	1.19	.73		.2269	
06 normal outlet	1.19	.73		.2269	
09 total inflow	1.19	.73		.2269	
10 surface outflow	1.19	.73		.2269	
12 total outflow	1.19	.73		.2269	
15 mass balance check	.00	.00			
<pre>load removal efficiency =</pre>	.00 %,	adjusted =	.00 %		
continuity errors: volume =	.00 %,	load =	.00 %		
number of storms =	1				
interval = 144, hrs. storm	duration =	12. hrs.	precip	= .59	inches
device = 1 pipe , type ;	= pipe .	variable = 1	hc		
	flow	load		conc	
mass-balance term	acre-ft	lbs		mqq	
01 watershed inflows	1.19	12.99		4.0243	
06 normal outlet	1.19	12.99		4.0243	
09 total inflow	1.19	12.99		4.0243	
10 surface outflow	1.19	12.99		4.0243	
12 total outflow	1.19	12.99		4.0243	
15 mass balance check	.00	.00			
<pre>load removal efficiency =</pre>	.00 %,	adjusted =	.00 %		
continuity errors: volume =	.00 %,	load =	.00 %		

case title = Street Sweeping case case data file = sweep.cas storm data file = czmnest.stm particle file = nurp50.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 number of passes through storm file = 5 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Street sweeping case one watershed one device one particle class=NURP 50% Northeast rainfall watershed = 1 watersh surface runoff device = 1 pipe percolation device = 0acres = 100.000 watershed area impervious fraction .250 = impervious depression storage inches = .020
scs curve number (pervious portion) = 60.000 sweeping frequency times/week = .250 1.000 water quality load factor - = device = 1 pipe , type = 5 pipe time of concentration = .000 hours normal outlet routed to device 0 OUT number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe , type = pipe , variable = tss flow load conc mass-balance term acre-ft lbs ppm 557.84 01 watershed inflows 1.19 172.8340 06 normal outlet 1.19 557.84 172.8340 557.84172.8340557.84172.8340557.84172.8340 09 total inflow 1.19 10 surface outflow 1.19 12 total outflow 1.19 15 mass balance check .00 .00 load removal efficiency = .00 %, adjusted = .00 % ·
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe, type = pipe, variable = tpflowloadconcmass-balance termacre-ftlbsppm01 watershed inflows1.191.61.499406 normal outlet1.191.61.4994 09 total inflow1.191.61.499410 surface outflow1.191.61.499412 total outflow1.191.61.499415 mass balance check.00.00 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe , type = pipe , variable = tkn flow load conc mass-balance term acre-ft lbs ppm 01 watershed inflows 1.19 6.97 2.1600 06 normal outlet 1.19 6.97 2.1600 09 total inflow1.196.972.160010 surface outflow1.196.972.160012 total outflow1.196.972.160015 mass balance check.00.00 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1
interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe , type = pipe , variable = cu devicei pipe, typepipe, variableoutflowloadconcmass-balance termacre-ftlbsppm01 watershed inflows1.19.16.049006 normal outlet1.19.16.0490 conc 09 total inflow1.19.16.049010 surface outflow1.19.16.049012 total outflow1.19.16.049015 mass balance check.00.00 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe , type = pipe , variable = pb mass-balance termacre-ftloadconc01 watershed inflows1.19.11.033106 normal outlet1.19.11.0331 09 total inflow1.19.11.033110 surface outflow1.19.11.033112 total outflow1.19.11.033115 mass balance check.00.00 load removal efficiency = .00 %, adjusted = .00 %

continuity errors: volume = .	00 %,	load	=	.00 %			
number of storms = 1							
interval = 144. hrs, storm dura	tion =	12. hr	(s,]	precip	=	.59	inches
device - i pipe , cype - pip	flow	variabie	≠ - 21 Load		cor		
macc-halance term	ro-ft	-	lbau			1C \m	
1 watershed inflows	1 10		105 71		230		
06 pormal outlet	1 10		- 74		.230	14	
00 Hormar Ouclec	1.19		• 7 *		.230		
09 total inflow	1.19		.74		.230)4	
10 surface outflow	1.19		.74		.230)4	
12 total outflow	1.19		.74		.230)4	
15 mass balance check	.00		.00				
<pre>load removal efficiency =</pre>	.00 %,	adjusted	=	.00 %			
continuity errors: volume =	.00 %,	load	=	.00 %			
number of storms = 1							
interval = 144. hrs, storm dura	ation =	12. hi	rs,	precip	=	.59	inches
device = 1 pipe , type = pip	pe ,	variable	e = h	С			
	flow		load		cor	nc	
mass-balance term ac	cre-ft		lbs		pp	om	
01 watershed inflows	1.19	1:	3.36		4.138	38	
06 normal outlet	1.19	1:	3.36		4.138	38	
09 total inflow	1.19	1:	3.36		4.138	38	
10 surface outflow	1.19	1:	3.36		4.138	38	
12 total outflow	1.19	1:	3.36		4.138	38	
15 mass balance check	.00		.00				
<pre>load removal efficiency =</pre>	.00 %,	adjusted	=	.00 %			
continuity errors: volume =	.00 %,	load	=	.00 %			

case title = Street Sweeping case case data file = sweep.cas storm data file = czmnest.stm particle file = nurp50.par air temp file = prov6988.tmp precipitation volume factor = 1.000 storm duration factor = 1.000 = 1.000 number of passes through storm file = 5 storm dates <yymmdd> start = 0, keep = 0, stop = 0 case notes: Street sweeping case one watershed one device one particle class=NURP 50% Northeast rainfall watershed = 1 watersh surface runoff device = 1 pipe percolation device = 0 acres = 100.000watershed area impervious fraction = .250 Impervious fraction=.250impervious depression storageinches=.020scs curve number (pervious portion)=60.000sweeping frequencytimes/week.500water quality load factor-=1.000 device = 1 pipe , type = 5 pipe time of concentration = .000 hours normal outlet routed to device 0 OUT number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches device = 1 pipe, type = pipe, variable = tssflowloadconcmass-balance termacre-ftlbsppm01 watershed inflows1.19552.26171.103506 normal outlet1.19552.26171.1035 552.26171.1035552.26171.1035 09 total inflow 1.19 552.26 552.26 10 surface outflow 1.19 1.19 12 total outflow 171.1035. .00 15 mass balance check .00 load removal efficiency = .00 %, adjusted = .00 %
continuity errors: volume = .00 %, load = .00 % number of storms = 1 interval = 144. hrs, storm duration = 12. hrs, precip = .59 inches

device = 1 pipe , type	= pipe ,	variable = tp	þ	
magg-balango torm	flow	load	conc	
01 watershed inflows	acre-10 1 19	1 60	2965	
06 normal outlet	1.19	1.60	.4965	
	2.27	2000		
09 total inflow	1.19	1.60	.4965	
10 surface outflow	1.19	1.60	.4965	
12 total outflow	1.19	1.60	.4965	
15 mass balance check	.00	.00		
load removal efficiency	= 00 %	adjusted =	00 %	
continuity errors: volume	= .00 %,	load =	.00 %	
number of storms =	1			
interval = 144. hrs, stor	m duration =	12. hrs, p	precip = .59	inches
device = 1 pipe , type	e = pipe ,	variable = t	<u>k</u> n	
waaa balanaa taaw	tlow	Load	conc	
Mass-balance term	acre-it			
Of watershed inflows	1.19	6.94	2.1488	
oo normar outret	1.19	0.94	2.1400	
09 total inflow	1.19	6.94	2.1488	
10 surface outflow	1.19	6.94	2.1488	
12 total outflow	1.19	6.94	2.1488	
15 mass balance check	.00	.00		
	00 8		00 8	
load removal efficiency	= .00 %,	adjusted =	•00 %	
continuity errors: volume	= .00 %,	1040 =	.00 %	
number of storms =	1			
<pre>number of storms = interval = 144. hrs, stor</pre>	1 rm duration =	12. hrs, }	precip = .59	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type</pre>	1 rm duration = e = pipe ,	12. hrs, 1 variable = cu	precip = .59 u	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type</pre>	1 rm duration = e = pipe , flow	12. hrs, p variable = cu load	precip = .59 u conc	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term</pre>	1 fm duration = e = pipe , flow acre-ft	12. hrs, p variable = cu load lbs	precip = .59 u conc ppm	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows</pre>	1 cm duration = e = pipe , flow acre-ft 1.19	12. hrs, p variable = cu load lbs .16	precip = .59 u conc ppm .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet</pre>	1 cm duration = e = pipe , flow acre-ft 1.19 1.19	12. hrs, p variable = cu load lbs .16 .16	precip = .59 u conc ppm .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow</pre>	1 fm duration = e = pipe , flow acre-ft 1.19 1.19	12. hrs, p variable = cu load lbs .16 .16	precip = .59 u conc ppm .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow</pre>	1 cm duration = e = pipe , flow acre-ft 1.19 1.19 1.19 1.19	12. hrs, p variable = cu load lbs .16 .16 .16	precip = .59 u conc ppm .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow</pre>	1 cm duration = e = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19	12. hrs, 1 variable = cu load lbs .16 .16 .16 .16 .16 .16	precip = .59 u conc ppm .0487 .0487 .0487 .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	1 fm duration = e = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.00	12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .16 .16 .00	precip = .59 u conc ppm .0487 .0487 .0487 .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	1 cm duration = e = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 00	12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .16 .00	precip = .59 u conc ppm .0487 .0487 .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency</pre>	1 m duration = e = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.9 1.	12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .16 .00 adjusted =	precip = .59 u conc ppm .0487 .0487 .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume</pre>	1 cm duration = e = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 .00 = .00 %, = .00 %,	12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .16 .00 adjusted = load =	precip = .59 u conc ppm .0487 .0487 .0487 .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume</pre>	1 cm duration = e = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 .00 = .00 %, = .00 %,	12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .00 adjusted = load =	precip = .59 u conc ppm .0487 .0487 .0487 .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs. stor</pre>	1 m duration = e = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.9 1.	12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .16 .00 adjusted = load =	precip = .59 u conc ppm .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type</pre>	<pre>1 m duration = pipe flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.0 1</pre>	<pre>12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, p variable = p</pre>	precip = .59 u conc ppm .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type</pre>	<pre>1 m duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.0 1.19 1.0 1.0 1.0 1.0 1.0 1.0 1.19</pre>	<pre>12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, p variable = p load</pre>	precip = .59 u conc ppm .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term</pre>	<pre>1 m duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.00 = .00 %, = .00 %, m duration = pipe , flow acre-ft</pre>	<pre>12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, p variable = p load lbs</pre>	precip = .59 u conc ppm .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487 .0487	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows</pre>	<pre>1 m duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.00 = .00 %, = .00 %, = .00 %, interpret inte</pre>	<pre>12. hrs, p variable = co load lbs .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, p variable = p load lbs .11</pre>	precip = .59 u conc ppm .0487 .00888 .00888 .00888 .00888 .00888 .00888 .00888 .00888 .008888 .008888 .008888 .00888888 .0088888888	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet</pre>	<pre>1 m duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.00 = .00 %, = .00 %, induration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 </pre>	12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, p variable = p load lbs .11 .11	precip = .59 u conc ppm .0487 .0088 .0088 .0088 .0028 .0028 .00328 .00328 .00328 .00328 .00328	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow</pre>	<pre>1 m duration = pipe , flow acre-ft 1.19 1.10 </pre>	<pre>12. hrs, } variable = ci load lbs .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, p variable = p load lbs .11 .11</pre>	precip = .59 u conc ppm .0487 .0088 .0088 .0028 .00328 .00328 .00328 .00328 .00328	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow</pre>	<pre>1 m duration = pipe , flow acre-ft 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.19 1.0 1.19</pre>	<pre>12. hrs, } variable = cu load lbs .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, p variable = pl load lbs .11 .11 .11 .11</pre>	precip = .59 u conc ppm .0487 .008 .008 .0028 .00328 .00328 .00328 .00328 .00328	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow</pre>	<pre>1 m duration = pipe , flow acre-ft 1.19</pre>	<pre>12. hrs, } variable = cu load lbs .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, p variable = p load lbs .11 .11 .11 .11 .11</pre>	precip = .59 u conc ppm .0487 .0328 .0328 .0328 .0328 .0328 .0328	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	<pre>1 m duration = pipe , flow acre-ft 1.19</pre>	<pre>12. hrs, } variable = ci load lbs .16 .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, p variable = p load lbs .11 .11 .11 .11 .11 .11 .11 .11</pre>	precip = .59 u conc ppm .0487 .0328 .0328 .0328 .0328 .0328	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check</pre>	<pre>1 m duration = pipe , flow acre-ft 1.19</pre>	<pre>12. hrs, p variable = cu load lbs .16 .16 .16 .16 .16 .16 .10 adjusted = load = 12. hrs, p variable = pl load lbs .11 .11 .11 .11 .11 .11 .11 .00</pre>	precip = .59 u conc ppm .0487 .0328 .0328 .0328 .0328	inches
<pre>number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency continuity errors: volume number of storms = interval = 144. hrs, stor device = 1 pipe , type mass-balance term 01 watershed inflows 06 normal outlet 09 total inflow 10 surface outflow 12 total outflow 15 mass balance check load removal efficiency</pre>	<pre>1 fm duration =</pre>	<pre>12. hrs, } variable = cu load lbs .16 .16 .16 .16 .16 .00 adjusted = load = 12. hrs, p variable = p load lbs .11 .11 .11 .11 .11 .00 adjusted =</pre>	precip = .59 u conc ppm .0487 .0328 .0328 .0328 .0328 .0328 .0328	inches

continuity errors: volume =	.ÒO %,	load =	.00 %		
number of storms = 1		10		50	
interval = 144. nrs, storm (uration =	12. nrs,	precip	= .59	inches
device = 1 pipe , type =	pipe ,	variable = 2	zn		
macc-balanco torm	agro-ft	IDau		CONC	
Al watershed inflows	1 10	105		2202	
06 normal outlot	1 10	./4 7/		.2292	
oo normal outlet	1.19	./4		• 2 2 9 2	
09 total inflow	1.19	.74		.2292	
10 surface outflow	1.19	.74		.2292	
12 total outflow	1.19	.74		.2292	
15 mass balance check	.00	.00			
<pre>load removal efficiency =</pre>	.00 %,	adjusted =	.00 %		
continuity errors: volume =	.00 %,	load =	.00 %		
<pre>number of storms = 1 interval = 144. hrs, storm device = 1 pipe , type =</pre>	duration = pipe ,	12. hrs, variable = 1	precip nc	= .59	inches
	flow	load		conc	
mass-balance term	acre-ft	lbs		ppm	
01 watershed inflows	1.19	13.23		4.0998	
06 normal outlet	1.19	13.23		4.0998	
09 total inflow	1,19	13 23		4.0998	
10 surface outflow	1,19	13.23		4.0998	
12 total outflow	1,19	13 23		4 0998	
15 mass balance check	.00	00			
		.00			
<pre>load removal efficiency = continuity errors: volume =</pre>	.00 %,	adjusted =	.00 %		
concinuity circlis. vorume		10uu –	.00 %		