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
One Church Street, Suite 700
Rockville, MD 20850
(301) 309-0800

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
One Church Street, Suite 700
Rockville, MD 20850
(301) 309-0800

ROADS, HIGHWAYS AND BRIDGES BMP's COST ANALYSIS

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 pre-development 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

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.

	Sheet 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

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 Analysis of Storm Event Characteristics for Selected Rainfall Gages Throughout the United States (Woodward-Clyde, 1989):

	Average Storm Duration	Average Storm Rainfall	Average Interval 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

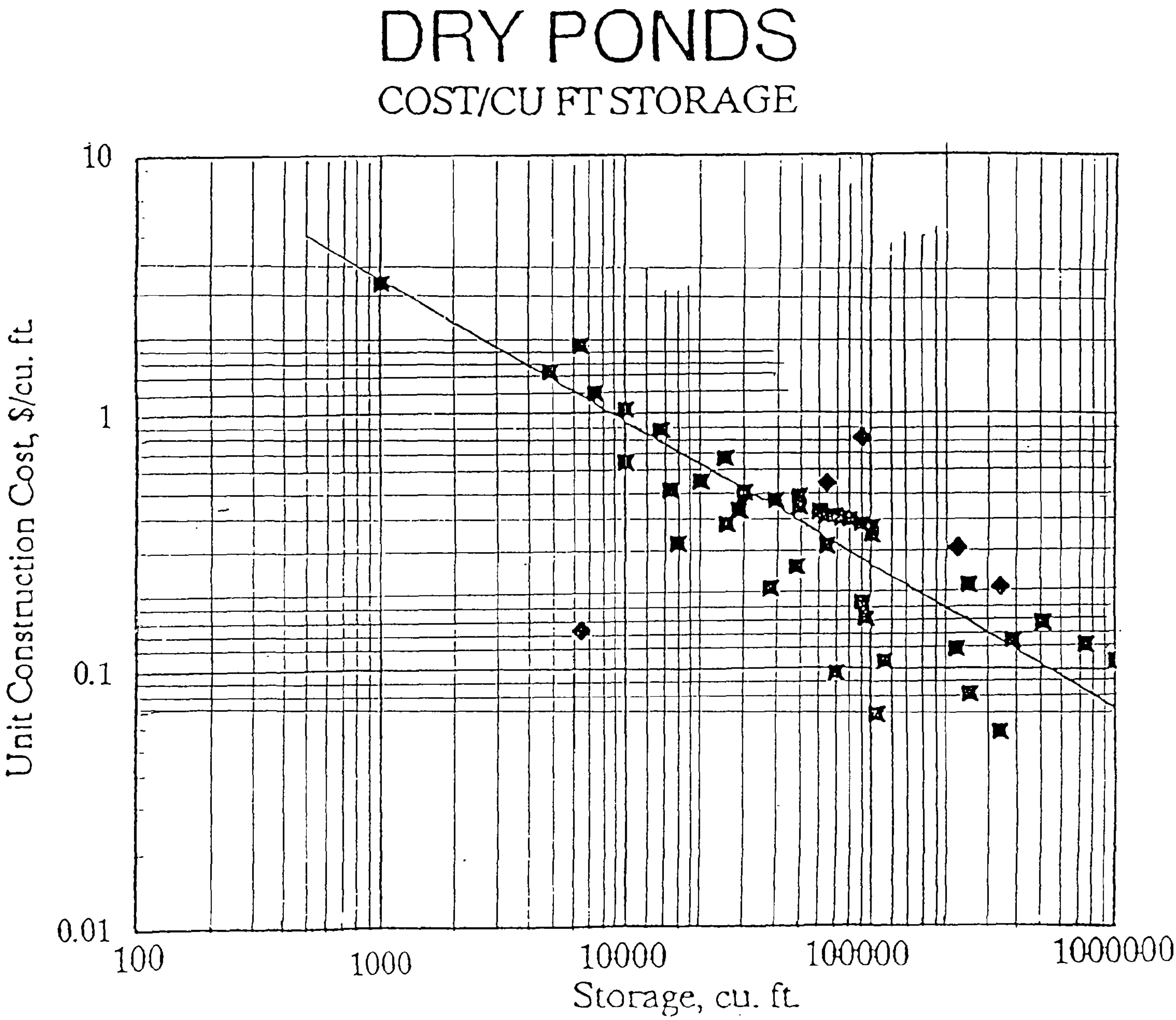
In order to distribute the rainfall over the storm duration, the SCS Type I, IA, II, and III curves were used and the rainfall was distributed over the appropriate storm duration. For example, in the GL region, 0.59 inches of rainfall was distributed over 12 hours using a Type II storm distribution.

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

C. 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.

FIGURE 1. UNIT CONSTRUCTION COSTS OF DRY PONDS



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 Rainfall:	2yr. 24 Hr. Rainfall, (in) (1)	Control of 2 yr 24 hour Peak Only							Control of 2 yr. 24 hour Peak & 80% TSS Removal						
	Type I Type IA Type II Type III	SW, i=2.5 NW, i=3.0 GL, i=3.0 SE, i=4.5	Control Volume (ac-ft) (2)	Unit Cost ($/cf) (3)	Construction Cost	Planning & Design Cost (4)	Total Cost	Area Lost (acres) (5)	Maint. Cost ($/yr) (6)	Control Vol. (ac-ft) (2)	Unit Cost ($/cf) (3)	Construction Cost	Planning & Design Cost (4)	Total Cost	Area Lost (acres) (5)	Maint. Cost ($/yr) (7)
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 III	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	Type I	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

(1) 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 24-hour rainfall distributions (I, IA, II, III) from available National Weather Service duration-frequency 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 Analysis of Storm Event Characteristics for Selected Rainfall Gages Throughout the United States (Woodward-Clyde, 1989):

	Average Storm Duration	Average Storm Rainfall	Average Interval 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 hour Peak Only							Control of 2 yr. 24 hour Peak & 80% TSS Removal						
	Type I Type IA Type II Type III	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 ($/cf) (3)	Construction Cost of Dry Pond	Planning & Design Cost (4)	Total Cost	Area Lost (acres) (5)	Maint. Cost ($/yr) (6)	Control Vol. (ac-ft) (2)	Unit Cost ($/cf) (3)	Construction Cost of Dry Pond	Planning & Design Cost (4)	Total Cost	Area Lost (acres) (5)	Maint. Cost ($/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
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 of Pipe and Dry Pond
(5) Control Volume/Avg. Depth of 3.5

(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	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

EROSION AND SEDIMENT CONTROL COST SCENARIO'S

SCEN NO	SITE SIZE (ACRES)	TREAT STND (80%)	TOPO (3 OR 15%)	SOIL ERODIB (K= 0.2)	RAINFALL INDEX (I = 150 OR 400)	LS FACTOR (500 FT LENGTH)	UNCONT. EROSION (C = 1) (TONS/YR)	ERO CONT C FACT	SED CONT P FACT	EROSION WT BMPs (TONS/YR)	ERO CNTL COST	SED CNTL COST	PLN & DSN COST	TOTAL COST	MAINT COST ($/YR)	DSN LIFE OF BMPs (YRS)
1	0.5	80	15	0.2	150	5.78	87	0.495	0.3	13	$850	$350	$180	$1,380	$170	1
2	5	80	3	0.2	150	0.68	102	0.585	0.12	7	$3,000	$9,000	$1,800	$13,800	$1,700	1
3	0.5	80	15	0.2	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).

DERIVATION OF C VALUE FOR SCENARIO # 1						
ITEM	AREA AFFECT. BY ITEM (ACRES)	RAIN QUARTER	EROS INDEX IN PERIOD (1)	SOIL LOSS RATIO (2)	COLUMN (1)*(2)	C FACTOR
BARE	0 5	1	0 05	1	0 05	0 05
BARE	0 5	2	0 3	1	0 3	0.3
SD/MULC	0 5	3	0 45	0.3	0 135	0 135
NEW VEG	0 5	4	0 2	0 05	0 01	0 01
					0	0
					0	0
					0	0
					0	0
					0	0
					0	0
					0	0
					0	0
					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

ITEM	AREA AFFECT BY ITEM (ACRES)	RAIN QUARTER	EROS. INDEX IN PERIOD (1)	SOIL LOSS RATIO (2)	COLUMN (1)*(2)	C FACTOR
BARE	5	1	0 05	1	0 05	0 05
BARE	5	2	0 3	1	0 3	0 3
SEED	5	3	0 45	0 5	0.225	0.225
NEW VEG	5	4	0.2	0 05	0 01	0.01
					0	0
					0	0
					0	0
					0	0
					0	0
					0	0
					0	0
					0	0
					0	0
TOTAL						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.

DERIVATION OF C VALUE FOR SCENARIO # 3						
ITEM	AREA AFFECT BY ITEM (ACRES)	RAIN QUARTER	EROS. INDEX IN PERIOD (1)	SOIL LOSS RATIO (2)	COLUMN (1)*(2)	C FACTOR
BARE	0.5	1	0.15	1	0.15	0.15
BARE	0.5	2	0.35	1	0.35	0.35
SD/MULC	0.5	3	0.4	0.4	0.16	0.16
NEW VEG	0.5	4	0.1	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.

DERIVATION OF C VALUE FOR SCENARIO # 4

ITEM	AREA AFFECT BY ITEM (ACRES)	RAIN QUARTER	EROS INDEXIN PERIOD (1)	SOIL LOSS RATIO (2)	COLUMN (1)*(2)	C FACTOR
BARE	5	1	0.15	1	0 15	0 15
BARE	5	2	0 35	1	0.35	0 35
SEED	5	3	0 4	0 5	0 2	0 2
NEW VEG	5	4	0 1	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						0 705

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 SWEEPING COST SCENARIO'S										
SCEN. NO.	FREQ.	RAIN. ZONE	TSS	TP	TKN	ZN	HC	CURB MILE	COST	TOTAL COST
	(SWEEPS /MON.)	(NE OR SW)	(% REM.)	(% REM.)	(% REM.)	(% REM.)	(% REM.)	(MILES)	($/MILE)	($/YR)
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

Means, 1991, Building and Construction Cost Data.

Palmstrom, N. and W. Walker. 1990. P8 Urban (attachment Model: User's Manual and Program Documentation. Prepared for the Narragansett Bay Project, U.S. EPA. #NBP-90-50.

Salt Institute. 1987. The Salt Storage Handbook.

Soil Conservation Service. 1986. Urban Hydrology for Small Watersheds. Technical Release 55.

Woodward-Clyde. 1992. "Urban BMPs Cost and Effectiveness summary data for 6217 (q) Guidance - Roads, Highways, and Bridges," Prepared for the U.S. EPA.

Woodward-Clyde. 1992. "Urban BMPs Cost and Effectiveness summary Data for 6217 (q) Guidance - Post - Construction Stormwater Runoff Treatment," prepared for the U.S. EPA.

Woodward-Clyde. 1989. Analysis of Storm Event Characteristics for Selected Rainfall Gages Throughout the United states. Prepared for the U.S. EPA.

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
mass-balance term                acre-ft          lbs           ppm
01 watershed inflows                1.99       807.32      149.2786
06 normal outlet                    1.99       161.56       29.8701
08 sedimen + decay                   .00       645.76         .0000

09 total inflow                     1.99       807.32      149.2786
10 surface outflow                  1.99       161.56       29.8701
12 total outflow                    1.99       161.56       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

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
water quality load factor             -     =     1.000



device =  1  dry pond,   type   =  1  pond

bottom elevation             feet    =      .000
bottom area                  acres   =      .705
```

permanent pool area	acres	=	.000
permanent pool volume	ac-ft	=	.000
perm. pool infiltration rate	in/hr	=	.000000
flood pool area	acres	=	.941
flood pool volume	ac-ft	=	3.292
flood pool infiltration rate	in/hr	=	.000000
flood pool drain time	hours	=	48.000
outlet orifice diameter	inches	=	.000
orifice discharge coefficient		=	.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 factor		=	1.000

exfiltrate routed to device	0	OUT
normal outlet routed to device	0	OUT
spillway outlet routed to device	0	OUT

Coastal Zone Study(SE)

watershed areas contributing surface runoff to each device

	total	impervious		dead-storage		zmean	total-storage		zmea
device	acres	acres	%	acres	ac-ft	feet	acres	ac-ft	feet
1 dry pond	50.00	31.50	63.0	.71	.00	.00	.94	3.29	3.5
24 OVERALL	50.00	31.50	63.0	.71	.00	.00	.94	3.29	3.5

normalized device areas and volumes

	------- dead-storage -------				total-storage		flood-storage
	ab/ai	vb/ai	ab/at	vb/at	ab/at	vb/at	vb/at
device	%	inches	%	inches	%	inches	inches
1 dry pond	2.24	.00	1.41	.00	1.88	.79	.79
25 OVERALL	2.24	.00	1.41	.00	1.88	.79	.79

```
number of storms =           1
interval =   476. hrs, storm duration =    12. hrs,  precip =    .54 inches
device =  1 dry pond,  type = pond     ,  variable = tss
                                    flow            load            conc
mass-balance term                 acre-ft            lbs             ppm
01 watershed inflows                 1.37         597.89        160.8434
06 normal outlet                     1.37         119.52         32.1495
08 sedimen + decay                    .00         478.37           .0000

09 total inflow                      1.37         597.89        160.8434
10 surface outflow                   1.37         119.52         32.1495
12 total outflow                     1.37         119.52         32.1495
13 total trapped                      .00         478.37
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   maximum     wet
               elev    elev    elev    inflow   outflow  velocity  period
device           ft      ft      ft       cfs       cfs    ft/sec       %
 1 dry pond     .00     .00    1.88      3.94       .75       .00    12.4
case title      = Coastal Zone Study(SW)
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
water quality load factor                =     1.000
```

device = 1 dry pond, type = 1 pond

bottom elevation	feet	=	.000
bottom area	acres	=	.454
permanent pool area	acres	=	.000
permanent pool volume	ac-ft	=	.000
perm. pool infiltration rate	in/hr	=	.000000
flood pool area	acres	=	.605
flood pool volume	ac-ft	=	2.119
flood pool infiltration rate	in/hr	=	.000000
flood pool drain time	hours	=	48.000
outlet orifice diameter	inches	=	.000
orifice discharge coefficient		=	.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 factor		=	1.000

exfiltrate routed to device	0	OUT
normal outlet routed to device	0	OUT
spillway outlet routed to device	0	OUT

Coastal Zone Study(SW)
watershed areas contributing surface runoff to each device

device	total acres	impervious acres	%	dead-storage acres	ac-ft	zmean feet	total-storage acres	ac-ft	zmean fe
1 dry pond	50.00	31.50	63.0	.45	.00	.00	.61	2.12	3.
24 OVERALL	50.00	31.50	63.0	.45	.00	.00	.61	2.12	3.50

normalized device areas and volumes

	------- dead-storage -------				total-storage		flood-storage
	ab/ai	vb/ai	ab/at	vb/at	ab/at	vb/at	vb/at
device	%	inches	%	inches	%	inches	inches
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
01 watershed inflows              1.37        378.05      101.8991
06 normal outlet                  1.37         75.57       20.3666
08 sedimen + decay                 .00        302.49         .0000

09 total inflow                   1.37        378.05      101.8991
10 surface outflow                1.37         75.57       20.3666
12 total outflow                  1.37         75.57       20.3666
13 total trapped                   .00        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   maximum     wet
               elev    elev    elev    inflow   outflow  velocity  period
device           ft      ft      ft       cfs       cfs    ft/sec       %
 1 dry pond     .00     .00    1.85      3.43       .65       .00    52.0
case title      = Coastal Zone Study(NW)
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    =  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
water quality load factor          -      =     1.000
```

device = 1 dry pond, type = 1 pond

bottom elevation	feet	=	.000
bottom area	acres	=	.403
permanent pool area	acres	=	.000
permanent pool volume	ac-ft	=	.000
perm. pool infiltration rate	in/hr	=	.000000
flood pool area	acres	=	.537
flood pool volume	ac-ft	=	1.880
flood pool infiltration rate	in/hr	=	.000000
flood pool drain time	hours	=	48.000
outlet orifice diameter	inches	=	.000
orifice discharge coefficient		=	.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 factor		=	1.000

exfiltrate routed to device	0	OUT
normal outlet routed to device	0	OUT
spillway outlet routed to device	0	OUT

Coastal Zone Study(NW)

watershed areas contributing surface runoff to each device

device	total acres	impervious acres	impervious %	dead-storage acres	dead-storage ac-ft	zmean feet	total-storage acres	total-storage ac-ft	zmean fee
1 dry pond	50.00	31.50	63.0	.40	.00	.00	.54	1.88	3.5
24 OVERALL	50.00	31.50	63.0	.40	.00	.00	.54	1.88	3.50

normalized device areas and volumes

	------- dead-storage -------				total-storage		flood-storage
device	ab/ai %	vb/ai inches	ab/at %	vb/at inches	ab/at %	vb/at inches	vb/at inches
1 dry pond	1.28	.00	.81	.00	1.07	.45	.45
25 OVERALL	1.28	.00	.81	.00	1.07	.45	.45

```
number of storms =           1
interval =   144. hrs, storm duration =    12. hrs,  precip =    .59 inches
device =  1 dry pond,  type = pond     ,  variable = tss
                                     flow          load          conc
mass-balance term                  acre-ft          lbs           ppm
01 watershed inflows                  1.50        709.02      174.3422
06 normal outlet                      1.50        141.71       34.8415
08 sedimen + decay                     .00        567.31         .0000

09 total inflow                       1.50        709.02      174.3422
10 surface outflow                    1.50        141.71       34.8415
12 total outflow                      1.50        141.71       34.8415
13 total trapped                       .00        567.31
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   maximum     wet
               elev    elev    elev    inflow   outflow  velocity  period
device           ft      ft      ft       cfs       cfs    ft/sec       %
 1 dry pond     .00     .00    1.93      6.54       .91       .00    40.3
case title      = Coastal Zone Study(NE)
case data file  = nehi50d.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
         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
water quality load factor           -       =     1.000
```

device = 1 dry pond, type = 1 pond

bottom elevation	feet	=	.000
bottom area	acres	=	.540
permanent pool area	acres	=	.000
permanent pool volume	ac-ft	=	.000
perm. pool infiltration rate	in/hr	=	.000000
flood pool area	acres	=	.719
flood pool volume	ac-ft	=	2.518
flood pool infiltration rate	in/hr	=	.000000
flood pool drain time	hours	=	48.000
outlet orifice diameter	inches	=	.000
orifice discharge coefficient		=	.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 factor		=	1.000

exfiltrate routed to device	0	OUT
normal outlet routed to device	0	OUT
spillway outlet routed to device	0	OUT

Coastal Zone Study(NE)
watershed areas contributing surface runoff to each device

device	total acres	impervious acres	%	dead-storage acres	ac-ft	zmean feet	total-storage acres	ac-ft	zmean fe
1 dry pond	50.00	31.50	63.0	.54	.00	.00	.72	2.52	3.5
24 OVERALL	50.00	31.50	63.0	.54	.00	.00	.72	2.52	3.50

normalized device areas and volumes

	------- dead-storage -------				total-storage		flood-storage
	ab/ai	vb/ai	ab/at	vb/at	ab/at	vb/at	vb/at
device	%	inches	%	inches	%	inches	inches
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 BJD Date 5/8/92

Location Southwest Checked ____ Date ____

Circle one: Present Developed

Circle one: T_c T_t through subarea

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.

		EXIST		DEVELOPED	
Sheet flow (Applicable to T_c only)	Segment ID				
1. Surface description (table 3-1)		Lightly Wooded		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	2.5		2.5	
5. Land slope, s	ft/ft	.03		0.03	
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr	0.83	+	0.02	=
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. $T_t = \frac{L}{3600\ V}$ 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, $r = \frac{a}{p_w}$ 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. Flow length, L	ft				
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+		=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr				

$T_{c\,EXIST} = 0.95$ hr

$T_{c\,DEV} = 0.12$ hr

Worksheet 4: Graphical Peak Discharge method

Project Highway Interchange By BJD Date 5/8/92

Location Southwest Checked ____ Date ____

Circle one: Present Developed ____________

1. Data: EXISTING | DEVELOPED

Drainage area .... A_{m_E} = 0.078 mi^2 (acres/640) A_{m_D} = .078 mi^2

Runoff curve number .... CN_E = 60 (From worksheet 2) CN_D = 98

Time of concentration .. T_{c_E} = 0.95 hr (From worksheet 3) T_{c_D} = 0.12 hr

Rainfall distribution type = I (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = ∅ percent of A_m (∅ acres or mi^2 covered)

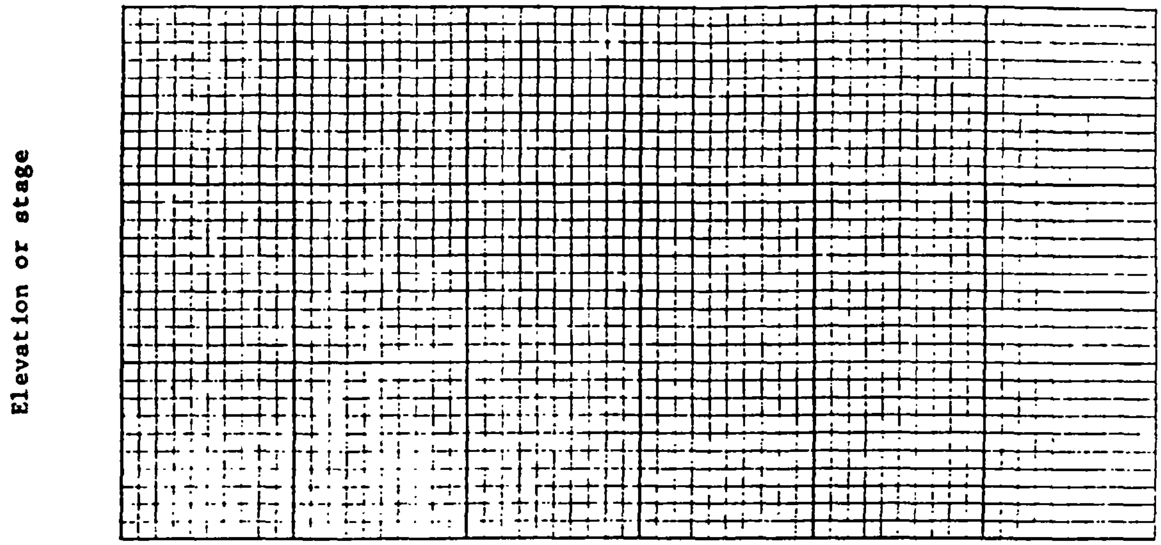
		EXISTING ~~Storm #1~~	~~Storm #2~~	DEVELOPED ~~Storm #3~~
2. Frequency	yr	2-yr		2-yr
3. Rainfall, P (24-hour)	in	2.5		2.5
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	1.33		.041
5. Compute I_a/P		0.53		0.02
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-I)	csm/in	48		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 $q_p = q_u A_m Q F_p$)	cfs	0.64		83.22

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

Project ______________________ By _____ Date ________

Location ______________________ Checked _____ Date ________

Circle one: Present Developed ______________________



Detention basin storage

1. Data:
   Drainage area .... A_m = .078 mi^2
   Rainfall distribution type (I, IA, II, III) = I

	1st stage	2nd stage
2. Frequency ...... yr	2-yr	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	83.22	
4. Peak outflow discharge, q_o .... cfs [1/]	0.64	
5. Compute $\frac{q_o}{q_i}$	.01	
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	.57	
7. Runoff, Q ...... in (From worksheet 2)	2.27	
8. Runoff volume, V_r .... ac-ft (V_r = QA_m53.33)	9.4	
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	5.4	
10. Maximum stage, E_{max} (From plot)		

1/ 2nd stage q_o includes 1st stage q_o.

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_c T_t through subarea

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.

		EXISTING	DEVELOPED	
Sheet flow (Applicable to T_c only)	Segment ID			
1. Surface description (table 3-1)		Lightly Wooded	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 =	$\cancel{}$
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. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.12 +	0.10 =	$\cancel{}$
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	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. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	+	=	$\cancel{}$
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			$\cancel{}$

$T_{c\ EXIS} = 0.88$ hr.

$T_{c\ DEV} = 0.12$ hr.

Worksheet 4: Graphical Peak Discharge method

Project Highway Interchange By BJD Date 5/8/92

Location Great Lakes Checked ____ Date ____

Circle one: Present Developed

1. Data: EXISTING / DEVELOPED

Drainage area .... A_m = 0.078 mi^2 (acres/640) A_m = 0.078 mi^2

Runoff curve number .... CN = 60 (From worksheet 2) CN = 98

Time of concentration .. T_c = 0.88 hr (From worksheet 3) T_c = 0.12 hr

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = ∅ percent of A_m (∅ acres or mi^2 covered)

		EXISTING ~~Storm #1~~	~~Storm #2~~	DEVELOPED ~~Storm #3~~
2. Frequency	yr	2		2
3. Rainfall, P (24-hour)	in	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		0.443		0.014
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II)	csm/in	220		950
7. Runoff, Q .... (From worksheet 2).	in	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 $q_p = q_u A_m Q F_p$)	cfs	5.66		205.3

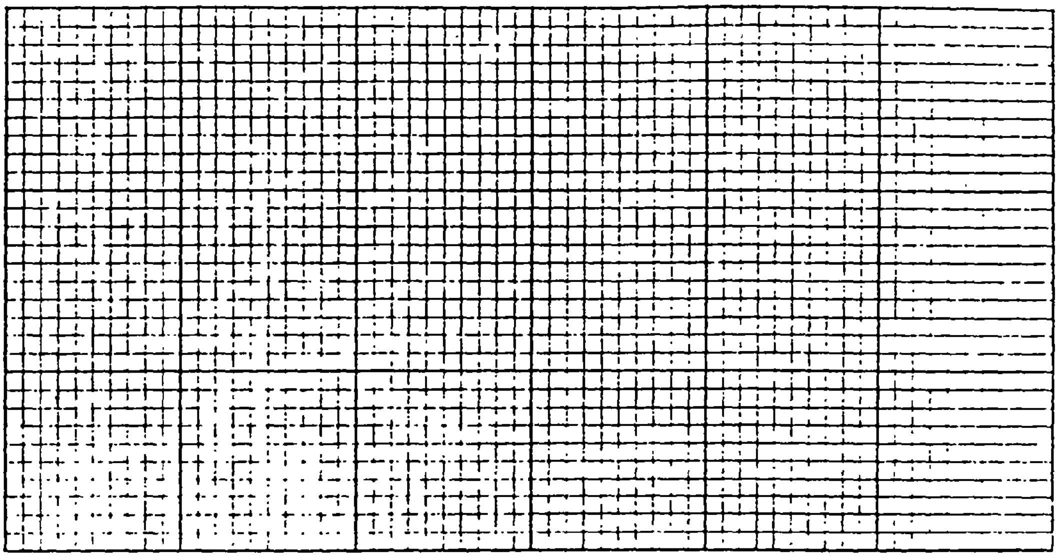
Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project Highway Interchange By BJD Date 5/8/92

Location Great Lakes Checked ____ Date ____

Circle one: Present Developed ________________

Elevation or stage



Detention basin storage

1. Data:
   Drainage area .... A_m = .078 mi^2
   Rainfall distribution type (I, IA, II, III) = II

	1st stage	2nd stage
2. Frequency ...... yr	2-yr	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	205.3	
4. Peak outflow discharge, q_o .... cfs 1/	5.66	
5. Compute $\frac{q_o}{q_i}$	0.03	
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	0.6	
7. Runoff, Q ...... in (From worksheet 2)	2.77	
8. Runoff volume, V_r .... ac-ft ($V_r = QA_m53.33$)	11.5	
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	6.9	
10. Maximum stage, E_{max} (From plot)		

1/ 2nd stage q_o includes 1st stage q_o.

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

Project: Highway Interchange By: BJD Date: 5/8/92

Location: Southeast Checked: ____ Date: ____

Circle one: Present Developed

Circle one: T_c T_t through subarea

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.

			EXISTING	DEVELOPED	
Sheet flow (Applicable to T_c only)	Segment ID				
1. Surface description (table 3-1)			Lightly wooded	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	=
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. $T_t = \frac{L}{3600\ V}$	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, $r = \frac{a}{p_w}$	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. Flow length, L		ft			
19. $T_t = \frac{L}{3600\ V}$	Compute T_t	hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)		hr			

$T_{c\ EXG} = 0.74$ hr

$T_{c\ DEV} \approx 0.11$ hr

Worksheet 4: Graphical Peak Discharge method

Project Highway Interchange By BJD Date 5/8/92

Location Southeast Checked ____ Date ____

Circle one: Present Developed ____________

1. Data:

	EXISTING		DEVELOPED
Drainage area .... A_m =	0.078	mi^2 (acres/640)	Am_D = .078 mi^2
Runoff curve number .... CN =	60	(From worksheet 2)	CN_D = 98
Time of concentration .. T_c =	0.74	hr (From worksheet 3)	Tc_D = 0.11 hr
Rainfall distribution type =	III	(I, IA, II, III)	
Pond and swamp areas spread throughout watershed ...... =	∅	percent of A_m (∅ acres or mi^2 covered)	

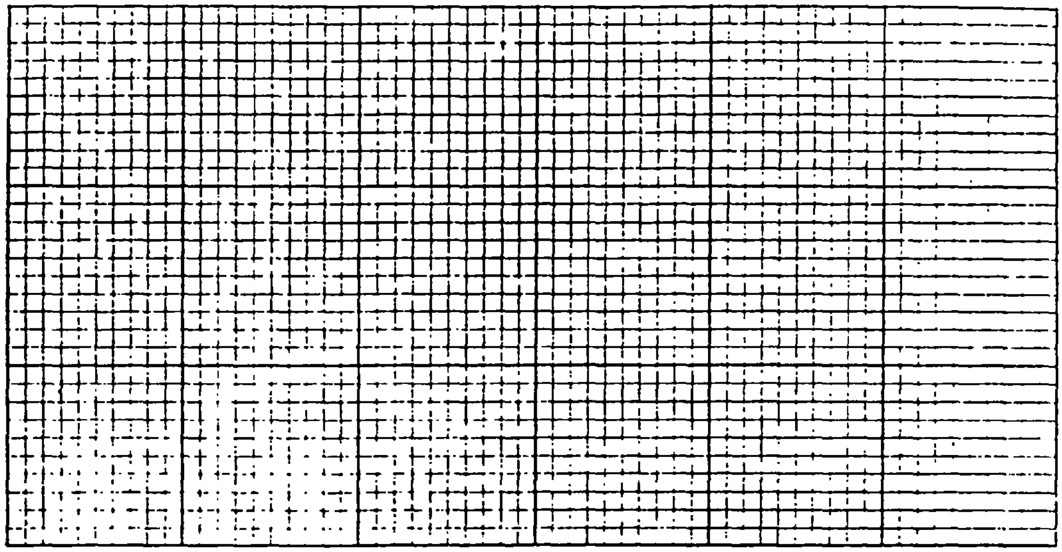
		EXISTING ~~Storm #1~~	~~Storm #2~~	DEVELOPED ~~Storm #3~~
2. Frequency	yr	2		2
3. Rainfall, P (24-hour)	in	4.5		4.5
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	1.33		0.041
5. Compute I_a/P		0.30		0.01
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-III)	csm/in	290		650
7. Runoff, Q .... (From worksheet 2).	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		1.0
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	23.1		216.0

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

Project Highway Interchange By BJD Date 5/8/92

Location Southeast Checked ____ Date ____

Circle one: Present Developed ____________



1. Data:
   Drainage area .... A_m = .078 mi^2
   Rainfall distribution type (I, IA, II, III) = III

	1st stage	2nd stage
2. Frequency ...... yr	2	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	216.0	
4. Peak outflow discharge, q_o .... cfs	23.1	1/
5. Compute $\frac{q_o}{q_i}$	0.11	

6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	0.54	
7. Runoff, Q ...... in (From worksheet 2)	4.26	
8. Runoff volume, V_r .... ac-ft ($V_r = QA_m53.33$)	17.7	
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	9.6	
10. Maximum stage, E_{max} (From plot)		

1/ 2nd stage q_o includes 1st stage q_o.

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

Project Highway Interchange By BJD Date 5/8/92

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 type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

			EXIST.		DEVELOPED	
Sheet flow (Applicable to T_c only)	Segment ID					
1. Surface description (table 3-1)			Lightly Wooded		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. $T_t = \frac{L}{3600\ V}$	Compute T_t	hr	0.09	+	0.08	=
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		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. $T_t = \frac{L}{3600\ V}$	Compute T_t	hr		+		=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)		hr				

$T_{c_{EX}}$ = 0.71 hr

$T_{c_{DEV}}$ = .09 hr ≅ 0.10 hr

Worksheet 4: Graphical Peak Discharge method

Project Highway Interchange By BJD Date 5/8/92

Location Northwest Checked ____ Date ____

Circle one: Present Developed

1. Data: EXISTING DEVELOPED

Drainage area .... A_m = 0.078 mi^2 (acres/640) A_{m_D} = 0.078 mi^2

Runoff curve number .... CN = 60 (From worksheet 2) CN_D = 98

Time of concentration .. T_c = 0.71 hr (From worksheet 3) T_{c_D} = 0.10 hr

Rainfall distribution type = IA (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = Ø percent of A_m (Ø acres or mi^2 covered)

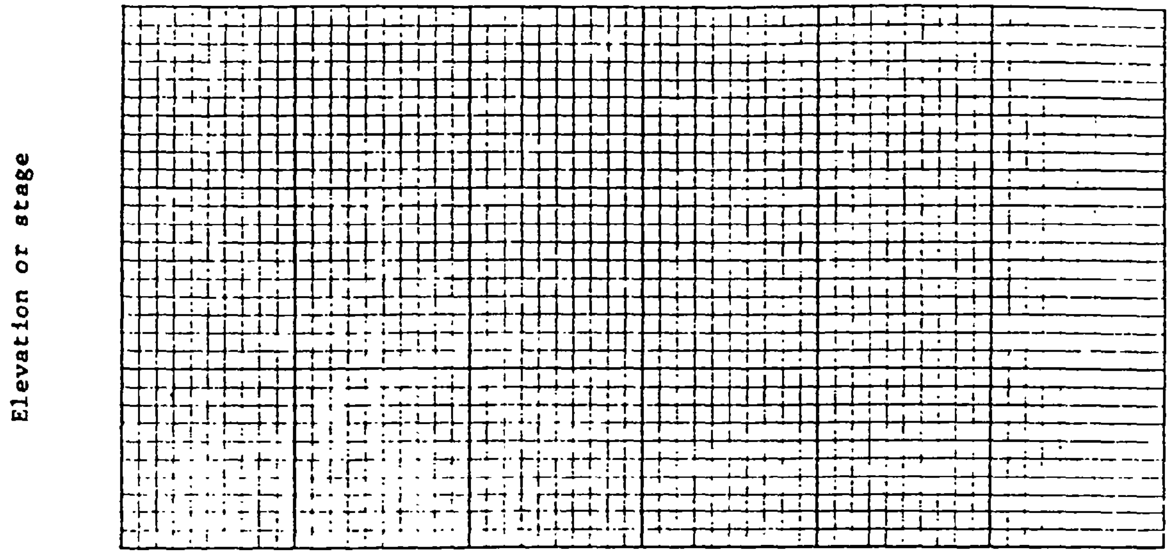
		EXISTING ~~Storm #1~~	~~Storm #2~~	DEVELOPED ~~Storm #3~~
2. Frequency	yr	2-yr		2-yr
3. Rainfall, P (24-hour)	in	3.0		3.0
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	1.33		0.041
5. Compute I_a/P		0.443		0.014
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-IA)	csm/in	47		165
7. Runoff, Q .... (From worksheet 2).	in	.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 $q_p = q_u A_m Q F_p$)	cfs	1.21		35.65

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

Project Highway Interchange By BTD Date 5/8/92

Location Northwest Checked ____ Date ____

Circle one: Present Developed ____



Detention basin storage

1. Data:
   Drainage area .... A_m = .078 mi^2
   Rainfall distribution type (I, IA, II, III) = IA

	1st stage	2nd stage
2. Frequency ...... yr	2	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	35.65	
4. Peak outflow discharge, q_o .... cfs	1.21	1/
5. Compute $\frac{q_o}{q_i}$	.03	
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	.55	
7. Runoff, Q ...... in (From worksheet 2)	2.77	
8. Runoff volume, V_r .... ac-ft ($V_r = QA_m 53.33$)	11.5	
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	6.3	
10. Maximum stage, E_{max} (From plot)		

1/ 2nd stage q_o includes 1st stage q_o.

APPENDIX B

Bridge Stormwater Treatment Design and Computer Simulation Results

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 type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

		Existing	Developed	
Sheet flow (Applicable to T_c only)	Segment ID			
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, s	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 =	$\boxtimes$
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. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.11 +	0.13 =	$\boxtimes$
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	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. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	+	=	$\boxtimes$
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			$\boxtimes$

$T_{c_{EXIT.}}$ = 0.66 hr.

$T_{c_{DEV.}}$ = 0.15 hr.

Worksheet 4: Graphical Peak Discharge method

Project Bridge Construction By BJD Date 5/4/92

Location Great Lakes Checked ____ Date ____

Circle one: Present Developed ____________________

1. Data: EXISTING DEVELOPED

   Drainage area .... A_{m_E} = 0.0052 mi^2 (acres/640) $A_{M_{DEV}}$ = .0052 mi^2

   Runoff curve number .... CN_E = 60 (From worksheet 2) CN_{DEV} = 89

   Time of concentration .. T_{c_E} = 0.66 hr (From worksheet 3) $T_{c_{DEV}}$ = 0.15 hr.

   Rainfall distribution type = II (I, IA, II, III)

   Pond and swamp areas spread throughout watershed ...... = ____ percent of A_m (____ acres or mi^2 covered)

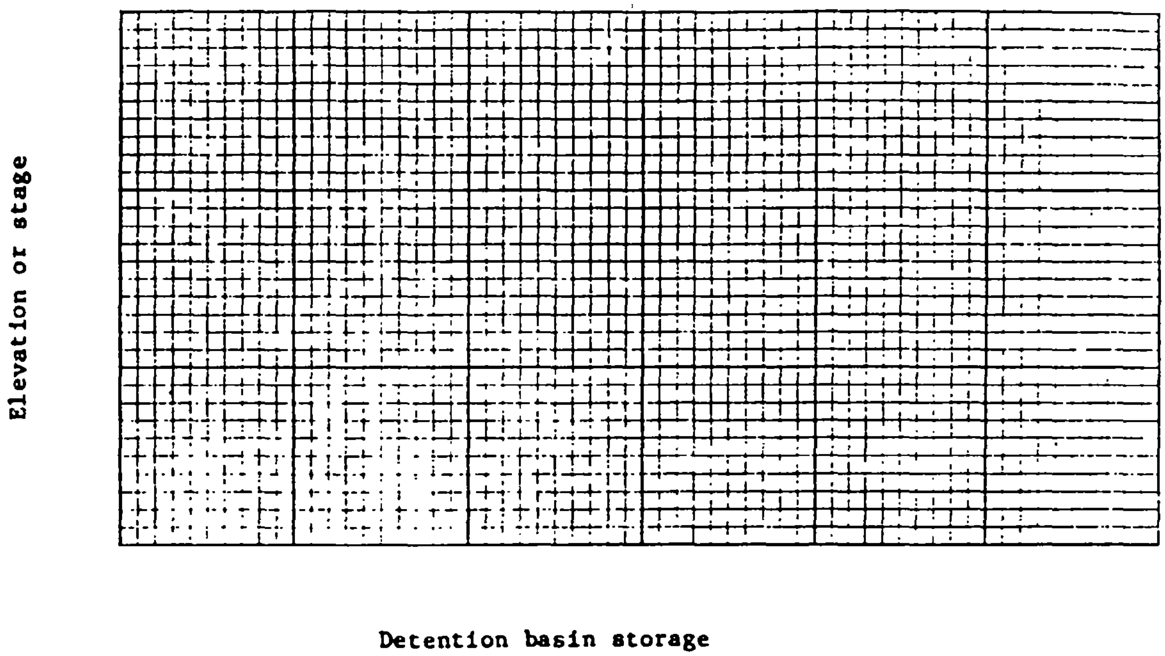
		Present ~~Storm #1~~	~~Storm #2~~	Developed ~~Storm #3~~
2. Frequency	yr	2		2
3. Rainfall, P (24-hour)	in	3.0		3.0
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	1.33		0.247
5. Compute I_a/P		0.443		0.082
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II)	csm/in	260		920
7. Runoff, Q .... (From worksheet 2).	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 $q_p = q_u A_m Q F_p$)	cfs	0.45		9.10

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

Project Bridge Construction By BJD Date 5/4/92

Location Great Lakes Checked ____ Date ____

Circle one: Present Developed ________________



1. Data:
   Drainage area .... A_m = .0052 mi^2 3.3 acres =
   Rainfall distribution type (I, IA, II, III) = II

	1st stage	2nd stage
2. Frequency ...... yr	2-yr	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	9.10	
4. Peak outflow discharge, q_o .... cfs [1/]	0.45	
5. Compute $\frac{q_o}{q_i}$	.05	
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	0.6	
7. Runoff, Q ...... in (From worksheet 2)	1.9	
8. Runoff volume, V_r .... ac-ft ($V_r = QA_m 53.33$)	0.53	
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$)	0.32	
10. Maximum stage, E_{max} (From plot)		

Sized for 1/2 of bridge

1/ 2nd stage q_o includes 1st stage q_o.

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

Project Bridge Construction By BJD Date 5/5/92

Location Southwest Checked ____ Date ____

Circle one: Present Developed

Circle one: T_c ~~T_t through~~ subarea

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.

			EXISTING	DEVELOPED	
Sheet flow (Applicable to T_c only)	Segment ID				
1. Surface description (table 3-1)			Light Underbrush	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	
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$	Compute T_t	hr	0.60 +	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. $T_t = \frac{L}{3600\ V}$	Compute T_t	hr	0.11 +	0.13	= ~~ ~~
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		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. $T_t = \frac{L}{3600\ V}$	Compute T_t	hr	+		=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)		hr			

$T_{c\,EXIS} = 0.71$ hr
$T_{c\,DEV} = 0.15$ hr

Worksheet 4: Graphical Peak Discharge method

Project Bridge Construction By BJD Date 5/5/92

Location Southwest Checked ______ Date ______

Circle one: Present Developed ____________________

1. Data: EXISTING DEVELOPED

Drainage area .... A_{m_E} = .0052 mi² (acres/640) A_{m_D} = .0052

Runoff curve number .... CN_E = 60 (From worksheet 2) CN_D = 89

Time of concentration .. T_{c_E} = 0.71 hr (From worksheet 3) T_{c_D} = 0.15 hr.

Rainfall distribution type = I (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = ∅ percent of A_m (∅ acres or mi² covered)

		EXISTING ~~Storm #1~~	~~Storm #2~~	DEVELOPED ~~Storm #3~~
2. Frequency	yr	2-yr		2-yr
3. Rainfall, P (24-hour)	in	2.5		2.5
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	in	1.33		.247
5. Compute I_a/P		0.53		0.10
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-I)	csm/in	49		450
7. Runoff, Q .... (From worksheet 2).	in	.17		1.46
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 $q_p = q_u A_m Q F_p$)	cfs	0.04		3.41

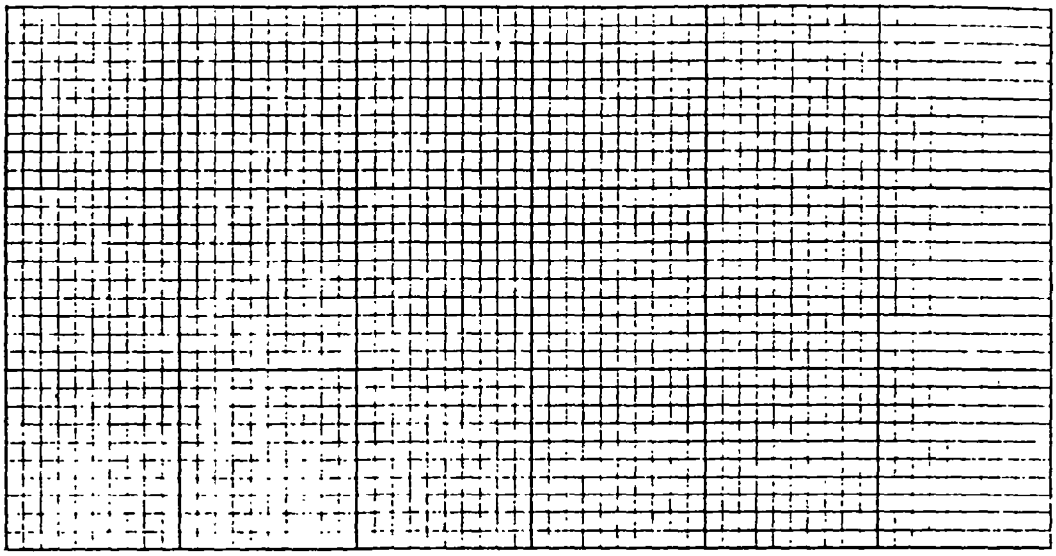
Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project Bridge Construction By BJD Date 5/5/92

Location Southwest Checked ____ Date ____

Circle one: Present Developed ____________

Elevation or stage



Detention basin storage

1. Data:
   Drainage area .... A_m = .0052 mi^2
   Rainfall distribution type (I, IA, II, III) = I

	1st stage	2nd stage
2. Frequency ...... yr	2	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	3.41	
4. Peak outflow discharge, q_o .... cfs 1/	0.04	
5. Compute $\frac{q_o}{q_i}$	.01	
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	.6	
7. Runoff, Q ...... in (From worksheet 2)	1.46	
8. Runoff volume, V_r .... ac-ft (V_r = QA_m53.33)	0.40	
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$) V sized for 1/2 of bridge runoff	0.24	
10. Maximum stage, E_{max} (From plot)		

1/ 2nd stage q_o includes 1st stage q_o.

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

Project Bridge Construction By BJD Date 5/5/92

Location Southeast Checked ____ Date ____

Circle one: Present Developed

Circle one: T_c T_t through subarea

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.

Sheet flow (Applicable to T_c only)

	Unit	Existing	Developed	
Segment ID				
1. Surface description (table 3-1)		Light Underbrush	Smooth	
2. Manning's roughness coeff., n (table 3-1)		0.4	.011	
3. Flow length, L (total L $\leq$ 300 ft)	ft	200	100	
4. Two-yr 24-hr rainfall, P_2	in	4.5	4.5	
5. Land slope, s	ft/ft	.03	.03	
6. $T_t = \frac{0.007\,(nL)^{0.8}}{P_2^{0.5}\,s^{0.4}}$ Compute T_t	hr	0.45	+ .01	= ~~ ~~

Shallow concentrated flow

	Unit	Existing	Developed	
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. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.11	+ 0.13	=

Channel flow

	Unit	Existing	Developed	
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	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. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr

$\boxed{T_{c\,EX} = 0.56\ hr \quad T_{c\,DEV} = 0.14\ hr}$

Worksheet 4: Graphical Peak Discharge method

Project Bridge Construction By BJD Date 5/5/92

Location Southeast Checked ____ Date ____

Circle one: Present Developed ____

1. Data: EXISTING DEVELOPED

Drainage area .... A_{m_E} = .0052 mi^2 (acres/640) A_{m_D} = .0052

Runoff curve number .... CN_E = 60 (From worksheet 2) CN_D = 89

Time of concentration .. T_{c_E} = 0.56 hr (From worksheet 3) T_{c_D} = 0.14 hr

Rainfall distribution type = III (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = ∅ percent of A_m (∅ acres or mi^2 covered)

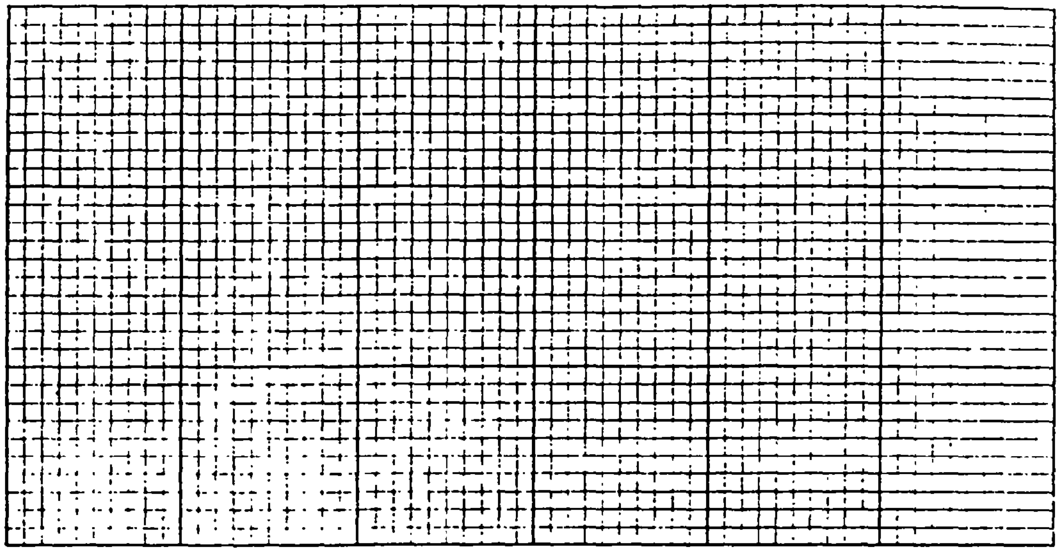
			Present ~~Storm #1~~	~~Storm #2~~	Developed ~~Storm #3~~
2.	Frequency	yr	2-yr		2-yr
3.	Rainfall, P (24-hour)	in	4.5		4.5
4.	Initial abstraction, I_a (Use CN with table 4-1.)	in	1.33		.247
5.	Compute I_a/P		0.30		.055
6.	Unit peak discharge, q_u (Use T_c and I_a/P with exhibit 4-III)	csm/in	325		620
7.	Runoff, Q (From worksheet 2).	in	1.02		3.3
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 $q_p = q_u A_m Q F_p$)	cfs	1.72		10.64

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

Project Bridge Construction By BJD Date 5/5/92

Location Southeast Checked ____ Date ____

Circle one: Present Developed



1. Data:
   Drainage area .... A_m = .0052 mi^2
   Rainfall distribution type (I, IA, II, III) = III

	1st stage	2nd stage
2. Frequency ...... yr	2-yr	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	10.64	
4. Peak outflow discharge, q_o .... cfs	1.72	1/
5. Compute $\frac{q_o}{q_i}$	0.16	
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	.49	
7. Runoff, Q ...... in (From worksheet 2)	3.3	
8. Runoff volume, V_r .... ac-ft ($V_r = QA_m 53.33$)	0.92	
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$) sized for 1/2 of bridge	0.45	
10. Maximum stage, E_{max} (From plot)		

1/ 2nd stage q_o includes 1st stage q_o.

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

Project Bridge Construction By BJD 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 type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

	Unit	Existing	Developed	Total
Sheet flow (Applicable to T_c only) Segment ID				
1. Surface description (table 3-1)		Light Underbrush	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, s	ft/ft	.05	.05	
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ Compute T_t	hr	0.45	+ 0.01	=
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	.05	.05	
10. Average velocity, V (figure 3-1)	ft/s	3.6	3.6	
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.09	+ 0.10	=
Channel flow Segment ID				
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \frac{a}{p_w}$ 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. Flow length, L	ft			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			

$T_{c_{EX}} = 0.54$ hr.
$T_{c_{DEV}} = 0.11$ hr.

Worksheet 4: Graphical Peak Discharge method

Project Bridge Construction By BJD Date 5/5/92

Location Northwest Checked ____ Date ____

Circle one: Present Developed

1. Data: EXISTING DEVELOPED

Drainage area .... A_m = .0052 mi^2 (acres/640) A_{m_D} = .0052 mi^2

Runoff curve number .... CN = 60 (From worksheet 2) CN_D = 89

Time of concentration .. T_c = 0.54 hr (From worksheet 3) T_{c_D} = 0.11 hr.

Rainfall distribution type = IA (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = Ø percent of A_m (Ø acres or mi^2 covered)

		EXISTING ~~Storm #1~~	~~Storm #2~~	DEVELOPED ~~Storm #3~~
2. Frequency	yr	2-yr		2-yr
3. Rainfall, P (24-hour)	in	3.0		3.0
4. Initial abstraction, I_a .... (Use CN with table 4-1.)	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-IA)	csm/in	47		160
7. Runoff, Q .... (From worksheet 2).	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 $q_p = q_u A_m Q F_p$)	cfs	0.08		1.58

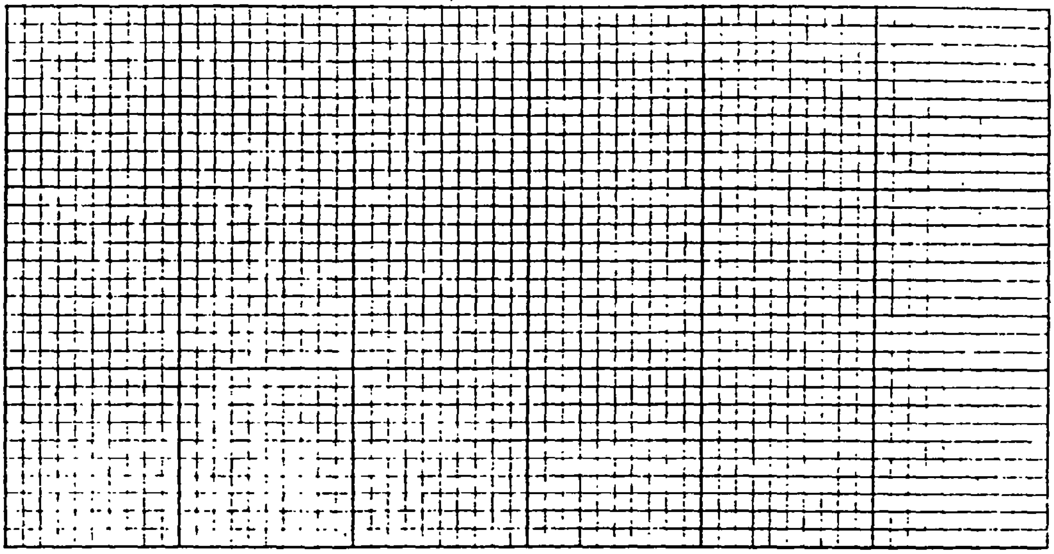
Worksheet 6a: Detention basin storage, peak outflow discharge (q_o) known

Project Bridge Construction By BJD Date 5/5/92

Location Northwest Checked _____ Date _____

Circle one: Present Developed

Elevation or stage



Detention basin storage

1. Data:
   Drainage area .... A_m = .0052 mi^2
   Rainfall distribution type (I, IA, II, III) = IA

	1st stage	2nd stage
2. Frequency ...... yr	2-yr	
3. Peak inflow discharge, q_i .... cfs (From worksheet 4 or 5b)	1.58	
4. Peak outflow discharge, q_o .... cfs	0.08	1/
5. Compute $\frac{q_o}{q_i}$	0.05	
6. $\frac{V_s}{V_r}$ .... (Use $\frac{q_o}{q_i}$ with figure 6-1)	0.56	
7. Runoff, Q ...... in (From worksheet 2)	1.9	
8. Runoff volume, V_r .... ac-ft ($V_r = QA_m 53.33$)	0.53	
9. Storage volume, V_s .... ac-ft ($V_s = V_r(\frac{V_s}{V_r})$) sized for 1/2 of bridge runoff	0.30	
10. Maximum stage, E_{max} (From plot)		

1/ 2nd stage q_o includes 1st stage q_o.

number of storms = 1
interval = 133. hrs, storm duration = 8. hrs, precip = .78 inches
device = 1 dry pond, type = pond , variable = tss

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	.13	53.28	149.2786
06 normal outlet	.13	10.65	29.8390
08 sedimen + decay	.00	42.63	.0000
09 total inflow	.13	53.28	149.2786
10 surface outflow	.13	10.65	29.8390
12 total outflow	.13	10.65	29.8390
13 total trapped	.00	42.63	
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

device	base elev ft	minimum elev ft	maximum elev ft	maximum inflow cfs	maximum outflow cfs	maximum velocity ft/sec	wet period %
1 dry pond	.00	.00	2.07	.64	.09	.00	42.9

case 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

watershed area	acres	=	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 pond, type = 1 pond

bottom elevation	feet	=	.000
bottom area	acres	=	.047
permanent pool area	acres	=	.000
permanent pool volume	ac-ft	=	.000
perm. pool infiltration rate	in/hr	=	.000000
flood pool area	acres	=	.062
flood pool volume	ac-ft	=	.218
flood pool infiltration rate	in/hr	=	.000000
flood pool drain time	hours	=	48.000
outlet orifice diameter	inches	=	.000
orifice discharge coefficient		=	.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 factor		=	1.000

exfiltrate routed to device	0	OUT
normal outlet routed to device	0	OUT
spillway outlet routed to device	0	OUT

Coastal Zone Study(SE)

watershed areas contributing surface runoff to each device

device	total acres	impervious acres	impervious %	dead-storage acres	dead-storage ac-ft	zmean feet	total-storage acres	total-storage ac-ft	zmean fee
1 dry pond	3.30	2.08	63.0	.05	.00	.00	.06	.22	3.[illegible]
24 OVERALL	3.30	2.08	63.0	.05	.00	.00	.06	.22	3.50

normalized device areas and volumes

device	dead-storage ab/ai %	dead-storage vb/ai inches	dead-storage ab/at %	dead-storage vb/at inches	total-storage ab/at %	total-storage vb/at inches	flood-storage vb/at inches
1 dry pond	2.25	.00	1.42	.00	1.89	.79	.79
25 OVERALL	2.25	.00	1.42	.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          conc
mass-balance term                 acre-ft           lbs           ppm
01 watershed inflows                  .10         46.80      174.3422
06 normal outlet                      .10          9.35       34.8337
08 sedimen + decay                    .00         37.44         .0000

09 total inflow                       .10         46.80      174.3422
10 surface outflow                    .10          9.35       34.8337
12 total outflow                      .10          9.35       34.8337
13 total trapped                      .00         37.44
14 storage increase                   .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   maximum     wet
               elev    elev    elev    inflow   outflow  velocity  period
device           ft      ft      ft       cfs       cfs    ft/sec       %
 1 dry pond     .00     .00    1.93       .43       .06       .00    40.3
case 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    =  0

watershed area                   acres     =     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 pond, type = 1 pond

bottom elevation	feet	=	.000
bottom area	acres	=	.036
permanent pool area	acres	=	.000
permanent pool volume	ac-ft	=	.000
perm. pool infiltration rate	in/hr	=	.000000
flood pool area	acres	=	.048
flood pool volume	ac-ft	=	.166
flood pool infiltration rate	in/hr	=	.000000
flood pool drain time	hours	=	48.000
outlet orifice diameter	inches	=	.000
orifice discharge coefficient		=	.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 factor		=	1.000

exfiltrate routed to device	0	OUT
normal outlet routed to device	0	OUT
spillway outlet routed to device	0	OUT

Coastal Zone Study(NE)

watershed areas contributing surface runoff to each device

	total	impervious		dead-storage		zmean	total-storage		zmean
device	acres	acres	%	acres	ac-ft	feet	acres	ac-ft	fe
1 dry pond	3.30	2.08	63.0	.04	.00	.00	.05	.17	3.5
24 OVERALL	3.30	2.08	63.0	.04	.00	.00	.05	.17	3.5

normalized device areas and volumes

	------- dead-storage -------				total-storage		flood-storage
	ab/ai	vb/ai	ab/at	vb/at	ab/at	vb/at	vb/at
device	%	inches	%	inches	%	inches	inches
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
                                   flow            load           conc
mass-balance term                acre-ft            lbs            ppm
01 watershed inflows                 .09          24.95       101.8991
06 normal outlet                     .09           4.99        20.3666
08 sedimen + decay                   .00          19.96          .0000

09 total inflow                      .09          24.95       101.8991
10 surface outflow                   .09           4.99        20.3666
12 total outflow                     .09           4.99        20.3666
13 total trapped                     .00          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   maximum     wet
               elev    elev    elev    inflow   outflow  velocity  period
device           ft      ft      ft       cfs       cfs    ft/sec       %
 1 dry pond     .00     .00    1.84       .23       .04       .00    52.0
case title        = Coastal Zone Study(NW)
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

watershed area                     acres     =     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 pond, type = 1 pond

bottom elevation	feet	=	.000
bottom area	acres	=	.027
permanent pool area	acres	=	.000
permanent pool volume	ac-ft	=	.000
perm. pool infiltration rate	in/hr	=	.000000
flood pool area	acres	=	.035
flood pool volume	ac-ft	=	.124
flood pool infiltration rate	in/hr	=	.000000
flood pool drain time	hours	=	48.000
outlet orifice diameter	inches	=	.000
orifice discharge coefficient		=	.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 factor		=	1.000

exfiltrate routed to device	0	OUT
normal outlet routed to device	0	OUT
spillway outlet routed to device	0	OUT

Coastal Zone Study(NW)

watershed areas contributing surface runoff to each device

	total	impervious		dead-storage		zmean	total-storage		zmean
device	acres	acres	%	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	3.5

normalized device areas and volumes

	------- dead-storage -------				total-storage		flood-storage
	ab/ai	vb/ai	ab/at	vb/at	ab/at	vb/at	vb/at
device	%	inches	%	inches	%	inches	inches
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
                                  flow          load          conc
mass-balance term               acre-ft          lbs           ppm
01 watershed inflows                .09        39.46      160.8434
06 normal outlet                    .09         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
12 total outflow                    .09         7.85       32.0065
13 total trapped                    .00        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   maximum     wet
               elev    elev    elev   inflow   outflow  velocity  period
device           ft      ft      ft      cfs       cfs    ft/sec       %
 1 dry pond     .00     .00    1.86      .26       .05       .00    12.4
case title      = Coastal Zone Study(SW)
case data file  = swbred.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
         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     =      .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

bottom elevation	feet	=	.000
bottom area	acres	=	.030
permanent pool area	acres	=	.000
permanent pool volume	ac-ft	=	.000
perm. pool infiltration rate	in/hr	=	.000000
flood pool area	acres	=	.040
flood pool volume	ac-ft	=	.142
flood pool infiltration rate	in/hr	=	.000000
flood pool drain time	hours	=	48.000
outlet orifice diameter	inches	=	.000
orifice discharge coefficient		=	.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 factor		=	1.000

exfiltrate routed to device	0	OUT
normal outlet routed to device	0	OUT
spillway outlet routed to device	0	OUT

Coastal Zone Study(SW)

watershed areas contributing surface runoff to each device

device	total acres	impervious acres	impervious %	dead-storage acres	dead-storage ac-ft	zmean feet	total-storage acres	total-storage ac-ft	zmean fe
1 dry pond	3.30	2.08	63.0	.03	.00	.00	.04	.14	3.
24 OVERALL	3.30	2.08	63.0	.03	.00	.00	.04	.14	3.5

normalized device areas and volumes

device	dead-storage ab/ai %	dead-storage vb/ai inches	dead-storage ab/at %	dead-storage vb/at inches	total-storage ab/at %	total-storage vb/at inches	flood-storage vb/at inches
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 bridge By BJD 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 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)			Smooth		
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~~ Ten-yr 24-hr rainfall, P_2	in		3.5		
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, s	ft/ft		.02		
10. Average velocity, V (figure 3-1)	ft/s		2.9		
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	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. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr			+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr				

Tc = .03 hr

Assume Tc = 0.1 hr

Worksheet 4: Graphical Peak Discharge method

Project Sizing pipe on bridge By BJD Date 5/12/92

Location Southwest Checked ______ Date ______

Circle one: Present Developed ______________________

1. Data:

Drainage area .... A_m = 0.00043 mi^2 (acres/640)

Runoff curve number .... CN = 98 (From worksheet 2)

Time of concentration .. T_c = 0.1 hr (From worksheet 3)

Rainfall distribution type = I (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = ∅ percent of A_m (∅ acres or mi^2 covered)

			~~Storm #1~~	~~Storm #2~~	~~Storm #3~~
2.	Frequency	yr	10		
3.	Rainfall, P (24-hour)	in	3.5		
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 .... (Use T_c and I_a/P with exhibit 4-I)	csm/in	500		
7.	Runoff, Q .... (From worksheet 2).	in	3.27		
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		
9.	Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	0.70		

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

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

Project Determine peak discharge from bridge　　By BJD　　Date 5/11/92

Location Great Lakes　　Checked ______　　Date ______

Circle one: Present　Developed　　10-year, 24-hour peak rainfall

Circle one: T_c　T_t through subarea

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.

Sheet flow (Applicable to T_c only)

	Unit	Segment ID: DEVELOPED	Segment ID	
1. Surface description (table 3-1)		Smooth		
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~~ Ten-yr 24-hr rainfall, P_2	in	4.0		
5. Land slope, s	ft/ft	0.02		
6. $T_t = \dfrac{0.007\,(nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$　Compute T_t	hr	0.02	+	=

Shallow concentrated flow

	Unit	Segment ID	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. $T_t = \dfrac{L}{3600\ V}$　Compute T_t	hr	0.02	+	=

Channel flow

	Unit	Segment ID	Segment ID	
12. Cross sectional flow area, a	ft^2			
13. Wetted perimeter, p_w	ft			
14. Hydraulic radius, $r = \dfrac{a}{p_w}$　Compute r	ft			
15. Channel slope, s	ft/ft			
16. Manning's roughness coeff., n				
17. $V = \dfrac{1.49\ r^{2/3}\ s^{1/2}}{n}$　Compute V	ft/s			
18. Flow length, L	ft			
19. $T_t = \dfrac{L}{3600\ V}$　Compute T_t	hr		+	=
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			

$T_c = .04\ hr \cong 0.10\ hr$

Worksheet 4: Graphical Peak Discharge method

Project Sizing pipe for bridge By BJD Date 5/11/92

Location Great Lakes Checked ______ Date ______

Circle one: Present Developed

1. Data:

   Drainage area .... A_m = .00043 mi^2 (acres/640)

   Runoff curve number .... CN = 98 (From worksheet 2)

   Time of concentration .. T_c = 0.1 hr (From worksheet 3)

   Rainfall distribution type = II (I, IA, II, III)

   Pond and swamp areas spread throughout watershed ...... = ∅ percent of A_m (∅ acres or mi^2 covered)

		DEVELOPED ~~Storm #1~~	~~Storm #2~~	~~Storm #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 .... (Use T_c and I_a/P with exhibit 4-II)	csm/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 $q_p = q_u A_m Q F_p$)	cfs	1.62		

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 Northwest 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 per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Unit	Segment ID	Segment ID	
1. Surface description (table 3-1)		Smooth		
2. Manning's roughness coeff., n (table 3-1) ..		0.011		
3. Flow length, L (total L $\leq$ 300 ft)	ft	60		
4. Ten-yr ~~Two-yr~~ 24-hr rainfall, P_2	in	4.0		
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	Unit	Segment ID	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. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.02	+	=

Channel flow	Unit	Segment ID	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	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. $T_t = \frac{L}{3600\ V}$ 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 = 0.04 hr.
Assume: T_c = 0.1 hr.

Worksheet 4: Graphical Peak Discharge method

Project Sizing pipe on bridge By BJD Date 5/12/92

Location Northwest Checked ____ Date ______

Circle one: Present Developed ____________________

1. Data:

   Drainage area .... A_m = 0.00043 mi^2 (acres/640)

   Runoff curve number .... CN = 98 (From worksheet 2)

   Time of concentration .. T_c = 0.1 hr (From worksheet 3)

   Rainfall distribution type = IA (I, IA, II, III)

   Pond and swamp areas spread throughout watershed ...... = ∅ percent of A_m (∅ acres or mi^2 covered)

		~~Storm #1~~	~~Storm #2~~	~~Storm #3~~
2. Frequency	yr	10-yr		
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 .... (Use T_c and I_a/P with exhibit 4-IA)	csm/in	165		
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 $q_p = q_u A_m Q F_p$)	cfs	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 Southeast 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 per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only)	Units	DEVELOPED		
Segment ID				
1. Surface description (table 3-1)		Smooth		
2. Manning's roughness coeff., n (table 3-1) ..		0.011		
3. Flow length, L (total L ≤ 300 ft)	ft	60		
4. ~~Two-yr~~ Ten-yr 24-hr rainfall, P_2	in	7.0		
5. Land slope, s	ft/ft	.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	Units			
Segment ID				
7. Surface description (paved or unpaved)		Paved		
8. Flow length, L	ft	200		
9. Watercourse slope, s	ft/ft	.02		
10. Average velocity, V (figure 3-1)	ft/s	2.9		
11. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr	0.02	+	=

Channel flow	Units			
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	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. $T_t = \frac{L}{3600\,V}$ Compute T_t	hr		+	=

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr

$T_c = 0.03$ hr

Assume $T_c = 0.1$ hr

Worksheet 4: Graphical Peak Discharge method

Project Sizing Pipe on bridge By ____ Date ______

Location Southeast Checked ____ Date ______

Circle one: Present Developed ______________

1. Data:

   Drainage area .... A_m = .00043 mi^2 (acres/640)

   Runoff curve number .... CN = 98 (From worksheet 2)

   Time of concentration .. T_c = 0.1 hr (From worksheet 3)

   Rainfall distribution type = III (I, IA, II, III)

   Pond and swamp areas spread throughout watershed ...... = ∅ percent of A_m (∅ acres or mi^2 covered)

		DEVELOPED ~~Storm #1~~	~~Storm #2~~	~~Storm #3~~
2. Frequency	yr	10		
3. Rainfall, P (24-hour)	in	7.0		
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 .... (Use T_c and I_a/P with exhibit 4-III)	csm/in	650		
7. Runoff, Q .... (From worksheet 2).	in	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 $q_p = q_u A_m Q F_p$)	cfs	1.89		

Subject Pipe sizing & cost | Project No. 8005
Task No. 000
By BRIAN DONOVAN Checked By DAZ | File No.
Date 5/14/92 Date 5/14/92 | Sheet 1 of 2

Northeast Region : q_{peak} = 1.62 cfs
Northwest Region : q_{peak} = 0.27 cfs
Southeast Region : q_{peak} = 1.89 cfs
Southwest Region : q_{peak} = 0.70 cfs

General Assumptions:

1.) Pipe is only 1/2 full
2.) Pipe design based on 10-year, 24-hour rainfall
3.) Pipe is made of reinforced steel
4.) Means "Building Construction Cost Data" dated 1991 used for pipe pricing

Northeast

Assume pipe diameter = 6 inches

$$\text{Area} = \pi d^2/4 = \pi\left(\frac{6}{12}\right)^2\Big/4 = 0.20\ ft^2$$

$$\text{Hydraulic Radius} \rightarrow R = \frac{\text{Area}}{\text{Wetted Perimeter}} = \frac{0.20}{\pi r} = \frac{0.20}{\pi(.25)} =$$

$$= 0.25$$

$n = 0.010$

Slope = 0.02

using Manning's eq:

$$Q_{MAX} = AV = \frac{1.49}{0.01}(0.20)(0.25)^{2/3}(.02)^{1/2} = 1.67\ cfs$$

$1.67 > 1.62 \therefore$ OK

Cost of pipe for each half of bridge = 200 ft × 7.15/ft = $1,430

TOTAL COST OF PIPE = 1430 × 2 = $\boxed{\$2,860}$

Subject Pipe sizing & cost

By BRIAN DONOVAN Checked By [illegible initials]

Date 5/14/92 Date 5/19/92

Project No. 8005

Task No. 000

File No.

For Northwest & Southwest regions, the pipe size and cost will be the same as Northeast. A 6-inch diameter pipe is the smallest reinforced drainage pipe listed in Means book.

Northwest : Cost = \$ 2,860
Southwest : Cost = \$ 2,860

Southeast

Assume pipe diameter = 8 inches

$$Area = \pi (8/12)^2 / 4 = 0.35$$

$$R = \frac{0.35}{\pi(0.33)} = 0.34$$

$$n = 0.010$$

$$Slope = 0.02$$

$$Q_{MAX} = AV = \frac{1.49}{0.01} (0.35)(0.34)^{2/3} (0.02)^{1/2} = 3.59 \text{ cfs}$$

$$3.59 > 1.89 \therefore \underline{OK}$$

Cost of pipe for each half of bridge = 200 × 7.90/ft = \$1,580

TOTAL COST OF PIPE = \$1,580 × 2 = $\boxed{\$3,160}$

NOTE: COSTS INCLUDE LABOR AND OVERHEAD FEES.

APPENDIX C

Street Sweeping Computer Simulation Results

```
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
impervious fraction                        =      .250
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  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
                                 flow          load          conc
mass-balance term              acre-ft          lbs           ppm
01 watershed inflows              1.09       474.52      160.8447
06 normal outlet                  1.09       474.52      160.8447

09 total inflow                   1.09       474.52      160.8447
10 surface outflow                1.09       474.52      160.8447
12 total outflow                  1.09       474.52      160.8447

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
```

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.09	1.39	.4706
06 normal outlet	1.09	1.39	.4706
09 total inflow	1.09	1.39	.4706
10 surface outflow	1.09	1.39	.4706
12 total outflow	1.09	1.39	.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

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.09	6.04	2.0476
06 normal outlet	1.09	6.04	2.0476
09 total inflow	1.09	6.04	2.0476
10 surface outflow	1.09	6.04	2.0476
12 total outflow	1.09	6.04	2.0476

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

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.09	.14	.0464
06 normal outlet	1.09	.14	.0464
09 total inflow	1.09	.14	.0464
10 surface outflow	1.09	.14	.0464
12 total outflow	1.09	.14	.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
device = 1 Pipe , type = pipe , variable = pb

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.09	.09	.0310
06 normal outlet	1.09	.09	.0310
09 total inflow	1.09	.09	.0310
10 surface outflow	1.09	.09	.0310
12 total outflow	1.09	.09	.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,  precip =    .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

load removal efficiency    =    .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

watershed area	acres	=	100.000
impervious fraction		=	.250
impervious depression storage	inches	=	.020
scs curve number (pervious portion)		=	60.000
sweeping frequency	times/week	=	1.000
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

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.09	446.88	151.4759
06 normal outlet	1.09	446.88	151.4759
09 total inflow	1.09	446.88	151.4759
10 surface outflow	1.09	446.88	151.4759
12 total outflow	1.09	446.88	151.4759
15 mass balance check	.00	.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
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         5.86        1.9862
06 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

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
mass-balance term                acre-ft          lbs           ppm
01 watershed inflows                1.09          .13         .0450
06 normal outlet                    1.09          .13         .0450

09 total inflow                     1.09          .13         .0450
10 surface outflow                  1.09          .13         .0450
12 total outflow                    1.09          .13         .0450
15 mass balance check                .00          .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 = pb
                                   flow          load          conc
mass-balance term                acre-ft          lbs           ppm
01 watershed inflows                1.09          .09         .0293
06 normal outlet                    1.09          .09         .0293

09 total inflow                     1.09          .09         .0293
10 surface outflow                  1.09          .09         .0293
12 total outflow                    1.09          .09         .0293
15 mass balance check                .00          .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 = zn
                                   flow          load          conc
mass-balance term                acre-ft          lbs           ppm
01 watershed inflows                1.09          .63         .2119
06 normal outlet                    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 %,  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 = 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

load removal efficiency    =    .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

watershed 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
                                    flow           load          conc
mass-balance term                 acre-ft           lbs           ppm
01 watershed inflows                 1.09         467.25      158.3796
06 normal outlet                     1.09         467.25      158.3796

09 total inflow                      1.09         467.25      158.3796
10 surface outflow                   1.09         467.25      158.3796
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
```

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.09	1.38	.4665
06 normal outlet	1.09	1.38	.4665
09 total inflow	1.09	1.38	.4665
10 surface outflow	1.09	1.38	.4665
12 total outflow	1.09	1.38	.4665

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

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.09	5.99	2.0317
06 normal outlet	1.09	5.99	2.0317
09 total inflow	1.09	5.99	2.0317
10 surface outflow	1.09	5.99	2.0317
12 total outflow	1.09	5.99	2.0317

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 term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.09	.14	.0461
06 normal outlet	1.09	.14	.0461
09 total inflow	1.09	.14	.0461
10 surface outflow	1.09	.14	.0461
12 total outflow	1.09	.14	.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
device = 1 pipe , type = pipe , variable = pb

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.09	.09	.0305
06 normal outlet	1.09	.09	.0305
09 total inflow	1.09	.09	.0305
10 surface outflow	1.09	.09	.0305
12 total outflow	1.09	.09	.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

mass-balance term	flow acre-ft	load lbs	conc ppm
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	.64	.2167
12 total outflow	1.09	.64	.2167

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 = hc

mass-balance term	flow acre-ft	load lbs	conc 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

load removal efficiency = .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

watershed area                    acres     =   100.000
impervious fraction                         =      .250
impervious depression storage    inches     =      .020
scs curve number (pervious portion)         =    60.000
sweeping frequency              times/week =      .500
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
                                   flow          load          conc
mass-balance term                acre-ft          lbs           ppm
01 watershed inflows                1.09        460.22      155.9995
06 normal outlet                    1.09        460.22      155.9995

09 total inflow                     1.09        460.22      155.9995
10 surface outflow                  1.09        460.22      155.9995
12 total outflow                    1.09        460.22      155.9995
15 mass balance check                .00           .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

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         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        2.0161
15 mass balance check                .00          .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 = cu
                                   flow          load          conc
mass-balance term                acre-ft          lbs           ppm
01 watershed inflows                1.09          .13         .0457
06 normal outlet                    1.09          .13         .0457

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

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 = pb
                                   flow          load          conc
mass-balance term                acre-ft          lbs           ppm
01 watershed inflows                1.09          .09         .0301
06 normal outlet                    1.09          .09         .0301

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 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

mass-balance term	flow acre-ft	load lbs	conc 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	

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 = hc

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.09	11.09	3.7600
06 normal outlet	1.09	11.09	3.7600
09 total inflow	1.09	11.09	3.7600
10 surface outflow	1.09	11.09	3.7600
12 total outflow	1.09	11.09	3.7600
15 mass balance check	.00	.00	

load removal efficiency = .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    =  0

watershed area                   acres     =   100.000
impervious fraction                        =      .250
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  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
01 watershed inflows                 1.19         563.54       174.5998
06 normal outlet                     1.19         563.54       174.5998

09 total inflow                      1.19         563.54       174.5998
10 surface outflow                   1.19         563.54       174.5998
12 total outflow                     1.19         563.54       174.5998

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
```

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	1.62	.5023
06 normal outlet	1.19	1.62	.5023
09 total inflow	1.19	1.62	.5023
10 surface outflow	1.19	1.62	.5023
12 total outflow	1.19	1.62	.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 = tkn

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	7.01	2.1714
06 normal outlet	1.19	7.01	2.1714
09 total inflow	1.19	7.01	2.1714
10 surface outflow	1.19	7.01	2.1714
12 total outflow	1.19	7.01	2.1714

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

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	.16	.0492
06 normal outlet	1.19	.16	.0492
09 total inflow	1.19	.16	.0492
10 surface outflow	1.19	.16	.0492
12 total outflow	1.19	.16	.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
device = 1 pipe , type = pipe , variable = pb

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	.11	.0334
06 normal outlet	1.19	.11	.0334
09 total inflow	1.19	.11	.0334
10 surface outflow	1.19	.11	.0334
12 total outflow	1.19	.11	.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	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	.75	.2316
06 normal outlet	1.19	.75	.2316
09 total inflow	1.19	.75	.2316
10 surface outflow	1.19	.75	.2316
12 total outflow	1.19	.75	.2316

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 = hc

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	13.49	4.1785
06 normal outlet	1.19	13.49	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

load removal efficiency = .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    =  0

watershed area                  acres     =   100.000
impervious fraction                       =      .250
impervious depression storage    inches   =      .020
scs curve number (pervious portion)       =    60.000
sweeping frequency            times/week  =     1.000
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 =   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
 01 watershed inflows             1.19        541.42       167.7446
 06 normal outlet                 1.19        541.42       167.7446

 09 total inflow                  1.19        541.42       167.7446
 10 surface outflow               1.19        541.42       167.7446
 12 total outflow                 1.19        541.42       167.7446
 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 = tp
                                      flow           load           conc
mass-balance term                   acre-ft          lbs            ppm
01 watershed inflows                  1.19           1.58          .4909
06 normal outlet                      1.19           1.58          .4909

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 %
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 = tkn
                                      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

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
                                      flow           load           conc
mass-balance term                   acre-ft          lbs            ppm
01 watershed inflows                  1.19            .16          .0482
06 normal outlet                      1.19            .16          .0482

09 total inflow                       1.19            .16          .0482
10 surface outflow                    1.19            .16          .0482
12 total outflow                      1.19            .16          .0482
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 = pb
                                      flow           load           conc
mass-balance term                   acre-ft          lbs            ppm
01 watershed inflows                  1.19            .10          .0322
06 normal outlet                      1.19            .10          .0322

09 total inflow                       1.19            .10          .0322
10 surface outflow                    1.19            .10          .0322
12 total outflow                      1.19            .10          .0322
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 = zn

mass-balance term	flow acre-ft	load lbs	conc 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	

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 = hc

mass-balance term	flow acre-ft	load lbs	conc ppm
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	

load removal efficiency = .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    =  0

watershed 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 =   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
01 watershed inflows               1.19        557.84      172.8340
06 normal outlet                   1.19        557.84      172.8340

09 total inflow                    1.19        557.84      172.8340
10 surface outflow                 1.19        557.84      172.8340
12 total outflow                   1.19        557.84      172.8340
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 = tp
                                   flow           load            conc
mass-balance term                acre-ft          lbs              ppm
01 watershed inflows                1.19          1.61           .4994
06 normal outlet                    1.19          1.61           .4994

09 total inflow                     1.19          1.61           .4994
10 surface outflow                  1.19          1.61           .4994
12 total outflow                    1.19          1.61           .4994
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 = 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 inflow                     1.19          6.97          2.1600
10 surface outflow                  1.19          6.97          2.1600
12 total outflow                    1.19          6.97          2.1600
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 = cu
                                   flow           load            conc
mass-balance term                acre-ft          lbs              ppm
01 watershed inflows                1.19           .16           .0490
06 normal outlet                    1.19           .16           .0490

09 total inflow                     1.19           .16           .0490
10 surface outflow                  1.19           .16           .0490
12 total outflow                    1.19           .16           .0490
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 = pb
                                   flow           load            conc
mass-balance term                acre-ft          lbs              ppm
01 watershed inflows                1.19           .11           .0331
06 normal outlet                    1.19           .11           .0331

09 total inflow                     1.19           .11           .0331
10 surface outflow                  1.19           .11           .0331
12 total outflow                    1.19           .11           .0331
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 = zn
                                    flow           load           conc
mass-balance term                 acre-ft           lbs            ppm
01 watershed inflows                 1.19           .74          .2304
06 normal outlet                     1.19           .74          .2304

09 total inflow                      1.19           .74          .2304
10 surface outflow                   1.19           .74          .2304
12 total outflow                     1.19           .74          .2304
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 = hc
                                    flow           load           conc
mass-balance term                 acre-ft           lbs            ppm
01 watershed inflows                 1.19         13.36         4.1388
06 normal outlet                     1.19         13.36         4.1388

09 total inflow                      1.19         13.36         4.1388
10 surface outflow                   1.19         13.36         4.1388
12 total outflow                     1.19         13.36         4.1388
15 mass balance check                 .00           .00

load removal efficiency    =    .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    =  0

watershed area                  acres    =   100.000
impervious fraction                      =      .250
impervious depression storage    inches  =      .020
scs curve number (pervious portion)      =    60.000
sweeping frequency             times/week =     .500
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 =   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
01 watershed inflows               1.19        552.26      171.1035
06 normal outlet                   1.19        552.26      171.1035

09 total inflow                    1.19        552.26      171.1035
10 surface outflow                 1.19        552.26      171.1035
12 total outflow                   1.19        552.26      171.1035
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 = tp

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	1.60	.4965
06 normal outlet	1.19	1.60	.4965
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, storm duration = 12. hrs, precip = .59 inches
device = 1 pipe , type = pipe , variable = tkn

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	6.94	2.1488
06 normal outlet	1.19	6.94	2.1488
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	

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

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	.16	.0487
06 normal outlet	1.19	.16	.0487
09 total inflow	1.19	.16	.0487
10 surface outflow	1.19	.16	.0487
12 total outflow	1.19	.16	.0487
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 = pb

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	.11	.0328
06 normal outlet	1.19	.11	.0328
09 total inflow	1.19	.11	.0328
10 surface outflow	1.19	.11	.0328
12 total outflow	1.19	.11	.0328
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 = zn

mass-balance term	flow acre-ft	load lbs	conc ppm
01 watershed inflows	1.19	.74	.2292
06 normal outlet	1.19	.74	.2292
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	

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 = hc

mass-balance term	flow acre-ft	load lbs	conc 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	

load removal efficiency   =   .00 %, adjusted =   .00 %
continuity errors: volume =   .00 %, load   =   .00 %