# CALCULATION SUMMARY SHEET



PROJECT NUMBER: 143418

PROJECT NAME: Trench 13 Design

DATE: December 1, 2014

CALCULATION NUMBER: C.01 Revision: 1 (March 11, 2016)

**CALCULATION TITLE: Surface-Water Management**

**DESCRIPTION OF CALCULATION:**

The surface-water management calculation calculates the on-site and off-site surface-water flows from a 25-yr 24-hr precipitation event and determines the necessary management features to divert surface water around Trench 13.

**REFERENCES USED:**

1. NOAA Atlas 14, Volume 1, Version 5, Amargosa Farms Precipitation Frequency
2. Surface-Water Management Plan Drawings
3. Technical Release - 55 Model Runs and Summary
4. TR-55 Method Procedures
5. Open Channel Flow Procedure and Models Runs for Diversion Channels
6. Lindeburg, Environmental Engineering Reference Manual - Manning's Number

**REVIEW COMMENTS:**

| | | | |
|---|---|---|---|
| CALCULATION MADE BY: | CWK | DATE: | 12/01/14 |
| CALCULATION CHECKED BY: | CAB | DATE: | 12/09/14 |
| CALCULATION REVISED BY: | CWK | DATE: | 12/22/14 |
| CALCULATION REVIEWED BY: | SLW/PAZ (SRES) | DATE: | 06/26/15 |

## PURPOSE OF CALCULATION

Determine the potential on-site and off-site surface-water flow from 25-yr/24-hr and 100-yr/24 precipitation events at the US Ecology Nevada (USEN) facility and necessary management features for protection of proposed Trench 13 during development, operation, and closure in accordance with 40 CFR 264.301(h). Design of new surface-water management features.

## METHOD

Surface-water management features around Trench 13 are designed to manage precipitation from the 100-year, 24-hour storm event. The 25-year, 24-hour storm event is estimated at 2.26 inches and the 100-year, 24-hour event is estimated at 3.13 inches, as determined by the National Oceanic and Atmospheric Administration (NOAA, 1973), NOAA Atlas 14, Volume 1, Version 6, Amargosa Farms and is included as **Reference 1**.

Basin delineation is determined from the natural topography of the USEN Facility and surrounding drainage areas, existing current features, and future development (including Trench 12 closure and Trench 13 development, use, and closure), which will directly affect the location of Trench 13 and modification of current drainages. The basin identifications are provided in surface-water management plan drawings in **Reference 2**.

The USDA Technical Release 55 (TR-55) Model was used to calculate surface-water run-off volume and peak rate of discharge for small watersheds using two independent hydrologic soil groups. This is the preferred method in the state of Nevada as reported in the 1996 Surface-Water Management Calculation for Trench 12 of the USEN Facility. The model output runs and description of the TR-55 procedure is provided in **Reference 3** and **Reference 4**, respectively.

Surface water management features will be necessary to route surface-water around Trench 13 during construction and operation. At closure, the cover and design of the area immediately surround Trench 13 are designed to prevent run-on. Surface water management features were designed using Manning's Equation for open channel flow. The method and procedure are provided in **Reference 5**.

## RUN-OFF AND DISCHARGE ESTIMATED FROM THE TR-55 MODEL

Calculate peak run-off rates expected from drainage basins flowing toward the proposed Trench 13 at the USEN Facility under the influence of design rain storm. The TR-55 is the preferred method of run-off calculation by the state of Nevada and was created by the United States Department of Agriculture.

The USDA Natural Resource Conservation Service Technical Release 55 (TR-55) titled Urban Hydrology for Small Watersheds (June 1986) was used to estimate storm run-off volume and peak rate of storm discharge. To estimate run-off from storm rainfall, TR-55 uses the run-off curve number (CN) method. The CN method is based on the soil type of the native materials and trench final covers, including hydrologic soil group and hydrologic condition. The run-off equations are:

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad S = \frac{1000}{(CN)} - 10$$

Where:

Q = run-off (in)

P = rainfall (in)

S = potential maximum retention after run-off begins (in)

$I_a$ = initial abstraction (in) and $I_a = 0.2S$

Rearranging and substituting 0.2S for $I_a$ yields the following.

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

The CN was chosen from options provided in the TR-55 Table 2-2. The following soil conditions were chosen.

| | |
|---|---|
| cover type | Desert shrub |
| treatment (vegetation cover) | Poor condition |
| hydrologic soil group | A |
| curve number | 63 |

This calculation evaluates both the 25-year, 24-hour storm of approximately 2.26 inches and the 100-year, 24-hour storm of 3.13 inches of precipitation (**Reference 1**).

The next step in the TR-55 guidance is calculation of the travel time or the time it takes water to travel from one location to another on the USEN site. The factors influencing the time of travel include the surface type, the surface roughness (Manning's coefficient), flow length, rainfall, and land slope. The soil cover surface is modeled as desert shrub and a curve number of 63, (as described in Table 2-2d of the TR-55 guidance (**Reference 4**)) and assumes sheet flow over a planar surface.

A drawing of the drainage basin configuration contributing to run-off at the USEN site; is provided in **Reference 2** of this calculation. Drainage characteristics contributing to surface-water management at the USEN site were determined, including basin area and average slope. Sheet flow slope length was set at 100 ft for all basins to minimize time of concentration and produce a conservative estimate of maximum volume and flow to all drainage reaches. .

**Surface Water Basins with Drainage Impacting Trench 13**

The basin evaluation located in **Reference 2** includes Reach paths and outfall locations. Basins and discharge calculations are provided in the TR-55 Model Runs in **Reference 3**.

**Analysis**

This analysis evaluates peak discharge (in cubic feet per second (cfs)) for the 25-year/24-hour and 100 year/24-hour precipitation events. Basins of similar flow characteristics were established and modeled.

N-Basins

Consist of all north facility basins (N-Basins), with a cumulative area of 74.64 acres. The 25-yr peak discharge at Outfall 1 is **7.2 cfs**. The 100-year/24-hour peak discharge at Outfall 1 is **43 cfs** (**Reference 3)**.

Basin N-1 consists of 11.15 acres of undeveloped land. The topography is a mild slope from north-west to south-east. The basin drains to Reach 1 on the northern-most road along the existing property line and eastward to Outfall 1.

Basin N-2 consists of 49.33 acres of undeveloped land. The topography is a mild slope from north to south. The basin empties to a natural drainage path then to Reach 1 on the northern-most road along the existing property line and eastward to Outfall 1.

Basin N-3 consists of 11.13 acres of cover soil on the north facing slopes of Trench 12 (currently unfinished), Trench 11, and Trench 10. All Trenches have slopes at 3:1 from south to north. The basin drains to Reach 1 on the northern-most road along the existing property line and east to Outfall 1.

Basin N-4 consists of 0.81 acres of cover soil on the northern portion of closed Trench 11, and has a slope of 20:1 from south to north and west to east. The basin drains to Reach 1 on the northern-most road along the existing property line and east to Outfall 1.

Basin N-5 consists of 2.21 acres of cover soil on the northwest half of closed Trench 10, and has a slope of 20:1 from south to north and east to west. The basin drains to Reach 1 on the northern-most road along the existing property line and east to Outfall 1.

E-Basins

Consists of all eastern basins (E-Basins), with a cumulative area of 17.94 acres, and Reach 2. The 25-yr peak discharge is **2.5 cfs**. The 100-year/24-hour peak discharge is **11 cfs** (**Reference 3)**.

Basin E-1 consists of 3.23 acres of cover soil on the eastern half of closed Trench 10, and has a slope of 20:1 draining to the east and south. The basin drains to Reach 2, then south to Outfall 2.

Basin E-2 consists of 1.03 acres of cover soil on the east-facing slope of closed Trench 10, and has a slope of 3:1 draining from west to east. The basin drains to Reach 2, then south to Outfall 2.

Basin E-3 consists of 0.86 acres of cover soil on the south-facing slope of closed Trench 10, and has a slope of 3:1 draining from north to south. The basin drains to Reach 2, then south to Outfall 2.

Basin E-4 consists of 2.19 acres of cover soil on the east-facing slope of closed Trench 11, and has a slope of 3:1 draining from west to east. The basin drains to Reach 2, then south to Outfall 2.

Basin E-5 consists of 3.28 acres above closed Trenches 1 to 9, and the topography is a mild slope from north-west to south-east. The basin drains to Reach 2, then south to Outfall 2.

Basin E-6 consists of 0.87 acres above closed Trenches 1 to 9, and the topography is a mild slope from north-west to south-east. The basin drains to Reach 2, then south to Outfall 2.

Basin E-7 consists of 0.51 acres above closed Trenches 1 to 9, and the topography is a mild slope from west to east. The basin drains to Reach 2, then south to Outfall 2.

Basin E-8 consists of 1.48 acres above closed Trenches 1 to 9, and the topography is a mild slope from west to east. The basin drains to Reach 2, then south to Outfall 2.

Basin E-9 consists of 4.49 acres of undeveloped land and the topography is a mild slope from north to south. The basin drains to Reach 2, then south to Outfall 2.

<u>SE-Basins</u>

Consists of all south eastern basins (SE-Basins) with a cumulative area of 5.60 Acres and Reach 3. The 25-yr peak discharge is **0.77 cfs**. The 100-year/24-hour peak discharge is **305 cfs** (**Reference 3).**

Basin SE-1 consists of 0.36 acres of final cover soil on a portion of closed Trench 11, and has a slope of 20:1 draining to the east. The basin drains via sheet flow over basins SE-2 and SE-4 to Reach 3, then to Outfall 3.

Basin SE-2 consists of 1.10 acres of final cover soil on a portion of closed Trench 11, and has a slope of 3:1 draining west to east. The basin drains via sheet flow over basin SE-4 to Reach 3, then to Outfall 3.

Basin SE-3 consists of 1.19 acres above closed Trenches 1 to 9, and the topography is a mild slope from north to south. The basin drains to Reach 3, then to Outfall 3.

Basin SE-4 consists of 1.14 acres above closed Trenches 1 to 9, and the topography is a mild slope from north to south. The basin drains to Reach 3, then to Outfall 3.

Basin SE-5 consists of 1.82 acres of final cover soil on a portion of closed Trench 11, and has a slope of 3:1 draining north to south. The basin drains to Reach 3, then to Outfall 3.

Trench 13 Final Cover Basins

The Trench 13 Final Cover Basins (FC-Basins) are comprised of all drainage basins within the cell footprint of Trench 13. The FC-Basins have a cumulative area of 53.91 Acres (following final cover placement) and are collected by multiple lateral drain benches, flumes, and berms. Because of Trench 13's symmetry, not all basins were evaluated. The hydraulic soil group for the cover is modeled as Type A. The Trench 13 cover has been evaluated at the 25-year and 100-year precipitation event. The basin delineation map for the Trench 13 final cover is provided in **Reference 2.**

FC-Northwest Basins (FC-NW): consists of 6.59 acres at a 3H:1V slope. Basins include FC-NW-1, FC-NW-2, FC-NW-3, and FC-NW-4, FC-NW-5, and FC-NW-6. Runoff collects in lateral drainages, flows down a sideslope flume and results in a 25-year peak discharge of 0.92 cfs and a 100-year peak discharge of 4.11 cfs at Outfall FC-NW. Run-off discharges on the north side of Trench 13 and is carried by ditches to the eastern drainage, then off-site.

FC-Northeast Basins (FC-NE): consists of 6.59 acres at a 3H:1V slope. Basins include FC-NE-1, FC-NE-2, FC-NE-3, FC-NE-4, FC-NE-5, and FC-NE-6. Runoff collects in lateral drainages, flows down a sideslope flume and results in a 25-year peak discharge of 0.92 cfs and a 100-year peak discharge of 4.11 cfs at Outfall FC-NE. Run-off discharges on the north side of Trench 13 and is carried by ditches to the eastern drainage, then off-site.

FC-West-A Basins (FC-W-A): consists of 2.39 acres at a 3H:1V slope. Basins include FC-W1, FC-W2, and FC-W3. Runoff collects in lateral drainages, flows down a drainage along a final cover access road, and results in a 25-year peak discharge of 0.33 cfs and a 100-year peak discharge of 1.48 cfs at Outfall FC-W-A. Run-off discharges on the west

side of Trench 13 and is carried south in a ditch along the western access road, then off-site.

FC-East-A Basins (FC-E-A): consists of 2.39 acres at a 3H:1V slope. Basins include FC-E1, FC-E2, and FC-E3. Runoff collects in lateral drainages, flow down a drainage along a final cover access road, and results in a 25-year peak discharge of 0.33 cfs and a 100-year peak discharge of 1.48 cfs at Outfall FC-E-A. Run-off discharges on the east side of Trench 13 and is carried by ditches to the eastern drainage, then off-site.

FC-West-B Basins (FC-W-B): consists of 2.69 acres at 3H:1V slope. Basins include FC-W4, FC-W5, FC-W6, and FC-W7. Runoff collects in lateral drainages, flows down a sideslope flume and results in a 25-year peak discharge of 0.38 cfs and a 100-year peak discharge of 1.68 cfs at Outfall FC-W-B. Run-off discharges on the west side of Trench 13 and is carried south in a ditch along the western access road, then off-site.

FC-East-B Basins (FC-E-B): consists of 2.69 acres at 3H:1V slope. Basins include FC-E4, FC-E5, FC-E6, and FC-E7. Runoff collects in lateral drainages, flows down a sideslope flume and results in a 25-year peak discharge is 0.38 cfs and a 100-year peak discharge of 1.68 cfs at Outfall FC-E-B. Run-off discharges on the east side of Trench 13 and is carried by ditches to the eastern drainage, then off-site.

FC-Southwest Basins (FC-SW) and FC-Upper Deck West Basins (FC-UDW): consists of 8.08 acres. Basins include FC-SW-1, FC-SW-2, FC-SW-3, FC-SW-4, FC-SW-5, and FC-SW-6 for the sideslope areas and FC-UDW-1, FC-UDW-2, and FC-UDW-3, for the upper deck areas. The slopes are 20H:1V on the upper deck transitioning to 3H:1V on the side slopes. Runoff collects in lateral drainages, flows down a sideslope flume, and results in a 25-year peak discharge of 1.08 cfs and a 100-year peak discharge of 5.02 cfs at Outfall FC-SW. Run-off discharges on the southwest side of Trench 13 and is carried by ditches and natural drainage pathways to the southern property line.

FC-Southeast Basins (FC-SE) and FC-Upper Deck East Basins (FC-UDE): consists of 8.08 acres. Basins include FC-SE-1, FC-SE-2, FC-SE-3, FC-SE-4, FC-SE-5, and FC-SE-6 for the sideslope areas and FC-UDE-1, FC-UDE-2, and FC-UDE-3, for the upper deck areas. The slopes are 20H:1V on the upper deck transitioning to 3H:1V on the side slopes. Runoff collects in lateral drainages, flows down a sideslope flume, and results in a 25-year peak discharge of 1.08 cfs and a 100-year peak discharge of 5.02 cfs at Outfall FC-SE. Run-off discharges on the southeast side of Trench 13 and is carried by ditches and natural drainage pathways to the southern property line.

FC-South-A Basins (FC-SA) and FC-Upper-Deck Middle-West (FC-UD-MW) Basins consists of 7.88 acres. Basins include FC-SA-1, FC-SA-2, FC-SA-3, FC-SA-4, FC-SA-5, and FC-SA-6 for the sideslope areas, and FC-UD-MW-1, FC-UD-MW-2, FC-UD-MW-3 for the upper deck areas. The slopes are 20H:1V on the upper deck transitioning to 3H:1V on the side slopes. Runoff collects in lateral drainages, flows down a sideslope flume, and results in a 25-year peak discharge of 1.02 cfs and a 100-year peak discharge of 4.91 cfs at Outfall FC-SA. Run-off discharges on the south side of Trench 13 and carried by ditches and natural drainage pathways to the southern property line.

FC-South-B Basins (FC-SB) and FC-Upper-Deck Middle-East (FC-UD-ME) Basins consists of 7.88 acres. Basins include FC-SB-1, FC-SB-2, FC-SB-3, FC-SB-4, FC-SB-5, and FC-SB-6 for the sideslope areas, and FC-UD-ME-1, FC-UD-ME-2, FC-UD-ME-3 for the upper deck areas. The slopes are 20H:1V on the upper deck transitioning to 3H:1V on the side slopes. Runoff collects in lateral drainages, flows down a sideslope flume, and results in a 25-year peak discharge of 1.02 cfs and a 100-year peak discharge of 4.91 cfs at Outfall FC-SB. Run-off discharges on the south side of Trench 13 and carried by ditches and natural drainage pathways to the southern property line

EE-Basins

The EE-Basins have a cumulative area of 61.79 Acres. The 25-yr peak discharge is **6.8 cfs**. The 10-year/24-hour peak discharge is **36 cfs** (**Reference 3)**

Basin EE-1 consists of 16.41 acres of undeveloped land and the topography is a mild slope from north-east to south-west. The basin drains to a natural channel and then to a proposed man-made channel on the north side of Trench 13 (Reach 4), then to Outfall 4.

Basin EE-2 consists of 20.22 acres of undeveloped land and the topography is a mild slope from north-east to south-west. The basin drains to a natural channel then to a proposed man-made channel on the north side of Trench 13 (Reach 4), then to Outfall 4.

Basin EE-3 consists of 25.19 acres of undeveloped land and the topography is a mild slope from east to west. The basin drains by overland flow to a proposed man-made channel on the north side of Trench 13 (Reach 4), then to Outfall 4.

SC-Basins

Consists of all south central basins (SC-Basins) with a cumulative area of 29.18 acres. The 25-yr peak discharge is **2.6 cfs**. The 100-year/24-hour peak discharge is **14 cfs** (**Reference 3)**

Basin SC-1 consists of 5.98 acres of cover soil on a portion of closed Trench 12 (not yet completed) and has a slope of 3:1 from north to south. The run-off flows to Reach 5 and south to Outfall 5.

Basin SC-2 consists of 16.05 acres of previously closed radiological waste Trenches. The basin drains to Reach 5 and then to Outfall 5.

Basin SC-3 consists of 1.21 acres of final cover soil on a portion of closed Trench 11, and has a slope of 20:1 from north-east to south-west. The basin drains to Reach 5 on the west side of Trench 11 and south to Outfall 5.

Basin SC-4 consists of 5.95 acres of cover soil on a portion of closed Trench 11, and has a slope of 3:1 from east to west. The basin drains to Reach 5, then south to Outfall 5.

SW-Basins

Consists of all south western basins (SW-Basins) with a cumulative area of 36.45 acres. The 25-yr peak discharge is **3.7 cfs**. The 100-year/24-hour peak discharge is **20 cfs** (**Reference 3)**.

Basin SW-1 consists of 16.77 acres of previously closed radiological waste Trenches. The basin drains east via man-made channels to proposed Reach 6 on the west side of Trench 13. The basin then drains south off-site at Outfall 6.

Basin SW-2 consists of 17.80 acres of undeveloped land used by USGS, and the topography is a mild slope from north-west to south-east. The basin drains east via man-made channels and to proposed Reach 6 on the west side of Trench 13. The basin then drains south off-site at Outfall 6.

Basin SW-3 consists of 1.89 acres of undeveloped land used by USGS and the topography is a mild slope from north-west to south-east. The basin drains east via man-made channels to proposed Reach 6 on the west side of Trench 13. The basin then drains south off-site at Outfall 6.

**Outfalls**

Outfall numbering and flows are for the purposes of this calculation only and do not correspond to specific Outfalls currently identified in USEN's Stormwater Permit.

The construction of Trench 13 will result in two outfall locations at USEN (identified as Outfalls 4 and 6 for the purposes of this calculation) that will result in flow off-site. Peak run-off expected in drainage basins is described below and summarized in **Reference 3**.

Outfall 1: A combination of run-offs from all the N-Basins with a cumulative area of 75 acres.

Outfall 2
A combination of run-offs from the N-Basins and E-basins, with a cumulative area of 93 acres.

Outfall 3
A combination of run-offs from the N-Basins, SE-basins, E-basins, and the FC-NW Basin of Trench 13, with a cumulative area of 105 acres.

Outfall 4
A combination of run-off from N-Basins, SE-Basins, E-Basins, EE Basins, FC-NW Basins, FC-NE Basins, FC-E Basins, FC-SE, FC-South , and FC-W Basins, with a cumulative area of 210 acres. Outfall 4 includes contributions from Outfall 1, Outfall 2, and Outfall 3, and flows that enter a proposed man-made channel along the east side of proposed Trench 13. Surface-water is released off-site at Outfall 4 located at the property boundary.

Outfall 5
A combination of run-offs from the all SC-Basins and run-off from a cumulative area of 29 acres.

Outfall 6
A combination of run-off from SC-Basins, SW-Basins, and FC-West Basins with a cumulative area of 71 acres. Outfall 6 is the release point for diverted surface-water around the western limits of proposed Trench 13.

**Table 1: Sum of Basin Contributions for Designated Outfalls (cfs)**

| OUTFALL (BASIN) | 1 (N) | 2 (N+E) | 3 (N+E+SE+T1) | 4 (N+E+SE+FC+EE) | 5 (SC) | 6 (SC+SW+FC-W) |
|---|---|---|---|---|---|---|
| **25-yr** | 7.2 | 9.6 | 11 | **24** | 2.6 | **7.0** |
| **100-yr** | 43 | 54 | 61 | **124** | 14 | **37** |

The values in bold are the discharge rates (cfs) for the two outfalls at the USEN site, located at the southeast and southwest corners of Trench 13. These calculated values will be used for capacity analysis of berms, ditches, and diversion channels for the transport of surface-water. Tabular spread sheets for these values are provided as **Reference 3**

## Conclusions

Using the USDA TR-55 model, storm run-off volume and peak rate of discharge have been estimated for the 25-year/24 hour and 100-year/24-hour precipitation events within drainage areas at or flowing towards the USEN facility and proposed Trench 13.

Drainage basin areas were summed at six locations to determine peak discharge at points of interest. Two of the locations represent the discharge as surface water leaves the USEN property. At Outfall 4, off the southeast corner of Trench 13, surface water is estimated to leave the USEN property at 24 cfs during a 25-year/24-hour precipitation event and at 124 cfs during a 100-year/24-hour precipitation event. At Outfall 6, off the southwest corner of Trench 13, surface water is estimated to leave the USEN property at 7.0 cfs during a 25-year/24-hour precipitation event and at 37 cfs during a 100-year/24-hour precipitation event.

## DIVERSION CHANNELS AND TRENCH 13 RUN-ON PROTECTION

### Purpose

Run-on control at Trench 13 is required only during the period that disposal operations are occurring below grade; however, diversion trenches and ditches, established to control run-off will also be used to control run-off as waste fill occurs above grade and following Trench 13 closure. Preventing run-on from 25-yr storm event is a regulatory requirement. In addition, these features have been evaluated to the 100-year, 24-hour storm

Run-on control diverts surface-water flow from all sides of Trench 13. The plan drawings are shown in **Reference 2** of this calculation and specify the location and design of the diversion features and drainages. The diversion features (constructed slopes at 2 percent away from the limits of waste placement (Horizontal Control Line), 1 foot of soil above grade at the anchor trenches, and temporary berms) and drainages divert surface-water from large rain events during excavation, waste placement, and closure of Trench 13. Drainage features can be built as construction of the Trench progresses and do not need to be completely built-out at the on-set of construction. Calculations of leachate control, described in the Leachate Collection and Removal (LCRS) calculation (**C.03** and **C.04**), account for precipitation that falls within the Horizontal Control Line.

Run-off control features, specific to the Trench 13 final cover are evaluated in Calculation C.12.

### Approach

Using Manning's equation for open-channel flow (**Reference 5**), determine if the Trench 13 surface water management features adequately handle the flow of water and appropriately divert the flow around Trench 13.

From the Trench 13 design, channel slope and geometry are per design. The flow capacity of drainages is assumed as the 25 year 24 hour peak discharge at the respective Outfall locations, Outfalls 4 and 6.

Mannings Equation is:

$$Q/A = V = \frac{k}{n} R_h^{\frac{2}{3}} S^{\frac{1}{2}}$$

Where:

$Q$= Flow [ $\frac{ft^3}{sec}$ ]
$A$= Cross Sectional Area [ $ft^2$]
$V$= Velocity [ $\frac{ft}{sec}$ ]
$K$= Conversion Factor = 1.4859
$R_h$ = A / Wp = Hydraulic Radius [ft]
$Wp$= Wetted Perimeter [ft]
$S$= Slope [ $\frac{ft}{ft}$ ]
$n$=Manning's Coefficient [unit-less]

1. The flow capacity of the channel (Q) will be compared to the flow rate for the specified Reach and Outfall the channel will serve. . These flow values were determined using the TR-55 model and are calculated in the section above for each specific Reach and Outfall, using the 25-year, 24-hour and 100-year, 24-hour precipitation events. Manning's Formula is used to determine if the channel design has adequate flow capacity.
2. The cross-sectional area of the channel is an independent variable and initial design assumption used as input to Manning's Formula.
3. Velocity of flow through the channel is a dependent variable and will be determined using values for slope, channel geometry, and surface roughness.
4. K is a unit less conversion factor
5. The hydraulic radius is a dependent value and is calculated using the cross-sectional area of the channel and the wetted perimeter. The value for hydraulic radius will become larger as the channel fills with water, this is a critical value in determining velocity of flow through the channel and strictly dependent on channel geometry.
6. Wetted perimeter refers to the length of wetted contact of the side slopes and base of the channel. As the channel fills with water the wetted perimeter becomes larger, this value is dependent upon channel geometry.
7. The slope of the channel is an initial design variable input for Manning's Formula. The minimum value for slope at any stage is the critical value; the maximum value for channel slope at any stage will not exceed 1.0%.
8. Manning's Coefficient represents the roughness of the channel surface, with 0.018 corresponding to the roughness of smooth earth (see **Reference 6**). This is a conservative value and will be used in

this calculation. For a given Q, a rougher channel will decrease the flowrate, and consequently, increase the depth of the flow in the channel.

Eastern Diversion Channel

The eastern diversion channel will be designed to carry the flow from Reach 4 around the north-east corner of Trench 13, and then south to Outfall 4, where the flow is discharged off-site. The design criteria will be focused on the critical stage of the channel, where slope and channel geometry are at a minimum, which occurs at the northwest corner of Trench 13.

Initial Conditions:

Q = 24 CFS (25-year, 24-hour)

Q = 124 CFS (100-year, 24-hour)

Trapezoidal Channel

Base: 12 ft

H Ratio: 3 ft

V Ratio: 1ft

Slope: 0.003 ft/ft (minimum)

Manning's Coefficient: 0.018

Using an iterative approach with Manning's Equation and varying water depth to determine maximum flow, the following is determined:

| Storm Event | Water Depth ft Y | Flow Area Sq. ft A | Wetted Perimeter ft Wp | Hydraulic Radius ft R | Flow Velocity fps U | Flow Max cfs Q |
|---|---|---|---|---|---|---|
| **25-yr** | **0.60** | 8.2 | 15..8 | 0.52 | **2.9** | 24 |
| **100-yr** | **1.5** | 24.9 | 22.5 | 1.16 | **5.0** | 124 |

The maximum water depth the eastern channel design can handle at the channels critical depth (minimum depth) is 3 feet in depth. Therefore, the channel as designed, will effectively carry the required flow from the beginning of Reach 4 to Outfall 4 where the flow is discharged off-site.

Western Diversion Channel or Control Berm

A western diversion channel or control berm will be necessary to carry the flow from Reach 6 south along the west side of Trench 13 to Outfall 6, where the flow is discharged off-site. The design criteria will be focused on the critical stage of the channel, where slope and channel geometry are at a minimum, which is uniform throughout the length of the channel.

Initial Conditions:

Q= 7.0 CFS (25-year, 24-hour)

Q = 37 CFS (100-year, 24-hour)

Trapezoidal Channel

Base: 6 ft

H Ratio: 3 ft

V Ratio: 1ft

Slope: 0.004 ft/ft (minimum)

Manning's Coefficient: .018 (conservative)

Using an iterative approach with Manning's Equation and varying water depth to determine maximum flow, the following is determined:

| Storm Event | Water Depth ft Y | Flow Area Sq. ft A | Wetted Perimeter ft Wp | Hydraulic Radius ft R | Flow Velocity fps U | Flow cubic ft per sec Q |
|---|---|---|---|---|---|---|
| **25-yr** | **0.42** | 3.1 | 8.7 | 0.36 | **2.3** | 7.0 |
| **100-yr** | **1.1** | 9.8 | 12.7 | .77 | **3.8** | 37 |

The information above verifies that a channel design with 2.1 feet in depth, a 6 foot wide base and 3H:1V sideslopes will effectively convey the required flow from the beginning of Reach 6 to Outlet 6 where the flow is discharged off-site.

**Conclusions**

The eastern diversion channel is adequately sized to convey the maximum anticipated design flow of the 100-year, 24-hour storm. A western drainage with 2.1 foot high sideslopes at 3H:1V and a 6 foot base or a protective berm at 2 foot high and open to the west will provide run-on protection to the western portion of Trench 13. Annual maintenance, or maintenance following heavy precipitation events, might be required to mitigate scour and debris build-up which could compromise the effectiveness of the diversion channels.

Diversion Channels

- The eastern and western diversion channel are designed with a maximum of 3:1 sideslopes. Gentler slopes are acceptable as they increase the cross-sectional area of the channel and increase capacity
- The channel bottom of the eastern channel is modeled at 12 feet wide in the base to accommodate construction with a D-9 bulldozer or similar equipment. The channel bottom in the western channel is modeled at 6 feet wide to accommodate construction with smaller equipment.
- The specified geometry of the channel will accommodate a flow greater than

that of a 100-year event, providing assurance the channel will operate effectively under degraded channel conditions or in larger than design precipitation events.

The locations of the channels are illustrated in **Reference 2** of this calculation, and additional information on Manning's Equation is provided in **Reference 5**.

The design adequately handles run-on from a 100-year storm event and will handle run-off following above-grade construction and final closure.

## CONTROL OF SURFACE WATER IN THE PROPOSED TRENCH 13 DISPOSAL AREA

For the purposes of this calculation, precipitation which falls within the Trench 13 Horizontal Control Line is grouped into the following four categories:

- Precipitation on the 0.5H: 1V Trench sidewalls.
- Precipitation on placed waste.
- Precipitation within the Trench 13 Horizontal Control Line that by design does not contact the placed waste.
- Precipitation on the interim cover.

Precipitation which has fallen on the 0.5H: 1V Trench sidewalls will not have contacted waste. This precipitation can be managed separate from that which has contacted waste. If Trench sidewall precipitation is captured with a sidewall "rain gutter" (or similar) system, it can be diverted for discharge and/or evaporation together with other clean surface-water. A rain gutter system could be placed at the base of the sacrificial FML that overlies the sidewall liner system. If allowed to commingle with water that have contacted waste, Trench sidewall waters will be managed following appropriate site protocols for contact water.

Precipitation that falls on placed waste will be managed following appropriate site protocols for contact water. Placed waste should be graded so that water run-off in severe precipitation events is directed to an in-Trench ponding point located against one of the Trench sidewalls, from which it can be removed for proper management.

Precipitation that falls within the Trench 13 footprint, but which by design does not contact place waste, can be handled separately from waters which has contacted waste.

Precipitation that falls on interim cover or final cover slopes will not have contacted waste. It will be discharged and/or evaporated together with other clean surface-water.

**Calculation C.04** evaluates the expected surface-water infiltration and sump removal volumes from the 25-year, 24-hour design storm event.

It is not expected that more than one Phase of Trench 13 will be open at one time with exposed waste. Assuming a 25-year, 24 hour storm were to occur with a full Phase open, all surface of the Phase with waste exposed to surface water contact, and the in-place waste having no water holding capacity, the event would be expected to generate approximately 606,000 gallons of leachate and/or surface water runoff (Phases 13A or 13E).

$$2.26\ \text{in} \times \frac{1\text{ft}}{12\text{in}} \times 430{,}370\text{ft}^2 \times \frac{7.48\text{gal}}{1\text{ft}^3} = 606{,}000\ \text{gallons}$$

This situation is considered extremely unlikely because of the arid environment at the USEN site. However, if such an event were to occur, surface-water collection and holding units would need to be provided by USEN. These units must be emptied or otherwise managed expeditiously after storms to maintain the design capacity of the system.

# REFERENCE 1

**NOAA Atlas 14, Volume 1, Version 5**
**AMARGOSA FARMS GAREY**
**Station ID: 26-0150**
**Location name: Amargosa Valley, Nevada, US***
**Latitude: 36.5717°, Longitude: -116.4619°**
**Elevation:**
**Elevation (station metadata): 2450 ft***
* source: Google Maps

**POINT PRECIPITATION FREQUENCY ESTIMATES**

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

## PF tabular

**PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]**

| Duration | Average recurrence interval (years) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 5 | 10 | 25 | 50 | 100 | 200 | 500 | 1000 |
| 5-min | 0.108 (0.072–0.109) | 0.140 (0.097–0.147) | 0.196 (0.148–0.223) | 0.244 (0.190–0.289) | 0.319 (0.257–0.396) | 0.384 (0.312–0.490) | 0.459 (0.376–0.606) | 0.543 (0.446–0.746) | 0.677 (0.557–0.976) | 0.795 (0.653–1.20) |
| 10-min | 0.165 (0.109–0.166) | 0.213 (0.148–0.224) | 0.298 (0.225–0.339) | 0.372 (0.288–0.439) | 0.485 (0.391–0.602) | 0.584 (0.474–0.746) | 0.699 (0.572–0.923) | 0.827 (0.679–1.14) | 1.03 (0.848–1.49) | 1.21 (0.995–1.82) |
| 15-min | 0.205 (0.136–0.206) | 0.265 (0.183–0.277) | 0.370 (0.279–0.421) | 0.461 (0.358–0.545) | 0.602 (0.484–0.746) | 0.724 (0.588–0.925) | 0.866 (0.709–1.14) | 1.03 (0.841–1.41) | 1.28 (1.05–1.84) | 1.50 (1.23–2.26) |
| 30-min | 0.276 (0.183–0.278) | 0.356 (0.246–0.373) | 0.498 (0.376–0.566) | 0.621 (0.482–0.734) | 0.810 (0.652–1.01) | 0.974 (0.792–1.25) | 1.17 (0.955–1.54) | 1.38 (1.13–1.90) | 1.72 (1.42–2.48) | 2.02 (1.66–3.04) |
| 60-min | 0.341 (0.226–0.344) | 0.441 (0.305–0.462) | 0.616 (0.465–0.701) | 0.768 (0.596–0.908) | 1.00 (0.807–1.24) | 1.21 (0.980–1.54) | 1.44 (1.18–1.91) | 1.71 (1.40–2.35) | 2.13 (1.75–3.07) | 2.50 (2.06–3.76) |
| 2-hr | 0.326 (0.275–0.396) | 0.438 (0.370–0.538) | 0.657 (0.545–0.801) | 0.843 (0.694–1.04) | 1.15 (0.924–1.41) | 1.42 (1.13–1.73) | 1.73 (1.36–2.15) | 2.11 (1.61–2.63) | 2.71 (2.01–3.41) | 3.25 (2.34–4.14) |
| 3-hr | 0.375 (0.314–0.446) | 0.503 (0.426–0.605) | 0.728 (0.617–0.881) | 0.923 (0.774–1.11) | 1.24 (1.02–1.49) | 1.51 (1.22–1.82) | 1.83 (1.46–2.22) | 2.20 (1.73–2.70) | 2.80 (2.13–3.49) | 3.35 (2.48–4.21) |
| 6-hr | 0.469 (0.399–0.558) | 0.628 (0.540–0.746) | 0.910 (0.778–1.08) | 1.15 (0.970–1.35) | 1.49 (1.25–1.76) | 1.79 (1.48–2.11) | 2.14 (1.74–2.54) | 2.53 (2.02–3.03) | 3.16 (2.47–3.82) | 3.72 (2.85–4.55) |
| 12-hr | 0.591 (0.502–0.678) | 0.785 (0.677–0.917) | 1.15 (0.987–1.33) | 1.43 (1.23–1.66) | 1.84 (1.57–2.13) | 2.17 (1.83–2.52) | 2.54 (2.12–2.96) | 2.94 (2.41–3.45) | 3.52 (2.83–4.17) | 4.07 (3.23–4.89) |
| 24-hr | 0.694 (0.580–0.836) | 0.944 (0.787–1.12) | 1.39 (1.15–1.66) | 1.75 (1.43–2.08) | 2.26 (1.83–2.68) | 2.68 (2.15–3.17) | 3.13 (2.48–3.74) | 3.63 (2.82–4.34) | 4.35 (3.29–5.24) | 4.95 (3.66–6.02) |
| 2-day | 0.766 (0.647–0.914) | 1.04 (0.877–1.23) | 1.54 (1.30–1.82) | 1.94 (1.62–2.28) | 2.50 (2.07–2.90) | 2.97 (2.42–3.45) | 3.47 (2.79–4.05) | 4.02 (3.14–4.74) | 4.81 (3.65–5.77) | 5.47 (4.05–6.68) |
| 3-day | 0.791 (0.670–0.943) | 1.08 (0.909–1.27) | 1.60 (1.35–1.88) | 2.01 (1.69–2.36) | 2.60 (2.15–3.02) | 3.09 (2.52–3.59) | 3.63 (2.90–4.24) | 4.21 (3.29–4.98) | 5.06 (3.84–6.09) | 5.76 (4.27–7.05) |
| 4-day | 0.816 (0.694–0.973) | 1.11 (0.941–1.31) | 1.65 (1.40–1.93) | 2.08 (1.75–2.43) | 2.70 (2.24–3.14) | 3.22 (2.62–3.73) | 3.79 (3.02–4.42) | 4.40 (3.45–5.22) | 5.30 (4.03–6.40) | 6.06 (4.48–7.43) |
| 7-day | 0.887 (0.750–1.05) | 1.21 (1.03–1.44) | 1.83 (1.55–2.14) | 2.31 (1.93–2.70) | 2.99 (2.47–3.49) | 3.56 (2.90–4.15) | 4.17 (3.33–4.89) | 4.84 (3.79–5.76) | 5.80 (4.43–7.03) | 6.60 (4.92–8.11) |
| 10-day | 0.965 (0.797–1.17) | 1.32 (1.10–1.59) | 1.99 (1.66–2.37) | 2.51 (2.08–2.98) | 3.25 (2.65–3.85) | 3.86 (3.10–4.61) | 4.52 (3.59–5.43) | 5.24 (4.08–6.35) | 6.27 (4.74–7.73) | 7.13 (5.27–8.92) |
| 20-day | 1.15 (0.950–1.38) | 1.57 (1.31–1.88) | 2.35 (1.96–2.79) | 2.95 (2.45–3.49) | 3.79 (3.13–4.48) | 4.48 (3.62–5.31) | 5.21 (4.15–6.23) | 6.00 (4.70–7.24) | 7.11 (5.42–8.72) | 8.02 (5.96–9.99) |
| 30-day | 1.32 (1.08–1.58) | 1.81 (1.48–2.16) | 2.72 (2.23–3.23) | 3.41 (2.79–4.05) | 4.39 (3.56–5.19) | 5.17 (4.17–6.14) | 6.00 (4.80–7.14) | 6.89 (5.42–8.28) | 8.14 (6.27–9.95) | 9.16 (6.93–11.3) |
| 45-day | 1.45 (1.18–1.75) | 2.00 (1.63–2.41) | 3.07 (2.51–3.67) | 3.90 (3.18–4.65) | 5.08 (4.08–6.04) | 6.03 (4.83–7.20) | 7.07 (5.59–8.49) | 8.18 (6.38–9.93) | 9.78 (7.42–12.1) | 11.1 (8.26–13.8) |
| 60-day | 1.61 (1.30–1.97) | 2.24 (1.81–2.74) | 3.48 (2.82–4.20) | 4.45 (3.59–5.34) | 5.84 (4.65–6.98) | 7.00 (5.54–8.39) | 8.26 (6.47–9.98) | 9.63 (7.42–11.7) | 11.6 (8.69–14.3) | 13.3 (9.75–16.6) |

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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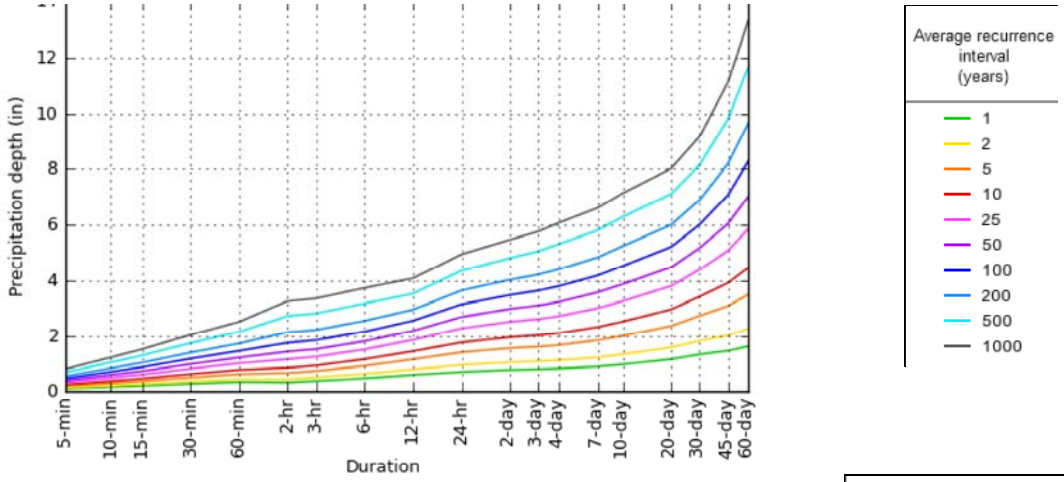
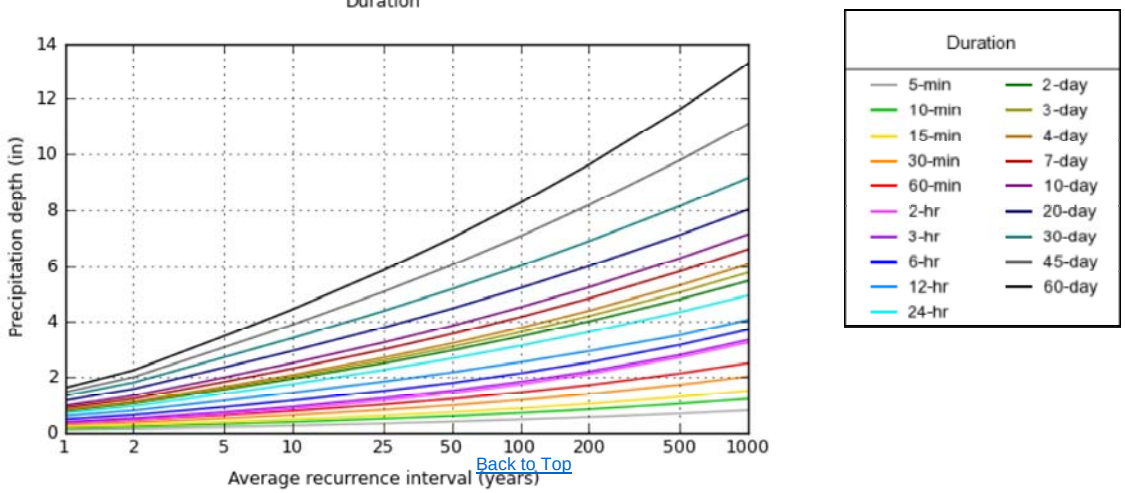
## PF graphical

REFERENCE 1

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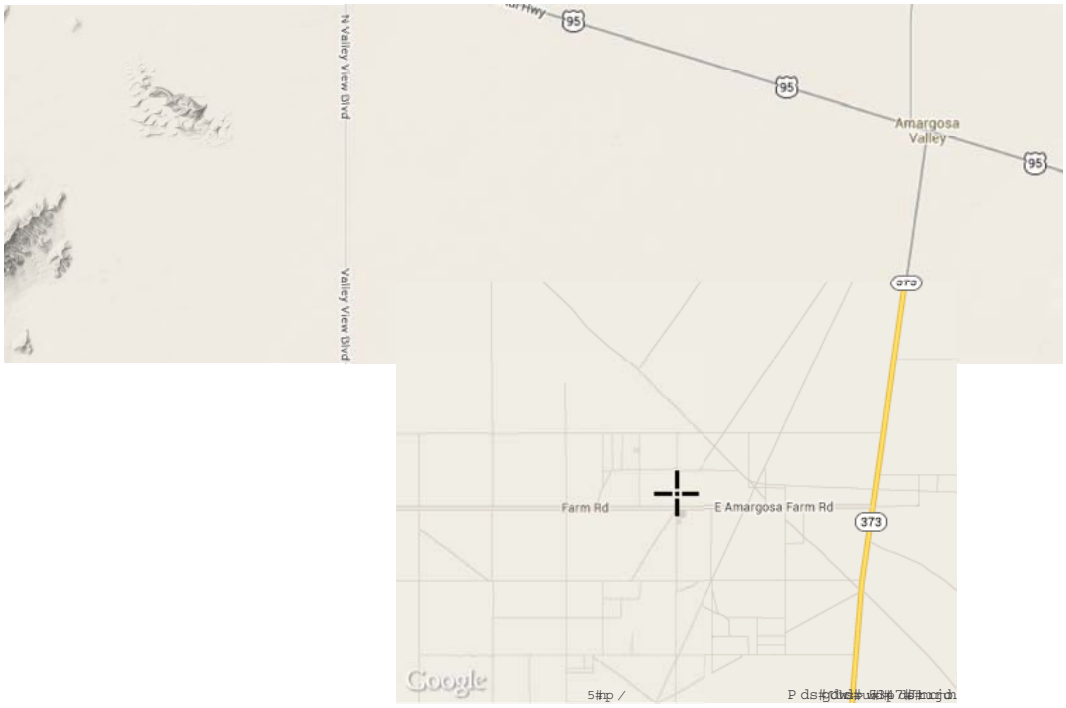
## Maps & aerials

NOAA Atlas 14, Volume 1, Version 5 Created (GMT): Fri Jul 25 17:05:28 2014

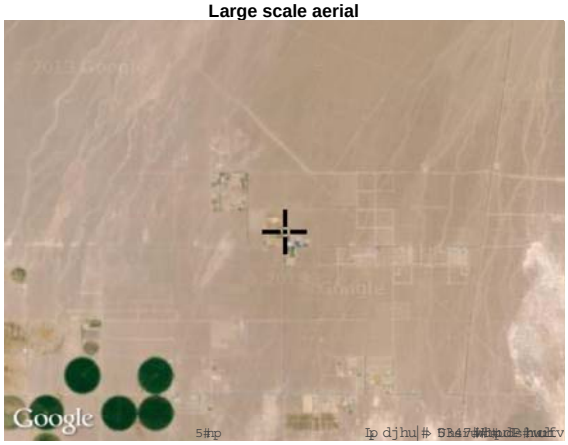
**Small scale terrain**

**Large scale terrain**

REFERENCE 1




**Large scale aerial**

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
Office of Hydrologic Development
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

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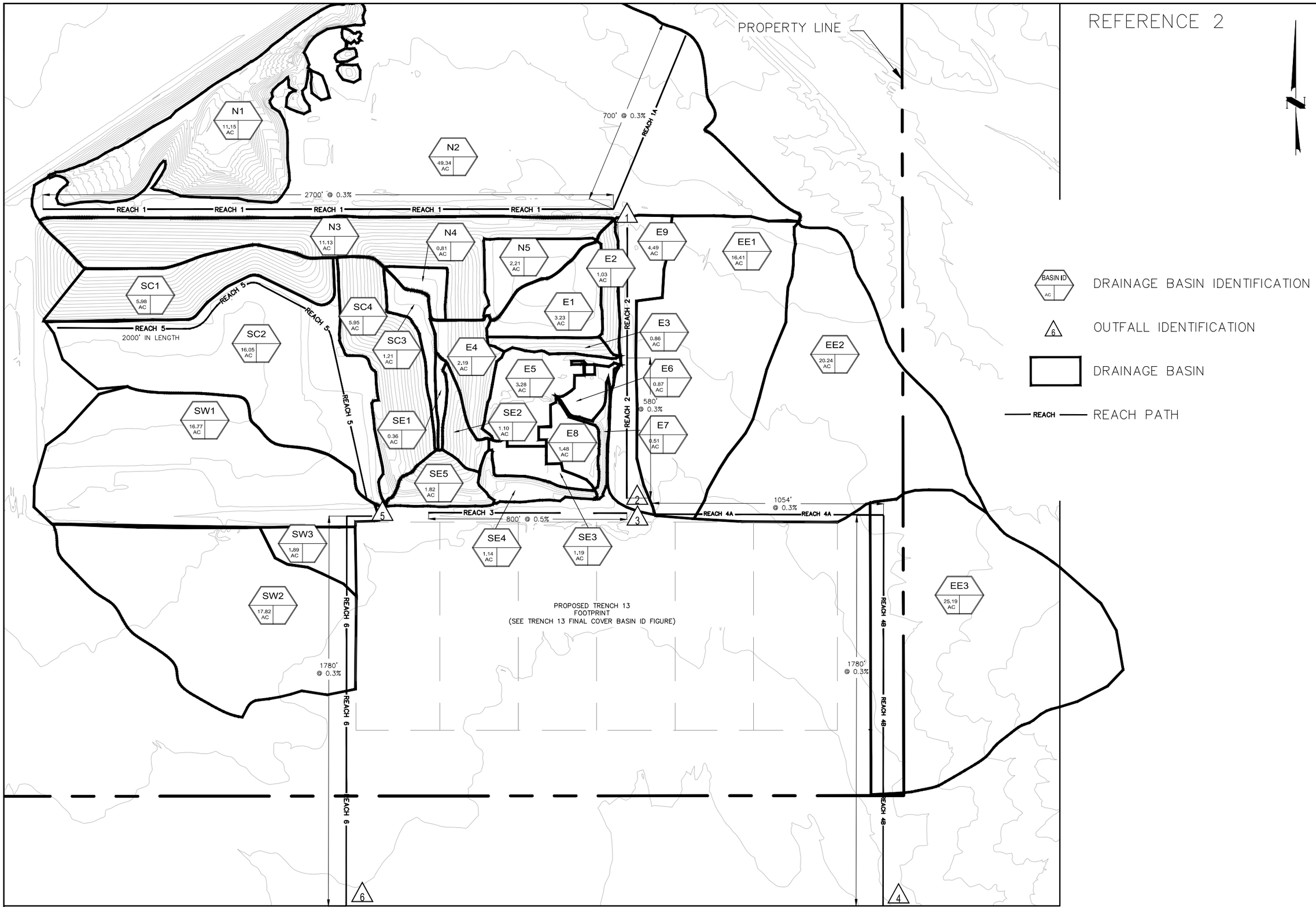


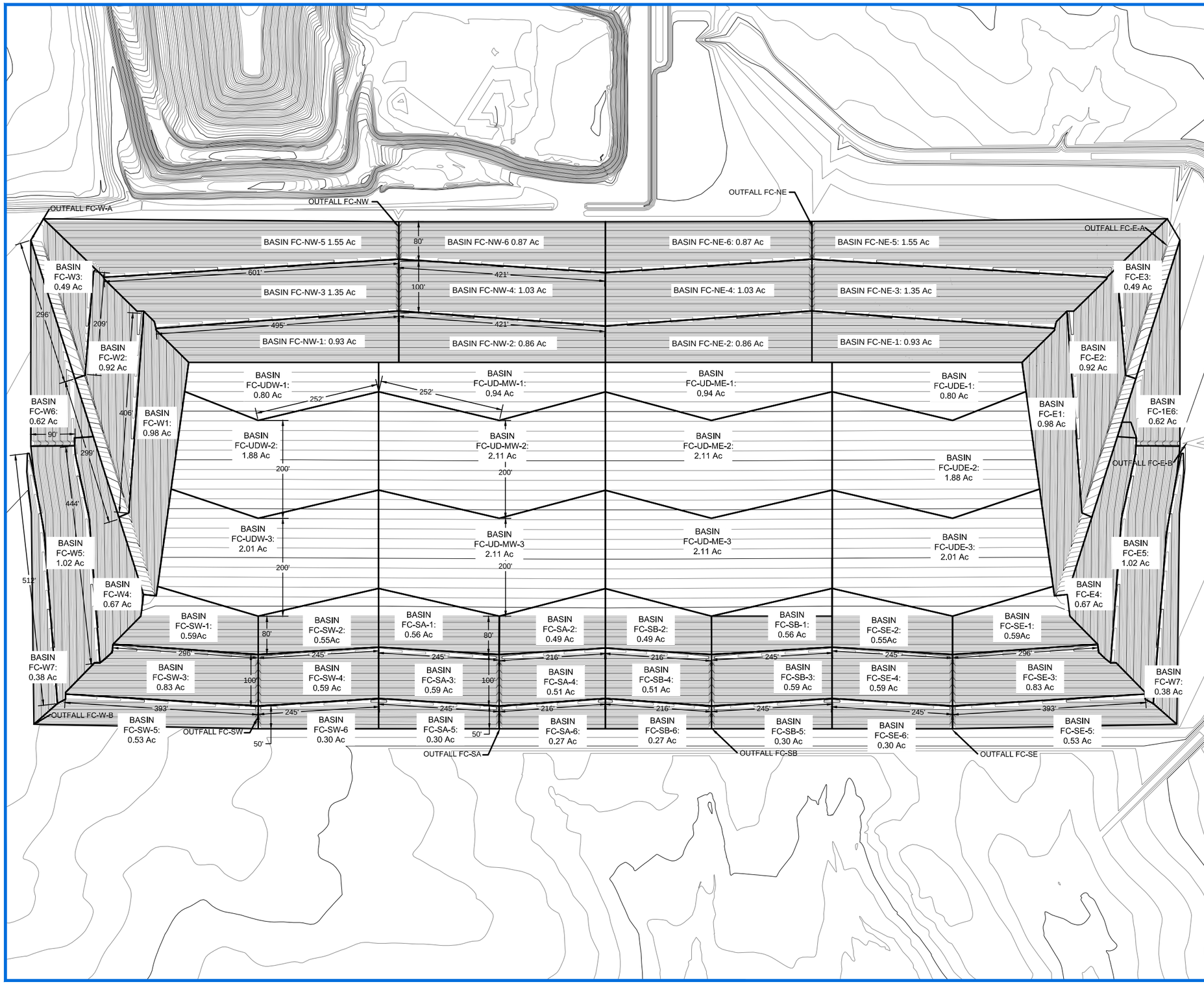

AquAeTer
optimizing resources | water, air, earth

REVISION COMMENTS

DATE

US ecology

STORMWATER MANAGEMENT BASIN DELINEATION




TRENCH 13 FINAL COVER

BASIN IDENTIFICATION

REFERENCE 2

| | |
|---|---|
| CLIENT: | US ECOLOGY |
| LOCATION: | BEATTY, NV |
| PROJECT NUMBER: | 143418 |
| DATE: | 3/4/16 |
| DRAWN BY: | CWK |

AquAeTer

optimizing resources | water, air, earth

# TR-55 Model Input Values and Summary - REFERENCE 3

US Ecology
Beatty, Nevada

| | |
|---|---|
| Curve Number[a/] | 63 |
| Hydrologic Soil Group | A |
| Rainfall[b/] | Type II |
| 2yr/24hr (in) | 0.944 |
| 10yr/24hr (in) | 1.75 |
| 25yr/24hr (in) | 2.26 |
| 100yr/24hr (in) | 3.13 |

| ID | Area ($ft^2$) | Area (acres) | | MIN=0.1 hr Time of Concentration (hr) | 2-yr Peak Discharge (cfs) | 5-yr Peak Discharge (cfs) | 25-yr Peak Discharge (cfs) | 100-yr Peak Discharge (cfs) |
|---|---|---|---|---|---|---|---|---|
| N1 | 485757 | 11.15 | Sheet Flow and Channelized Flow | 0.10 | 0.00 | 0.00 | 1.56 | 6.96 |
| N2 | 2149023 | 49.33 | See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.05 | 6.92 | 30.82 |
| N3 | 484890 | 11.13 | | 0.10 | 0.00 | 0.00 | 1.56 | 6.95 |
| N4 | 35316 | 0.81 | | 0.10 | 0.00 | 0.00 | 0.11 | 0.51 |
| N5 | 96150 | 2.21 | | 0.10 | 0.00 | 0.00 | 0.31 | 1.38 |
| | N Total | 74.64 | | | *Discharge for N-Basins | | 7.17 | 42.74 |
| E1 | 140845 | 3.23 | Sheet Flow and Channelized Flow | 0.10 | 0.00 | 0.00 | 0.45 | 2.02 |
| E2 | 44684 | 1.03 | See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.14 | 0.64 |
| E3 | 37303 | 0.86 | | 0.10 | 0.00 | 0.00 | 0.12 | 0.54 |
| E4 | 95608 | 2.19 | | 0.11 | 0.00 | 0.00 | 0.31 | 1.37 |
| E5 | 143031 | 3.28 | | 0.10 | 0.00 | 0.00 | 0.46 | 2.05 |
| E6 | 37957 | 0.87 | | 0.10 | 0.00 | 0.00 | 0.12 | 0.54 |
| E7 | 22125 | 0.51 | | 0.10 | 0.00 | 0.00 | 0.07 | 0.32 |
| E8 | 64515 | 1.48 | | 0.10 | 0.00 | 0.00 | 0.21 | 0.92 |
| E9 | 195452 | 4.49 | | 0.10 | 0.00 | 0.00 | 0.63 | 2.81 |
| | E Total | 17.94 | | | *Discharge for E-Basins | | 2.47 | 11.08 |
| SE1 | 15712 | 0.36 | Sheet Flow and Channelized Flow | 0.10 | 0.00 | 0.00 | 0.05 | 0.22 |
| SE2 | 47704 | 1.10 | See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.15 | 0.69 |
| SE3 | 51644 | 1.19 | | 0.10 | 0.00 | 0.00 | 0.17 | 0.74 |
| SE4 | 49715 | 1.14 | | 0.10 | 0.00 | 0.00 | 0.16 | 0.71 |
| SE5 | 79262 | 1.82 | | 0.10 | 0.00 | 0.00 | 0.25 | 1.14 |
| | SE Total | 5.60 | | | *Discharge for SE-Basins | | 0.77 | 3.49 |
| EE1 | 714799 | 16.41 | Sheet Flow and Channelized Flow | 0.10 | 0.00 | 0.00 | 2.09 | 9.86 |
| EE2 | 880686 | 20.22 | See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 2.84 | 12.63 |
| EE3 | 1095979 | 25.16 | | 0.10 | 0.00 | 0.00 | 3.05 | 14.77 |
| | EE Total | 61.79 | | | *Discharge for EE-Basins | | 6.77 | 35.60 |
| SC1 | 260445 | 5.98 | Sheet Flow and Channelized Flow | 0.10 | 0.00 | 0.00 | 0.55 | 2.93 |
| SC2 | 699005 | 16.05 | See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 1.47 | 7.87 |
| SC3 | 52536 | 1.21 | | 0.10 | 0.00 | 0.00 | 0.11 | 0.59 |
| SC4 | 259261 | 5.95 | | 0.10 | 0.00 | 0.00 | 0.55 | 2.92 |
| | SC Total | 29.18 | | | *Discharge for SC-Basins | | 2.58 | 13.85 |
| SW1 | 730436 | 16.77 | Sheet Flow and Channelized Flow | 0.10 | 0.00 | 0.00 | 2.35 | 10.45 |
| SW2 | 775298 | 17.80 | See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 1.62 | 8.77 |
| SW3 | 82208 | 1.89 | | 0.10 | 0.00 | 0.00 | 0.26 | 1.18 |
| | SW Total | 36.45 | | | *Discharge for SW-Basins | | 3.72 | 19.52 |

| Final Cover Northwest Basins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC-NW-1 | 40511 | 0.93 | Sheet Flow and Channelized Flow<br>See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.13 | 0.58 |
| FC-NW-2 | 37462 | 0.86 | | 0.10 | 0.00 | 0.00 | 0.12 | 0.54 |
| FC-NW-3 | 58806 | 1.35 | | 0.10 | 0.00 | 0.00 | 0.19 | 0.84 |
| FC-NW-4 | 44867 | 1.03 | | 0.10 | 0.00 | 0.00 | 0.14 | 0.64 |
| FC-NW-5 | 67518 | 1.55 | | 0.10 | 0.00 | 0.00 | 0.22 | 0.97 |
| FC-NW-6 | 37897 | 0.87 | | 0.10 | 0.00 | 0.00 | 0.12 | 0.54 |
| | NW Total | 6.59 | | | Discharge to Outfall FC-NW | | 0.92 | 4.11 |

| Final Cover Northeast Basins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC-NE-1 | 40511 | 0.93 | Sheet Flow and Channelized Flow<br>See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.13 | 0.58 |
| FC-NE-2 | 37462 | 0.86 | | 0.10 | 0.00 | 0.00 | 0.12 | 0.54 |
| FC-NE-3 | 58806 | 1.35 | | 0.10 | 0.00 | 0.00 | 0.19 | 0.84 |
| FC-NE-4 | 44867 | 1.03 | | 0.10 | 0.00 | 0.00 | 0.14 | 0.64 |
| FC-NE-5 | 67518 | 1.55 | | 0.10 | 0.00 | 0.00 | 0.22 | 0.97 |
| FC-NE-6 | 37897 | 0.87 | | 0.10 | 0.00 | 0.00 | 0.12 | 0.54 |
| | NE Total | 6.59 | | | Discharge to Outfall FC-NE | | 0.92 | 4.11 |

| Final Cover East - A - Basins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC-E-1 | 42689 | 0.98 | Sheet Flow and Channelized Flow<br>See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.14 | 0.61 |
| FC-E-2 | 40075 | 0.92 | | 0.10 | 0.00 | 0.00 | 0.13 | 0.58 |
| FC-E-3 | 21344 | 0.49 | | 0.10 | 0.00 | 0.00 | 0.07 | 0.31 |
| | E-A Total | 2.39 | | | Discharge to Outfall FC-E-A | | 0.33 | 1.49 |

| Final Cover East - B - Basins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC-E-4 | 29185 | 0.67 | Sheet Flow and Channelized Flow<br>See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.09 | 0.42 |
| FC-E-5 | 44431 | 1.02 | | 0.10 | 0.00 | 0.00 | 0.14 | 0.64 |
| FC-E-6 | 27007 | 0.62 | | 0.10 | 0.00 | 0.00 | 0.09 | 0.39 |
| FC-E-7 | 16553 | 0.38 | | 0.10 | 0.00 | 0.00 | 0.05 | 0.24 |
| | E-B Total | 2.69 | | | Discharge to Outfall FC-E-B | | 0.38 | 1.68 |

| Final Cover Southeast Basins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC-SE-1 | 25700 | 0.59 | Sheet Flow and Channelized Flow<br>See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.08 | 0.37 |
| FC-SE-2 | 23958 | 0.55 | | 0.10 | 0.00 | 0.00 | 0.08 | 0.34 |
| FC-SE-3 | 36155 | 0.83 | | 0.10 | 0.00 | 0.00 | 0.12 | 0.52 |
| FC-SE-4 | 25700 | 0.59 | | 0.10 | 0.00 | 0.00 | 0.08 | 0.37 |
| FC-SE-5 | 23087 | 0.53 | | 0.10 | 0.00 | 0.00 | 0.07 | 0.33 |
| FC-SE-6 | 13068 | 0.30 | | 0.10 | 0.00 | 0.00 | 0.00 | 0.19 |
| FC-UDE-3 | 87556 | 2.01 | | 0.10 | 0.00 | 0.00 | 0.28 | 1.26 |
| FC-UDE-2 | 81893 | 1.88 | | 0.10 | 0.00 | 0.00 | 0.26 | 1.18 |
| FC-UDE-1 | 34848 | 0.80 | | 0.10 | 0.00 | 0.00 | 0.11 | 0.50 |
| | SE Total | 8.08 | | | Discharge to Outfall FC-SE | | 1.08 | 5.03 |

| Final Cover South B Basins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC-SB-1 | 24394 | 0.56 | Sheet Flow and Channelized Flow<br>See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.08 | 0.35 |
| FC-SB-2 | 21344 | 0.49 | | 0.10 | 0.00 | 0.00 | 0.07 | 0.31 |
| FC-SB-3 | 25700 | 0.59 | | 0.10 | 0.00 | 0.00 | 0.08 | 0.37 |
| FC-SB-4 | 22216 | 0.51 | | 0.10 | 0.00 | 0.00 | 0.07 | 0.32 |
| FC-SB-5 | 13068 | 0.30 | | 0.10 | 0.00 | 0.00 | 0.00 | 0.19 |
| FC-SB-6 | 11761 | 0.27 | | 0.10 | 0.00 | 0.00 | 0.00 | 0.17 |
| FC-UD-ME-3 | 91912 | 2.11 | | 0.10 | 0.00 | 0.00 | 0.30 | 1.32 |
| FC-UD-ME-2 | 91912 | 2.11 | | 0.10 | 0.00 | 0.00 | 0.30 | 1.32 |
| FC-UD-ME-1 | 40946.4 | 0.94 | | 0.10 | 0.00 | 0.00 | 0.13 | 0.59 |
| | S-B Total | 7.88 | | | Discharge to Outfall FC-SB | | 1.02 | 4.91 |

| Final Cover South A Basins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC-SA-1 | 24394 | 0.56 | Sheet Flow and Channelized Flow<br>See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.08 | 0.35 |
| FC-SA-2 | 21344 | 0.49 | | 0.10 | 0.00 | 0.00 | 0.07 | 0.31 |
| FC-SA-3 | 25700 | 0.59 | | 0.10 | 0.00 | 0.00 | 0.08 | 0.37 |
| FC-SA-4 | 22216 | 0.51 | | 0.10 | 0.00 | 0.00 | 0.07 | 0.32 |
| FC-SA-5 | 13068 | 0.30 | | 0.10 | 0.00 | 0.00 | 0.00 | 0.19 |
| FC-SA-6 | 11761 | 0.27 | | 0.10 | 0.00 | 0.00 | 0.00 | 0.17 |
| FC-UD-MW-3 | 91912 | 2.11 | | 0.10 | 0.00 | 0.00 | 0.30 | 1.32 |
| FC-UD-MW-2 | 91912 | 2.11 | | 0.10 | 0.00 | 0.00 | 0.30 | 1.32 |
| FC-UD-MW-1 | 40946.4 | 0.94 | | 0.10 | 0.00 | 0.00 | 0.13 | 0.59 |
| | S-A Total | 7.88 | | | Discharge to Outfall FC-SA | | 1.02 | 4.91 |

| Final Cover Southwest Basins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC-SW-1 | 25700 | 0.59 | Sheet Flow and Channelized Flow<br>See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.08 | 0.37 |
| FC-SW-2 | 23958 | 0.55 | | 0.10 | 0.00 | 0.00 | 0.08 | 0.34 |
| FC-SW-3 | 36155 | 0.83 | | 0.10 | 0.00 | 0.00 | 0.12 | 0.52 |
| FC-SW-4 | 25700 | 0.59 | | 0.10 | 0.00 | 0.00 | 0.08 | 0.37 |
| FC-SW-5 | 23087 | 0.53 | | 0.10 | 0.00 | 0.00 | 0.07 | 0.33 |
| FC-SW-6 | 13068 | 0.30 | | 0.10 | 0.00 | 0.00 | 0.00 | 0.19 |
| FC-UDW-3 | 87556 | 2.01 | | 0.10 | 0.00 | 0.00 | 0.28 | 1.26 |
| FC-UDW-2 | 81893 | 1.88 | | 0.10 | 0.00 | 0.00 | 0.26 | 1.18 |
| FC-UDW-1 | 34848 | 0.80 | | 0.10 | 0.00 | 0.00 | 0.11 | 0.50 |
| | SW Total | 8.08 | | | Discharge to Outfall FC-SW | | 1.08 | 5.03 |

| Final Cover West Basins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC-W-1 | 42689 | 0.98 | Sheet Flow and Channelized Flow<br>See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.14 | 0.61 |
| FC-W-2 | 40075 | 0.92 | | 0.10 | 0.00 | 0.00 | 0.13 | 0.58 |
| FC-W-3 | 21344 | 0.49 | | 0.10 | 0.00 | 0.00 | 0.07 | 0.31 |
| | W-A Total | 2.39 | | | Discharge to Outfall FC-W-A | | 0.33 | 1.48 |

| Final Cover West Basins | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| FC-W-4 | 29185 | 0.67 | Sheet Flow and Channelized Flow<br>See TR-55 Model Runs in Reference | 0.10 | 0.00 | 0.00 | 0.09 | 0.42 |
| FC-W-5 | 44431 | 1.02 | | 0.10 | 0.00 | 0.00 | 0.14 | 0.64 |
| FC-W-6 | 27007 | 0.62 | | 0.10 | 0.00 | 0.00 | 0.09 | 0.39 |
| FC-W-7 | 16553 | 0.38 | | 0.10 | 0.00 | 0.00 | 0.05 | 0.24 |
| | W-B Total | 2.69 | | | Discharge to Outfall FC-W-B | | 0.38 | 1.68 |

| | | | | Discharge | |
|---|---|---|---|---|---|
| **Outfall** | | **Acres** | | 25-yr event (cfs) | 100-yr event (cfs) |
| 1 | | 75 | | 7.2 | 43 |
| 2 | | 93 | | 9.6 | 54 |
| 3 | | 105 | | 11 | 61 |
| 4 | | 210 | | **24** | **124** |
| 5 | | 29 | | 2.6 | 14 |
| 6 | | 71 | | **7.0** | **37** |

Notes:
[a/] = TR-55 Table 2-2d
[b/] = NOAA Atlas 14, Volume 1, Version 5, Amargosa Farms Garey, Station ID: 26-0150
Precipitation Type II Rainfall Distribution
* Discharge values are not a sum of each basin, reach flow path and time of concetration
determine final values for discharge

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CAB
Project: USEN
SubTitle: Basin Area North N
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Stormwater\WinTR55\Basin N.w55

Date: 4/1/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| N1 | | REACH 1 | 11.15 | 63 | 0.1 |
| N2 | | REACH 1A | 49.33 | 63 | 0.1 |
| N3 | | REACH 1 | 11.13 | 63 | 0.1 |
| N4 | | REACH 1 | 0.81 | 63 | 0.1 |
| N5 | | REACH 1 | 2.21 | 63 | 0.1 |

Total area: 74.63 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CAB USEN
Basin Area North N
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CAB USEN
Basin Area North N
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| N1 | .00 | .00 | 1.56 | 6.96 |
| N2 | .00 | 0.05 | 6.92 | 30.82 |
| N3 | .00 | .00 | 1.56 | 6.95 |
| N4 | .00 | .00 | 0.11 | 0.51 |
| N5 | .00 | .00 | 0.31 | 1.38 |
| REACHES | | | | |
| REACH 1 | .00 | .00 | 3.55 | 15.80 |
| Down | .00 | .00 | 3.22 | 15.18 |
| REACH 1A | .00 | 0.05 | 6.92 | 30.82 |
| Down | .00 | 0.05 | 6.66 | 30.43 |
| OUTLET | .00 | 0.05 | 7.17 | 42.74 |

REFERENCE 3

CAB USEN
Basin Area North N
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| N1 | .00 | n/a | .00 | n/a | 1.56 | 12.04 | 6.96 | 12.02 |
| N2 | .00 | n/a | 0.05 | 23.94 | 6.92 | 12.04 | 30.82 | 12.02 |
| N3 | .00 | n/a | .00 | n/a | 1.56 | 12.04 | 6.95 | 12.02 |
| N4 | .00 | n/a | .00 | n/a | 0.11 | 12.04 | 0.51 | 12.02 |
| N5 | .00 | n/a | .00 | n/a | 0.31 | 12.04 | 1.38 | 12.02 |
| REACHES | | | | | | | | |
| REACH 1 | .00 | n/a | .00 | n/a | 3.55 | 12.04 | 15.80 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 3.22 | 12.19 | 15.18 | 12.12 |
| REACH 1A | .00 | n/a | 0.05 | 23.94 | 6.92 | 12.04 | 30.82 | 12.02 |
| Down | .00 | n/a | 0.05 | 23.97 | 6.66 | 12.07 | 30.43 | 12.04 |
| OUTLET | .00 | | 0.05 | | 7.17 | | 42.74 | |

REFERENCE 3

CAB USEN
Basin Area North N
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| N1 | 11.15 | 0.100 | 63 | REACH 1 | |
| N2 | 49.33 | 0.100 | 63 | REACH 1A | |
| N3 | 11.13 | 0.100 | 63 | REACH 1 | |
| N4 | .81 | 0.100 | 63 | REACH 1 | |
| N5 | 2.21 | 0.100 | 63 | REACH 1 | |

Total Area: 74.63 (ac)

REFERENCE 3

CAB USEN

Basin Area North N
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| REACH 1 | Outlet | 2700 | CHANNEL |
| REACH 1A | Outlet | 700 | CHANNEL |

REFERENCE 3

CAB

USEN
Basin Area North N
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| N1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| N2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| N3 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| N4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| N5 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |

REFERENCE 3

CAB

USEN
Basin Area North N
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| N1 | Desert shrub | (poor) | A | 11.15 | 63 |
| | Total Area / Weighted Curve Number | | | 11.15 | 63 |
| | | | | ===== | == |
| N2 | Desert shrub | (poor) | A | 49.33 | 63 |
| | Total Area / Weighted Curve Number | | | 49.33 | 63 |
| | | | | ===== | == |
| N3 | Desert shrub | (poor) | A | 11.13 | 63 |
| | Total Area / Weighted Curve Number | | | 11.13 | 63 |
| | | | | ===== | == |
| N4 | Desert shrub | (poor) | A | .81 | 63 |
| | Total Area / Weighted Curve Number | | | .81 | 63 |
| | | | | === | == |
| N5 | Natural desert (pervious areas only) | | A | 2.21 | 63 |
| | Total Area / Weighted Curve Number | | | 2.21 | 63 |
| | | | | ==== | == |

REFERENCE 3

CAB USEN
Basin Area North N
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| REACH 1 | 2700 | 0.011 | 0.003 | 2 | 3 :1 |
| REACH 1A | 700 | 0.011 | 0.003 | 2 | 3 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| REACH 1 | 0.0 | 0.000 | 0 | 2 | 0.003 |
| | 0.5 | 6.295 | 1.8 | 5 | |
| | 1.0 | 26.337 | 5 | 8 | |
| | 2.0 | 125.558 | 16 | 14 | |
| | 5.0 | 1167.157 | 85 | 32 | |
| | 10.0 | 6834.962 | 320 | 62 | |
| | 20.0 | 41588.589 | 1240 | 122 | |
| REACH 1A | 0.0 | 0.000 | 0 | 2 | 0.003 |
| | 0.5 | 6.295 | 1.8 | 5 | |
| | 1.0 | 26.337 | 5 | 8 | |
| | 2.0 | 125.558 | 16 | 14 | |
| | 5.0 | 1167.157 | 85 | 32 | |
| | 10.0 | 6834.962 | 320 | 62 | |
| | 20.0 | 41588.589 | 1240 | 122 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: USEN
SubTitle: Basin Area E
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Stormwater\WinTR55\Basin E.w55

Date: 4/1/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| E1 | | REACH 2 | 3.23 | 63 | 0.1 |
| E2 | | REACH 2 | 1.03 | 63 | 0.1 |
| E3 | | REACH 2 | 0.86 | 63 | 0.1 |
| E4 | | REACH 2 | 2.19 | 63 | 0.1 |
| E5 | | REACH 2 | 3.28 | 63 | 0.1 |
| E6 | | REACH 2 | 0.87 | 63 | 0.1 |
| E7 | | REACH 2 | 0.51 | 63 | 0.1 |
| E8 | | REACH 2 | 1.48 | 63 | 0.1 |
| E9 | | REACH 2 | 4.49 | 63 | 0.1 |

Total area: 17.94 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK USEN
Basin Area E
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

USEN
Basin Area E
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| E1 | .00 | .00 | 0.45 | 2.02 |
| E2 | .00 | .00 | 0.14 | 0.64 |
| E3 | .00 | .00 | 0.12 | 0.54 |
| E4 | .00 | .00 | 0.31 | 1.37 |
| E5 | .00 | .00 | 0.46 | 2.05 |
| E6 | .00 | .00 | 0.12 | 0.54 |
| E7 | .00 | .00 | 0.07 | 0.32 |
| E8 | .00 | .00 | 0.21 | 0.92 |
| E9 | .00 | .00 | 0.63 | 2.81 |
| REACHES | | | | |
| REACH 2 | .00 | .00 | 2.52 | 11.21 |
| Down | .00 | .00 | 2.47 | 11.08 |
| OUTLET | .00 | .00 | 2.47 | 11.08 |

REFERENCE 3

CWK USEN
Basin Area E
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| E1 | .00 | n/a | .00 | n/a | 0.45 | 12.04 | 2.02 | 12.02 |
| E2 | .00 | n/a | .00 | n/a | 0.14 | 12.04 | 0.64 | 12.02 |
| E3 | .00 | n/a | .00 | n/a | 0.12 | 12.04 | 0.54 | 12.02 |
| E4 | .00 | n/a | .00 | n/a | 0.31 | 12.04 | 1.37 | 12.02 |
| E5 | .00 | n/a | .00 | n/a | 0.46 | 12.04 | 2.05 | 12.02 |
| E6 | .00 | n/a | .00 | n/a | 0.12 | 12.04 | 0.54 | 12.02 |
| E7 | .00 | n/a | .00 | n/a | 0.07 | 12.04 | 0.32 | 12.02 |
| E8 | .00 | n/a | .00 | n/a | 0.21 | 12.04 | 0.92 | 12.02 |
| E9 | .00 | n/a | .00 | n/a | 0.63 | 12.04 | 2.81 | 12.02 |
| REACHES | | | | | | | | |
| REACH 2 | .00 | n/a | .00 | n/a | 2.52 | 12.04 | 11.21 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 2.47 | 12.07 | 11.08 | 12.04 |
| OUTLET | .00 | | .00 | | 2.47 | | 11.08 | |

REFERENCE 3

CWK USEN
Basin Area E
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| E1 | 3.23 | 0.100 | 63 | REACH 2 | |
| E2 | 1.03 | 0.100 | 63 | REACH 2 | |
| E3 | .86 | 0.100 | 63 | REACH 2 | |
| E4 | 2.19 | 0.100 | 63 | REACH 2 | |
| E5 | 3.28 | 0.100 | 63 | REACH 2 | |
| E6 | .87 | 0.100 | 63 | REACH 2 | |
| E7 | .51 | 0.100 | 63 | REACH 2 | |
| E8 | 1.48 | 0.100 | 63 | REACH 2 | |
| E9 | 4.49 | 0.100 | 63 | REACH 2 | |

Total Area: 17.94 (ac)

REFERENCE 3

CWK

USEN
Basin Area E
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| REACH 2 | Outlet | 580 | CHANNEL |

REFERENCE 3

CWK

USEN
Basin Area E
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| E1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | | Time of Concentration | 0.1 |
| | | | | | | | ======== |
| E2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | | Time of Concentration | 0.1 |
| | | | | | | | ======== |
| E3 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | | Time of Concentration | 0.1 |
| | | | | | | | ======== |
| E4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | | Time of Concentration | 0.1 |
| | | | | | | | ======== |
| E5 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| | | | | | | Time of Concentration | 0.1 |
| | | | | | | | ======== |
| E6 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| | | | | | | Time of Concentration | 0.1 |
| | | | | | | | ======== |
| E7 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | | Time of Concentration | 0.1 |
| | | | | | | | ======== |
| E8 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | | Time of Concentration | 0.1 |
| | | | | | | | ======== |
| E9 | | | | | | | |
| SHEET | 100 | 0.0200 | 0.011 | | | | 0.037 |
| | | | | | | Time of Concentration | 0.1 |
| | | | | | | | ======== |

REFERENCE 3

CWK

USEN
Basin Area E
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| E1 | Desert shrub | (poor) | A | 3.23 | 63 |
| | Total Area / Weighted Curve Number | | | 3.23 | 63 |
| | | | | ==== | == |
| E2 | Desert shrub | (poor) | A | 1.03 | 63 |
| | Total Area / Weighted Curve Number | | | 1.03 | 63 |
| | | | | ==== | == |
| E3 | Desert shrub | (poor) | A | .86 | 63 |
| | Total Area / Weighted Curve Number | | | .86 | 63 |
| | | | | === | == |
| E4 | Desert shrub | (poor) | A | 2.19 | 63 |
| | Total Area / Weighted Curve Number | | | 2.19 | 63 |
| | | | | ==== | == |
| E5 | Desert shrub | (poor) | A | 3.28 | 63 |
| | Total Area / Weighted Curve Number | | | 3.28 | 63 |
| | | | | ==== | == |
| E6 | Desert shrub | (poor) | A | .87 | 63 |
| | Total Area / Weighted Curve Number | | | .87 | 63 |
| | | | | === | == |
| E7 | Desert shrub | (poor) | A | .51 | 63 |
| | Total Area / Weighted Curve Number | | | .51 | 63 |
| | | | | === | == |
| E8 | Desert shrub | (poor) | A | 1.48 | 63 |
| | Total Area / Weighted Curve Number | | | 1.48 | 63 |
| | | | | ==== | == |
| E9 | Desert shrub | (poor) | A | 4.49 | 63 |
| | Total Area / Weighted Curve Number | | | 4.49 | 63 |
| | | | | ==== | == |

REFERENCE 3

CWK USEN
Basin Area E
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| REACH 2 | 580 | 0.011 | 0.003 | 2 | 3 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| REACH 2 | 0.0 | 0.000 | 0 | 2 | 0.003 |
| | 0.5 | 6.295 | 1.8 | 5 | |
| | 1.0 | 26.337 | 5 | 8 | |
| | 2.0 | 125.558 | 16 | 14 | |
| | 5.0 | 1167.157 | 85 | 32 | |
| | 10.0 | 6834.962 | 320 | 62 | |
| | 20.0 | 41588.589 | 1240 | 122 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: JTP
Project: USEN
SubTitle: Basin Area SE
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Stormwater\WinTR55\Basin SE.w55

Date: 4/1/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| SE1 | | Reach 3 | 0.36 | 63 | 0.1 |
| SE2 | | Reach 3 | 1.1 | 63 | 0.1 |
| SE3 | | Reach 3 | 1.19 | 63 | 0.1 |
| SE4 | | Reach 3 | 1.14 | 63 | 0.1 |
| SE5 | | Reach 3 | 1.82 | 63 | 0.1 |

Total area: 5.61 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

JTP

USEN
Basin Area SE
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

JTP USEN
Basin Area SE
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| SE1 | .00 | .00 | 0.05 | 0.22 |
| SE2 | .00 | .00 | 0.15 | 0.69 |
| SE3 | .00 | .00 | 0.17 | 0.74 |
| SE4 | .00 | .00 | 0.16 | 0.71 |
| SE5 | .00 | .00 | 0.25 | 1.14 |
| REACHES | | | | |
| Reach 3 | .00 | .00 | 0.79 | 3.50 |
| Down | .00 | .00 | 0.77 | 3.49 |
| OUTLET | .00 | .00 | 0.77 | 3.49 |

REFERENCE 3

JTP USEN
Basin Area SE
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| SE1 | .00 | n/a | .00 | n/a | 0.05 | 12.04 | 0.22 | 12.02 |
| SE2 | .00 | n/a | .00 | n/a | 0.15 | 12.04 | 0.69 | 12.02 |
| SE3 | .00 | n/a | .00 | n/a | 0.17 | 12.04 | 0.74 | 12.02 |
| SE4 | .00 | n/a | .00 | n/a | 0.16 | 12.04 | 0.71 | 12.02 |
| SE5 | .00 | n/a | .00 | n/a | 0.25 | 12.04 | 1.14 | 12.02 |
| REACHES | | | | | | | | |
| Reach 3 | .00 | n/a | .00 | n/a | 0.79 | 12.04 | 3.50 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.77 | 12.07 | 3.49 | 12.05 |
| OUTLET | .00 | | .00 | | 0.77 | | 3.49 | |

REFERENCE 3

JTP

USEN
Basin Area SE
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| SE1 | .36 | 0.100 | 63 | Reach 3 | |
| SE2 | 1.10 | 0.100 | 63 | Reach 3 | |
| SE3 | 1.19 | 0.100 | 63 | Reach 3 | |
| SE4 | 1.14 | 0.100 | 63 | Reach 3 | |
| SE5 | 1.82 | 0.100 | 63 | Reach 3 | |

Total Area: 5.61 (ac)

REFERENCE 3

JTP

USEN
Basin Area SE
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| Reach 3 | Outlet | 800 | CHANNEL |

REFERENCE 3

JTP

USEN
Basin Area SE
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| SE1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| SE2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| SE3 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| SE4 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| SE5 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |

REFERENCE 3

JTP

USEN
Basin Area SE
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| SE1 | Desert shrub | (poor) | A | .36 | 63 |
| | Total Area / Weighted Curve Number | | | .36 | 63 |
| | | | | === | == |
| SE2 | Desert shrub | (poor) | A | 1.1 | 63 |
| | Total Area / Weighted Curve Number | | | 1.1 | 63 |
| | | | | === | == |
| SE3 | Desert shrub | (poor) | A | 1.19 | 63 |
| | Total Area / Weighted Curve Number | | | 1.19 | 63 |
| | | | | ==== | == |
| SE4 | Desert shrub | (poor) | A | 1.14 | 63 |
| | Total Area / Weighted Curve Number | | | 1.14 | 63 |
| | | | | ==== | == |
| SE5 | Desert shrub | (poor) | A | 1.82 | 63 |
| | Total Area / Weighted Curve Number | | | 1.82 | 63 |
| | | | | ==== | == |

REFERENCE 3

JTP USEN
Basin Area SE
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| Reach 3 | 800 | 0.011 | 0.005 | 3 | 3 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| Reach 3 | 0.0 | 0.000 | 0 | 3 | 0.005 |
| | 0.5 | 10.980 | 2.3 | 6 | |
| | 1.0 | 42.718 | 6 | 9 | |
| | 2.0 | 188.758 | 18 | 15 | |
| | 5.0 | 1625.327 | 90 | 33 | |
| | 10.0 | 9194.537 | 330 | 63 | |
| | 20.0 | 54857.424 | 1260 | 123 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: USEN
SubTitle: Basin Area North EE
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Stormwater\WinTR55\Basin EE.w55

Date: 4/1/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| EE1 | | REACH 4A | 16.41 | 63 | 0.1 |
| EE2 | | REACH 4A | 20.22 | 63 | 0.1 |
| EE3 | | REACH 4B | 25.16 | 63 | 0.1 |

Total area: 61.79 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

USEN
Basin Area North EE
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

USEN
Basin Area North EE
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| EE1 | .00 | .00 | 2.09 | 9.86 |
| EE2 | .00 | .00 | 2.84 | 12.63 |
| EE3 | .00 | .00 | 3.05 | 14.77 |
| REACHES | | | | |
| REACH 4A | .00 | .00 | 4.90 | 22.46 |
| Down | .00 | .00 | 4.63 | 22.00 |
| REACH 4B | .00 | .00 | 6.95 | 35.99 |
| Down | .00 | .00 | 6.77 | 35.60 |
| OUTLET | .00 | .00 | 6.77 | 35.60 |

REFERENCE 3

CWK

USEN
Basin Area North EE
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 5-Yr (cfs) (hr) | 25-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| EE1 | .00 | .00 | 2.09 | 9.86 |
| | n/a | n/a | 12.04 | 12.02 |
| EE2 | .00 | .00 | 2.84 | 12.63 |
| | n/a | n/a | 12.04 | 12.02 |
| EE3 | .00 | .00 | 3.05 | 14.77 |
| | n/a | n/a | 12.05 | 12.03 |
| REACHES | | | | |
| REACH 4A | .00 | .00 | 4.90 | 22.46 |
| | n/a | n/a | 12.04 | 12.02 |
| Down | .00 | .00 | 4.63 | 22.00 |
| | n/a | n/a | 12.11 | 12.07 |
| REACH 4B | .00 | .00 | 6.95 | 35.99 |
| | n/a | n/a | 12.10 | 12.04 |
| Down | .00 | .00 | 6.77 | 35.60 |
| | n/a | n/a | 12.16 | 12.08 |
| OUTLET | .00 | .00 | 6.77 | 35.60 |

REFERENCE 3

CWK USEN
Basin Area North EE
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| EE1 | 16.41 | 0.100 | 63 | REACH 4A | |
| EE2 | 20.22 | 0.100 | 63 | REACH 4A | |
| EE3 | 25.16 | 0.100 | 63 | REACH 4B | |

Total Area: 61.79 (ac)

REFERENCE 3

CWK

USEN
Basin Area North EE
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| REACH 4A | REACH 4B | 1054 | CHANNEL |
| REACH 4B | Outlet | 1780 | CHANNEL |

REFERENCE 3

CWK

USEN
Basin Area North EE
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| EE1 | | | | | | | |
| SHEET | 100 | 0.0030 | 0.011 | | | | 0.079 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| EE2 | | | | | | | |
| SHEET | 100 | 0.0030 | 0.011 | | | | 0.079 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| EE3 | | | | | | | |
| SHEET | 100 | 0.0030 | 0.011 | | | | 0.079 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |

REFERENCE 3

CWK

USEN
Basin Area North EE
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| EE1 | Desert shrub | (poor) | A | 16.41 | 63 |
| | Total Area / Weighted Curve Number | | | 16.41 | 63 |
| | | | | ===== | == |
| EE2 | Desert shrub | (poor) | A | 20.22 | 63 |
| | Total Area / Weighted Curve Number | | | 20.22 | 63 |
| | | | | ===== | == |
| EE3 | Desert shrub | (poor) | A | 25.16 | 63 |
| | Total Area / Weighted Curve Number | | | 25.16 | 63 |
| | | | | ===== | == |

REFERENCE 3

CWK

USEN
Basin Area North EE
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| REACH 4A | 1054 | 0.011 | 0.003 | 12 | 2 :1 |
| REACH 4B | 1780 | 0.011 | 0.003 | 12 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| REACH 4A | 0.0 | 0.000 | 0 | 12 | 0.003 |
| | 0.5 | 28.518 | 6.5 | 14 | |
| | 1.0 | 92.947 | 14 | 16 | |
| | 2.0 | 314.094 | 32 | 20 | |
| | 5.0 | 1767.937 | 110 | 32 | |
| | 10.0 | 7503.645 | 320 | 52 | |
| | 20.0 | 36315.754 | 1040 | 92 | |
| REACH 4B | 0.0 | 0.000 | 0 | 12 | 0.003 |
| | 0.5 | 28.518 | 6.5 | 14 | |
| | 1.0 | 92.947 | 14 | 16 | |
| | 2.0 | 314.094 | 32 | 20 | |
| | 5.0 | 1767.937 | 110 | 32 | |
| | 10.0 | 7503.645 | 320 | 52 | |
| | 20.0 | 36315.754 | 1040 | 92 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: USEN
SubTitle: Basin Area SC
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Stormwater\WinTR55\SC Basins.w55

Date: 4/1/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| SC1 | | REACH 5 | 5.98 | 63 | 0.1 |
| SC2 | | REACH 5 | 16.05 | 63 | 0.1 |
| SC3 | | REACH 5 | 1.21 | 63 | 0.1 |
| SC4 | | REACH 5 | 5.95 | 63 | 0.1 |

Total area: 29.19 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: delmarva

REFERENCE 3

CWK USEN
Basin Area SC
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: delmarva

REFERENCE 3

CWK

USEN
Basin Area SC
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| SC1 | .00 | .00 | 0.55 | 2.93 |
| SC2 | .00 | .00 | 1.47 | 7.87 |
| SC3 | .00 | .00 | 0.11 | 0.59 |
| SC4 | .00 | .00 | 0.55 | 2.92 |
| REACHES | | | | |
| REACH 5 | .00 | .00 | 2.68 | 14.32 |
| Down | .00 | .00 | 2.58 | 13.85 |
| OUTLET | .00 | .00 | 2.58 | 13.85 |

REFERENCE 3

CWK USEN
Basin Area SC
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| SC1 | .00 | n/a | .00 | n/a | 0.55 | 12.04 | 2.93 | 12.02 |
| SC2 | .00 | n/a | .00 | n/a | 1.47 | 12.04 | 7.87 | 12.02 |
| SC3 | .00 | n/a | .00 | n/a | 0.11 | 12.04 | 0.59 | 12.02 |
| SC4 | .00 | n/a | .00 | n/a | 0.55 | 12.04 | 2.92 | 12.02 |
| REACHES | | | | | | | | |
| REACH 5 | .00 | n/a | .00 | n/a | 2.68 | 12.04 | 14.32 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 2.58 | 12.16 | 13.85 | 12.11 |
| OUTLET | .00 | | .00 | | 2.58 | | 13.85 | |

REFERENCE 3

CWK USEN
Basin Area SC
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| SC1 | 5.98 | 0.100 | 63 | REACH 5 | |
| SC2 | 16.05 | 0.100 | 63 | REACH 5 | |
| SC3 | 1.21 | 0.100 | 63 | REACH 5 | |
| SC4 | 5.95 | 0.100 | 63 | REACH 5 | |

Total Area: 29.19 (ac)

REFERENCE 3

CWK USEN
Basin Area SC
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| REACH 5 | Outlet | 2000 | CHANNEL |

REFERENCE 3

CWK

USEN
Basin Area SC
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| SC1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| SC2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| SC3 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| SC4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |

REFERENCE 3

CWK

USEN
Basin Area SC
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| SC1 | Desert shrub | (poor) | A | 5.98 | 63 |
| | Total Area / Weighted Curve Number | | | 5.98 | 63 |
| | | | | ==== | == |
| SC2 | Desert shrub | (poor) | A | 16.05 | 63 |
| | Total Area / Weighted Curve Number | | | 16.05 | 63 |
| | | | | ===== | == |
| SC3 | Desert shrub | (poor) | A | 1.21 | 63 |
| | Total Area / Weighted Curve Number | | | 1.21 | 63 |
| | | | | ==== | == |
| SC4 | Desert shrub | (poor) | A | 5.95 | 63 |
| | Total Area / Weighted Curve Number | | | 5.95 | 63 |
| | | | | ==== | == |

REFERENCE 3

CWK

USEN
Basin Area SC
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| REACH 5 | 2000 | 0.011 | 0.003 | 2 | 3 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| REACH 5 | 0.0 | 0.000 | 0 | 2 | 0.003 |
| | 0.5 | 6.295 | 1.8 | 5 | |
| | 1.0 | 26.337 | 5 | 8 | |
| | 2.0 | 125.558 | 16 | 14 | |
| | 5.0 | 1167.157 | 85 | 32 | |
| | 10.0 | 6834.962 | 320 | 62 | |
| | 20.0 | 41588.589 | 1240 | 122 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: USEN
SubTitle: Basin SW
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Stormwater\WinTR55\Basin SW.w55

Date: 4/1/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| SW 1 | | REACH 6 | 16.77 | 63 | 0.1 |
| SW 2 | | REACH 6 | 17.8 | 63 | 0.1 |
| SW 3 | | REACH 6 | 1.89 | 63 | 0.1 |

Total area: 36.46 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

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USEN
Basin SW
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 10-Yr (in) | 25-Yr (in) | 50-Yr (in) | 100-Yr (in) | 1-Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 1.75 | 2.26 | 2.68 | 3.13 | .69 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

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USEN
Basin SW
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| SW 1 | .00 | .00 | 2.35 | 10.45 |
| SW 2 | .00 | .00 | 1.62 | 8.77 |
| SW 3 | .00 | .00 | 0.26 | 1.18 |
| REACHES | | | | |
| REACH 6 | .00 | .00 | 3.72 | 19.52 |
| Down | .00 | .00 | 3.72 | 19.52 |
| OUTLET | .00 | .00 | 3.72 | 19.52 |

REFERENCE 3

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Basin SW
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) (hr) | 5-Yr (cfs) (hr) | 25-Yr (cfs) (hr) | 100-Yr (cfs) (hr) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| SW 1 | .00 | .00 | 2.35 | 10.45 |
| | n/a | n/a | 12.03 | 12.02 |
| SW 2 | .00 | .00 | 1.62 | 8.77 |
| | n/a | n/a | 12.10 | 12.07 |
| SW 3 | .00 | .00 | 0.26 | 1.18 |
| | n/a | n/a | 12.04 | 12.02 |
| REACHES | | | | |
| REACH 6 | .00 | .00 | 3.72 | 19.52 |
| | n/a | n/a | 12.04 | 12.02 |
| Down | .00 | .00 | 3.72 | 19.52 |
| | n/a | n/a | 12.12 | 12.06 |
| OUTLET | .00 | .00 | 3.72 | 19.52 |

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Basin SW
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| SW 1 | 16.77 | 0.100 | 63 | REACH 6 | |
| SW 2 | 17.80 | 0.100 | 63 | REACH 6 | |
| SW 3 | 1.89 | 0.100 | 63 | REACH 6 | |

Total Area: 36.46 (ac)

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Basin SW
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| REACH 6 | Outlet | 1780 | CHANNEL |

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USEN
Basin SW
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| SW 1 | | | | | | | |
| SHEET | 100 | 0.0200 | 0.011 | | | | 0.037 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| SW 2 | | | | | | | |
| SHEET | 100 | 0.0200 | 0.011 | | | | 0.037 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |
| SW 3 | | | | | | | |
| SHEET | 100 | 0.0200 | 0.011 | | | | 0.037 |
| | | | | | Time of Concentration | | 0.1 |
| | | | | | | | ======== |

REFERENCE 3

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USEN
Basin SW
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| SW 1 | Desert shrub | (poor) | A | 16.77 | 63 |
| | Total Area / Weighted Curve Number | | | 16.77 | 63 |
| | | | | ===== | == |
| SW 2 | Desert shrub | (poor) | A | 17.8 | 63 |
| | Total Area / Weighted Curve Number | | | 17.8 | 63 |
| | | | | ==== | == |
| SW 3 | Desert shrub | (poor) | A | 1.89 | 63 |
| | Total Area / Weighted Curve Number | | | 1.89 | 63 |
| | | | | ==== | == |

REFERENCE 3

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USEN
Basin SW
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| REACH 6 | 1780 | 0.011 | 0.003 | 3 | 3 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| REACH 6 | 0.0 | 0.000 | 0 | 3 | 0.003 |
| | 0.5 | 5.772 | 1.5 | 3 | |
| | 1.0 | 15.791 | 3 | 3 | |
| | 2.0 | 40.060 | 6 | 3 | |
| | 5.0 | 122.098 | 15 | 3 | |
| | 10.0 | 264.995 | 30 | 3 | |
| | 20.0 | 554.362 | 60 | 3 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project:
SubTitle: OUTFALL FC-NW
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Erosion\Water Erosion\TR-55 Model Runs - Fi

Date: 3/7/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| FC-NW-1 | | FLUME NW-A | 0.93 | 63 | 0.1 |
| FC-NW-2 | | FLUME NW-A | 0.86 | 63 | 0.1 |
| FC-NW-3 | | FLUME NW-B | 1.35 | 63 | 0.1 |
| FC-NW-4 | | FLUME NW-B | 1.03 | 63 | 0.1 |
| FC-NW-5 | | Outlet | 1.55 | 63 | 0.1 |
| FC-NW-6 | | Outlet | 0.87 | 63 | 0.1 |

Total area: 6.59 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

OUTFALL FC-NW
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

OUTFALL FC-NW
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| FC-NW-1 | .00 | .00 | 0.13 | 0.58 |
| FC-NW-2 | .00 | .00 | 0.12 | 0.54 |
| FC-NW-3 | .00 | .00 | 0.19 | 0.84 |
| FC-NW-4 | .00 | .00 | 0.14 | 0.64 |
| FC-NW-5 | .00 | .00 | 0.22 | 0.97 |
| FC-NW-6 | .00 | .00 | 0.12 | 0.54 |
| REACHES | | | | |
| FLUME NW-B | .00 | .00 | 0.58 | 2.60 |
| Down | .00 | .00 | 0.58 | 2.60 |
| FLUME NW-A | .00 | .00 | 0.25 | 1.12 |
| Down | .00 | .00 | 0.25 | 1.12 |
| OUTLET | .00 | .00 | 0.92 | 4.11 |

REFERENCE 3

CWK

OUTFALL FC-NW
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| FC-NW-1 | .00 | n/a | .00 | n/a | 0.13 | 12.04 | 0.58 | 12.02 |
| FC-NW-2 | .00 | n/a | .00 | n/a | 0.12 | 12.04 | 0.54 | 12.02 |
| FC-NW-3 | .00 | n/a | .00 | n/a | 0.19 | 12.04 | 0.84 | 12.02 |
| FC-NW-4 | .00 | n/a | .00 | n/a | 0.14 | 12.04 | 0.64 | 12.02 |
| FC-NW-5 | .00 | n/a | .00 | n/a | 0.22 | 12.04 | 0.97 | 12.02 |
| FC-NW-6 | .00 | n/a | .00 | n/a | 0.12 | 12.04 | 0.54 | 12.02 |
| REACHES | | | | | | | | |
| FLUME NW-B | .00 | n/a | .00 | n/a | 0.58 | 12.04 | 2.60 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.58 | 12.04 | 2.60 | 12.02 |
| FLUME NW-A | .00 | n/a | .00 | n/a | 0.25 | 12.04 | 1.12 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.25 | 12.04 | 1.12 | 12.02 |
| OUTLET | .00 | | .00 | | 0.92 | | 4.11 | |

REFERENCE 3

CWK

OUTFALL FC-NW
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| FC-NW-1 | .93 | 0.100 | 63 | FLUME NW-A | |
| FC-NW-2 | .86 | 0.100 | 63 | FLUME NW-A | |
| FC-NW-3 | 1.35 | 0.100 | 63 | FLUME NW-B | |
| FC-NW-4 | 1.03 | 0.100 | 63 | FLUME NW-B | |
| FC-NW-5 | 1.55 | 0.100 | 63 | Outlet | |
| FC-NW-6 | .87 | 0.100 | 63 | Outlet | |

Total Area: 6.59 (ac)

REFERENCE 3

CWK

OUTFALL FC-NW
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| FLUME NW-B | Outlet | 80 | CHANNEL |
| FLUME NW-A | FLUME NW-B | 100 | CHANNEL |

REFERENCE 3

CWK

OUTFALL FC-NW
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| FC-NW-1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 495 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.594 | 0.016 |
| | | | | | Time of Concentration | | 0.1 |
| FC-NW-2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 421 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.996 | 0.013 |
| | | | | | Time of Concentration | | 0.1 |
| FC-NW-3 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 610 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.918 | 0.019 |
| | | | | | Time of Concentration | | 0.1 |
| FC-NW-4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 421 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.996 | 0.013 |
| | | | | | Time of Concentration | | 0.1 |
| FC-NW-5 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| FC-NW-6 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |

REFERENCE 3

CWK

OUTFALL FC-NW
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| FC-NW-1 | Desert shrub | (poor) | A | .93 | 63 |
| | Total Area / Weighted Curve Number | | | .93 | 63 |
| | | | | === | == |
| FC-NW-2 | Desert shrub | (poor) | A | .86 | 63 |
| | Total Area / Weighted Curve Number | | | .86 | 63 |
| | | | | === | == |
| FC-NW-3 | Desert shrub | (poor) | A | 1.35 | 63 |
| | Total Area / Weighted Curve Number | | | 1.35 | 63 |
| | | | | ==== | == |
| FC-NW-4 | Desert shrub | (poor) | A | 1.03 | 63 |
| | Total Area / Weighted Curve Number | | | 1.03 | 63 |
| | | | | ==== | == |
| FC-NW-5 | Desert shrub | (poor) | A | 1.55 | 63 |
| | Total Area / Weighted Curve Number | | | 1.55 | 63 |
| | | | | ==== | == |
| FC-NW-6 | Desert shrub | (poor) | A | .87 | 63 |
| | Total Area / Weighted Curve Number | | | .87 | 63 |
| | | | | === | == |

REFERENCE 3

CWK

OUTFALL FC-NW
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| FLUME NW-B | 80 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME NW-A | 100 | 0.036 | 0.33 | 4 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| FLUME NW-B | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME NW-A | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project:
SubTitle: OUTFALL FC-NE
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Erosion\Water Erosion\TR-55 Model Runs - Fi

Date: 3/7/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| FC-NE-1 | | FLUME NE-A | 0.93 | 63 | 0.1 |
| FC-NE-2 | | FLUME NE-A | 0.86 | 63 | 0.1 |
| FC-NE-3 | | FLUME NE-B | 1.35 | 63 | 0.1 |
| FC-NE-4 | | FLUME NE-B | 1.03 | 63 | 0.1 |
| FC-NE-5 | | Outlet | 1.55 | 63 | 0.1 |
| FC-NE-6 | | Outlet | 0.87 | 63 | 0.1 |

Total area: 6.59 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

OUTFALL FC-NE
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

OUTFALL FC-NE
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| FC-NE-1 | .00 | .00 | 0.13 | 0.58 |
| FC-NE-2 | .00 | .00 | 0.12 | 0.54 |
| FC-NE-3 | .00 | .00 | 0.19 | 0.84 |
| FC-NE-4 | .00 | .00 | 0.14 | 0.64 |
| FC-NE-5 | .00 | .00 | 0.22 | 0.97 |
| FC-NE-6 | .00 | .00 | 0.12 | 0.54 |
| REACHES | | | | |
| FLUME NE-B | .00 | .00 | 0.58 | 2.60 |
| Down | .00 | .00 | 0.58 | 2.60 |
| FLUME NE-A | .00 | .00 | 0.25 | 1.12 |
| Down | .00 | .00 | 0.25 | 1.12 |
| OUTLET | .00 | .00 | 0.92 | 4.11 |

REFERENCE 3

CWK

OUTFALL FC-NE
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| FC-NE-1 | .00 | n/a | .00 | n/a | 0.13 | 12.04 | 0.58 | 12.02 |
| FC-NE-2 | .00 | n/a | .00 | n/a | 0.12 | 12.04 | 0.54 | 12.02 |
| FC-NE-3 | .00 | n/a | .00 | n/a | 0.19 | 12.04 | 0.84 | 12.02 |
| FC-NE-4 | .00 | n/a | .00 | n/a | 0.14 | 12.04 | 0.64 | 12.02 |
| FC-NE-5 | .00 | n/a | .00 | n/a | 0.22 | 12.04 | 0.97 | 12.02 |
| FC-NE-6 | .00 | n/a | .00 | n/a | 0.12 | 12.04 | 0.54 | 12.02 |
| REACHES | | | | | | | | |
| FLUME NE-B | .00 | n/a | .00 | n/a | 0.58 | 12.04 | 2.60 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.58 | 12.04 | 2.60 | 12.02 |
| FLUME NE-A | .00 | n/a | .00 | n/a | 0.25 | 12.04 | 1.12 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.25 | 12.04 | 1.12 | 12.02 |
| OUTLET | .00 | | .00 | | 0.92 | | 4.11 | |

REFERENCE 3

CWK

OUTFALL FC-NE
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| FC-NE-1 | .93 | 0.100 | 63 | FLUME NE-A | |
| FC-NE-2 | .86 | 0.100 | 63 | FLUME NE-A | |
| FC-NE-3 | 1.35 | 0.100 | 63 | FLUME NE-B | |
| FC-NE-4 | 1.03 | 0.100 | 63 | FLUME NE-B | |
| FC-NE-5 | 1.55 | 0.100 | 63 | Outlet | |
| FC-NE-6 | .87 | 0.100 | 63 | Outlet | |

Total Area: 6.59 (ac)

REFERENCE 3

CWK

OUTFALL FC-NE
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| FLUME NE-B | Outlet | 80 | CHANNEL |
| FLUME NE-A | FLUME NE-B | 100 | CHANNEL |

REFERENCE 3

CWK

OUTFALL FC-NE
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| FC-NE-1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 495 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.594 | 0.016 |
| | | | | | Time of Concentration | | 0.1 |
| FC-NE-2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 421 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.996 | 0.013 |
| | | | | | Time of Concentration | | 0.1 |
| FC-NE-3 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 610 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.918 | 0.019 |
| | | | | | Time of Concentration | | 0.1 |
| FC-NE-4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 421 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.996 | 0.013 |
| | | | | | Time of Concentration | | 0.1 |
| FC-NE-5 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| FC-NE-6 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |

REFERENCE 3

CWK

OUTFALL FC-NE
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| FC-NE-1 | Desert shrub | (poor) | A | .93 | 63 |
| | Total Area / Weighted Curve Number | | | .93 | 63 |
| | | | | === | == |
| FC-NE-2 | Desert shrub | (poor) | A | .86 | 63 |
| | Total Area / Weighted Curve Number | | | .86 | 63 |
| | | | | === | == |
| FC-NE-3 | Desert shrub | (poor) | A | 1.35 | 63 |
| | Total Area / Weighted Curve Number | | | 1.35 | 63 |
| | | | | ==== | == |
| FC-NE-4 | Desert shrub | (poor) | A | 1.03 | 63 |
| | Total Area / Weighted Curve Number | | | 1.03 | 63 |
| | | | | ==== | == |
| FC-NE-5 | Desert shrub | (poor) | A | 1.55 | 63 |
| | Total Area / Weighted Curve Number | | | 1.55 | 63 |
| | | | | ==== | == |
| FC-NE-6 | Desert shrub | (poor) | A | .87 | 63 |
| | Total Area / Weighted Curve Number | | | .87 | 63 |
| | | | | === | == |

REFERENCE 3

CWK

OUTFALL FC-NE
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| FLUME NE-B | 80 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME NE-A | 100 | 0.036 | 0.33 | 4 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| FLUME NE-B | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME NE-A | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: T13 Final Cover
SubTitle: OUTFALL FC-E-A
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Erosion\Water Erosion\TR-55 Model Runs - Fi

Date: 3/7/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| FC-E1 | | UpperDitch | 0.98 | 63 | 0.1 |
| FC-E2 | | LowerDitch | 0.92 | 63 | 0.1 |
| FC-E3 | | Outlet | 0.49 | 63 | 0.1 |

Total area: 2.39 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-E-A
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-E-A
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| FC-E1 | .00 | .00 | 0.14 | 0.61 |
| FC-E2 | .00 | .00 | 0.13 | 0.58 |
| FC-E3 | .00 | .00 | 0.07 | 0.31 |
| REACHES | | | | |
| LowerDitch | .00 | .00 | 0.26 | 1.18 |
| Down | .00 | .00 | 0.26 | 1.18 |
| UpperDitch | .00 | .00 | 0.14 | 0.61 |
| Down | .00 | .00 | 0.14 | 0.61 |
| OUTLET | .00 | .00 | 0.33 | 1.48 |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-E-A
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| FC-E1 | .00 | n/a | .00 | n/a | 0.14 | 12.04 | 0.61 | 12.02 |
| FC-E2 | .00 | n/a | .00 | n/a | 0.13 | 12.04 | 0.58 | 12.02 |
| FC-E3 | .00 | n/a | .00 | n/a | 0.07 | 12.04 | 0.31 | 12.02 |
| REACHES | | | | | | | | |
| LowerDitch | .00 | n/a | .00 | n/a | 0.26 | 12.02 | 1.18 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.26 | 12.00 | 1.18 | 12.04 |
| UpperDitch | .00 | n/a | .00 | n/a | 0.14 | 12.04 | 0.61 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.14 | 11.99 | 0.61 | 12.03 |
| OUTLET | .00 | | .00 | | 0.33 | | 1.48 | |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-E-A
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| FC-E1 | .98 | 0.100 | 63 | UpperDitch | |
| FC-E2 | .92 | 0.100 | 63 | LowerDitch | |
| FC-E3 | .49 | 0.100 | 63 | Outlet | |

Total Area: 2.39 (ac)

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-E-A
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| LowerDitch | Outlet | 296 | CHANNEL |
| UpperDitch | LowerDitch | 299 | CHANNEL |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-E-A
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| FC-E1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 406 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.675 | 0.013 |
| | | | | | Time of Concentration | | 0.1 |
| FC-E2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 209 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.294 | 0.007 |
| | | | | | Time of Concentration | | 0.1 |
| FC-E3 | | | | | | | |
| SHEET | 100 | 0.3330 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-E-A
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| FC-E1 | Desert shrub | (poor) | A | .98 | 63 |
| | Total Area / Weighted Curve Number | | | .98 | 63 |
| | | | | === | == |
| FC-E2 | Desert shrub | (poor) | A | .92 | 63 |
| | Total Area / Weighted Curve Number | | | .92 | 63 |
| | | | | === | == |
| FC-E3 | Desert shrub | (poor) | A | .49 | 63 |
| | Total Area / Weighted Curve Number | | | .49 | 63 |
| | | | | === | == |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-E-A
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| LowerDitch | 296 | 0.036 | 0.1 | 0.3 | 2 :1 |
| UpperDitch | 299 | 0.036 | 0.1 | 0.3 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| LowerDitch | 0.0 | 0.000 | 0 | 0.3 | 0.1 |
| | 0.5 | 3.250 | 0.6 | 2.3 | |
| | 1.0 | 17.917 | 2.3 | 4.3 | |
| | 2.0 | 105.294 | 8.5 | 8.3 | |
| | 5.0 | 1154.331 | 51.3 | 20.3 | |
| | 10.0 | 7207.766 | 202.5 | 40.3 | |
| | 20.0 | 45380.713 | 805 | 80.3 | |
| UpperDitch | 0.0 | 0.000 | 0 | 0.3 | 0.1 |
| | 0.5 | 3.250 | 0.6 | 2.3 | |
| | 1.0 | 17.917 | 2.3 | 4.3 | |
| | 2.0 | 105.294 | 8.5 | 8.3 | |
| | 5.0 | 1154.331 | 51.3 | 20.3 | |
| | 10.0 | 7207.766 | 202.5 | 40.3 | |
| | 20.0 | 45380.713 | 805 | 80.3 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: T13 Final Cover
SubTitle: FC-E-B
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Erosion\Water Erosion\TR-55 Model Runs - Fi

Date: 3/7/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| FC-E4 | | FLUME EAST | 0.67 | 63 | 0.1 |
| FC-E5 | | Outlet | 1.02 | 63 | 0.1 |
| FC-E6 | | Outlet | 0.62 | 63 | 0.1 |
| FC-E7 | | Outlet | 0.38 | 63 | 0.1 |

Total area: 2.69 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
FC-E-B
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
FC-E-B
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| FC-E4 | .00 | .00 | 0.09 | 0.42 |
| FC-E5 | .00 | .00 | 0.14 | 0.64 |
| FC-E6 | .00 | .00 | 0.09 | 0.39 |
| FC-E7 | .00 | .00 | 0.05 | 0.24 |
| REACHES | | | | |
| FLUME EAST | .00 | .00 | 0.09 | 0.42 |
| Down | .00 | .00 | 0.09 | 0.42 |
| OUTLET | .00 | .00 | 0.38 | 1.68 |

REFERENCE 3

CWK

T13 Final Cover
FC-E-B
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| FC-E4 | .00 | n/a | .00 | n/a | 0.09 | 12.04 | 0.42 | 12.02 |
| FC-E5 | .00 | n/a | .00 | n/a | 0.14 | 12.04 | 0.64 | 12.02 |
| FC-E6 | .00 | n/a | .00 | n/a | 0.09 | 12.04 | 0.39 | 12.02 |
| FC-E7 | .00 | n/a | .00 | n/a | 0.05 | 12.04 | 0.24 | 12.02 |
| REACHES | | | | | | | | |
| FLUME EAST | .00 | n/a | .00 | n/a | 0.09 | 12.04 | 0.42 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.09 | 11.99 | 0.42 | 12.02 |
| OUTLET | .00 | | .00 | | 0.38 | | 1.68 | |

REFERENCE 3

CWK

T13 Final Cover
FC-E-B
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| FC-E4 | .67 | 0.100 | 63 | FLUME EAST | |
| FC-E5 | 1.02 | 0.100 | 63 | Outlet | |
| FC-E6 | .62 | 0.100 | 63 | Outlet | |
| FC-E7 | .38 | 0.100 | 63 | Outlet | |

Total Area: 2.69 (ac)

REFERENCE 3

CWK

T13 Final Cover
FC-E-B
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| FLUME EAST | Outlet | 90 | CHANNEL |

REFERENCE 3

CWK

T13 Final Cover
FC-E-B
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| FC-E4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 444 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.810 | 0.014 |
| | | | | | Time of Concentration | | 0.1 |
| FC-E5 | | | | | | | |
| SHEET | 100 | 0.3330 | 0.011 | | | | 0.012 |
| CHANNEL | 512 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.889 | 0.016 |
| | | | | | Time of Concentration | | 0.1 |
| FC-E6 | | | | | | | |
| SHEET | 90 | 0.3330 | 0.011 | | | | 0.011 |
| | | | | | Time of Concentration | | 0.1 |
| FC-E7 | | | | | | | |
| SHEET | 90 | 0.3300 | 0.011 | | | | 0.011 |
| | | | | | Time of Concentration | | 0.1 |

REFERENCE 3

CWK

T13 Final Cover
FC-E-B
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| FC-E4 | Desert shrub | (poor) | A | .67 | 63 |
| | Total Area / Weighted Curve Number | | | .67 | 63 |
| | | | | === | == |
| FC-E5 | Desert shrub | (poor) | A | 1.02 | 63 |
| | Total Area / Weighted Curve Number | | | 1.02 | 63 |
| | | | | ==== | == |
| FC-E6 | Desert shrub | (poor) | A | .62 | 63 |
| | Total Area / Weighted Curve Number | | | .62 | 63 |
| | | | | === | == |
| FC-E7 | Desert shrub | (poor) | A | .38 | 63 |
| | Total Area / Weighted Curve Number | | | .38 | 63 |
| | | | | === | == |

REFERENCE 3

CWK

T13 Final Cover
FC-E-B
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| FLUME EAST | 90 | 0.036 | 0.33 | 4 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| FLUME EAST | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: T13 Final Cover
SubTitle: Outfall FC-SE
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Erosion\Water Erosion\TR-55 Model Runs - Fi

Date: 3/7/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| FC-SE-1 | | FLUME SE-B | 0.59 | 63 | 0.1 |
| FC-SE-2 | | FLUME SE-B | 0.55 | 63 | 0.1 |
| FC-SE-3 | | FLUME SE-A | 0.83 | 63 | 0.1 |
| FC-SE-4 | | FLUME SE-A | 0.59 | 63 | 0.1 |
| FC-SE-5 | | Outlet | 0.53 | 63 | 0.1 |
| FC-SE-6 | | Outlet | 0.3 | 63 | 0.1 |
| FC-UDE-3 | | FLUME SE-C | 2.01 | 63 | 0.1 |
| FC-UDE-2 | | FLUME SE-D | 1.88 | 63 | 0.1 |
| FC-UDE-1 | | FLUME SE-E | 0.8 | 63 | 0.1 |

Total area: 8.08 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SE
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SE
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| FC-SE-1 | .00 | .00 | 0.08 | 0.37 |
| FC-SE-2 | .00 | .00 | 0.08 | 0.34 |
| FC-SE-3 | .00 | .00 | 0.12 | 0.52 |
| FC-SE-4 | .00 | .00 | 0.08 | 0.37 |
| FC-SE-5 | .00 | .00 | 0.07 | 0.33 |
| FC-SE-6 | .00 | .00 | .00 | 0.19 |
| FC-UDE-3 | .00 | .00 | 0.28 | 1.26 |
| FC-UDE-2 | .00 | .00 | 0.26 | 1.18 |
| FC-UDE-1 | .00 | .00 | 0.11 | 0.50 |
| REACHES | | | | |
| FLUME SE-A | .00 | .00 | 1.01 | 4.52 |
| Down | .00 | .00 | 1.01 | 4.52 |
| FLUME SE-B | .00 | .00 | 0.81 | 3.63 |
| Down | .00 | .00 | 0.81 | 3.63 |
| FLUME SE-C | .00 | .00 | 0.66 | 2.92 |
| Down | .00 | .00 | 0.66 | 2.92 |
| FLUME SE-D | .00 | .00 | 0.38 | 1.67 |
| Down | .00 | .00 | 0.38 | 1.67 |
| FLUME SE-E | .00 | .00 | 0.11 | 0.50 |
| Down | .00 | .00 | 0.11 | 0.50 |
| OUTLET | .00 | .00 | 1.08 | 5.03 |

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SE
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| FC-SE-1 | .00 | n/a | .00 | n/a | 0.08 | 12.04 | 0.37 | 12.02 |
| FC-SE-2 | .00 | n/a | .00 | n/a | 0.08 | 12.04 | 0.34 | 12.02 |
| FC-SE-3 | .00 | n/a | .00 | n/a | 0.12 | 12.04 | 0.52 | 12.02 |
| FC-SE-4 | .00 | n/a | .00 | n/a | 0.08 | 12.04 | 0.37 | 12.02 |
| FC-SE-5 | .00 | n/a | .00 | n/a | 0.07 | 12.04 | 0.33 | 12.02 |
| FC-SE-6 | .00 | n/a | .00 | n/a | .00 | n/a | 0.19 | 12.02 |
| FC-UDE-3 | .00 | n/a | .00 | n/a | 0.28 | 12.04 | 1.26 | 12.02 |
| FC-UDE-2 | .00 | n/a | .00 | n/a | 0.26 | 12.04 | 1.18 | 12.02 |
| FC-UDE-1 | .00 | n/a | .00 | n/a | 0.11 | 12.04 | 0.50 | 12.02 |
| REACHES | | | | | | | | |
| FLUME SE-A | .00 | n/a | .00 | n/a | 1.01 | 12.04 | 4.52 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 1.01 | 12.04 | 4.52 | 12.02 |
| FLUME SE-B | .00 | n/a | .00 | n/a | 0.81 | 12.04 | 3.63 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.81 | 12.04 | 3.63 | 12.02 |
| FLUME SE-C | .00 | n/a | .00 | n/a | 0.66 | 12.04 | 2.92 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.66 | 12.04 | 2.92 | 12.02 |
| FLUME SE-D | .00 | n/a | .00 | n/a | 0.38 | 12.04 | 1.67 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.38 | 12.04 | 1.67 | 12.02 |
| FLUME SE-E | .00 | n/a | .00 | n/a | 0.11 | 12.04 | 0.50 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.11 | 12.04 | 0.50 | 12.02 |
| OUTLET | .00 | | .00 | | 1.08 | | 5.03 | |

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SE
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| FC-SE-1 | .59 | 0.100 | 63 | FLUME SE-B | |
| FC-SE-2 | .55 | 0.100 | 63 | FLUME SE-B | |
| FC-SE-3 | .83 | 0.100 | 63 | FLUME SE-A | |
| FC-SE-4 | .59 | 0.100 | 63 | FLUME SE-A | |
| FC-SE-5 | .53 | 0.100 | 63 | Outlet | |
| FC-SE-6 | .30 | 0.100 | 63 | Outlet | |
| FC-UDE-3 | 2.01 | 0.100 | 63 | FLUME SE-C | |
| FC-UDE-2 | 1.88 | 0.100 | 63 | FLUME SE-D | |
| FC-UDE-1 | .80 | 0.100 | 63 | FLUME SE-E | |

Total Area: 8.08 (ac)

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SE
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| FLUME SE-A | Outlet | 50 | CHANNEL |
| FLUME SE-B | FLUME SE-A | 100 | CHANNEL |
| FLUME SE-C | FLUME SE-B | 80 | CHANNEL |
| FLUME SE-D | FLUME SE-C | 200 | CHANNEL |
| FLUME SE-E | FLUME SE-D | 200 | CHANNEL |

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SE
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| FC-SE-1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 296 | 0.0200 | 0.023 | 10.00 | 10.79 | 9.136 | 0.009 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SE-2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 245 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.507 | 0.008 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SE-3 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 393 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.397 | 0.013 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SE-4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 245 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.507 | 0.008 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SE-5 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SE-6 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UDE-3 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UDE-2 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UDE-1 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SE
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| FC-SE-1 | Desert shrub | (poor) | A | .59 | 63 |
| | Total Area / Weighted Curve Number | | | .59 | 63 |
| | | | | === | == |
| FC-SE-2 | Desert shrub | (poor) | A | .55 | 63 |
| | Total Area / Weighted Curve Number | | | .55 | 63 |
| | | | | === | == |
| FC-SE-3 | Desert shrub | (poor) | A | .83 | 63 |
| | Total Area / Weighted Curve Number | | | .83 | 63 |
| | | | | === | == |
| FC-SE-4 | Desert shrub | (poor) | A | .59 | 63 |
| | Total Area / Weighted Curve Number | | | .59 | 63 |
| | | | | === | == |
| FC-SE-5 | Desert shrub | (poor) | A | .53 | 63 |
| | Total Area / Weighted Curve Number | | | .53 | 63 |
| | | | | === | == |
| FC-SE-6 | Desert shrub | (poor) | A | .3 | 63 |
| | Total Area / Weighted Curve Number | | | .3 | 63 |
| | | | | == | == |
| FC-UDE-3 | Desert shrub | (poor) | A | 2.01 | 63 |
| | Total Area / Weighted Curve Number | | | 2.01 | 63 |
| | | | | ==== | == |
| FC-UDE-2 | Desert shrub | (poor) | A | 1.88 | 63 |
| | Total Area / Weighted Curve Number | | | 1.88 | 63 |
| | | | | ==== | == |
| FC-UDE-1 | Desert shrub | (poor) | A | .8 | 63 |
| | Total Area / Weighted Curve Number | | | .8 | 63 |
| | | | | == | == |

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SE
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| FLUME SE-A | 50 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SE-B | 100 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SE-C | 80 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SE-D | 200 | 0.023 | 0.05 | 4 | 2 :1 |
| FLUME SE-E | 200 | 0.023 | 0.05 | 4 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| FLUME SE-A | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SE-B | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SE-C | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SE-D | 0.0 | 0.000 | 0 | 4 | 0.05 |
| | 0.5 | 19.637 | 2.5 | 6 | |
| | 1.0 | 68.870 | 6 | 8 | |
| | 2.0 | 266.230 | 16 | 12 | |
| | 5.0 | 1939.255 | 70 | 24 | |
| | 10.0 | 10038.029 | 240 | 44 | |
| | 20.0 | 56695.699 | 880 | 84 | |
| FLUME SE-E | 0.0 | 0.000 | 0 | 4 | 0.05 |
| | 0.5 | 19.637 | 2.5 | 6 | |
| | 1.0 | 68.870 | 6 | 8 | |
| | 2.0 | 266.230 | 16 | 12 | |
| | 5.0 | 1939.255 | 70 | 24 | |
| | 10.0 | 10038.029 | 240 | 44 | |
| | 20.0 | 56695.699 | 880 | 84 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: T13 Final Cover
SubTitle: OUTFALL FC-SB
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Erosion\Water Erosion\TR-55 Model Runs - Fi

Date: 3/7/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| FC-SB-1 | | FLUME SB-D | 0.56 | 63 | 0.1 |
| FC-SB-2 | | FLUME SB-D | 0.49 | 63 | 0.1 |
| FC-SB-3 | | FLUME SB-E | 0.59 | 63 | 0.1 |
| FC-SB-4 | | FLUME SB-E | 0.51 | 63 | 0.1 |
| FC-SB-5 | | Outlet | 0.3 | 63 | 0.1 |
| FC-SB-6 | | Outlet | 0.27 | 63 | 0.1 |
| FC-UD-ME-3 | | FLUME SB-C | 2.11 | 63 | 0.1 |
| FC-UD-ME-2 | | FLUME SB-B | 2.11 | 63 | 0.1 |
| FC-UD-ME-1 | | FLUME SB-A | 0.94 | 63 | 0.1 |

Total area: 7.88 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SB
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SB
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| FC-SB-1 | .00 | .00 | 0.08 | 0.35 |
| FC-SB-2 | .00 | .00 | 0.07 | 0.31 |
| FC-SB-3 | .00 | .00 | 0.08 | 0.37 |
| FC-SB-4 | .00 | .00 | 0.07 | 0.32 |
| FC-SB-5 | .00 | .00 | .00 | 0.19 |
| FC-SB-6 | .00 | .00 | .00 | 0.17 |
| FC-UD-ME-3 | .00 | .00 | 0.30 | 1.32 |
| FC-UD-ME-2 | .00 | .00 | 0.30 | 1.32 |
| FC-UD-ME-1 | .00 | .00 | 0.13 | 0.59 |
| REACHES | | | | |
| FLUME SB-E | .00 | .00 | 1.02 | 4.56 |
| Down | .00 | .00 | 1.02 | 4.56 |
| FLUME SB-D | .00 | .00 | 0.87 | 3.88 |
| Down | .00 | .00 | 0.87 | 3.88 |
| FLUME SB-C | .00 | .00 | 0.72 | 3.22 |
| Down | .00 | .00 | 0.72 | 3.22 |
| FLUME SB-B | .00 | .00 | 0.43 | 1.91 |
| Down | .00 | .00 | 0.43 | 1.90 |
| FLUME SB-A | .00 | .00 | 0.13 | 0.59 |
| Down | .00 | .00 | 0.13 | 0.59 |
| OUTLET | .00 | .00 | 1.02 | 4.91 |

REFERENCE 3

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T13 Final Cover
OUTFALL FC-SB
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| FC-SB-1 | .00 | n/a | .00 | n/a | 0.08 | 12.04 | 0.35 | 12.02 |
| FC-SB-2 | .00 | n/a | .00 | n/a | 0.07 | 12.04 | 0.31 | 12.02 |
| FC-SB-3 | .00 | n/a | .00 | n/a | 0.08 | 12.04 | 0.37 | 12.02 |
| FC-SB-4 | .00 | n/a | .00 | n/a | 0.07 | 12.04 | 0.32 | 12.02 |
| FC-SB-5 | .00 | n/a | .00 | n/a | .00 | n/a | 0.19 | 12.02 |
| FC-SB-6 | .00 | n/a | .00 | n/a | .00 | n/a | 0.17 | 12.02 |
| FC-UD-ME-3 | .00 | n/a | .00 | n/a | 0.30 | 12.04 | 1.32 | 12.02 |
| FC-UD-ME-2 | .00 | n/a | .00 | n/a | 0.30 | 12.04 | 1.32 | 12.02 |
| FC-UD-ME-1 | .00 | n/a | .00 | n/a | 0.13 | 12.04 | 0.59 | 12.02 |
| REACHES | | | | | | | | |
| FLUME SB-E | .00 | n/a | .00 | n/a | 1.02 | 12.04 | 4.56 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 1.02 | 12.03 | 4.56 | 12.02 |
| FLUME SB-D | .00 | n/a | .00 | n/a | 0.87 | 12.04 | 3.88 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.87 | 12.04 | 3.88 | 12.02 |
| FLUME SB-C | .00 | n/a | .00 | n/a | 0.72 | 12.04 | 3.22 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.72 | 12.04 | 3.22 | 12.02 |
| FLUME SB-B | .00 | n/a | .00 | n/a | 0.43 | 12.04 | 1.91 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.43 | 12.04 | 1.90 | 12.02 |
| FLUME SB-A | .00 | n/a | .00 | n/a | 0.13 | 12.04 | 0.59 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.13 | 12.04 | 0.59 | 12.02 |
| OUTLET | .00 | | .00 | | 1.02 | | 4.91 | |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SB
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| FC-SB-1 | .56 | 0.100 | 63 | FLUME SB-D | |
| FC-SB-2 | .49 | 0.100 | 63 | FLUME SB-D | |
| FC-SB-3 | .59 | 0.100 | 63 | FLUME SB-E | |
| FC-SB-4 | .51 | 0.100 | 63 | FLUME SB-E | |
| FC-SB-5 | .30 | 0.100 | 63 | Outlet | |
| FC-SB-6 | .27 | 0.100 | 63 | Outlet | |
| FC-UD-ME-3 | 2.11 | 0.100 | 63 | FLUME SB-C | |
| FC-UD-ME-2 | 2.11 | 0.100 | 63 | FLUME SB-B | |
| FC-UD-ME-1 | .94 | 0.100 | 63 | FLUME SB-A | |

Total Area: 7.88 (ac)

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SB
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| FLUME SB-E | Outlet | 50 | CHANNEL |
| FLUME SB-D | FLUME SB-E | 100 | CHANNEL |
| FLUME SB-C | FLUME SB-D | 80 | CHANNEL |
| FLUME SB-B | FLUME SB-C | 200 | CHANNEL |
| FLUME SB-A | FLUME SB-B | 200 | CHANNEL |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SB
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| FC-SB-1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 245 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.507 | 0.008 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SB-2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 216 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.571 | 0.007 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SB-3 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 245 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.507 | 0.008 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SB-4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 216 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.571 | 0.007 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SB-5 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SB-6 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UD-ME-3 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UD-ME-2 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UD-ME-1 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SB
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| FC-SB-1 | Desert shrub | (poor) | A | .56 | 63 |
| | Total Area / Weighted Curve Number | | | .56 | 63 |
| | | | | === | == |
| FC-SB-2 | Desert shrub | (poor) | A | .49 | 63 |
| | Total Area / Weighted Curve Number | | | .49 | 63 |
| | | | | === | == |
| FC-SB-3 | Desert shrub | (poor) | A | .59 | 63 |
| | Total Area / Weighted Curve Number | | | .59 | 63 |
| | | | | === | == |
| FC-SB-4 | Desert shrub | (poor) | A | .51 | 63 |
| | Total Area / Weighted Curve Number | | | .51 | 63 |
| | | | | === | == |
| FC-SB-5 | Desert shrub | (poor) | A | .3 | 63 |
| | Total Area / Weighted Curve Number | | | .3 | 63 |
| | | | | == | == |
| FC-SB-6 | Desert shrub | (poor) | A | .27 | 63 |
| | Total Area / Weighted Curve Number | | | .27 | 63 |
| | | | | === | == |
| FC-UD-ME-3 | Desert shrub | (poor) | A | 2.11 | 63 |
| | Total Area / Weighted Curve Number | | | 2.11 | 63 |
| | | | | ==== | == |
| FC-UD-ME-2 | Desert shrub | (poor) | A | 2.11 | 63 |
| | Total Area / Weighted Curve Number | | | 2.11 | 63 |
| | | | | ==== | == |
| FC-UD-ME-1 | Desert shrub | (poor) | A | .94 | 63 |
| | Total Area / Weighted Curve Number | | | .94 | 63 |
| | | | | === | == |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SB
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| FLUME SB-E | 50 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SB-D | 100 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SB-C | 80 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SB-B | 200 | 0.023 | 0.05 | 4 | 2 :1 |
| FLUME SB-A | 200 | 0.023 | 0.05 | 4 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| FLUME SB-E | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SB-D | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SB-C | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SB-B | 0.0 | 0.000 | 0 | 4 | 0.05 |
| | 0.5 | 19.637 | 2.5 | 6 | |
| | 1.0 | 68.870 | 6 | 8 | |
| | 2.0 | 266.230 | 16 | 12 | |
| | 5.0 | 1939.255 | 70 | 24 | |
| | 10.0 | 10038.029 | 240 | 44 | |
| | 20.0 | 56695.699 | 880 | 84 | |
| FLUME SB-A | 0.0 | 0.000 | 0 | 4 | 0.05 |
| | 0.5 | 19.637 | 2.5 | 6 | |
| | 1.0 | 68.870 | 6 | 8 | |
| | 2.0 | 266.230 | 16 | 12 | |
| | 5.0 | 1939.255 | 70 | 24 | |
| | 10.0 | 10038.029 | 240 | 44 | |
| | 20.0 | 56695.699 | 880 | 84 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: T13 Final Cover
SubTitle: OUTFALL FC-SA
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Erosion\Water Erosion\TR-55 Model Runs - Fi

Date: 3/7/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| FC-SA-1 | | FLUME SA-D | 0.56 | 63 | 0.1 |
| FC-SA-2 | | FLUME SA-D | 0.49 | 63 | 0.1 |
| FC-SA-3 | | FLUME SA-E | 0.59 | 63 | 0.1 |
| FC-SA-4 | | FLUME SA-E | 0.51 | 63 | 0.1 |
| FC-SA-5 | | Outlet | 0.3 | 63 | 0.1 |
| FC-SA-6 | | Outlet | 0.27 | 63 | 0.1 |
| FC-UD-MW-3 | | FLUME SA-C | 2.11 | 63 | 0.1 |
| FC-UD-MW-2 | | FLUME SA-B | 2.11 | 63 | 0.1 |
| FC-UD-MW-1 | | FLUME SA-A | 0.94 | 63 | 0.1 |

Total area: 7.88 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SA
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SA
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| FC-SA-1 | .00 | .00 | 0.08 | 0.35 |
| FC-SA-2 | .00 | .00 | 0.07 | 0.31 |
| FC-SA-3 | .00 | .00 | 0.08 | 0.37 |
| FC-SA-4 | .00 | .00 | 0.07 | 0.32 |
| FC-SA-5 | .00 | .00 | .00 | 0.19 |
| FC-SA-6 | .00 | .00 | .00 | 0.17 |
| FC-UD-MW-3 | .00 | .00 | 0.30 | 1.32 |
| FC-UD-MW-2 | .00 | .00 | 0.30 | 1.32 |
| FC-UD-MW-1 | .00 | .00 | 0.13 | 0.59 |
| REACHES | | | | |
| FLUME SA-E | .00 | .00 | 1.02 | 4.56 |
| Down | .00 | .00 | 1.02 | 4.56 |
| FLUME SA-D | .00 | .00 | 0.87 | 3.88 |
| Down | .00 | .00 | 0.87 | 3.88 |
| FLUME SA-C | .00 | .00 | 0.72 | 3.22 |
| Down | .00 | .00 | 0.72 | 3.22 |
| FLUME SA-B | .00 | .00 | 0.43 | 1.91 |
| Down | .00 | .00 | 0.43 | 1.90 |
| FLUME SA-A | .00 | .00 | 0.13 | 0.59 |
| Down | .00 | .00 | 0.13 | 0.59 |
| OUTLET | .00 | .00 | 1.02 | 4.91 |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SA
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| FC-SA-1 | .00 | n/a | .00 | n/a | 0.08 | 12.04 | 0.35 | 12.02 |
| FC-SA-2 | .00 | n/a | .00 | n/a | 0.07 | 12.04 | 0.31 | 12.02 |
| FC-SA-3 | .00 | n/a | .00 | n/a | 0.08 | 12.04 | 0.37 | 12.02 |
| FC-SA-4 | .00 | n/a | .00 | n/a | 0.07 | 12.04 | 0.32 | 12.02 |
| FC-SA-5 | .00 | n/a | .00 | n/a | .00 | n/a | 0.19 | 12.02 |
| FC-SA-6 | .00 | n/a | .00 | n/a | .00 | n/a | 0.17 | 12.02 |
| FC-UD-MW-3 | .00 | n/a | .00 | n/a | 0.30 | 12.04 | 1.32 | 12.02 |
| FC-UD-MW-2 | .00 | n/a | .00 | n/a | 0.30 | 12.04 | 1.32 | 12.02 |
| FC-UD-MW-1 | .00 | n/a | .00 | n/a | 0.13 | 12.04 | 0.59 | 12.02 |
| REACHES | | | | | | | | |
| FLUME SA-E | .00 | n/a | .00 | n/a | 1.02 | 12.04 | 4.56 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 1.02 | 12.03 | 4.56 | 12.02 |
| FLUME SA-D | .00 | n/a | .00 | n/a | 0.87 | 12.04 | 3.88 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.87 | 12.04 | 3.88 | 12.02 |
| FLUME SA-C | .00 | n/a | .00 | n/a | 0.72 | 12.04 | 3.22 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.72 | 12.04 | 3.22 | 12.02 |
| FLUME SA-B | .00 | n/a | .00 | n/a | 0.43 | 12.04 | 1.91 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.43 | 12.04 | 1.90 | 12.02 |
| FLUME SA-A | .00 | n/a | .00 | n/a | 0.13 | 12.04 | 0.59 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.13 | 12.04 | 0.59 | 12.02 |
| OUTLET | .00 | | .00 | | 1.02 | | 4.91 | |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SA
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| FC-SA-1 | .56 | 0.100 | 63 | FLUME SA-D | |
| FC-SA-2 | .49 | 0.100 | 63 | FLUME SA-D | |
| FC-SA-3 | .59 | 0.100 | 63 | FLUME SA-E | |
| FC-SA-4 | .51 | 0.100 | 63 | FLUME SA-E | |
| FC-SA-5 | .30 | 0.100 | 63 | Outlet | |
| FC-SA-6 | .27 | 0.100 | 63 | Outlet | |
| FC-UD-MW-3 | 2.11 | 0.100 | 63 | FLUME SA-C | |
| FC-UD-MW-2 | 2.11 | 0.100 | 63 | FLUME SA-B | |
| FC-UD-MW-1 | .94 | 0.100 | 63 | FLUME SA-A | |

Total Area: 7.88 (ac)

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SA
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| FLUME SA-E | Outlet | 50 | CHANNEL |
| FLUME SA-D | FLUME SA-E | 100 | CHANNEL |
| FLUME SA-C | FLUME SA-D | 80 | CHANNEL |
| FLUME SA-B | FLUME SA-C | 200 | CHANNEL |
| FLUME SA-A | FLUME SA-B | 200 | CHANNEL |

REFERENCE 3

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T13 Final Cover
OUTFALL FC-SA
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| FC-SA-1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 245 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.507 | 0.008 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SA-2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 216 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.571 | 0.007 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SA-3 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 245 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.507 | 0.008 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SA-4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 216 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.571 | 0.007 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SA-5 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SA-6 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UD-MW-3 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UD-MW-2 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UD-MW-1 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SA
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| FC-SA-1 | Desert shrub | (poor) | A | .56 | 63 |
| | Total Area / Weighted Curve Number | | | .56 | 63 |
| | | | | === | == |
| FC-SA-2 | Desert shrub | (poor) | A | .49 | 63 |
| | Total Area / Weighted Curve Number | | | .49 | 63 |
| | | | | === | == |
| FC-SA-3 | Desert shrub | (poor) | A | .59 | 63 |
| | Total Area / Weighted Curve Number | | | .59 | 63 |
| | | | | === | == |
| FC-SA-4 | Desert shrub | (poor) | A | .51 | 63 |
| | Total Area / Weighted Curve Number | | | .51 | 63 |
| | | | | === | == |
| FC-SA-5 | Desert shrub | (poor) | A | .3 | 63 |
| | Total Area / Weighted Curve Number | | | .3 | 63 |
| | | | | == | == |
| FC-SA-6 | Desert shrub | (poor) | A | .27 | 63 |
| | Total Area / Weighted Curve Number | | | .27 | 63 |
| | | | | === | == |
| FC-UD-MW-3 | Desert shrub | (poor) | A | 2.11 | 63 |
| | Total Area / Weighted Curve Number | | | 2.11 | 63 |
| | | | | ==== | == |
| FC-UD-MW-2 | Desert shrub | (poor) | A | 2.11 | 63 |
| | Total Area / Weighted Curve Number | | | 2.11 | 63 |
| | | | | ==== | == |
| FC-UD-MW-1 | Desert shrub | (poor) | A | .94 | 63 |
| | Total Area / Weighted Curve Number | | | .94 | 63 |
| | | | | === | == |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-SA
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| FLUME SA-E | 50 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SA-D | 100 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SA-C | 80 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SA-B | 200 | 0.023 | 0.05 | 4 | 2 :1 |
| FLUME SA-A | 200 | 0.023 | 0.05 | 4 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| FLUME SA-E | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SA-D | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SA-C | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SA-B | 0.0 | 0.000 | 0 | 4 | 0.05 |
| | 0.5 | 19.637 | 2.5 | 6 | |
| | 1.0 | 68.870 | 6 | 8 | |
| | 2.0 | 266.230 | 16 | 12 | |
| | 5.0 | 1939.255 | 70 | 24 | |
| | 10.0 | 10038.029 | 240 | 44 | |
| | 20.0 | 56695.699 | 880 | 84 | |
| FLUME SA-A | 0.0 | 0.000 | 0 | 4 | 0.05 |
| | 0.5 | 19.637 | 2.5 | 6 | |
| | 1.0 | 68.870 | 6 | 8 | |
| | 2.0 | 266.230 | 16 | 12 | |
| | 5.0 | 1939.255 | 70 | 24 | |
| | 10.0 | 10038.029 | 240 | 44 | |
| | 20.0 | 56695.699 | 880 | 84 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: T13 Final Cover
SubTitle: Outfall FC-SW
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Erosion\Water Erosion\TR-55 Model Runs - Fi

Date: 3/7/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| FC-SW-1 | | FLUME SW-B | 0.59 | 63 | 0.1 |
| FC-SW-2 | | FLUME SW-B | 0.55 | 63 | 0.1 |
| FC-SW-3 | | FLUME SW-A | 0.83 | 63 | 0.1 |
| FC-SW-4 | | FLUME SW-A | 0.59 | 63 | 0.1 |
| FC-SW-5 | | Outlet | 0.53 | 63 | 0.1 |
| FC-SW-6 | | Outlet | 0.3 | 63 | 0.1 |
| FC-UDW-3 | | FLUME SW-C | 2.01 | 63 | 0.1 |
| FC-UDW-2 | | FLUME SW-D | 1.88 | 63 | 0.1 |
| FC-UDW-1 | | FLUME SW-E | 0.8 | 63 | 0.1 |

Total area: 8.08 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SW
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SW
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| FC-SW-1 | .00 | .00 | 0.08 | 0.37 |
| FC-SW-2 | .00 | .00 | 0.08 | 0.34 |
| FC-SW-3 | .00 | .00 | 0.12 | 0.52 |
| FC-SW-4 | .00 | .00 | 0.08 | 0.37 |
| FC-SW-5 | .00 | .00 | 0.07 | 0.33 |
| FC-SW-6 | .00 | .00 | .00 | 0.19 |
| FC-UDW-3 | .00 | .00 | 0.28 | 1.26 |
| FC-UDW-2 | .00 | .00 | 0.26 | 1.18 |
| FC-UDW-1 | .00 | .00 | 0.11 | 0.50 |
| REACHES | | | | |
| FLUME SW-A | .00 | .00 | 1.01 | 4.52 |
| Down | .00 | .00 | 1.01 | 4.52 |
| FLUME SW-B | .00 | .00 | 0.81 | 3.63 |
| Down | .00 | .00 | 0.81 | 3.63 |
| FLUME SW-C | .00 | .00 | 0.66 | 2.92 |
| Down | .00 | .00 | 0.66 | 2.92 |
| FLUME SW-D | .00 | .00 | 0.38 | 1.67 |
| Down | .00 | .00 | 0.38 | 1.67 |
| FLUME SW-E | .00 | .00 | 0.11 | 0.50 |
| Down | .00 | .00 | 0.11 | 0.50 |
| OUTLET | .00 | .00 | 1.08 | 5.03 |

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SW
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| FC-SW-1 | .00 | n/a | .00 | n/a | 0.08 | 12.04 | 0.37 | 12.02 |
| FC-SW-2 | .00 | n/a | .00 | n/a | 0.08 | 12.04 | 0.34 | 12.02 |
| FC-SW-3 | .00 | n/a | .00 | n/a | 0.12 | 12.04 | 0.52 | 12.02 |
| FC-SW-4 | .00 | n/a | .00 | n/a | 0.08 | 12.04 | 0.37 | 12.02 |
| FC-SW-5 | .00 | n/a | .00 | n/a | 0.07 | 12.04 | 0.33 | 12.02 |
| FC-SW-6 | .00 | n/a | .00 | n/a | .00 | n/a | 0.19 | 12.02 |
| FC-UDW-3 | .00 | n/a | .00 | n/a | 0.28 | 12.04 | 1.26 | 12.02 |
| FC-UDW-2 | .00 | n/a | .00 | n/a | 0.26 | 12.04 | 1.18 | 12.02 |
| FC-UDW-1 | .00 | n/a | .00 | n/a | 0.11 | 12.04 | 0.50 | 12.02 |
| REACHES | | | | | | | | |
| FLUME SW-A | .00 | n/a | .00 | n/a | 1.01 | 12.04 | 4.52 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 1.01 | 12.04 | 4.52 | 12.02 |
| FLUME SW-B | .00 | n/a | .00 | n/a | 0.81 | 12.04 | 3.63 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.81 | 12.04 | 3.63 | 12.02 |
| FLUME SW-C | .00 | n/a | .00 | n/a | 0.66 | 12.04 | 2.92 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.66 | 12.04 | 2.92 | 12.02 |
| FLUME SW-D | .00 | n/a | .00 | n/a | 0.38 | 12.04 | 1.67 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.38 | 12.04 | 1.67 | 12.02 |
| FLUME SW-E | .00 | n/a | .00 | n/a | 0.11 | 12.04 | 0.50 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.11 | 12.04 | 0.50 | 12.02 |
| OUTLET | .00 | | .00 | | 1.08 | | 5.03 | |

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SW
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| FC-SW-1 | .59 | 0.100 | 63 | FLUME SW-B | |
| FC-SW-2 | .55 | 0.100 | 63 | FLUME SW-B | |
| FC-SW-3 | .83 | 0.100 | 63 | FLUME SW-A | |
| FC-SW-4 | .59 | 0.100 | 63 | FLUME SW-A | |
| FC-SW-5 | .53 | 0.100 | 63 | Outlet | |
| FC-SW-6 | .30 | 0.100 | 63 | Outlet | |
| FC-UDW-3 | 2.01 | 0.100 | 63 | FLUME SW-C | |
| FC-UDW-2 | 1.88 | 0.100 | 63 | FLUME SW-D | |
| FC-UDW-1 | .80 | 0.100 | 63 | FLUME SW-E | |

Total Area: 8.08 (ac)

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SW
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| FLUME SW-A | Outlet | 50 | CHANNEL |
| FLUME SW-B | FLUME SW-A | 100 | CHANNEL |
| FLUME SW-C | FLUME SW-B | 80 | CHANNEL |
| FLUME SW-D | FLUME SW-C | 200 | CHANNEL |
| FLUME SW-E | FLUME SW-D | 200 | CHANNEL |

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SW
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| FC-SW-1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 296 | 0.0200 | 0.023 | 10.00 | 10.79 | 9.136 | 0.009 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SW-2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 245 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.507 | 0.008 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SW-3 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 393 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.397 | 0.013 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SW-4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 245 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.507 | 0.008 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SW-5 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| FC-SW-6 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UDW-3 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UDW-2 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |
| FC-UDW-1 | | | | | | | |
| SHEET | 100 | 0.0500 | 0.011 | | | | 0.026 |
| SHALLOW | 252 | 0.0100 | 0.944 | | | | 0.043 |
| | | | | | Time of Concentration | | 0.1 |

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SW
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| FC-SW-1 | Desert shrub | (poor) | A | .59 | 63 |
| | Total Area / Weighted Curve Number | | | .59 | 63 |
| | | | | === | == |
| FC-SW-2 | Desert shrub | (poor) | A | .55 | 63 |
| | Total Area / Weighted Curve Number | | | .55 | 63 |
| | | | | === | == |
| FC-SW-3 | Desert shrub | (poor) | A | .83 | 63 |
| | Total Area / Weighted Curve Number | | | .83 | 63 |
| | | | | === | == |
| FC-SW-4 | Desert shrub | (poor) | A | .59 | 63 |
| | Total Area / Weighted Curve Number | | | .59 | 63 |
| | | | | === | == |
| FC-SW-5 | Desert shrub | (poor) | A | .53 | 63 |
| | Total Area / Weighted Curve Number | | | .53 | 63 |
| | | | | === | == |
| FC-SW-6 | Desert shrub | (poor) | A | .3 | 63 |
| | Total Area / Weighted Curve Number | | | .3 | 63 |
| | | | | == | == |
| FC-UDW-3 | Desert shrub | (poor) | A | 2.01 | 63 |
| | Total Area / Weighted Curve Number | | | 2.01 | 63 |
| | | | | ==== | == |
| FC-UDW-2 | Desert shrub | (poor) | A | 1.88 | 63 |
| | Total Area / Weighted Curve Number | | | 1.88 | 63 |
| | | | | ==== | == |
| FC-UDW-1 | Desert shrub | (poor) | A | .8 | 63 |
| | Total Area / Weighted Curve Number | | | .8 | 63 |
| | | | | == | == |

REFERENCE 3

CWK

T13 Final Cover
Outfall FC-SW
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| FLUME SW-A | 50 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SW-B | 100 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SW-C | 80 | 0.036 | 0.33 | 4 | 2 :1 |
| FLUME SW-D | 200 | 0.023 | 0.05 | 4 | 2 :1 |
| FLUME SW-E | 200 | 0.023 | 0.05 | 4 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| FLUME SW-A | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SW-B | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SW-C | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |
| FLUME SW-D | 0.0 | 0.000 | 0 | 4 | 0.05 |
| | 0.5 | 19.637 | 2.5 | 6 | |
| | 1.0 | 68.870 | 6 | 8 | |
| | 2.0 | 266.230 | 16 | 12 | |
| | 5.0 | 1939.255 | 70 | 24 | |
| | 10.0 | 10038.029 | 240 | 44 | |
| | 20.0 | 56695.699 | 880 | 84 | |
| FLUME SW-E | 0.0 | 0.000 | 0 | 4 | 0.05 |
| | 0.5 | 19.637 | 2.5 | 6 | |
| | 1.0 | 68.870 | 6 | 8 | |
| | 2.0 | 266.230 | 16 | 12 | |
| | 5.0 | 1939.255 | 70 | 24 | |
| | 10.0 | 10038.029 | 240 | 44 | |
| | 20.0 | 56695.699 | 880 | 84 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: T13 Final Cover
SubTitle: OUTFALL FC-W-A
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Erosion\Water Erosion\TR-55 Model Runs - Fi

Date: 3/7/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| FC-W1 | | UpperDitch | 0.98 | 63 | 0.1 |
| FC-W2 | | LowerDitch | 0.92 | 63 | 0.1 |
| FC-W3 | | Outlet | 0.49 | 63 | 0.1 |

Total area: 2.39 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-W-A
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

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T13 Final Cover
OUTFALL FC-W-A
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| FC-W1 | .00 | .00 | 0.14 | 0.61 |
| FC-W2 | .00 | .00 | 0.13 | 0.58 |
| FC-W3 | .00 | .00 | 0.07 | 0.31 |
| REACHES | | | | |
| LowerDitch | .00 | .00 | 0.27 | 1.18 |
| Down | .00 | .00 | 0.27 | 1.18 |
| UpperDitch | .00 | .00 | 0.14 | 0.61 |
| Down | .00 | .00 | 0.14 | 0.61 |
| OUTLET | .00 | .00 | 0.33 | 1.49 |

REFERENCE 3

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T13 Final Cover
OUTFALL FC-W-A
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| FC-W1 | .00 | n/a | .00 | n/a | 0.14 | 12.04 | 0.61 | 12.02 |
| FC-W2 | .00 | n/a | .00 | n/a | 0.13 | 12.04 | 0.58 | 12.02 |
| FC-W3 | .00 | n/a | .00 | n/a | 0.07 | 12.04 | 0.31 | 12.02 |
| REACHES | | | | | | | | |
| LowerDitch | .00 | n/a | .00 | n/a | 0.27 | 12.04 | 1.18 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.27 | 12.04 | 1.18 | 12.03 |
| UpperDitch | .00 | n/a | .00 | n/a | 0.14 | 12.04 | 0.61 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.14 | 11.98 | 0.61 | 12.02 |
| OUTLET | .00 | | .00 | | 0.33 | | 1.49 | |

REFERENCE 3

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T13 Final Cover
OUTFALL FC-W-A
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| FC-W1 | .98 | 0.100 | 63 | UpperDitch | |
| FC-W2 | .92 | 0.100 | 63 | LowerDitch | |
| FC-W3 | .49 | 0.100 | 63 | Outlet | |

Total Area: 2.39 (ac)

REFERENCE 3

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T13 Final Cover
OUTFALL FC-W-A
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| LowerDitch | Outlet | 296 | CHANNEL |
| UpperDitch | LowerDitch | 299 | CHANNEL |

REFERENCE 3

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T13 Final Cover
OUTFALL FC-W-A
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| FC-W1 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 406 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.675 | 0.013 |
| | | | | | Time of Concentration | | 0.1 |
| FC-W2 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 209 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.294 | 0.007 |
| | | | | | Time of Concentration | | 0.1 |
| FC-W3 | | | | | | | |
| SHEET | 100 | 0.3330 | 0.011 | | | | 0.012 |
| | | | | | Time of Concentration | | 0.1 |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-W-A
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| FC-W1 | Desert shrub | (poor) | A | .98 | 63 |
| | Total Area / Weighted Curve Number | | | .98 | 63 |
| | | | | === | == |
| FC-W2 | Desert shrub | (poor) | A | .92 | 63 |
| | Total Area / Weighted Curve Number | | | .92 | 63 |
| | | | | === | == |
| FC-W3 | Desert shrub | (poor) | A | .49 | 63 |
| | Total Area / Weighted Curve Number | | | .49 | 63 |
| | | | | === | == |

REFERENCE 3

CWK

T13 Final Cover
OUTFALL FC-W-A
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| LowerDitch | 296 | 0.023 | 0.1 | 0.3 | 2 :1 |
| UpperDitch | 299 | 0.023 | 0.1 | 0.3 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| LowerDitch | 0.0 | 0.000 | 0 | 0.3 | 0.1 |
| | 0.5 | 5.086 | 0.6 | 2.3 | |
| | 1.0 | 28.044 | 2.3 | 4.3 | |
| | 2.0 | 164.808 | 8.5 | 8.3 | |
| | 5.0 | 1806.779 | 51.3 | 20.3 | |
| | 10.0 | 11281.721 | 202.5 | 40.3 | |
| | 20.0 | 71030.681 | 805 | 80.3 | |
| UpperDitch | 0.0 | 0.000 | 0 | 0.3 | 0.1 |
| | 0.5 | 5.086 | 0.6 | 2.3 | |
| | 1.0 | 28.044 | 2.3 | 4.3 | |
| | 2.0 | 164.808 | 8.5 | 8.3 | |
| | 5.0 | 1806.779 | 51.3 | 20.3 | |
| | 10.0 | 11281.721 | 202.5 | 40.3 | |
| | 20.0 | 71030.681 | 805 | 80.3 | |

REFERENCE 3

WinTR-55 Current Data Description

--- Identification Data ---

User: CWK
Project: T13 Final Cover
SubTitle: FC-W-B
State: Nevada
County: Nye
Filename: F:\Data\143418 - USEN T13 Design\Design\Calculations\Erosion\Water Erosion\TR-55 Model Runs - Fi

Date: 3/7/2016
Units: English
Areal Units: Acres

--- Sub-Area Data ---

| Name | Description | Reach | Area(ac) | RCN | Tc |
|---|---|---|---|---|---|
| FC-W4 | | FLUME WEST | 0.67 | 63 | 0.1 |
| FC-W5 | | Outlet | 1.02 | 63 | 0.1 |
| FC-W6 | | Outlet | 0.62 | 63 | 0.1 |
| FC-W7 | | Outlet | 0.38 | 63 | 0.1 |

Total area: 2.69 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
FC-W-B
Nye County, Nevada

Storm Data

Rainfall Depth by Rainfall Return Period

| 2-Yr (in) | 5-Yr (in) | 25-Yr (in) | 100-Yr (in) | -Yr (in) | -Yr (in) | -Yr (in) |
|---|---|---|---|---|---|---|
| .94 | 1.39 | 2.26 | 3.13 | .0 | .0 | .0 |

Storm Data Source: User-provided custom storm data
Rainfall Distribution Type: Type II
Dimensionless Unit Hydrograph: <standard>

REFERENCE 3

CWK

T13 Final Cover
FC-W-B
Nye County, Nevada

Watershed Peak Table

| Sub-Area or Reach Identifier | Peak Flow by Rainfall Return Period 2-Yr (cfs) | 5-Yr (cfs) | 25-Yr (cfs) | 100-Yr (cfs) |
|---|---|---|---|---|
| SUBAREAS | | | | |
| FC-W4 | .00 | .00 | 0.09 | 0.42 |
| FC-W5 | .00 | .00 | 0.14 | 0.64 |
| FC-W6 | .00 | .00 | 0.09 | 0.39 |
| FC-W7 | .00 | .00 | 0.05 | 0.24 |
| REACHES | | | | |
| FLUME WEST | .00 | .00 | 0.09 | 0.42 |
| Down | .00 | .00 | 0.09 | 0.42 |
| OUTLET | .00 | .00 | 0.38 | 1.68 |

REFERENCE 3

CWK

T13 Final Cover
FC-W-B
Nye County, Nevada

Hydrograph Peak/Peak Time Table

| Sub-Area or Reach Identifier | Peak Flow and Peak Time (hr) by Rainfall Return Period 2-Yr (cfs) | (hr) | 5-Yr (cfs) | (hr) | 25-Yr (cfs) | (hr) | 100-Yr (cfs) | (hr) |
|---|---|---|---|---|---|---|---|---|
| SUBAREAS | | | | | | | | |
| FC-W4 | .00 | n/a | .00 | n/a | 0.09 | 12.04 | 0.42 | 12.02 |
| FC-W5 | .00 | n/a | .00 | n/a | 0.14 | 12.04 | 0.64 | 12.02 |
| FC-W6 | .00 | n/a | .00 | n/a | 0.09 | 12.04 | 0.39 | 12.02 |
| FC-W7 | .00 | n/a | .00 | n/a | 0.05 | 12.04 | 0.24 | 12.02 |
| REACHES | | | | | | | | |
| FLUME WEST | .00 | n/a | .00 | n/a | 0.09 | 12.04 | 0.42 | 12.02 |
| Down | .00 | n/a | .00 | n/a | 0.09 | 11.99 | 0.42 | 12.02 |
| OUTLET | .00 | | .00 | | 0.38 | | 1.68 | |

REFERENCE 3

CWK

T13 Final Cover
FC-W-B
Nye County, Nevada

Sub-Area Summary Table

| Sub-Area Identifier | Drainage Area (ac) | Time of Concentration (hr) | Curve Number | Receiving Reach | Sub-Area Description |
|---|---|---|---|---|---|
| FC-W4 | .67 | 0.100 | 63 | FLUME WEST | |
| FC-W5 | 1.02 | 0.100 | 63 | Outlet | |
| FC-W6 | .62 | 0.100 | 63 | Outlet | |
| FC-W7 | .38 | 0.100 | 63 | Outlet | |

Total Area: 2.69 (ac)

REFERENCE 3

CWK

T13 Final Cover
FC-W-B
Nye County, Nevada

Reach Summary Table

| Reach Identifier | Receiving Reach Identifier | Reach Length (ft) | Routing Method |
|---|---|---|---|
| FLUME WEST | Outlet | 90 | CHANNEL |

REFERENCE 3

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T13 Final Cover
FC-W-B
Nye County, Nevada

Sub-Area Time of Concentration Details

| Sub-Area Identifier/ | Flow Length (ft) | Slope (ft/ft) | Mannings's n | End Area (sq ft) | Wetted Perimeter (ft) | Velocity (ft/sec) | Travel Time (hr) |
|---|---|---|---|---|---|---|---|
| FC-W4 | | | | | | | |
| SHEET | 100 | 0.3300 | 0.011 | | | | 0.012 |
| CHANNEL | 444 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.810 | 0.014 |
| | | | | | Time of Concentration | | 0.1 |
| FC-W5 | | | | | | | |
| SHEET | 100 | 0.3330 | 0.011 | | | | 0.012 |
| CHANNEL | 512 | 0.0200 | 0.023 | 10.00 | 10.79 | 8.889 | 0.016 |
| | | | | | Time of Concentration | | 0.1 |
| FC-W6 | | | | | | | |
| SHEET | 90 | 0.3330 | 0.011 | | | | 0.011 |
| | | | | | Time of Concentration | | 0.1 |
| FC-W7 | | | | | | | |
| SHEET | 90 | 0.3300 | 0.011 | | | | 0.011 |
| | | | | | Time of Concentration | | 0.1 |

REFERENCE 3

CWK

T13 Final Cover
FC-W-B
Nye County, Nevada

Sub-Area Land Use and Curve Number Details

| Sub-Area Identifier | Land Use | | Hydrologic Soil Group | Sub-Area Area (ac) | Curve Number |
|---|---|---|---|---|---|
| FC-W4 | Desert shrub | (poor) | A | .67 | 63 |
| | Total Area / Weighted Curve Number | | | .67 | 63 |
| | | | | === | == |
| FC-W5 | Desert shrub | (poor) | A | 1.02 | 63 |
| | Total Area / Weighted Curve Number | | | 1.02 | 63 |
| | | | | ==== | == |
| FC-W6 | Desert shrub | (poor) | A | .62 | 63 |
| | Total Area / Weighted Curve Number | | | .62 | 63 |
| | | | | === | == |
| FC-W7 | Desert shrub | (poor) | A | .38 | 63 |
| | Total Area / Weighted Curve Number | | | .38 | 63 |
| | | | | === | == |

REFERENCE 3

CWK

T13 Final Cover
FC-W-B
Nye County, Nevada

Reach Channel Rating Details

| Reach Identifier | Reach Length (ft) | Reach Manning's n | Friction Slope (ft/ft) | Bottom Width (ft) | Side Slope |
|---|---|---|---|---|---|
| FLUME WEST | 90 | 0.036 | 0.33 | 4 | 2 :1 |

| Reach Identifier | Stage (ft) | Flow (cfs) | End Area (sq ft) | Top Width (ft) | Friction Slope (ft/ft) |
|---|---|---|---|---|---|
| FLUME WEST | 0.0 | 0.000 | 0 | 4 | 0.33 |
| | 0.5 | 32.230 | 2.5 | 6 | |
| | 1.0 | 113.039 | 6 | 8 | |
| | 2.0 | 436.973 | 16 | 12 | |
| | 5.0 | 3182.968 | 70 | 24 | |
| | 10.0 | 16475.771 | 240 | 44 | |
| | 20.0 | 93056.651 | 880 | 84 | |

REFERENCE 4

**United States Department of Agriculture**

Natural Resources Conservation Service

Conservation Engineering Division

Technical Release 55

June 1986

# Urban Hydrology for Small Watersheds

## TR-55

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# Preface

Technical Release 55 (TR-55) presents simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs. These procedures are applicable in small watersheds, especially urbanizing watersheds, in the United States. First issued by the Soil Conservation Service (SCS) in January 1975, TR-55 incorporates current SCS procedures. This revision includes results of recent research and other changes based on experience with use of the original edition.

The major revisions and additions are:

- A flow chart for selecting the appropriate procedure;
- Three additional rain distributions;
- Expansion of the chapter on runoff curve numbers;
- A procedure for calculating travel times of sheet flow;
- Deletion of a chapter on peak discharges;
- Modifications to the Graphical Peak Discharge method and Tabular Hydrograph method;
- A new storage routing procedure;
- Features of the TR-55 computer program; and
- Worksheets.

This revision was prepared by Roger Cronshey, hydraulic engineer, Hydrology Unit, SCS, Washington, DC; Dr. Richard H. McCuen, professor of Civil Engineering, University of Maryland, College Park, MD; Norman Miller, head, Hydrology Unit, SCS, Washington, DC; Dr.Walter Rawls, hydrologist, Agricultural Research Service, Beltsville, MD; Sam Robbins (deceased), formerly hydraulic engineer, SCS, South National Technical Center (NTC), Fort Worth, TX; and Don Woodward, hydraulic engineer, SCS, Northeast NTC, Chester, PA. Valuable contributions were made by John Chenoweth, Stan Hamilton, William Merkel, Robert Rallison (ret.), Harvey Richardson, Wendell Styner, other SCS hydraulic engineers, and Teresa Seeman.

Revised June 1986
Update of Appendix A  January 1999

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## Metric conversions

The English system of units is used in this TR. To convert to the International System of units (metric), use the following factors:

| From English unit | To metric unit | Multiply by |
|---|---|---|
| Acre | Hectare | 0.405 |
| Square mile | Square kilometer | 2.59 |
| Cubic feet per second | Cubic meters per second | 0.0283 |
| Inch | Millimeter | 25.4 |
| Feet per second | Meters per second | 0.3048 |
| Acre-foot | Cubic meter | 1233.489 |
| Cubic foot | Cubic meter | 0.0283 |

Perform rounding operations as appropriate to indicate the same level of precision as that of the original measurement. For example:

1. A stream discharge is recorded in cubic feet per second with three significant digits.
2. Convert stream discharge to cubic meters per second by multiplying by 0.0283.
3. Round to enough significant digits so that, when converting back to cubic feet per second, you obtain the original value (step 1) with three significant digits.

## Definitions of symbols

| Symbol | Unit | Definition |
|---|---|---|
| a | $ft^2$ | Cross sectional flow area |
| Am | $mi^2$ | Drainage area |
| CN | | Runoff curve number |
| $CN_e$ | | Composite runoff curve number |
| $CN_p$ | | Pervious runoff curve number |
| $E_{max}$ | | Maximum stage |
| $F_p$ | | Pond and swamp adjustment factor |
| $H_w$ | ft | Head over weir crest |
| $I_a$ | in | Initial abstraction |
| L | ft | Flow length |
| $L_w$ | ft | Weir crest length |
| m | | Number of flow segments |
| n | | Manning's roughness coefficient |
| P | in | Rainfall |
| $P_{imp}$ | | Percent imperviousness |
| $P_2$ | in | Two-year frequency, 24-hour rainfall |
| $p_w$ | ft | Wetted perimeter |
| q | $ft^3/s$ (cfs) | Hydrograph coordinate |
| $q_i$ | $ft^3/s$ (cfs) | Peak inflow discharge |
| $q_o$ | $ft^3/s$ (cfs) | Peak outflow discharge |
| $q_p$ | $ft^3/s$ (cfs) | Peak discharge |
| $q_t$ | csm/in | Tabular hydrograph unit discharge |
| $q_u$ | csm/in | Unit peak discharge |
| Q | in | Runoff |
| r | ft | Hydraulic radius |
| R | | Ratio of unconnected impervious area to total impervious area |
| s | ft/ft | Slope of hydraulic grade line |
| S | in | Potential maximum retention after runoff begins |
| t | hr | Hydrograph time |
| $T_c$ | hr | Time of concentration |
| $T_p$ | hr | Time to peak |
| $T_t$ | hr | Travel time |
| V | ft/s | Average velocity |
| $V_r$ | acre-ft, $ft^3$ or water-shed-inch | Runoff volume |
| $V_s$ | acre-ft, $ft^3$ or water-shed-inch | Storage volume |

# Chapter 1 Introduction

The conversion of rural land to urban land usually increases erosion and the discharge and volume of storm runoff in a watershed. It also causes other problems that affect soil and water. As part of programs established to alleviate these problems, engineers increasingly must assess the probable effects of urban development, as well as design and implement measures that will minimize its adverse effects.

Technical Release 55 (TR-55) presents simplified procedures for estimating runoff and peak discharges in small watersheds. In selecting the appropriate procedure, consider the scope and complexity of the problem, the available data, and the acceptable level of error. While this TR gives special emphasis to urban and urbanizing watersheds, the procedures apply to any small watershed in which certain limitations are met.

## Effects of urban development

An urban or urbanizing watershed is one in which impervious surfaces cover or will soon cover a considerable area. Impervious surfaces include roads, sidewalks, parking lots, and buildings. Natural flow paths in the watershed may be replaced or supplemented by paved gutters, storm sewers, or other elements of artificial drainage.

Hydrologic studies to determine runoff and peak discharge should ideally be based on long-term stationary streamflow records for the area. Such records are seldom available for small drainage areas. Even where they are available, accurate statistical analysis of them is usually impossible because of the conversion of land to urban uses during the period of record. It therefore is necessary to estimate peak discharges with hydrologic models based on measurable watershed characteristics. Only through an understanding of these characteristics and experience in using these models can we make sound judgments on how to alter model parameters to reflect changing watershed conditions.

Urbanization changes a watershed's response to precipitation. The most common effects are reduced infiltration and decreased travel time, which significantly increase peak discharges and runoff. Runoff is determined primarily by the amount of precipitation and by infiltration characteristics related to soil type, soil moisture, antecedent rainfall, cover type, impervious surfaces, and surface retention. Travel time is determined primarily by slope, length of flow path, depth of flow, and roughness of flow surfaces. Peak discharges are based on the relationship of these parameters and on the total drainage area of the watershed, the location of the development, the effect of any flood control works or other natural or manmade storage, and the time distribution of rainfall during a given storm event.

The model described in TR-55 begins with a rainfall amount uniformly imposed on the watershed over a specified time distribution. Mass rainfall is converted to mass runoff by using a runoff curve number (CN). CN is based on soils, plant cover, amount of impervious areas, interception, and surface storage. Runoff is then transformed into a hydrograph by using unit hydrograph theory and routing procedures that depend on runoff travel time through segments of the watershed.

For a description of the hydrograph development method used by SCS, see chapter 16 of the SCS National Engineering Handbook, Section 4—Hydrology (NEH-4) (SCS 1985). The routing method (Modified Att-Kin) is explained in appendixes G and H of draft Technical Release 20 (TR-20) (SCS 1983).

## Rainfall

TR-55 includes four regional rainfall time distributions. See appendix B for a discussion of how these distributions were developed.

All four distributions are for a 24-hour period. This period was chosen because of the general availability of daily rainfall data that were used to estimate 24-hour rainfall amounts. The 24-hour duration spans most of the applications of TR-55.

One critical parameter in the model is time of concentration ($T_c$), which is the time it takes for runoff to travel to a point of interest from the hydraulically most distant point. Normally a rainfall duration equal to or greater than $T_c$ is used. Therefore, the rainfall distributions were designed to contain the intensity of any duration of rainfall for the frequency of the event chosen. That is, if the 10-year frequency, 24-hour rainfall is used, the most intense hour will approximate the 10-year, 1-hour rainfall volume.

## Runoff

To estimate runoff from storm rainfall, SCS uses the runoff curve number (CN) method (see chapters 4 through 10 of NEH-4, SCS 1985). Determination of CN depends on the watershed's soil and cover conditions, which the model represents as hydrologic soil group, cover type, treatment, and hydrologic condition. Chapter 2 of this TR discusses the effect of urban development on CN and explains how to use CN to estimate runoff.

## Time parameters

Chapter 3 describes a method for estimating the parameters used to distribute the runoff into a hydrograph. The method is based on velocities of flow through segments of the watershed. Two major parameters are time of concentration ($T_c$) and travel time of flow through the segments ($T_t$). These and the other parameters used are the same as those used in accepted hydraulic analyses of open channels.

Many methods are empirically derived from actual runoff hydrographs and watershed characteristics. The method in chapter 3 was chosen because it is basic; however, other methods may be used.

## Peak discharge and hydrographs

Chapter 4 describes a method for approximating peak rates of discharge, and chapter 5 describes a method for obtaining or routing hydrographs. Both methods were derived from hydrographs prepared by procedures outlined in chapter 16 of NEH-4 (SCS 1985). The computations were made with a computerized SCS hydrologic model, TR-20 (SCS 1983).

The methods in chapters 4 and 5 should be used in accordance with specific guidelines. If basic data are improperly prepared or adjustments not properly used, errors will result.

## Storage effects

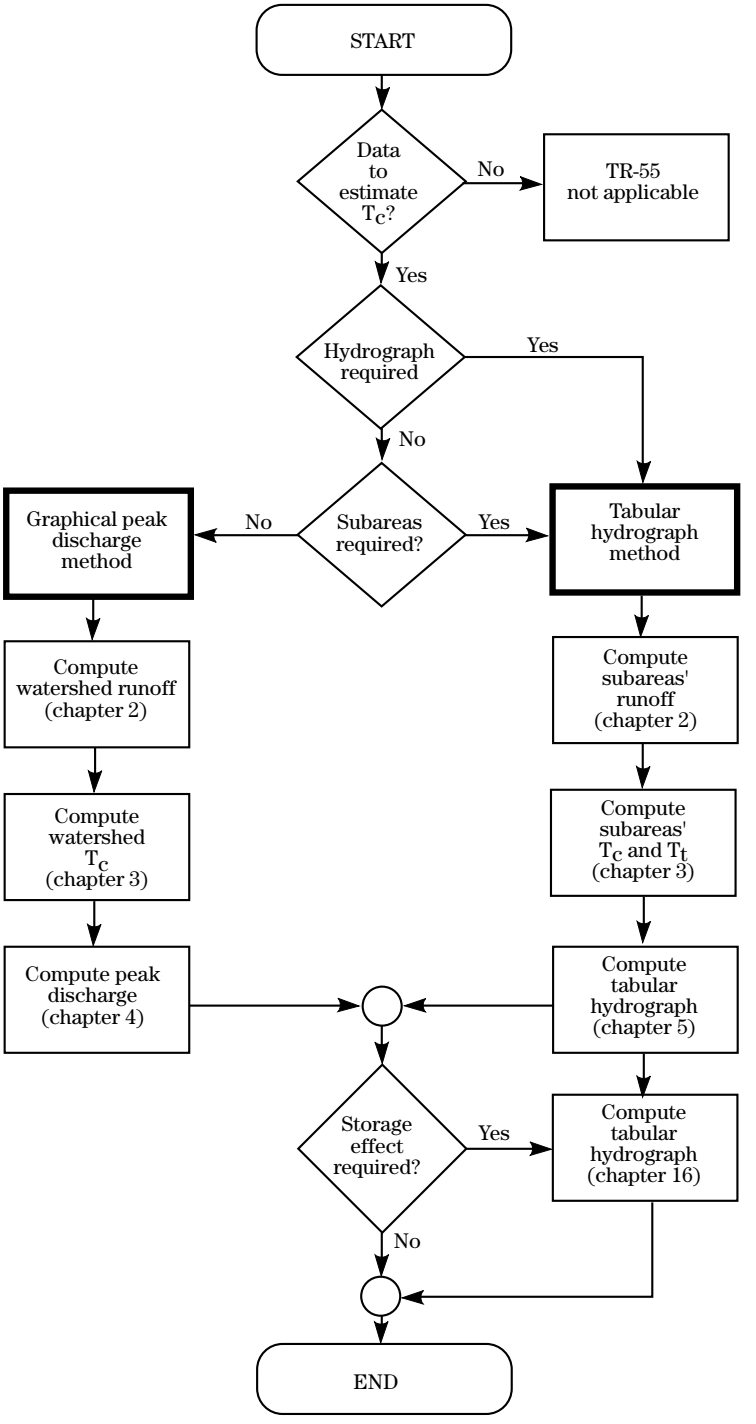
Chapter 6 outlines procedures to account for the effect of detention-type storage. It provides a shortcut method to estimate temporary flood storage based on hydrologic data developed from the Graphical Peak Discharge or Tabular Hydrograph methods.

By increasing runoff and decreasing travel times, urbanization can be expected to increase downstream peak discharges. Chapter 6 discusses how flood detention can modify the hydrograph so that, ideally, downstream peak discharge is reduced approximately to the predevelopment condition. The shortcuts in chapter 6 are useful in sizing a basin even though the final design may require a more detailed analysis.

## Selecting the appropriate procedures

Figure 1-1 is a flow chart that shows how to select the appropriate procedures to use in TR-55. In the figure, the diamond-shaped box labeled "Subareas required?" directs the user to the appropriate method based on whether the watershed needs to be divided into subareas. Watershed subdivision is required when significantly different conditions affecting runoff or timing are present in the watershed—for example, if the watershed has widely differing curve numbers or nonhomogeneous slope patterns.

**Figure 1-1** Flow chart for selecting the appropriate procedures in TR-55.



## Limitations

To save time, the procedures in TR-55 are simplified by assumptions about some parameters. These simplifications, however, limit the use of the procedures and can provide results that are less accurate than more detailed methods. The user should examine the sensitivity of the analysis being conducted to a variation of the peak discharge or hydrograph. To ensure that the degree of error is tolerable, specific limitations are given in chapters 2 through 6. Additional general constraints to the use of TR-55 are as follows:

- The methods in this TR are based on open and unconfined flow over land or in channels. For large events during which flow is divided between sewer and overland flow, more information about hydraulics than is presented here is needed to determine $T_c$. After flow enters a closed system, the discharge can be assumed constant until another flow is encountered at a junction or another inlet.

- Both the Graphical Peak Discharge and Tabular Hydrograph methods are derived from TR-20 (SCS 1983) output. Their accuracy is comparable; they differ only in their products. The use of $T_c$ permits them to be used for any size watershed within the scope of the curves or tables. The Graphical method (chapter 4) is used only for hydrologically homogeneous watersheds because the procedure is limited to a single watershed subarea. The Tabular method (chapter 5) can be used for a heterogeneous watershed that is divided into a number of homogeneous subwatersheds. Hydrographs for the subwatersheds can be routed and added.

- The approximate storage-routing curves (chapter 6) should not be used if the adjustment for ponding (chapter 4) is used. These storage-routing curves, like the peak discharge and hydrograph procedures, are generalizations derived from TR-20 routings.

# Chapter 2 Estimating Runoff

## SCS runoff curve number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{[eq. 2-1]}$$

where

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in) and
$I_a$ = initial abstraction (in)

Initial abstraction ($I_a$) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. $I_a$ is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, $I_a$ was found to be approximated by the following empirical equation:

$$I_a = 0.2S \qquad \text{[eq. 2-2]}$$

By removing $I_a$ as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \text{[eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10 \qquad \text{[eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

## Factors considered in determining runoff curve numbers

The major factors that determine CN are the hydrologic soil group (HSG), cover type, treatment, hydrologic condition, and antecedent runoff condition (ARC). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected). Figure 2-2 is provided to aid in selecting the appropriate figure or table for determining curve numbers.

CN's in table 2-2 (*a* to *d*) represent average antecedent runoff condition for urban, cultivated agricultural, other agricultural, and arid and semiarid rangeland uses. Table 2-2 assumes impervious areas are directly connected. The following sections explain how to determine CN's and how to modify them for urban conditions.

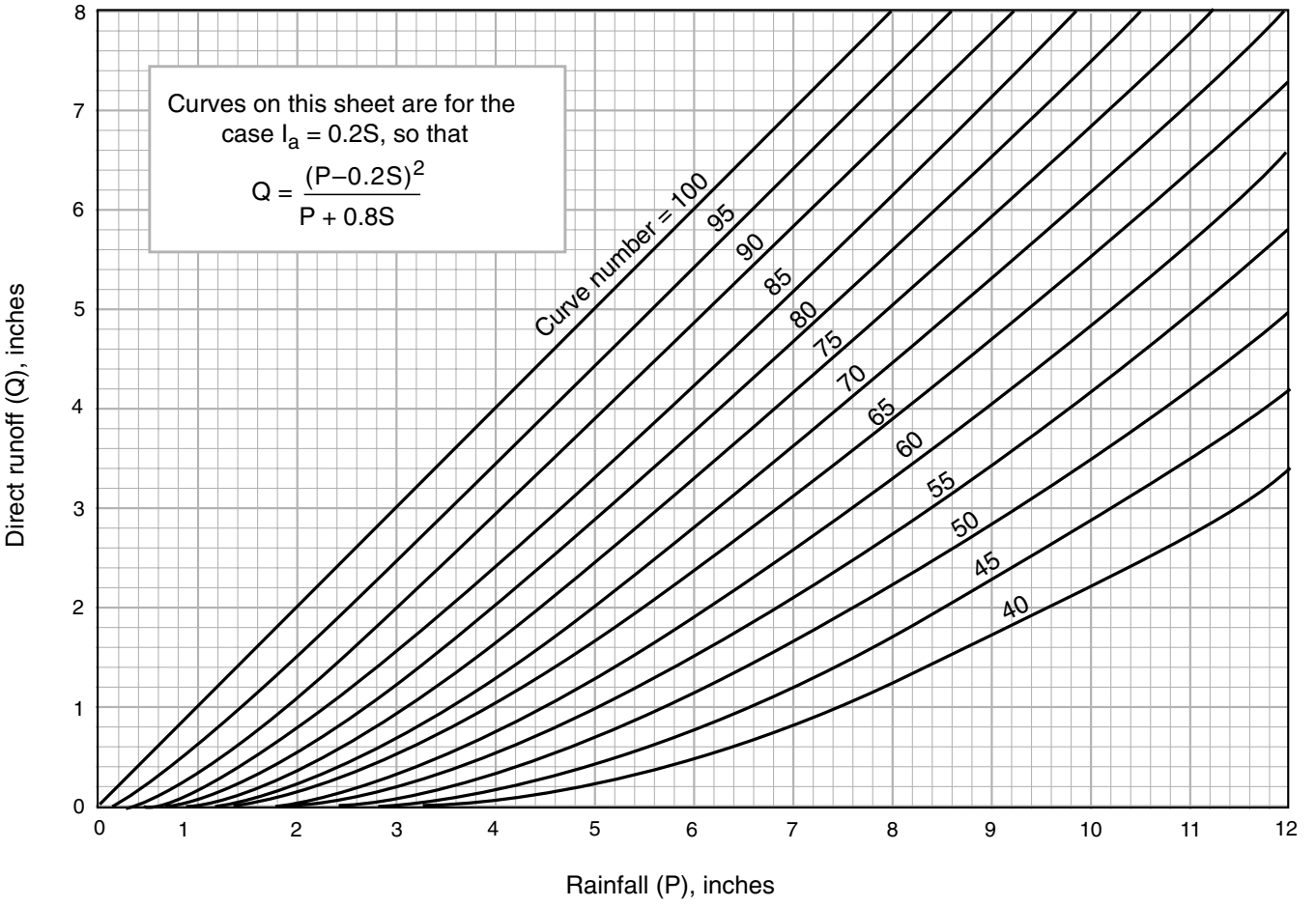
### Hydrologic soil groups

Infiltration rates of soils vary widely and are affected by subsurface permeability as well as surface intake rates. Soils are classified into four HSG's (A, B, C, and D) according to their minimum infiltration rate, which is obtained for bare soil after prolonged wetting. Appendix A defines the four groups and provides a list of most of the soils in the United States and their group classification. The soils in the area of interest may be identified from a soil survey report, which can be obtained from local SCS offices or soil and water conservation district offices.

Most urban areas are only partially covered by impervious surfaces: the soil remains an important factor in runoff estimates. Urbanization has a greater effect on runoff in watersheds with soils having high infiltration rates (sands and gravels) than in watersheds predominantly of silts and clays, which generally have low infiltration rates.

Any disturbance of a soil profile can significantly change its infiltration characteristics. With urbanization, native soil profiles may be mixed or removed or fill material from other areas may be introduced. Therefore, a method based on soil texture is given in appendix A for determining the HSG classification for disturbed soils.

**Figure 2-1** Solution of runoff equation.




## Cover type

Table 2-2 addresses most cover types, such as vegetation, bare soil, and impervious surfaces. There are a number of methods for determining cover type. The most common are field reconnaissance, aerial photographs, and land use maps.

## Treatment

*Treatment* is a cover type modifier (used only in table 2-2b) to describe the management of cultivated agricultural lands. It includes mechanical practices, such as contouring and terracing, and management practices, such as crop rotations and reduced or no tillage.

## Hydrologic condition

*Hydrologic condition* indicates the effects of cover type and treatment on infiltration and runoff and is generally estimated from density of plant and residue cover on sample areas. *Good* hydrologic condition indicates that the soil usually has a low runoff potential for that specific hydrologic soil group, cover type, and treatment. Some factors to consider in estimating the effect of cover on infiltration and runoff are (a) canopy or density of lawns, crops, or other vegetative areas; (b) amount of year-round cover; (c) amount of grass or close-seeded legumes in rotations; (d) percent of residue cover; and (e) degree of surface roughness.

**Table 2-1** Runoff depth for selected CN's and rainfall amounts [1/]

| Rainfall | Runoff depth for curve number of— | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 98 |
| | inches | | | | | | | | | | | | |
| 1.0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.08 | 0.17 | 0.32 | 0.56 | 0.79 |
| 1.2 | .00 | .00 | .00 | .00 | .00 | .00 | .03 | .07 | .15 | .27 | .46 | .74 | .99 |
| 1.4 | .00 | .00 | .00 | .00 | .00 | .02 | .06 | .13 | .24 | .39 | .61 | .92 | 1.18 |
| 1.6 | .00 | .00 | .00 | .00 | .01 | .05 | .11 | .20 | .34 | .52 | .76 | 1.11 | 1.38 |
| 1.8 | .00 | .00 | .00 | .00 | .03 | .09 | .17 | .29 | .44 | .65 | .93 | 1.29 | 1.58 |
| 2.0 | .00 | .00 | .00 | .02 | .06 | .14 | .24 | .38 | .56 | .80 | 1.09 | 1.48 | 1.77 |
| 2.5 | .00 | .00 | .02 | .08 | .17 | .30 | .46 | .65 | .89 | 1.18 | 1.53 | 1.96 | 2.27 |
| 3.0 | .00 | .02 | .09 | .19 | .33 | .51 | .71 | .96 | 1.25 | 1.59 | 1.98 | 2.45 | 2.77 |
| 3.5 | .02 | .08 | .20 | .35 | .53 | .75 | 1.01 | 1.30 | 1.64 | 2.02 | 2.45 | 2.94 | 3.27 |
| 4.0 | .06 | .18 | .33 | .53 | .76 | 1.03 | 1.33 | 1.67 | 2.04 | 2.46 | 2.92 | 3.43 | 3.77 |
| 4.5 | .14 | .30 | .50 | .74 | 1.02 | 1.33 | 1.67 | 2.05 | 2.46 | 2.91 | 3.40 | 3.92 | 4.26 |
| 5.0 | .24 | .44 | .69 | .98 | 1.30 | 1.65 | 2.04 | 2.45 | 2.89 | 3.37 | 3.88 | 4.42 | 4.76 |
| 6.0 | .50 | .80 | 1.14 | 1.52 | 1.92 | 2.35 | 2.81 | 3.28 | 3.78 | 4.30 | 4.85 | 5.41 | 5.76 |
| 7.0 | .84 | 1.24 | 1.68 | 2.12 | 2.60 | 3.10 | 3.62 | 4.15 | 4.69 | 5.25 | 5.82 | 6.41 | 6.76 |
| 8.0 | 1.25 | 1.74 | 2.25 | 2.78 | 3.33 | 3.89 | 4.46 | 5.04 | 5.63 | 6.21 | 6.81 | 7.40 | 7.76 |
| 9.0 | 1.71 | 2.29 | 2.88 | 3.49 | 4.10 | 4.72 | 5.33 | 5.95 | 6.57 | 7.18 | 7.79 | 8.40 | 8.76 |
| 10.0 | 2.23 | 2.89 | 3.56 | 4.23 | 4.90 | 5.56 | 6.22 | 6.88 | 7.52 | 8.16 | 8.78 | 9.40 | 9.76 |
| 11.0 | 2.78 | 3.52 | 4.26 | 5.00 | 5.72 | 6.43 | 7.13 | 7.81 | 8.48 | 9.13 | 9.77 | 10.39 | 10.76 |
| 12.0 | 3.38 | 4.19 | 5.00 | 5.79 | 6.56 | 7.32 | 8.05 | 8.76 | 9.45 | 10.11 | 10.76 | 11.39 | 11.76 |
| 13.0 | 4.00 | 4.89 | 5.76 | 6.61 | 7.42 | 8.21 | 8.98 | 9.71 | 10.42 | 11.10 | 11.76 | 12.39 | 12.76 |
| 14.0 | 4.65 | 5.62 | 6.55 | 7.44 | 8.30 | 9.12 | 9.91 | 10.67 | 11.39 | 12.08 | 12.75 | 13.39 | 13.76 |
| 15.0 | 5.33 | 6.36 | 7.35 | 8.29 | 9.19 | 10.04 | 10.85 | 11.63 | 12.37 | 13.07 | 13.74 | 14.39 | 14.76 |

[1/] Interpolate the values shown to obtain runoff depths for CN's or rainfall amounts not shown.

**Figure 2-2** Flow chart for selecting the appropriate figure or table for determining runoff curve numbers.

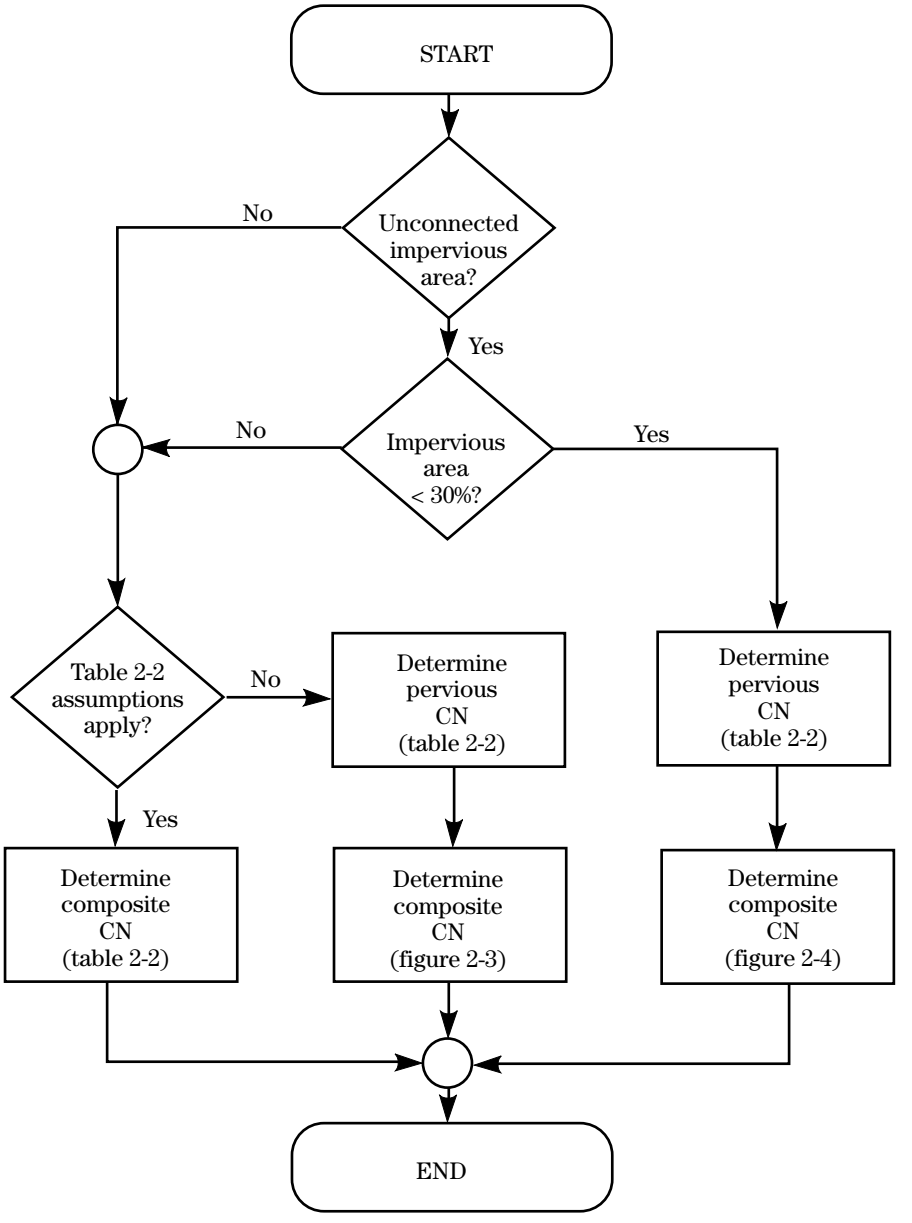


**Table 2-2a** Runoff curve numbers for urban areas [1]

| Cover description: Cover type and hydrologic condition | Average percent impervious area [2] | Curve numbers for hydrologic soil group: A | B | C | D |
|---|---|---|---|---|---|
| *Fully developed urban areas (vegetation established)* | | | | | |
| Open space (lawns, parks, golf courses, cemeteries, etc.) [3]: | | | | | |
| Poor condition (grass cover < 50%) | | 68 | 79 | 86 | 89 |
| Fair condition (grass cover 50% to 75%) | | 49 | 69 | 79 | 84 |
| Good condition (grass cover > 75%) | | 39 | 61 | 74 | 80 |
| Impervious areas: | | | | | |
| Paved parking lots, roofs, driveways, etc. (excluding right-of-way) | | 98 | 98 | 98 | 98 |
| Streets and roads: | | | | | |
| Paved; curbs and storm sewers (excluding right-of-way) | | 98 | 98 | 98 | 98 |
| Paved; open ditches (including right-of-way) | | 83 | 89 | 92 | 93 |
| Gravel (including right-of-way) | | 76 | 85 | 89 | 91 |
| Dirt (including right-of-way) | | 72 | 82 | 87 | 89 |
| Western desert urban areas: | | | | | |
| Natural desert landscaping (pervious areas only) [4] | | 63 | 77 | 85 | 88 |
| Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders) | | 96 | 96 | 96 | 96 |
| Urban districts: | | | | | |
| Commercial and business | 85 | 89 | 92 | 94 | 95 |
| Industrial | 72 | 81 | 88 | 91 | 93 |
| Residential districts by average lot size: | | | | | |
| 1/8 acre or less (town houses) | 65 | 77 | 85 | 90 | 92 |
| 1/4 acre | 38 | 61 | 75 | 83 | 87 |
| 1/3 acre | 30 | 57 | 72 | 81 | 86 |
| 1/2 acre | 25 | 54 | 70 | 80 | 85 |
| 1 acre | 20 | 51 | 68 | 79 | 84 |
| 2 acres | 12 | 46 | 65 | 77 | 82 |
| *Developing urban areas* | | | | | |
| Newly graded areas (pervious areas only, no vegetation) [5] | | 77 | 86 | 91 | 94 |
| Idle lands (CN's are determined using cover types similar to those in table 2-2c). | | | | | |

1 Average runoff condition, and $I_a = 0.2S$.
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

**Table 2-2b** Runoff curve numbers for cultivated agricultural lands [1]

| Cover description | | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|---|
| Cover type | Treatment [2] | Hydrologic condition [3] | A | B | C | D |
| Fallow | Bare soil | — | 77 | 86 | 91 | 94 |
| | Crop residue cover (CR) | Poor | 76 | 85 | 90 | 93 |
| | | Good | 74 | 83 | 88 | 90 |
| Row crops | Straight row (SR) | Poor | 72 | 81 | 88 | 91 |
| | | Good | 67 | 78 | 85 | 89 |
| | SR + CR | Poor | 71 | 80 | 87 | 90 |
| | | Good | 64 | 75 | 82 | 85 |
| | Contoured (C) | Poor | 70 | 79 | 84 | 88 |
| | | Good | 65 | 75 | 82 | 86 |
| | C + CR | Poor | 69 | 78 | 83 | 87 |
| | | Good | 64 | 74 | 81 | 85 |
| | Contoured & terraced (C&T) | Poor | 66 | 74 | 80 | 82 |
| | | Good | 62 | 71 | 78 | 81 |
| | C&T+ CR | Poor | 65 | 73 | 79 | 81 |
| | | Good | 61 | 70 | 77 | 80 |
| Small grain | SR | Poor | 65 | 76 | 84 | 88 |
| | | Good | 63 | 75 | 83 | 87 |
| | SR + CR | Poor | 64 | 75 | 83 | 86 |
| | | Good | 60 | 72 | 80 | 84 |
| | C | Poor | 63 | 74 | 82 | 85 |
| | | Good | 61 | 73 | 81 | 84 |
| | C + CR | Poor | 62 | 73 | 81 | 84 |
| | | Good | 60 | 72 | 80 | 83 |
| | C&T | Poor | 61 | 72 | 79 | 82 |
| | | Good | 59 | 70 | 78 | 81 |
| | C&T+ CR | Poor | 60 | 71 | 78 | 81 |
| | | Good | 58 | 69 | 77 | 80 |
| Close-seeded or broadcast legumes or rotation meadow | SR | Poor | 66 | 77 | 85 | 89 |
| | | Good | 58 | 72 | 81 | 85 |
| | C | Poor | 64 | 75 | 83 | 85 |
| | | Good | 55 | 69 | 78 | 83 |
| | C&T | Poor | 63 | 73 | 80 | 83 |
| | | Good | 51 | 67 | 76 | 80 |

[1] Average runoff condition, and $I_a$=0.2S
[2] Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
[3] Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

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

**Table 2-2c** Runoff curve numbers for other agricultural lands [1]

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

1 Average runoff condition, and $I_a = 0.2S$.
2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
*Fair:* 50 to 75% ground cover and not heavily grazed.
*Good:* > 75% ground cover and lightly or only occasionally grazed.
3 *Poor*: <50% ground cover.
*Fair:* 50 to 75% ground cover.
*Good:* >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
*Fair:* Woods are grazed but not burned, and some forest litter covers the soil.
*Good:* Woods are protected from grazing, and litter and brush adequately cover the soil.

**Table 2-2d** Runoff curve numbers for arid and semiarid rangelands [1]

| Cover description | | Curve numbers for hydrologic soil group | | | |
|---|---|---|---|---|---|
| Cover type | Hydrologic condition [2] | A [3] | B | C | D |
| Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element. | Poor | | 80 | 87 | 93 |
| | Fair | | 71 | 81 | 89 |
| | Good | | 62 | 74 | 85 |
| Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush. | Poor | | 66 | 74 | 79 |
| | Fair | | 48 | 57 | 63 |
| | Good | | 30 | 41 | 48 |
| Pinyon-juniper—pinyon, juniper, or both; grass understory. | Poor | | 75 | 85 | 89 |
| | Fair | | 58 | 73 | 80 |
| | Good | | 41 | 61 | 71 |
| Sagebrush with grass understory. | Poor | | 67 | 80 | 85 |
| | Fair | | 51 | 63 | 70 |
| | Good | | 35 | 47 | 55 |
| Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus. | Poor | 63 | 77 | 85 | 88 |
| | Fair | 55 | 72 | 81 | 86 |
| | Good | 49 | 68 | 79 | 84 |

1 Average runoff condition, and $I_a$, = 0.2S. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.

## Antecedent runoff condition

The index of runoff potential before a storm event is the antecedent runoff condition (ARC). ARC is an attempt to account for the variation in CN at a site from storm to storm. CN for the average ARC at a site is the median value as taken from sample rainfall and runoff data. The CN's in table 2-2 are for the average ARC, which is used primarily for design applications. See NEH-4 (SCS 1985) and Rallison and Miller (1981) for more detailed discussion of storm-to-storm variation and a demonstration of upper and lower enveloping curves.

## Urban impervious area modifications

Several factors, such as the percentage of impervious area and the means of conveying runoff from impervious areas to the drainage system, should be considered in computing CN for urban areas (Rawls et al., 1981). For example, do the impervious areas connect directly to the drainage system, or do they outlet onto lawns or other pervious areas where infiltration can occur?

**Connected impervious areas** — An impervious area is considered connected if runoff from it flows directly into the drainage system. It is also considered connected if runoff from it occurs as concentrated shallow flow that runs over a pervious area and then into the drainage system.

Urban CN's (table 2-2a) were developed for typical land use relationships based on specific assumed percentages of impervious area. These CN vales were developed on the assumptions that (a) pervious urban areas are equivalent to pasture in good hydrologic condition and (b) impervious areas have a CN of 98 and are directly connected to the drainage system. Some assumed percentages of impervious area are shown in table 2-2a

If all of the impervious area is directly connected to the drainage system, but the impervious area percentages or the pervious land use assumptions in table 2-2a are not applicable, use figure 2-3 to compute a composite CN. For example, table 2-2a gives a CN of 70 for a 1/2-acre lot in HSG B, with assumed impervious area of 25 percent. However, if the lot has 20 percent impervious area and a pervious area CN of 61, the composite CN obtained from figure 2-3 is 68. The CN difference between 70 and 68 reflects the difference in percent impervious area.

**Unconnected impervious areas** — Runoff from these areas is spread over a pervious area as sheet flow. To determine CN when all or part of the impervious area is not directly connected to the drainage system, (1) use figure 2-4 if total impervious area is less than 30 percent or (2) use figure 2-3 if the total impervious area is equal to or greater than 30 percent, because the absorptive capacity of the remaining pervious areas will not significantly affect runoff.

When impervious area is less than 30 percent, obtain the composite CN by entering the right half of figure 2-4 with the percentage of total impervious area and the ratio of total unconnected impervious area to total impervious area. Then move left to the appropriate pervious CN and read down to find the composite CN. For example, for a 1/2-acre lot with 20 percent total impervious area (75 percent of which is unconnected) and pervious CN of 61, the composite CN from figure 2-4 is 66. If all of the impervious area is connected, the resulting CN (from figure 2-3) would be 68.

**Figure 2-3** Composite CN with connected impervious area.

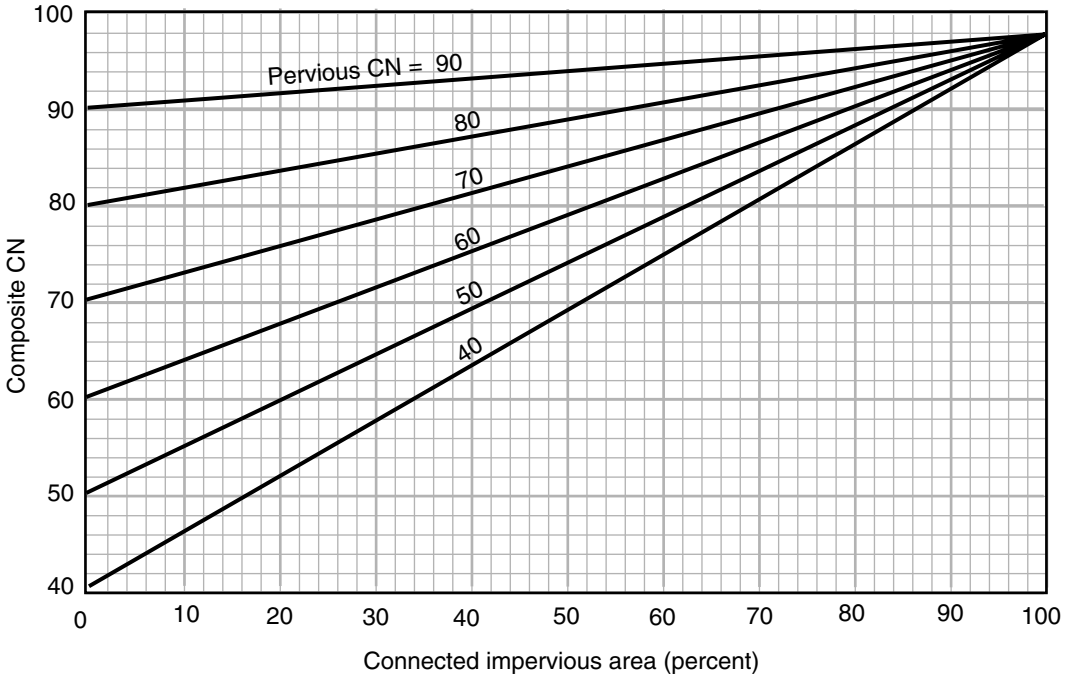
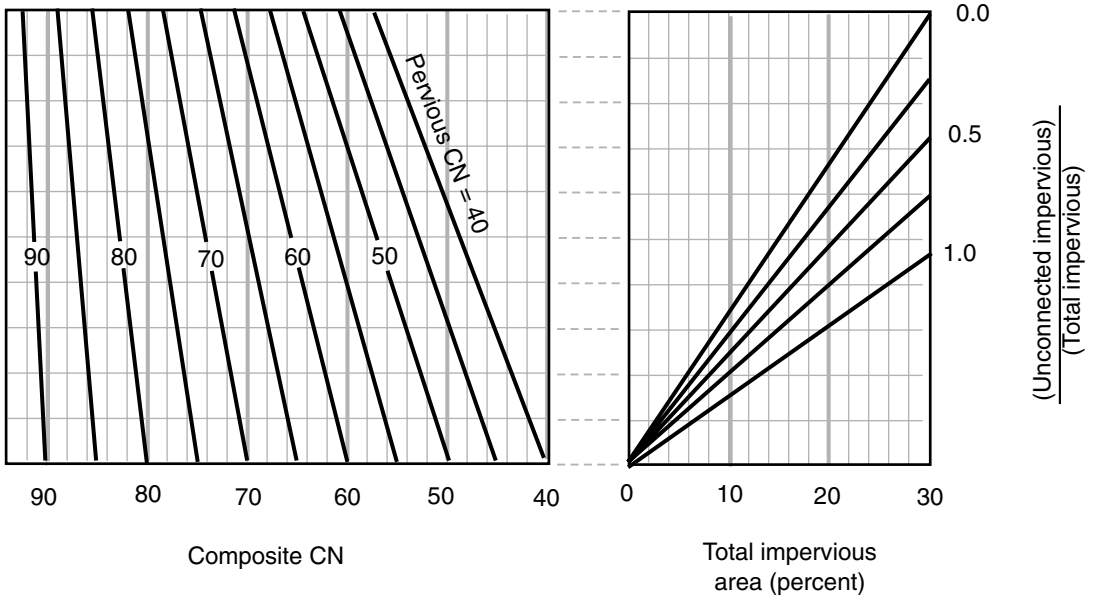



**Figure 2-4** Composite CN with unconnected impervious areas and total impervious area less than 30%



## Runoff

When CN and the amount of rainfall have been determined for the watershed, determine runoff by using figure 2-1, table 2-1, or equations 2-3 and 2-4. The runoff is usually rounded to the nearest hundredth of an inch.

## Limitations

- Curve numbers describe average conditions that are useful for design purposes. If the rainfall event used is a historical storm, the modeling accuracy decreases.

- Use the runoff curve number equation with caution when re-creating specific features of an actual storm. The equation does not contain an expression for time and, therefore, does not account for rainfall duration or intensity.

- The user should understand the assumption reflected in the initial abstraction term ($I_a$) and should ascertain that the assumption applies to the situation. $I_a$, which consists of interception, initial infiltration, surface depression storage, evapotranspiration, and other factors, was generalized as 0.2S based on data from agricultural watersheds (S is the potential maximum retention after runoff begins). This approximation can be especially important in an urban application because the combination of impervious areas with pervious areas can imply a significant initial loss that may not take place. The opposite effect, a greater initial loss, can occur if the impervious areas have surface depressions that store some runoff. To use a relationship other than $I_a = 0.2S$, one must redevelop equation 2-3, figure 2-1, table 2-1, and table 2-2 by using the original rainfall-runoff data to establish new S or CN relationships for each cover and hydrologic soil group.

- Runoff from snowmelt or rain on frozen ground cannot be estimated using these procedures.

- The CN procedure is less accurate when runoff is less than 0.5 inch. As a check, use another procedure to determine runoff.

- The SCS runoff procedures apply only to direct surface runoff: do not overlook large sources of subsurface flow or high ground water levels that contribute to runoff. These conditions are often related to HSG A soils and forest areas that have been assigned relatively low CN's in table 2-2. Good judgment and experience based on stream gage records are needed to adjust CN's as conditions warrant.

- When the weighted CN is less than 40, use another procedure to determine runoff.

## Examples

Four examples illustrate the procedure for computing runoff curve number (CN) and runoff (Q) in inches. Worksheet 2 in appendix D is provided to assist TR-55 users. Figures 2-5 to 2-8 represent the use of worksheet 2 for each example. All four examples are based on the same watershed and the same storm event.

The watershed covers 250 acres in Dyer County, northwestern Tennessee. Seventy percent (175 acres) is a Loring soil, which is in hydrologic soil group C. Thirty percent (75 acres) is a Memphis soil, which is in group B. The event is a 25-year frequency, 24-hour storm with total rainfall of 6 inches.

Cover type and conditions in the watershed are different for each example. The examples, therefore, illustrate how to compute CN and Q for various situations of proposed, planned, or present development.

### Example 2-1

The present cover type is pasture in good hydrologic condition. (See figure 2-5 for worksheet 2 information.)

### Example 2-2

Seventy percent (175 acres) of the watershed, consisting of all the Memphis soil and 100 acres of the Loring soil, is 1/2-acre residential lots with lawns in good hydrologic condition. The rest of the watershed is scattered open space in good hydrologic condition. (See figure 2-6.)

# Chapter 3 Time of Concentration and Travel Time

Travel time ( $T_t$ ) is the time it takes water to travel from one location to another in a watershed. $T_t$ is a component of time of concentration ( $T_c$ ), which is the time for runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. $T_c$ is computed by summing all the travel times for consecutive components of the drainage conveyance system.

$T_c$ influences the shape and peak of the runoff hydrograph. Urbanization usually decreases $T_c$, thereby increasing the peak discharge. But $T_c$ can be increased as a result of (a) ponding behind small or inadequate drainage systems, including storm drain inlets and road culverts, or (b) reduction of land slope through grading.

## Factors affecting time of concentration and travel time

### Surface roughness

One of the most significant effects of urban development on flow velocity is less retardance to flow. That is, undeveloped areas with very slow and shallow overland flow through vegetation become modified by urban development: the flow is then delivered to streets, gutters, and storm sewers that transport runoff downstream more rapidly. Travel time through the watershed is generally decreased.

### Channel shape and flow patterns

In small non-urban watersheds, much of the travel time results from overland flow in upstream areas. Typically, urbanization reduces overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases.

### Slope

Slopes may be increased or decreased by urbanization, depending on the extent of site grading or the extent to which storm sewers and street ditches are used in the design of the water management system. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers, street gutters, and diversions.

## Computation of travel time and time of concentration

Water moves through a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The type that occurs is a function of the conveyance system and is best determined by field inspection.

Travel time ( $T_t$ ) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V} \qquad \text{[eq. 3-1]}$$

where:

$T_t$ = travel time (hr)
L = flow length (ft)
V = average velocity (ft/s)
3600 = conversion factor from seconds to hours.

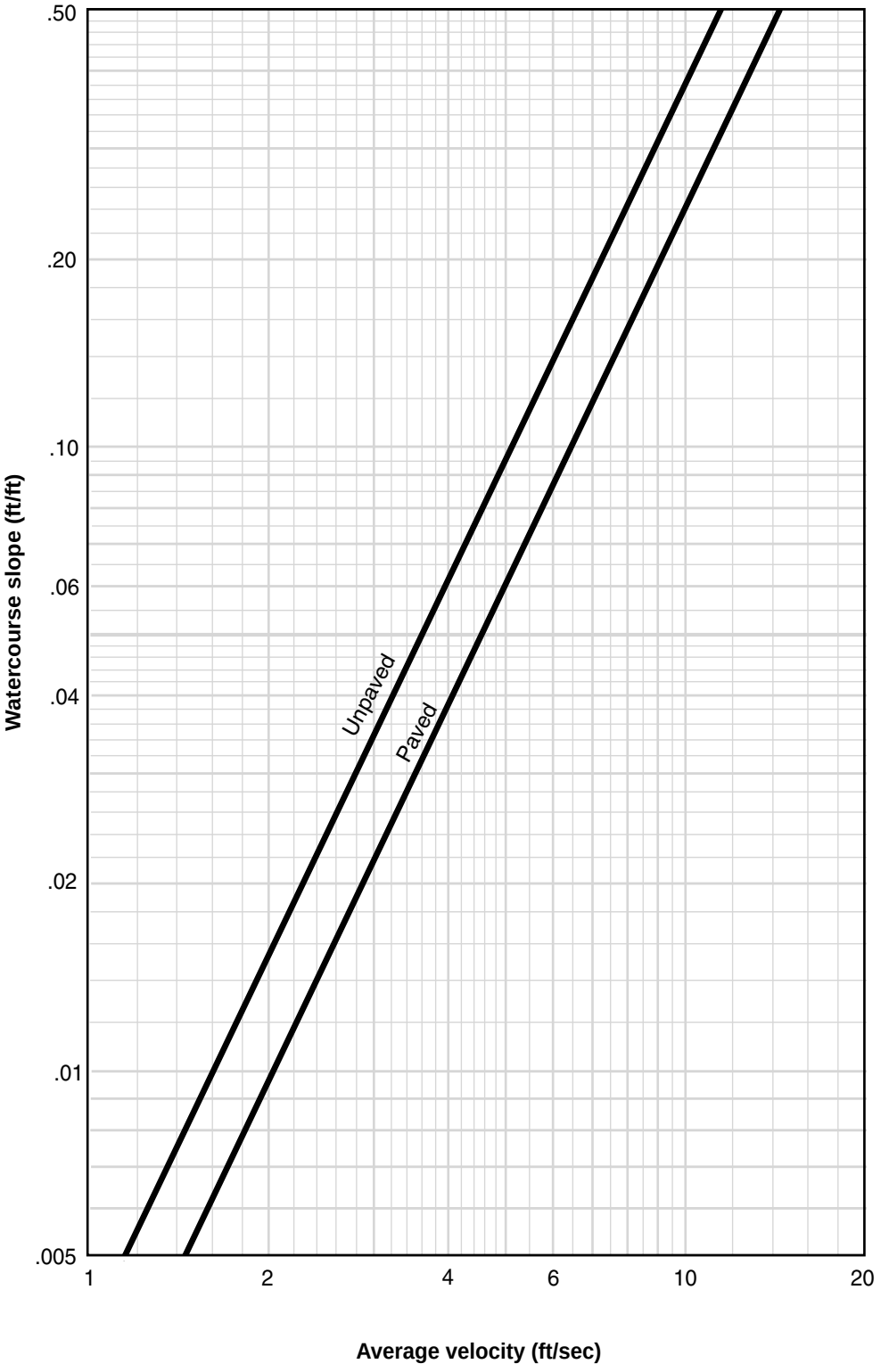
Time of concentration ( $T_c$ ) is the sum of $T_t$ values for the various consecutive flow segments:

$$T_c = T_{t_1} + T_{t_2} + \ldots T_{t_m} \qquad \text{[eq. 3-2]}$$

where:

$T_c$ = time of concentration (hr)
m = number of flow segments

**Figure 3-1** Average velocities for estimating travel time for shallow concentrated flow



## Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

**Table 3-1** Roughness coefficients (Manning's n) for sheet flow

| Surface description | n [1] |
|---|---|
| Smooth surfaces (concrete, asphalt, gravel, or bare soil) | 0.011 |
| Fallow (no residue) | 0.05 |
| Cultivated soils: | |
| Residue cover ≤20% | 0.06 |
| Residue cover >20% | 0.17 |
| Grass: | |
| Short grass prairie | 0.15 |
| Dense grasses [2] | 0.24 |
| Bermudagrass | 0.41 |
| Range (natural) | 0.13 |
| Woods:[3] | |
| Light underbrush | 0.40 |
| Dense underbrush | 0.80 |

[1] The n values are a composite of information compiled by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n , consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overtop and Meadows 1976) to compute $T_t$:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \qquad \text{[eq. 3-3]}$$

where:

$T_t$ = travel time (hr),
n = Manning's roughness coefficient (table 3-1)
L = flow length (ft)
$P_2$ = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

## Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

## Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bankfull elevation.

Manning's equation is:

$$V = \frac{1.49 r^{\frac{2}{3}} s^{\frac{1}{2}}}{n} \qquad \text{[eq. 3-4]}$$

where:

V = average velocity (ft/s)
r = hydraulic radius (ft) and is equal to $a/p_w$
a = cross sectional flow area ($ft^2$)
$p_w$ = wetted perimeter (ft)
s = slope of the hydraulic grade line (channel slope, ft/ft)
n = Manning's roughness coefficient for open channel flow.

Manning's n values for open channel flow can be obtained from standard textbooks such as Chow (1959) or Linsley et al. (1982). After average velocity is computed using equation 3-4, $T_t$ for the channel segment can be estimated using equation 3-1.

### Reservoirs or lakes

Sometimes it is necessary to estimate the velocity of flow through a reservoir or lake at the outlet of a watershed. This travel time is normally very small and can be assumed as zero.

## Limitations

- Manning's kinematic solution should not be used for sheet flow longer than 300 feet. Equation 3-3 was developed for use with the four standard rainfall intensity-duration relationships.

- In watersheds with storm sewers, carefully identify the appropriate hydraulic flow path to estimate $T_c$. Storm sewers generally handle only a small portion of a large event. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Consult a standard hydraulics textbook to determine average velocity in pipes for either pressure or nonpressure flow.

- The minimum $T_c$ used in TR-55 is 0.1 hour.

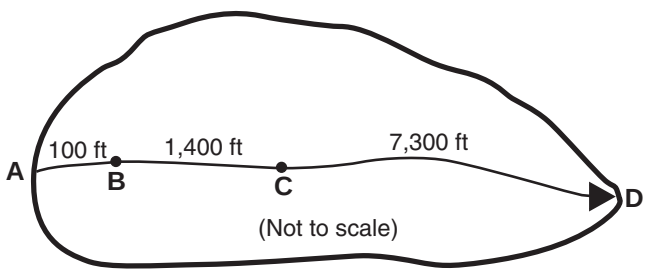
- A culvert or bridge can act as a reservoir outlet if there is significant storage behind it. The procedures in TR-55 can be used to determine the peak flow upstream of the culvert. Detailed storage routing procedures should be used to determine the outflow through the culvert.

## Example 3-1

The sketch below shows a watershed in Dyer County, northwestern Tennessee. The problem is to compute $T_c$ at the outlet of the watershed (point D). The 2-year 24-hour rainfall depth is 3.6 inches. All three types of flow occur from the hydraulically most distant point (A) to the point of interest (D). To compute $T_c$, first determine $T_t$ for each segment from the following information:

Segment AB: Sheet flow; dense grass; slope (s) = 0.01 ft/ft; and length (L) = 100 ft. Segment BC: Shallow concentrated flow; unpaved; s = 0.01 ft/ft; and L = 1,400 ft. Segment CD: Channel flow; Manning's n = .05; flow area (a) = 27 $ft^2$; wetted perimeter ($p_w$) = 28.2 ft; s = 0.005 ft/ft; and L = 7,300 ft.

See figure 3-2 for the computations made on worksheet 3.



# Chapter 4 Graphical Peak Discharge Method

This chapter presents the Graphical Peak Discharge method for computing peak discharge from rural and urban areas. The Graphical method was developed from hydrograph analyses using TR-20, "Computer Program for Project Formulation—Hydrology" (SCS 1983). The peak discharge equation used is:

$$q_p = q_u A_m Q F_p \qquad \text{[eq. 4-1]}$$

where:

$q_p$ = peak discharge (cfs)
$q_u$ = unit peak discharge (csm/in)
$A_m$ = drainage area (mi²)
$Q$ = runoff (in)
$F_p$ = pond and swamp adjustment factor

The input requirements for the Graphical method are as follows: (1) $T_c$ (hr), (2) drainage area (mi²), (3) appropriate rainfall distribution (I, IA, II, or III), (4) 24-hour rainfall (in), and (5) CN. If pond and swamp areas are spread throughout the watershed and are not considered in the $T_c$ computation, an adjustment for pond and swamp areas is also needed.

## Peak discharge computation

For a selected rainfall frequency, the 24-hour rainfall (P) is obtained from appendix B or more detailed local precipitation maps. CN and total runoff (Q) for the watershed are computed according to the methods outlined in chapter 2. The CN is used to determine the initial abstraction ($I_a$) from table 4-1. $I_a$ / P is then computed.

If the computed $I_a$ / P ratio is outside the range in exhibit 4 (4-I, 4-IA, 4-II, and 4-III) for the rainfall distribution of interest, then the limiting value should be used. If the ratio falls between the limiting values, use linear interpolation. Figure 4-1 illustrates the sensitivity of $I_a$ / P to CN and P.

Peak discharge per square mile per inch of runoff ($q_u$) is obtained from exhibit 4-I, 4-IA, 4-II, or 4-III by using $T_c$ (chapter 3), rainfall distribution type, and $I_a$ / P ratio. The pond and swamp adjustment factor is obtained from table 4-2 (rounded to the nearest table value). Use worksheet 4 in appendix D to aid in computing the peak discharge using the Graphical method.

**Figure 4-1** Variation of $I_a$ / P for P and CN

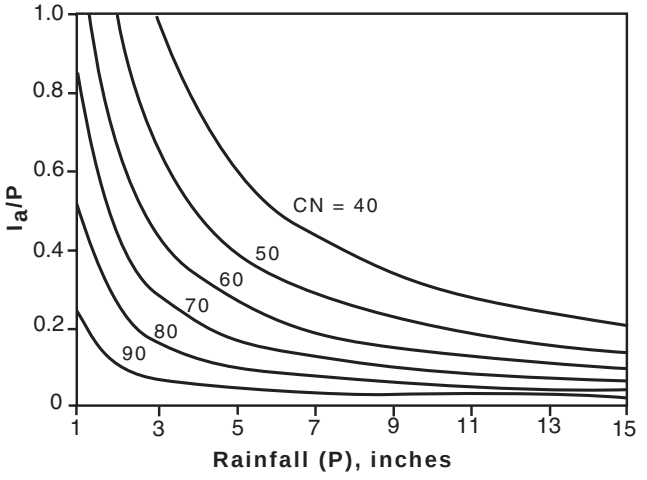



**Table 4-1** $I_a$ values for runoff curve numbers

| Curve number | $I_a$ (in) | Curve number | $I_a$ (in) |
|---|---|---|---|
| 40 | 3.000 | 70 | 0.857 |
| 41 | 2.878 | 71 | 0.817 |
| 42 | 2.762 | 72 | 0.778 |
| 43 | 2.651 | 73 | 0.740 |
| 44 | 2.545 | 74 | 0.703 |
| 45 | 2.444 | 75 | 0.667 |
| 46 | 2.348 | 76 | 0.632 |
| 47 | 2.255 | 77 | 0.597 |
| 48 | 2.167 | 78 | 0.564 |
| 49 | 2.082 | 79 | 0.532 |
| 50 | 2.000 | 80 | 0.500 |
| 51 | 1.922 | 81 | 0.469 |
| 52 | 1.846 | 82 | 0.439 |
| 53 | 1.774 | 83 | 0.410 |
| 54 | 1.704 | 84 | 0.381 |
| 55 | 1.636 | 85 | 0.353 |
| 56 | 1.571 | 86 | 0.326 |
| 57 | 1.509 | 87 | 0.299 |
| 58 | 1.448 | 88 | 0.273 |
| 59 | 1.390 | 89 | 0.247 |
| 60 | 1.333 | 90 | 0.222 |
| 61 | 1.279 | 91 | 0.198 |
| 62 | 1.226 | 92 | 0.174 |
| 63 | 1.175 | 93 | 0.151 |
| 64 | 1.125 | 94 | 0.128 |
| 65 | 1.077 | 95 | 0.105 |
| 66 | 1.030 | 96 | 0.083 |
| 67 | 0.985 | 97 | 0.062 |
| 68 | 0.941 | 98 | 0.041 |
| 69 | 0.899 | | |

**Table 4-2** Adjustment factor ($F_p$) for pond and swamp areas that are spread throughout the watershed

| Percentage of pond and swamp areas | $F_p$ |
|---|---|
| 0 | 1.00 |
| 0.2 | 0.97 |
| 1.0 | 0.87 |
| 3.0 | 0.75 |
| 5.0 | 0.72 |

## Limitations

The Graphical method provides a determination of peak discharge only. If a hydrograph is needed or watershed subdivision is required, use the Tabular Hydrograph method (chapter 5). Use TR-20 if the watershed is very complex or a higher degree of accuracy is required.

- The watershed must be hydrologically homogeneous, that is, describable by one CN. Land use, soils, and cover are distributed uniformly throughout the watershed.
- The watershed may have only one main stream or, if more than one, the branches must have nearly equal $T_C$' s.
- The method cannot perform valley or reservoir routing.
- The $F_p$ factor can be applied only for ponds or swamps that are not in the $T_c$ flow path.
- Accuracy of peak discharge estimated by this method will be reduced if $I_a$ / P values are used that are outside the range given in exhibit 4. The limiting $I_a$ / P values are recommended for use.
- This method should be used only if the weighted CN is greater than 40.
- When this method is used to develop estimates of peak discharge for both present and developed conditions of a watershed, use the same procedure for estimating $T_c$.
- $T_c$ values with this method may range from 0.1 to 10 hours.

## Example 4-1

Compute the 25-year peak discharge for the 250-acre watershed described in examples 2-2 and 3-1. Figure 4-2 shows how worksheet 4 is used to compute $q_p$ as 345 cfs.

**Exhibit 4-I** Unit peak discharge ($q_u$) for NRCS (SCS) type I rainfall distribution

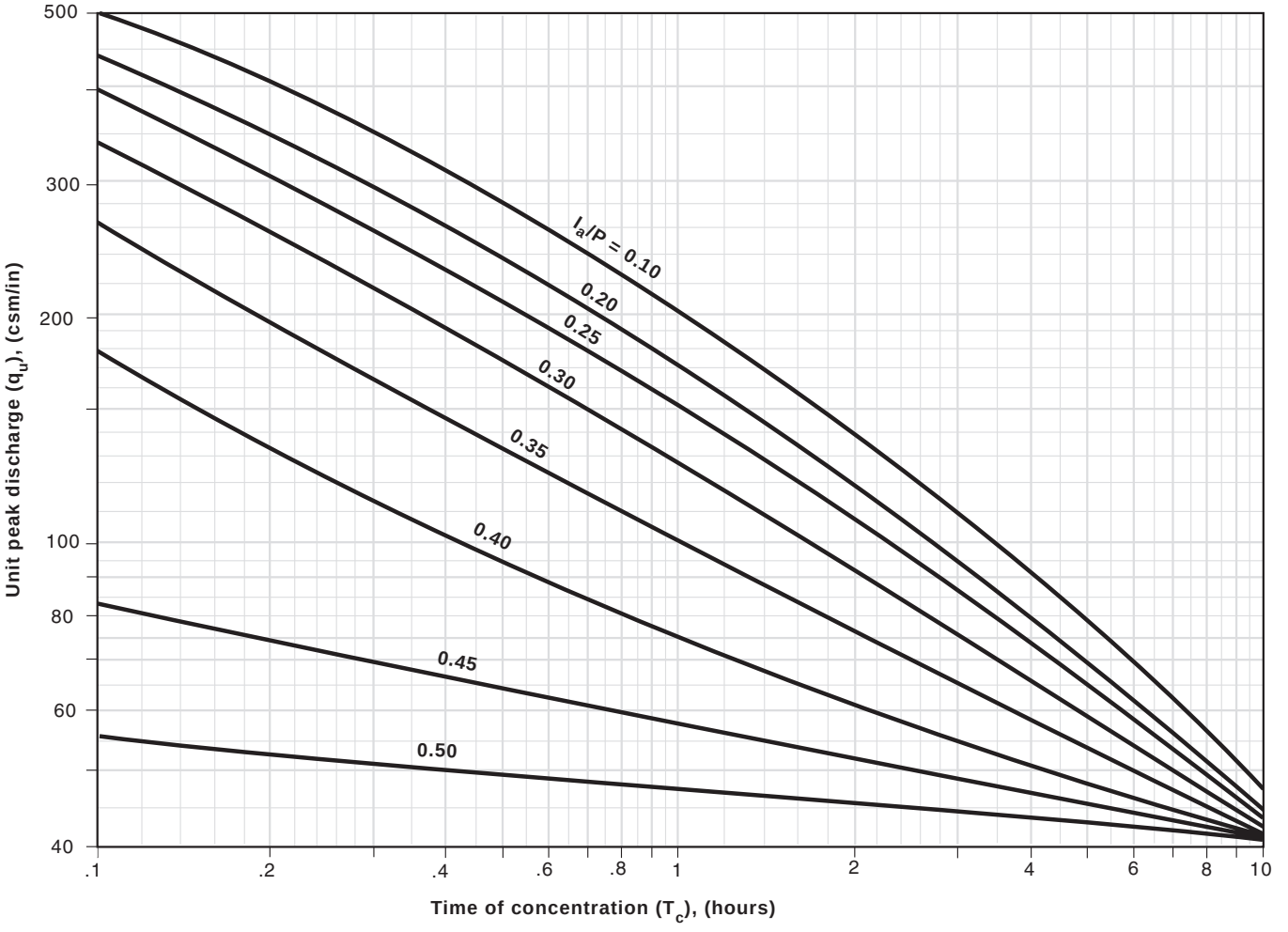


**Exhibit 4-IA** Unit peak discharge ($q_u$) for NRCS (SCS) type IA rainfall distribution

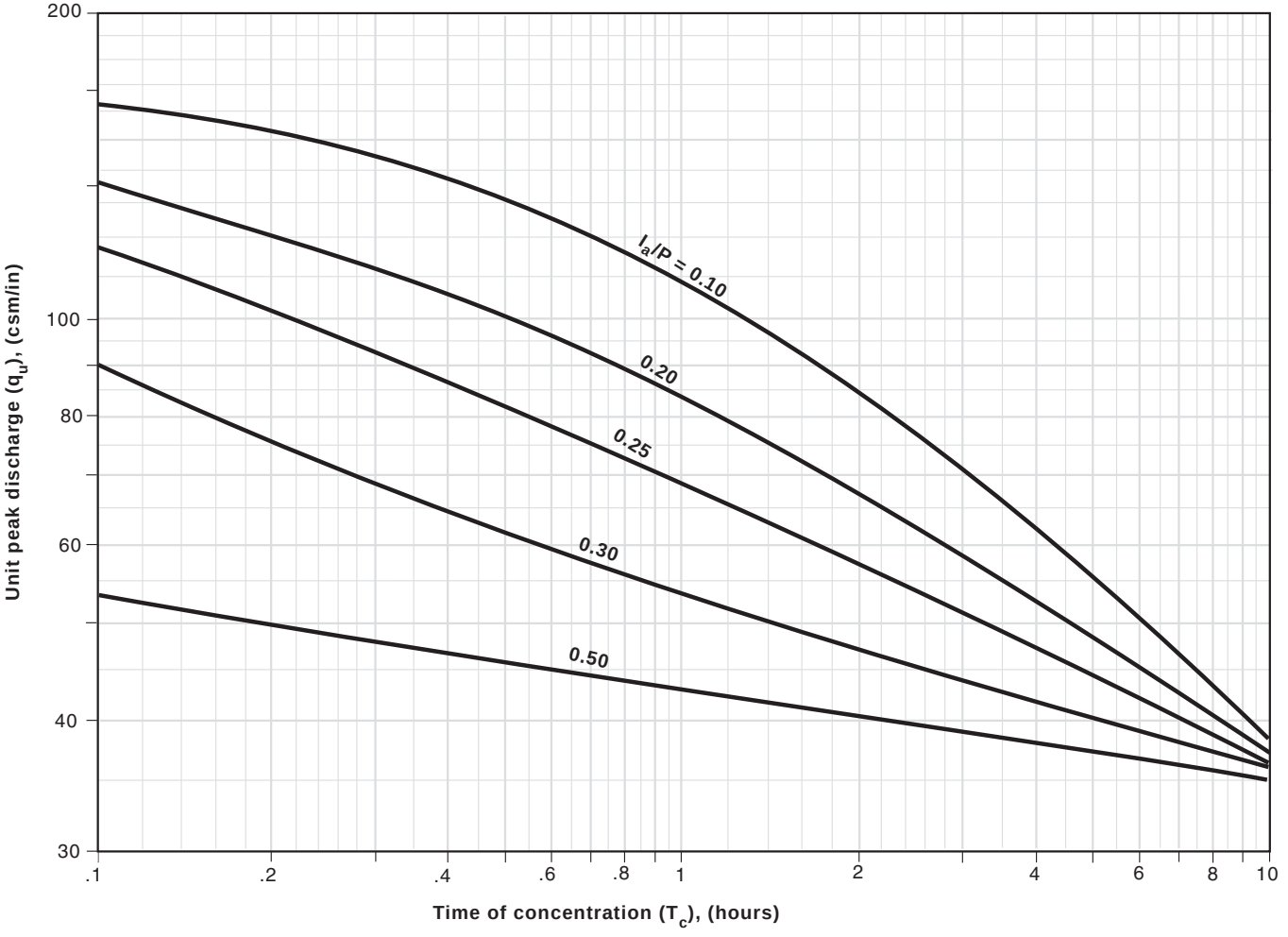


**Exhibit 4-II** Unit peal discharge ($q_u$) for NRCS (SCS) type II rainfall distribution

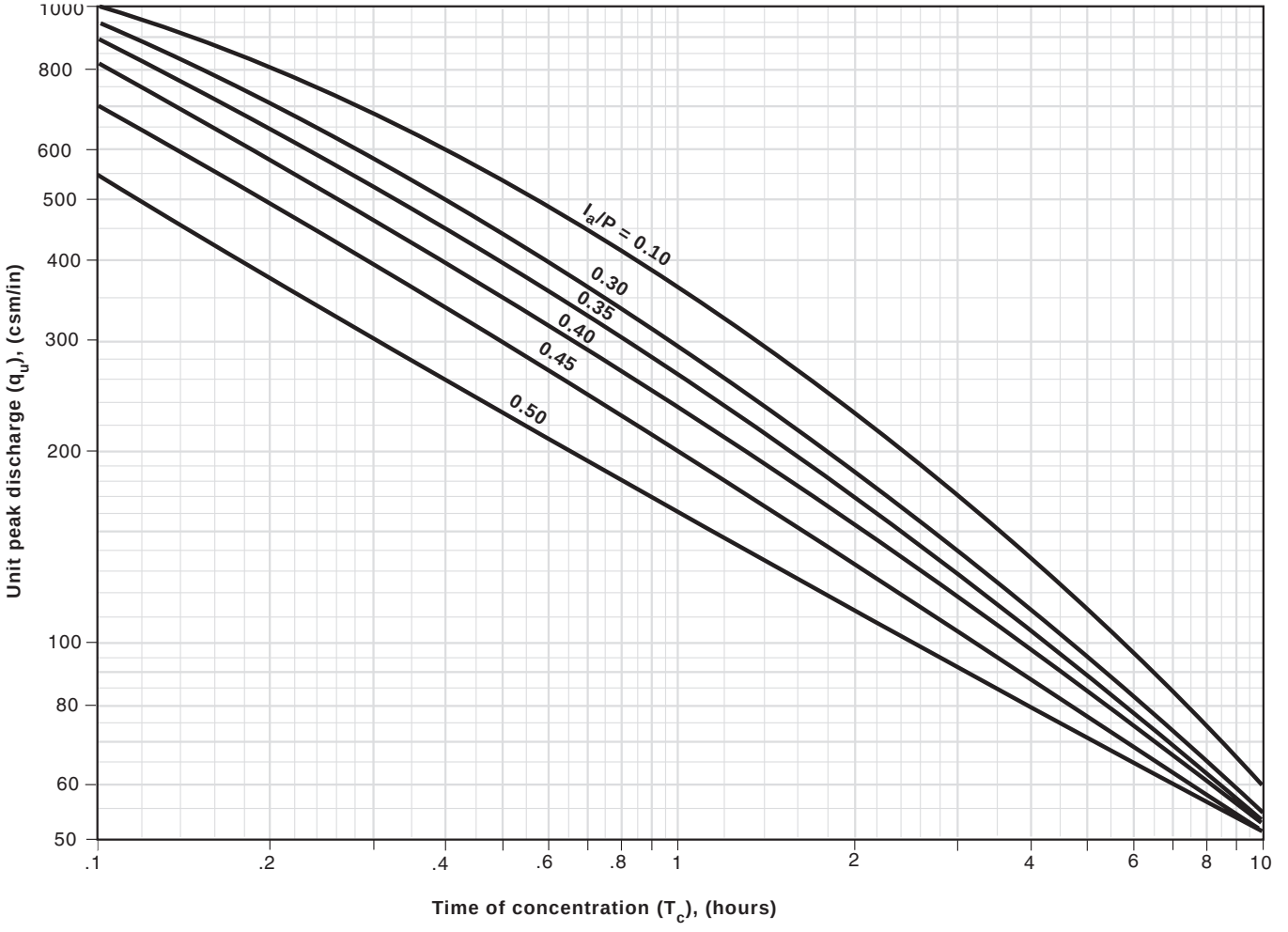
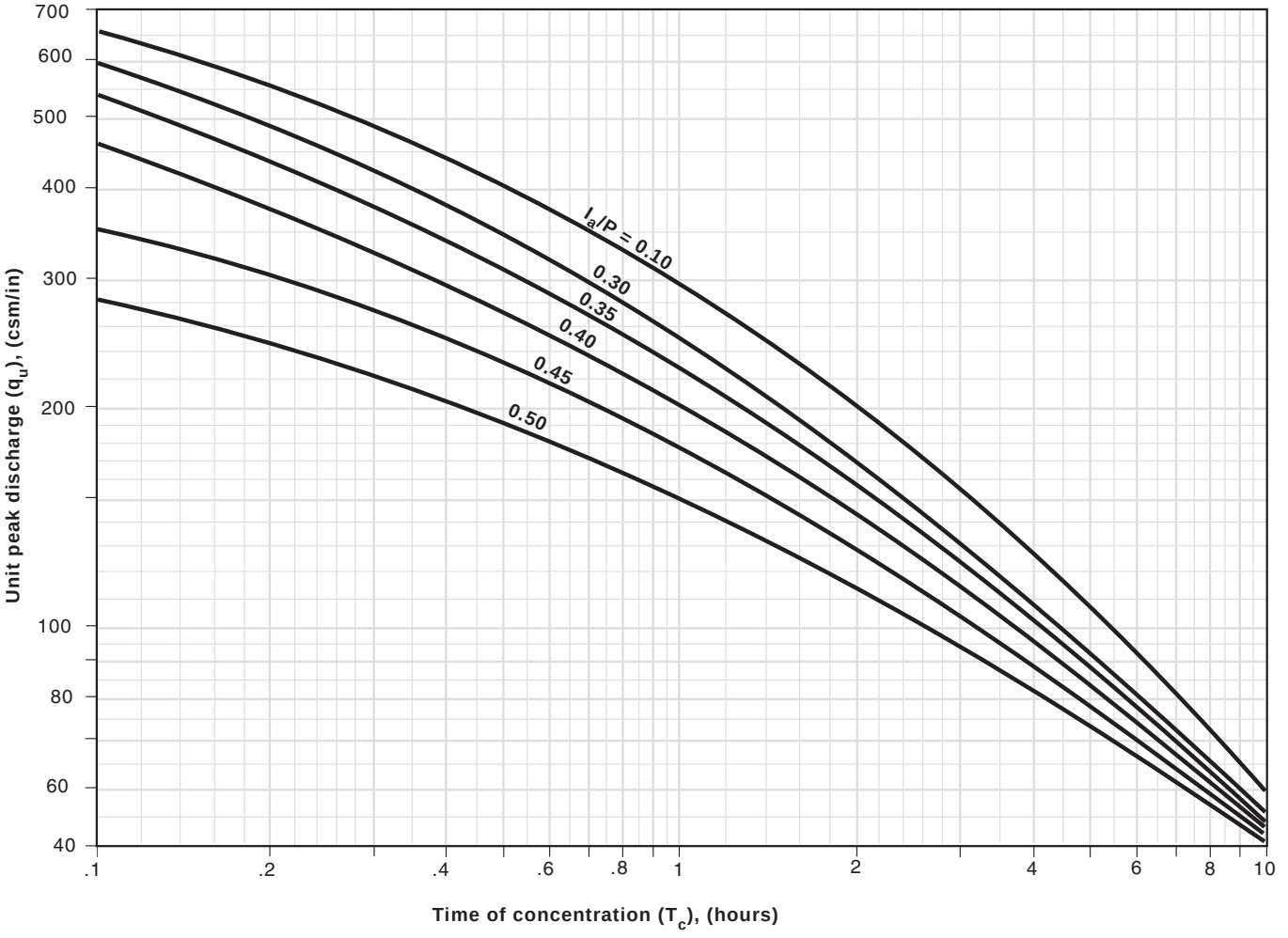


**Exhibit 4-III** Unit peal discharge ($q_u$) for NRCS (SCS) type III rainfall distribution



REFERENCE 4

# Chapter 5 Tabular Hydrograph Method

This chapter presents the Tabular Hydrograph method of computing peak discharges from rural and urban areas, using time of concentration ($T_c$) and travel time ($T_t$) from a subarea as inputs. This method approximates TR-20, a more detailed hydrograph procedure (SCS 1983).

The Tabular method can develop partial composite flood hydrographs at any point in a watershed by dividing the watershed into homogeneous subareas. In this manner, the method can estimate runoff from nonhomogeneous watersheds. The method is especially applicable for estimating the effects of land use change in a portion of a watershed. It can also be used to estimate the effects of proposed structures.

Input data needed to develop a partial composite flood hydrograph include (1) 24-hour rainfall (in), (2) appropriate rainfall distribution (I, IA, II, or III), (3) CN, (4) $T_c$ (hr), (5) $T_t$ (hr), and (6) drainage area (mi$^2$).

## Tabular Hydrograph method exhibits

Exhibit 5 (5-I, 5-IA, 5-II, and 5-III) shows tabular discharge values for the various rainfall distributions. Tabular discharges expressed in csm/in (cubic feet of discharge per second per square mile of watershed per inch of runoff) are given for a range of subarea $T_c$'s from 0.1 to 2 hours and reach $T_t$'s from 0 to 3 hours.

The exhibit was developed by computing hydrographs for 1 square mile of drainage area for selected $T_c$'s and routing them through stream reaches with the range of $T_t$'s indicated. The Modified Att-Kin method for reach routing, formulated by SCS in the late 1970's, was used to compute the tabular hydrographs (Comer et al., 1981). A CN of 75 and rainfall amounts generating appropriate $I_a/P$ ratios were used. The resulting runoff estimate was used to convert the hydrographs in exhibits 5-I through 5-III to cubic feet of discharge per second per square mile of watershed per inch of runoff.

An assumption in development of the tabular hydrographs is that all discharges for a stream reach flow at the same velocity. By this assumption, the subarea flood hydrographs may be routed separately and added at the reference point. The tabular hydrographs in exhibit 5 are prerouted hydrographs.

For $T_t$'s other than zero, the tabular discharge values represent the contribution from a single subarea to the composite hydrograph at $T_t$ downstream.

## Information required for Tabular Hydrograph method

The following information is required for the Tabular method:

1. Subdivision of the watershed into areas that are relatively homogeneous and have convenient routing reaches.

2. Drainage area of each subarea in square miles.

3. $T_c$ for each subarea in hours. The procedure for estimating $T_c$ is outlined in chapter 3. Worksheet 3 (appendix D) can be used to calculate $T_c$.

4. $T_t$ for each routing reach in hours. The procedure for estimating $T_t$ is outlined in chapter 3. Worksheet 3 can be used to calculate $T_t$ through a subarea for shallow concentrated and open channel flow.

5. Weighted CN for each subarea. Table 2-2 shows CN's for individual hydrologic soil cover combinations. Worksheet 2 can be used to calculate the weighted runoff curve number.

6. Appropriate rainfall distribution according to figure B-2 (appendix B).

7. The 24-hour rainfall for the selected frequency. Appendix B contains rainfall maps for various frequencies (figures B-3 to B-8).

8. Total runoff (Q) in inches computed from CN and rainfall.

9. $I_a$ for each subarea from table 5-1, which is the same as table 4-1.

10. Ratio of $I_a/P$ for each subarea. If the ratio for the rainfall distribution of interest is outside the range shown in exhibit 5, use the limiting value.

## Development of composite flood hydrograph

This section describes the procedure for developing the peak discharge and selected discharge values of a composite flood hydrograph.

### Selecting $T_c$ and $T_t$

First, use worksheet 5a to develop a summary of basic watershed data by subarea. Then use worksheet 5b to develop a tabular hydrograph discharge summary; this summary displays the effect of individual subarea hydrographs as routed to the watershed point of interest. Use $\sum T_t$ for each subarea as the total reach travel time from that subarea through the watershed to the point of interest. Compute the hydrograph coordinates for selected $\sum T_t$'s using the appropriate sheets in exhibit 5. The flow at any time is:

$$q = q_t A_m Q \qquad \text{[eq. 5-1]}$$

where:

$q$ = hydrograph coordinate (cfs) at hydrograph time t
$q_t$ = tabular hydrograph unit discharge from exhibit 5 (csm/in)
$A_m$ = drainage area of individual subarea ($mi^2$)
$Q$ = runoff (in)

Since the timing of peak discharge changes with $T_c$ and $T_t$, interpolation of peak discharge for $T_c$ and $T_t$ values for use in exhibit 5 is not recommended. Interpolation may result in an estimate of peak discharge that would be invalid because it would be lower than either of the hydrographs. Therefore, round the actual values of $T_c$ and $T_t$ to values presented in exhibit 5. Perform this rounding so that the sum of the selected table values is close to the sum of actual $T_c$ and $T_t$. An acceptable procedure is to select the results of one of three rounding operations:

1. Round $T_c$ and $T_t$ separately to the nearest table value and sum,
2. Round $T_c$ down and $T_t$ up to nearest table value and sum,
3. Round $T_c$ up and $T_t$ down to nearest table value and sum.

From these three alternatives, choose the pair of rounded $T_c$ and $T_t$ values whose sum is closest to the sum of the actual $T_c$ and $T_t$. If two rounding methods produce sums equally close to the actual sum, use the combination in which rounded $T_c$ is closest to actual $T_c$. An illustration of the rounding procedure is as follows:

**Table 5-1** $I_a$ values for runoff curve numbers

| Curve number | $I_a$ (in) | Curve number | $I_a$ (in) |
|---|---|---|---|
| 40 | 3.000 | 70 | 0.857 |
| 41 | 2.878 | 71 | 0.817 |
| 42 | 2.762 | 72 | 0.778 |
| 43 | 2.651 | 73 | 0.740 |
| 44 | 2.545 | 74 | 0.703 |
| 45 | 2.444 | 75 | 0.667 |
| 46 | 2.348 | 76 | 0.632 |
| 47 | 2.255 | 77 | 0.597 |
| 48 | 2.167 | 78 | 0.564 |
| 49 | 2.082 | 79 | 0.532 |
| 50 | 2.000 | 80 | 0.500 |
| 51 | 1.922 | 81 | 0.469 |
| 52 | 1.846 | 82 | 0.439 |
| 53 | 1.774 | 83 | 0.410 |
| 54 | 1.704 | 84 | 0.381 |
| 55 | 1.636 | 85 | 0.353 |
| 56 | 1.571 | 86 | 0.326 |
| 57 | 1.509 | 87 | 0.299 |
| 58 | 1.448 | 88 | 0.273 |
| 59 | 1.390 | 89 | 0.247 |
| 60 | 1.333 | 90 | 0.222 |
| 61 | 1.279 | 91 | 0.198 |
| 62 | 1.226 | 92 | 0.174 |
| 63 | 1.175 | 93 | 0.151 |
| 64 | 1.125 | 94 | 0.128 |
| 65 | 1.077 | 95 | 0.105 |
| 66 | 1.030 | 96 | 0.083 |
| 67 | 0.985 | 97 | 0.062 |
| 68 | 0.941 | 98 | 0.041 |
| 69 | 0.899 | | |

| | | Table values by rounding method | | |
|---|---|---|---|---|
| | Actual values | 1 | 2 | 3 |
| $T_c$ | 1.1 | 1.0 | 1.0 | 1.25 |
| $T_t$ | 1.7 | 1.5 | 2.0 | 1.5 |
| Sum | 2.8 | 2.5 | 3.0 | 2.75 |

In this instance, the results from method 3 would be selected because the sum 2.75 is closest to the actual sum of 2.8.

### Selecting $I_a$ / P

The computed $I_a$ / P value can be rounded to the nearest $I_a$ / P value in exhibits 5-I through 5-III, or the hydrograph values (csm/in) can be linearly interpolated because $I_a$ / P interpolation generally involves peaks that occur at the same time.

### Summing for the composite hydrograph

The composite hydrograph is the summation of prerouted individual subarea hydrographs at each time shown on worksheet 5b. Only the times encompassing the expected maximum composite discharge are summed to define a portion of the composite hydrograph.

If desired, the entire composite hydrograph can be approximated by linear extrapolation as follows:

1. Set up a table similar to worksheet 5b. Include on this table the full range of hydrograph times displayed in exhibit 5.
2. Compute the subarea discharge values for those times and insert them in the table.
3. Sum the values to obtain the composite hydrograph.
4. Apply linear extrapolation to the first two points and the last two points of the composite hydrograph. The volume under this approximation of the entire composite hydrograph may differ from the computed runoff volume.

## Limitations

The Tabular method is used to determine peak flows and hydrographs within a watershed. However, its accuracy decreases as the complexity of the watershed increases. If you want to compare present and developed conditions of a watershed, use the same procedure for estimating $T_c$ for both conditions.

Use the TR-20 computer program (SCS 1983) instead of the Tabular method if any of the following conditions applies:

- $T_t$ is greater than 3 hours (largest $T_t$ in exhibit 5).
- $T_c$ is greater than 2 hours (largest $T_c$ in exhibit 5).
- Drainage areas of individual subareas differ by a factor of 5 or more.
- The entire composite flood hydrograph or entire runoff volume is required for detailed flood routings. The hydrograph based on extrapolation is only an approximation of the entire hydrograph.
- The time of peak discharge must be more accurate than that obtained through the Tabular method.

The composite flood hydrograph should be compared with actual stream gage data where possible. The instantaneous peak flow value from the composite flood hydrograph can be compared with data from USGS curves of peak flow versus drainage area.

## Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution

TRVL----------HYDROGRAPH TIME(HOURS)----------

| TIME (hr) | 11.0 | 11.3 | 11.6 | 11.9 | 12.0 | 12.1 | 12.2 | 12.3 | 12.4 | 12.5 | 12.6 | 12.7 | 12.8 | 13.0 | 13.2 | 13.4 | 13.6 | 13.8 | 14.0 | 14.3 | 14.6 | 15.0 | 15.5 | 16.0 | 16.5 | 17.0 | 17.5 | 18.0 | 19.0 | 20.0 | 22.0 | 26.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA/P = 0.10 | | | | | | | | | | | | | * * * TC = 0.1 HR * * * | | | | | | | | | | | | | | | IA/P = 0.10 | | | | |
| 0.0 | 24 | 34 | 53 | 334 | 647 | 1010 | 623 | 217 | 147 | 123 | 104 | 86 | 76 | 66 | 57 | 51 | 46 | 42 | 38 | 34 | 32 | 29 | 26 | 23 | 21 | 20 | 19 | 18 | 15 | 13 | 12 | 0 |
| .10 | 21 | 29 | 43 | 134 | 267 | 520 | 847 | 701 | 378 | 224 | 157 | 122 | 98 | 75 | 64 | 56 | 50 | 45 | 41 | 36 | 33 | 30 | 27 | 24 | 21 | 20 | 19 | 18 | 16 | 13 | 12 | 0 |
| .20 | 18 | 25 | 35 | 61 | 110 | 215 | 418 | 704 | 702 | 486 | 312 | 209 | 151 | 94 | 73 | 62 | 54 | 49 | 44 | 38 | 34 | 31 | 28 | 25 | 22 | 21 | 19 | 18 | 16 | 14 | 12 | 0 |
| .30 | 17 | 23 | 33 | 56 | 92 | 174 | 337 | 582 | 662 | 545 | 389 | 269 | 190 | 109 | 79 | 65 | 56 | 50 | 45 | 39 | 35 | 32 | 29 | 25 | 22 | 21 | 20 | 18 | 16 | 14 | 12 | 0 |
| .40 | 15 | 20 | 28 | 41 | 51 | 78 | 142 | 272 | 478 | 601 | 563 | 447 | 328 | 172 | 104 | 76 | 63 | 55 | 49 | 42 | 37 | 33 | 29 | 26 | 23 | 21 | 20 | 19 | 17 | 14 | 12 | 0 |
| .50 | 14 | 19 | 26 | 39 | 47 | 68 | 117 | 220 | 392 | 531 | 553 | 482 | 380 | 209 | 121 | 84 | 67 | 57 | 51 | 43 | 38 | 33 | 30 | 27 | 23 | 21 | 20 | 19 | 17 | 14 | 12 | 0 |
| .75 | 12 | 15 | 21 | 29 | 33 | 38 | 49 | 73 | 126 | 224 | 343 | 432 | 464 | 385 | 252 | 156 | 103 | 76 | 62 | 50 | 43 | 36 | 31 | 28 | 25 | 22 | 21 | 19 | 17 | 15 | 12 | 0 |
| 1.0 | 9 | 12 | 15 | 21 | 23 | 26 | 29 | 33 | 40 | 55 | 86 | 148 | 238 | 406 | 434 | 317 | 205 | 130 | 89 | 62 | 50 | 41 | 34 | 30 | 27 | 24 | 22 | 20 | 18 | 16 | 12 | 0 |
| 1.5 | 7 | 8 | 10 | 14 | 15 | 16 | 18 | 20 | 22 | 25 | 29 | 34 | 45 | 101 | 220 | 339 | 373 | 320 | 234 | 131 | 80 | 53 | 40 | 34 | 30 | 27 | 24 | 21 | 19 | 17 | 12 | 2 |
| 2.0 | 4 | 6 | 7 | 9 | 9 | 10 | 11 | 12 | 13 | 15 | 16 | 18 | 20 | 25 | 37 | 72 | 150 | 252 | 336 | 312 | 216 | 109 | 58 | 42 | 34 | 30 | 27 | 24 | 20 | 18 | 13 | 8 |
| 2.5 | 3 | 4 | 5 | 6 | 7 | 7 | 8 | 8 | 9 | 10 | 11 | 12 | 13 | 16 | 19 | 25 | 39 | 75 | 142 | 262 | 308 | 229 | 108 | 58 | 41 | 34 | 30 | 27 | 22 | 19 | 14 | 11 |
| 3.0 | 1 | 2 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 8 | 10 | 12 | 14 | 17 | 22 | 31 | 76 | 169 | 288 | 236 | 122 | 64 | 43 | 35 | 30 | 24 | 20 | 16 | 11 |
| IA/P = 0.30 | | | | | | | | | | | | | * * * TC = 0.1 HR * * * | | | | | | | | | | | | | | | IA/P = 0.30 | | | | |
| 0.0 | 0 | 0 | 0 | 154 | 568 | 936 | 524 | 217 | 172 | 149 | 126 | 107 | 97 | 86 | 76 | 69 | 63 | 58 | 53 | 48 | 46 | 42 | 38 | 34 | 31 | 30 | 28 | 27 | 24 | 20 | 19 | 0 |
| .10 | 0 | 0 | 0 | 19 | 109 | 415 | 762 | 603 | 346 | 230 | 176 | 143 | 119 | 96 | 84 | 74 | 68 | 62 | 57 | 50 | 47 | 44 | 40 | 35 | 32 | 30 | 29 | 27 | 24 | 21 | 19 | 0 |
| .20 | 0 | 0 | 0 | 0 | 13 | 77 | 302 | 609 | 605 | 432 | 297 | 217 | 167 | 115 | 94 | 81 | 73 | 66 | 60 | 53 | 48 | 45 | 41 | 37 | 33 | 31 | 29 | 28 | 25 | 21 | 19 | 0 |
| .30 | 0 | 0 | 0 | 0 | 9 | 54 | 219 | 479 | 563 | 476 | 357 | 263 | 199 | 129 | 99 | 85 | 75 | 68 | 62 | 54 | 49 | 45 | 41 | 37 | 33 | 31 | 29 | 28 | 25 | 21 | 19 | 0 |
| .40 | 0 | 0 | 0 | 0 | 0 | 6 | 38 | 159 | 372 | 500 | 484 | 399 | 309 | 183 | 123 | 96 | 82 | 73 | 66 | 58 | 51 | 46 | 42 | 38 | 34 | 31 | 30 | 28 | 25 | 22 | 19 | 0 |
| .50 | 0 | 0 | 0 | 0 | 0 | 4 | 27 | 115 | 287 | 429 | 465 | 421 | 346 | 213 | 138 | 103 | 86 | 76 | 68 | 59 | 52 | 47 | 43 | 39 | 34 | 32 | 30 | 29 | 25 | 22 | 19 | 0 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 46 | 132 | 246 | 338 | 381 | 341 | 243 | 165 | 119 | 94 | 80 | 67 | 58 | 50 | 45 | 41 | 37 | 33 | 31 | 29 | 26 | 23 | 19 | 0 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 22 | 69 | 149 | 241 | 357 | 331 | 246 | 170 | 122 | 96 | 76 | 64 | 54 | 47 | 42 | 38 | 34 | 32 | 30 | 27 | 24 | 19 | 0 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 41 | 142 | 258 | 310 | 285 | 224 | 142 | 97 | 71 | 55 | 47 | 43 | 39 | 35 | 32 | 29 | 25 | 20 | 4 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 49 | 130 | 221 | 279 | 255 | 182 | 108 | 70 | 55 | 47 | 42 | 38 | 34 | 30 | 27 | 20 | 11 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 14 | 52 | 119 | 224 | 256 | 193 | 107 | 70 | 55 | 47 | 42 | 38 | 32 | 28 | 22 | 17 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 52 | 141 | 240 | 199 | 117 | 74 | 56 | 48 | 43 | 35 | 30 | 24 | 18 |
| IA/P = 0.50 | | | | | | | | | | | | | * * * TC = 0.1 HR * * * | | | | | | | | | | | | | | | IA/P = 0.50 | | | | |
| 0.0 | 0 | 0 | 0 | 0 | 70 | 539 | 377 | 196 | 171 | 154 | 134 | 117 | 108 | 99 | 89 | 83 | 77 | 72 | 67 | 61 | 59 | 56 | 51 | 46 | 43 | 42 | 40 | 38 | 34 | 30 | 28 | 0 |
| .10 | 0 | 0 | 0 | 0 | 47 | 375 | 376 | 256 | 199 | 169 | 146 | 126 | 114 | 102 | 92 | 85 | 79 | 73 | 68 | 62 | 59 | 56 | 52 | 47 | 43 | 42 | 40 | 38 | 34 | 30 | 28 | 0 |
| .20 | 0 | 0 | 0 | 0 | 0 | 31 | 260 | 338 | 283 | 227 | 189 | 160 | 138 | 112 | 99 | 90 | 83 | 77 | 72 | 64 | 60 | 57 | 53 | 48 | 44 | 42 | 41 | 39 | 35 | 30 | 28 | 0 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 180 | 285 | 284 | 246 | 208 | 176 | 131 | 110 | 97 | 88 | 82 | 76 | 68 | 62 | 59 | 54 | 50 | 45 | 43 | 41 | 39 | 36 | 31 | 28 | 0 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 125 | 232 | 266 | 253 | 223 | 192 | 142 | 115 | 100 | 91 | 83 | 77 | 69 | 63 | 59 | 55 | 50 | 45 | 43 | 41 | 40 | 36 | 31 | 28 | 0 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 86 | 183 | 239 | 248 | 231 | 205 | 154 | 122 | 104 | 93 | 85 | 79 | 71 | 64 | 59 | 55 | 51 | 46 | 43 | 41 | 40 | 36 | 32 | 28 | 0 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 31 | 87 | 147 | 190 | 211 | 213 | 184 | 147 | 121 | 103 | 92 | 84 | 75 | 67 | 61 | 57 | 52 | 47 | 44 | 42 | 40 | 37 | 32 | 28 | 0 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 13 | 45 | 92 | 141 | 205 | 197 | 165 | 134 | 112 | 98 | 84 | 75 | 65 | 59 | 55 | 50 | 46 | 43 | 41 | 38 | 34 | 28 | 0 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 9 | 51 | 118 | 170 | 183 | 167 | 143 | 111 | 92 | 77 | 65 | 59 | 54 | 50 | 45 | 43 | 39 | 35 | 28 | 2 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 15 | 51 | 103 | 148 | 168 | 156 | 127 | 96 | 76 | 65 | 58 | 54 | 49 | 45 | 41 | 37 | 29 | 12 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 31 | 69 | 131 | 159 | 140 | 101 | 78 | 66 | 59 | 54 | 50 | 43 | 39 | 31 | 24 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 11 | 46 | 101 | 151 | 134 | 99 | 77 | 65 | 59 | 54 | 45 | 41 | 33 | 26 |

RAINFALL TYPE = II * * * TC = 0.1 HR * * * SHEET 1 OF 10

## Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL----------HYDROGRAPH TIME(HOURS)----------

| TIME (hr) | 11.3 | 11.6 | 11.9 | 12.0 | 12.1 | 12.2 | 12.3 | 12.4 | 12.5 | 12.6 | 12.7 | 12.8 | 13.0 | 13.2 | 13.4 | 13.6 | 13.8 | 14.0 | 14.3 | 14.6 | 15.0 | 15.5 | 16.0 | 16.5 | 17.0 | 17.5 | 18.0 | 19.0 | 20.0 | 22.0 | 26.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA/P = 0.10 | | | | | | | | | | | | * * * TC = 0.2 HR * * * | | | | | | | | | | | | | | | IA/P = 0.10 | | | | |
| 0.0 | 23 | 31 | 47 | 209 | 403 | 739 | 800 | 481 | 250 | 166 | 128 | 102 | 86 | 70 | 61 | 54 | 49 | 44 | 40 | 35 | 33 | 30 | 27 | 24 | 21 | 20 | 19 | 18 | 16 | 13 | 12 | 0 |
| .10 | 19 | 26 | 39 | 86 | 168 | 325 | 601 | 733 | 565 | 355 | 229 | 161 | 122 | 83 | 69 | 59 | 53 | 47 | 43 | 37 | 34 | 31 | 28 | 25 | 22 | 21 | 19 | 18 | 16 | 14 | 12 | 0 |
| .20 | 17 | 23 | 32 | 49 | 74 | 136 | 262 | 488 | 652 | 594 | 435 | 298 | 207 | 115 | 81 | 67 | 58 | 51 | 46 | 40 | 35 | 32 | 29 | 26 | 23 | 21 | 20 | 19 | 16 | 14 | 12 | 0 |
| .30 | 16 | 22 | 30 | 46 | 64 | 112 | 212 | 396 | 566 | 585 | 485 | 360 | 258 | 139 | 90 | 71 | 60 | 53 | 48 | 41 | 36 | 32 | 29 | 26 | 23 | 21 | 20 | 19 | 16 | 14 | 12 | 0 |
| .40 | 14 | 19 | 25 | 37 | 43 | 57 | 94 | 173 | 322 | 485 | 551 | 507 | 409 | 227 | 129 | 87 | 68 | 58 | 52 | 44 | 38 | 33 | 30 | 27 | 24 | 21 | 20 | 19 | 17 | 14 | 12 | 0 |
| .50 | 13 | 18 | 24 | 35 | 40 | 52 | 80 | 142 | 262 | 410 | 504 | 506 | 441 | 269 | 153 | 98 | 73 | 61 | 53 | 45 | 39 | 34 | 30 | 27 | 24 | 22 | 20 | 19 | 17 | 15 | 12 | 0 |
| .75 | 10 | 13 | 17 | 23 | 26 | 30 | 34 | 40 | 55 | 86 | 150 | 247 | 349 | 438 | 360 | 240 | 151 | 101 | 75 | 57 | 47 | 39 | 33 | 29 | 26 | 23 | 21 | 20 | 18 | 15 | 12 | 0 |
| 1.0 | 9 | 11 | 14 | 19 | 21 | 24 | 26 | 30 | 35 | 44 | 62 | 101 | 167 | 337 | 413 | 353 | 245 | 157 | 104 | 68 | 53 | 42 | 35 | 31 | 28 | 24 | 22 | 20 | 18 | 16 | 12 | 0 |
| 1.5 | 6 | 8 | 10 | 13 | 14 | 15 | 17 | 19 | 21 | 23 | 26 | 30 | 37 | 73 | 166 | 288 | 356 | 337 | 264 | 154 | 91 | 57 | 42 | 35 | 30 | 27 | 24 | 22 | 19 | 17 | 13 | 3 |
| 2.0 | 4 | 5 | 7 | 8 | 9 | 10 | 10 | 11 | 12 | 14 | 15 | 16 | 18 | 23 | 31 | 55 | 114 | 206 | 291 | 324 | 239 | 125 | 63 | 44 | 35 | 31 | 28 | 24 | 20 | 18 | 14 | 9 |
| 2.5 | 3 | 4 | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 11 | 12 | 15 | 18 | 22 | 32 | 58 | 111 | 227 | 298 | 246 | 122 | 63 | 43 | 35 | 31 | 27 | 22 | 19 | 15 | 11 |
| 3.0 | 1 | 2 | 3 | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 11 | 13 | 16 | 19 | 27 | 59 | 138 | 280 | 248 | 137 | 70 | 46 | 36 | 31 | 25 | 21 | 16 | 11 |
| IA/P = 0.30 | | | | | | | | | | | | * * * TC = 0.2 HR * * * | | | | | | | | | | | | | | | IA/P = 0.30 | | | | |
| 0.0 | 0 | 0 | 0 | 39 | 180 | 545 | 697 | 497 | 276 | 198 | 158 | 130 | 110 | 93 | 81 | 73 | 67 | 61 | 56 | 49 | 46 | 43 | 39 | 35 | 32 | 30 | 29 | 27 | 24 | 21 | 19 | 0 |
| .10 | 0 | 0 | 0 | 2 | 27 | 129 | 407 | 600 | 532 | 361 | 252 | 190 | 150 | 108 | 90 | 79 | 71 | 65 | 59 | 52 | 48 | 44 | 41 | 36 | 32 | 31 | 29 | 28 | 25 | 21 | 19 | 0 |
| .20 | 0 | 0 | 0 | 2 | 19 | 92 | 302 | 501 | 521 | 415 | 306 | 228 | 176 | 119 | 95 | 82 | 73 | 67 | 61 | 53 | 48 | 45 | 41 | 37 | 33 | 31 | 29 | 28 | 25 | 21 | 19 | 0 |
| .30 | 0 | 0 | 0 | 0 | 1 | 13 | 66 | 223 | 408 | 484 | 438 | 350 | 269 | 163 | 114 | 93 | 80 | 72 | 65 | 57 | 51 | 46 | 42 | 38 | 34 | 31 | 30 | 28 | 25 | 22 | 19 | 0 |
| .40 | 0 | 0 | 0 | 0 | 1 | 9 | 47 | 164 | 327 | 431 | 436 | 379 | 306 | 189 | 127 | 98 | 83 | 74 | 67 | 58 | 52 | 47 | 43 | 38 | 34 | 31 | 30 | 28 | 25 | 22 | 19 | 0 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 33 | 120 | 258 | 374 | 415 | 391 | 271 | 173 | 121 | 95 | 81 | 72 | 62 | 55 | 48 | 44 | 40 | 35 | 32 | 30 | 29 | 26 | 22 | 19 | 0 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 13 | 50 | 126 | 221 | 302 | 348 | 323 | 240 | 167 | 121 | 96 | 81 | 68 | 59 | 50 | 45 | 41 | 37 | 33 | 31 | 29 | 26 | 23 | 19 | 0 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 24 | 69 | 139 | 285 | 331 | 280 | 204 | 145 | 109 | 82 | 68 | 56 | 48 | 43 | 39 | 35 | 32 | 30 | 27 | 24 | 19 | 0 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 16 | 79 | 186 | 271 | 288 | 247 | 165 | 110 | 76 | 58 | 49 | 44 | 40 | 35 | 32 | 29 | 26 | 20 | 5 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 24 | 80 | 163 | 235 | 262 | 202 | 123 | 76 | 58 | 49 | 43 | 39 | 35 | 30 | 27 | 21 | 13 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 28 | 77 | 179 | 242 | 207 | 120 | 75 | 57 | 48 | 43 | 39 | 32 | 29 | 22 | 17 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 30 | 101 | 207 | 227 | 130 | 80 | 59 | 49 | 44 | 35 | 30 | 24 | 18 |
| IA/P = 0.50 | | | | | | | | | | | | * * * TC = 0.2 HR * * * | | | | | | | | | | | | | | | IA/P = 0.50 | | | | |
| 0.0 | 0 | 0 | 0 | 0 | 7 | 98 | 371 | 322 | 221 | 182 | 158 | 137 | 120 | 104 | 94 | 86 | 80 | 74 | 69 | 62 | 60 | 57 | 52 | 47 | 44 | 42 | 40 | 39 | 35 | 30 | 28 | 0 |
| .10 | 0 | 0 | 0 | 0 | 4 | 67 | 270 | 305 | 249 | 204 | 174 | 149 | 130 | 108 | 97 | 88 | 82 | 76 | 71 | 64 | 60 | 57 | 53 | 48 | 44 | 42 | 41 | 39 | 35 | 30 | 28 | 0 |
| .20 | 0 | 0 | 0 | 0 | 0 | 3 | 45 | 195 | 268 | 255 | 221 | 189 | 163 | 125 | 106 | 95 | 87 | 80 | 75 | 67 | 62 | 58 | 54 | 49 | 45 | 43 | 41 | 39 | 35 | 31 | 28 | 0 |
| .30 | 0 | 0 | 0 | 0 | 0 | 2 | 31 | 140 | 226 | 245 | 229 | 203 | 176 | 134 | 111 | 98 | 89 | 82 | 76 | 68 | 62 | 59 | 55 | 50 | 45 | 43 | 41 | 39 | 36 | 31 | 28 | 0 |
| .40 | 0 | 0 | 0 | 0 | 0 | 1 | 21 | 101 | 184 | 225 | 228 | 211 | 188 | 144 | 117 | 101 | 91 | 84 | 78 | 69 | 63 | 59 | 55 | 50 | 45 | 43 | 41 | 40 | 36 | 31 | 28 | 0 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 14 | 72 | 146 | 199 | 218 | 213 | 175 | 137 | 113 | 99 | 89 | 82 | 73 | 66 | 60 | 56 | 52 | 47 | 43 | 42 | 40 | 36 | 32 | 28 | 0 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 28 | 71 | 121 | 162 | 186 | 193 | 161 | 133 | 112 | 98 | 88 | 78 | 70 | 62 | 57 | 53 | 48 | 44 | 42 | 41 | 37 | 33 | 28 | 0 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 13 | 38 | 77 | 154 | 186 | 174 | 147 | 122 | 105 | 89 | 78 | 68 | 60 | 56 | 51 | 46 | 43 | 42 | 38 | 34 | 28 | 0 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 22 | 71 | 129 | 163 | 168 | 150 | 120 | 98 | 80 | 67 | 60 | 55 | 51 | 46 | 43 | 40 | 36 | 28 | 4 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 25 | 65 | 112 | 146 | 157 | 134 | 103 | 79 | 67 | 60 | 55 | 50 | 46 | 41 | 38 | 29 | 14 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 26 | 60 | 117 | 148 | 136 | 101 | 79 | 66 | 59 | 54 | 50 | 43 | 39 | 31 | 24 |
| 3,0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 9 | 40 | 90 | 142 | 130 | 99 | 78 | 66 | 59 | 54 | 45 | 41 | 33 | 26 |

RAINFALL TYPE = II * * * TC = 0.2 HR * * * SHEET 2 OF 10

## Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL----------HYDROGRAPH TIME(HOURS)----------

| TIME (hr) | 11.0 | 11.3 | 11.6 | 11.9 | 12.0 | 12.1 | 12.2 | 12.3 | 12.4 | 12.5 | 12.6 | 12.7 | 12.8 | 13.0 | 13.2 | 13.4 | 13.6 | 13.8 | 14.0 | 14.3 | 14.6 | 15.0 | 15.5 | 16.0 | 16.5 | 17.0 | 17.5 | 18.0 | 19.0 | 20.0 | 22.0 | 26.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA/P = 0.10 | | | | | | | | | | | | | * * * TC = 0.3 HR * * * | | | | | | | | | | | | | | | IA/P = 0.10 | | | | |
| 0.0 | 20 | 28 | 41 | 118 | 235 | 447 | 676 | 676 | 459 | 283 | 196 | 146 | 114 | 80 | 66 | 57 | 51 | 46 | 42 | 37 | 33 | 31 | 28 | 24 | 22 | 20 | 19 | 18 | 16 | 13 | 12 | 0 |
| .10 | 19 | 26 | 39 | 99 | 189 | 361 | 571 | 641 | 520 | 362 | 251 | 181 | 136 | 89 | 70 | 60 | 53 | 48 | 43 | 37 | 34 | 31 | 28 | 25 | 22 | 21 | 19 | 18 | 16 | 14 | 12 | 0 |
| .20 | 17 | 23 | 32 | 53 | 83 | 154 | 292 | 478 | 587 | 542 | 422 | 308 | 223 | 127 | 86 | 68 | 58 | 52 | 46 | 40 | 35 | 32 | 29 | 26 | 23 | 21 | 20 | 19 | 16 | 14 | 12 | 0 |
| .30 | 16 | 22 | 30 | 49 | 72 | 127 | 237 | 398 | 524 | 536 | 460 | 359 | 268 | 151 | 97 | 73 | 61 | 53 | 48 | 41 | 36 | 32 | 29 | 26 | 23 | 21 | 20 | 19 | 16 | 14 | 12 | 0 |
| .40 | 14 | 19 | 25 | 37 | 45 | 63 | 105 | 193 | 330 | 459 | 510 | 477 | 398 | 237 | 139 | 92 | 70 | 59 | 52 | 44 | 38 | 34 | 30 | 27 | 24 | 21 | 20 | 19 | 17 | 14 | 12 | 0 |
| .50 | 13 | 18 | 24 | 35 | 42 | 56 | 89 | 158 | 272 | 397 | 472 | 475 | 424 | 274 | 163 | 104 | 76 | 62 | 54 | 46 | 39 | 34 | 30 | 27 | 24 | 22 | 20 | 19 | 17 | 15 | 12 | 0 |
| .75 | 11 | 14 | 19 | 26 | 30 | 34 | 42 | 59 | 95 | 160 | 250 | 339 | 417 | 398 | 299 | 196 | 128 | 89 | 69 | 54 | 45 | 37 | 32 | 29 | 26 | 23 | 21 | 20 | 17 | 15 | 12 | 0 |
| 1.0 | 9 | 11 | 14 | 19 | 21 | 24 | 27 | 30 | 36 | 46 | 68 | 109 | 174 | 328 | 396 | 346 | 248 | 163 | 109 | 70 | 54 | 43 | 35 | 31 | 28 | 24 | 22 | 20 | 18 | 16 | 12 | 0 |
| 1.5 | 6 | 8 | 10 | 13 | 14 | 15 | 17 | 19 | 21 | 23 | 26 | 31 | 38 | 77 | 169 | 282 | 347 | 330 | 264 | 158 | 94 | 58 | 42 | 35 | 31 | 27 | 24 | 22 | 19 | 17 | 13 | 3 |
| 2.0 | 4 | 5 | 7 | 8 | 9 | 10 | 10 | 11 | 12 | 14 | 15 | 16 | 18 | 23 | 32 | 57 | 116 | 205 | 285 | 317 | 239 | 128 | 64 | 44 | 36 | 31 | 28 | 25 | 20 | 18 | 14 | 9 |
| 2.5 | 2 | 4 | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 11 | 12 | 15 | 18 | 23 | 33 | 60 | 113 | 223 | 293 | 245 | 125 | 65 | 44 | 35 | 31 | 27 | 22 | 19 | 15 | 11 |
| 3.0 | 1 | 2 | 3 | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 11 | 13 | 16 | 20 | 27 | 61 | 138 | 275 | 246 | 139 | 72 | 46 | 36 | 31 | 25 | 21 | 16 | 11 |
| IA/P = 0.30 | | | | | | | | | | | | | * * * TC = 0.3 HR * * * | | | | | | | | | | | | | | | IA/P = 0.30 | | | | |
| 0.0 | 0 | 0 | 0 | 11 | 64 | 251 | 525 | 574 | 454 | 303 | 221 | 173 | 140 | 104 | 88 | 77 | 70 | 64 | 58 | 51 | 47 | 44 | 40 | 36 | 32 | 31 | 29 | 28 | 24 | 21 | 19 | 0 |
| .10 | 0 | 0 | 0 | 0 | 7 | 45 | 183 | 411 | 520 | 476 | 360 | 268 | 205 | 133 | 101 | 85 | 76 | 69 | 62 | 55 | 49 | 45 | 41 | 37 | 33 | 31 | 30 | 28 | 25 | 21 | 19 | 0 |
| .20 | 0 | 0 | 0 | 0 | 5 | 32 | 132 | 318 | 452 | 468 | 396 | 310 | 240 | 151 | 109 | 90 | 78 | 70 | 64 | 56 | 50 | 46 | 42 | 38 | 33 | 31 | 30 | 28 | 25 | 22 | 19 | 0 |
| .30 | 0 | 0 | 0 | 0 | 0 | 3 | 22 | 96 | 244 | 383 | 440 | 411 | 344 | 217 | 142 | 105 | 87 | 76 | 69 | 60 | 53 | 47 | 43 | 39 | 35 | 32 | 30 | 29 | 26 | 22 | 19 | 0 |
| .40 | 0 | 0 | 0 | 0 | 0 | 2 | 16 | 69 | 186 | 317 | 399 | 407 | 365 | 246 | 160 | 115 | 92 | 79 | 71 | 61 | 54 | 48 | 43 | 39 | 35 | 32 | 30 | 29 | 26 | 22 | 19 | 0 |
| ,50 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 11 | 50 | 140 | 258 | 352 | 389 | 327 | 223 | 149 | 110 | 89 | 77 | 66 | 57 | 50 | 45 | 41 | 36 | 33 | 31 | 29 | 26 | 23 | 19 | 0 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 20 | 63 | 135 | 219 | 290 | 335 | 281 | 205 | 146 | 110 | 89 | 72 | 62 | 52 | 46 | 42 | 38 | 34 | 31 | 30 | 27 | 23 | 19 | 0 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 9 | 32 | 78 | 216 | 320 | 306 | 243 | 176 | 128 | 90 | 72 | 59 | 49 | 44 | 40 | 36 | 33 | 31 | 28 | 24 | 19 | 1 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 20 | 84 | 185 | 264 | 281 | 246 | 168 | 112 | 77 | 58 | 49 | 44 | 40 | 36 | 32 | 29 | 26 | 20 | 5 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 12 | 50 | 121 | 200 | 257 | 224 | 141 | 83 | 61 | 50 | 44 | 40 | 36 | 31 | 28 | 21 | 14 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 16 | 51 | 145 | 239 | 223 | 137 | 82 | 60 | 50 | 44 | 40 | 33 | 29 | 22 | 17 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 19 | 74 | 184 | 224 | 146 | 89 | 63 | 51 | 45 | 36 | 31 | 24 | 18 |
| IA/P = 0.50 | | | | | | | | | | | | | * * * TC = 0.3 HR * * * | | | | | | | | | | | | | | | IA/P = 0.50 | | | | |
| 0.0 | 0 | 0 | 0 | 0 | 1 | 25 | 151 | 299 | 277 | 219 | 187 | 162 | 141 | 113 | 100 | 90 | 84 | 78 | 72 | 65 | 61 | 58 | 53 | 48 | 44 | 42 | 41 | 39 | 35 | 31 | 28 | 0 |
| .10 | 0 | 0 | 0 | 0 | 1 | 17 | 106 | 235 | 263 | 234 | 202 | 175 | 152 | 120 | 104 | 93 | 85 | 79 | 73 | 66 | 61 | 58 | 54 | 49 | 44 | 42 | 41 | 39 | 35 | 31 | 28 | 0 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 75 | 182 | 236 | 234 | 213 | 188 | 144 | 116 | 101 | 91 | 84 | 78 | 70 | 63 | 59 | 55 | 50 | 45 | 43 | 41 | 40 | 36 | 31 | 28 | 0 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 52 | 138 | 203 | 224 | 217 | 197 | 154 | 123 | 105 | 94 | 86 | 79 | 71 | 64 | 59 | 55 | 51 | 46 | 43 | 42 | 40 | 36 | 32 | 28 | 0 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 37 | 105 | 170 | 206 | 213 | 203 | 164 | 131 | 110 | 97 | 88 | 81 | 72 | 65 | 60 | 56 | 51 | 46 | 43 | 42 | 40 | 36 | 32 | 28 | 0 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 26 | 78 | 140 | 184 | 203 | 191 | 155 | 126 | 107 | 95 | 86 | 76 | 69 | 62 | 57 | 53 | 48 | 44 | 42 | 41 | 37 | 33 | 28 | 0 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 34 | 73 | 117 | 153 | 184 | 173 | 146 | 122 | 105 | 94 | 82 | 73 | 64 | 58 | 54 | 49 | 45 | 43 | 41 | 37 | 33 | 28 | 0 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 17 | 42 | 114 | 168 | 178 | 159 | 134 | 114 | 94 | 82 | 70 | 61 | 57 | 52 | 47 | 44 | 42 | 39 | 35 | 28 | 0 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 44 | 98 | 144 | 163 | 157 | 130 | 105 | 84 | 69 | 61 | 56 | 52 | 47 | 44 | 40 | 36 | 29 | 6 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 14 | 44 | 87 | 127 | 153 | 141 | 110 | 83 | 69 | 61 | 56 | 51 | 47 | 42 | 38 | 30 | 17 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 16 | 42 | 97 | 138 | 145 | 107 | 82 | 68 | 60 | 55 | 51 | 43 | 40 | 32 | 25 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 27 | 71 | 127 | 139 | 105 | 81 | 68 | 60 | 55 | 46 | 41 | 33 | 27 |

RAINFALL TYPE = II  * * * TC = 0.3 HR * * *  SHEET 3 OF 10

REFERENCE 4

## Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL----------HYDROGRAPH TIME(HOURS)----------

| TIME (hr) | 11.0 | 11.3 | 11.6 | 11.9 | 12.0 | 12.1 | 12.2 | 12.3 | 12.4 | 12.5 | 12.6 | 12.7 | 12.8 | 13.0 | 13.2 | 13.4 | 13.6 | 13.8 | 14.0 | 14.3 | 14.6 | 15.0 | 15.5 | 16.0 | 16.5 | 17.0 | 17.5 | 18.0 | 19.0 | 20.0 | 22.0 | 26.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA/P = 0.10 | | | | | | | | | | | | | * * * TC = 0.4 HR * * * | | | | | | | | | | | | | | | | IA/P = 0.10 | | | |
| 0.0 | 18 | 25 | 36 | 77 | 141 | 271 | 468 | 592 | 574 | 431 | 298 | 216 | 163 | 104 | 77 | 63 | 55 | 49 | 44 | 38 | 34 | 31 | 28 | 25 | 22 | 21 | 20 | 18 | 16 | 14 | 12 | 0 |
| .10 | 18 | 24 | 34 | 67 | 116 | 219 | 385 | 523 | 557 | 473 | 357 | 263 | 196 | 119 | 84 | 67 | 57 | 51 | 46 | 39 | 35 | 32 | 29 | 25 | 22 | 21 | 20 | 19 | 16 | 14 | 12 | 0 |
| .20 | 15 | 20 | 28 | 44 | 59 | 97 | 179 | 316 | 454 | 523 | 489 | 401 | 309 | 178 | 112 | 81 | 65 | 56 | 49 | 42 | 37 | 33 | 30 | 26 | 23 | 21 | 20 | 19 | 17 | 14 | 12 | 0 |
| .30 | 15 | 20 | 27 | 41 | 53 | 82 | 147 | 260 | 389 | 478 | 486 | 429 | 349 | 210 | 129 | 89 | 69 | 58 | 51 | 43 | 38 | 33 | 30 | 27 | 24 | 21 | 20 | 19 | 17 | 14 | 12 | 0 |
| .40 | 13 | 17 | 23 | 33 | 38 | 48 | 71 | 121 | 214 | 331 | 429 | 467 | 442 | 308 | 189 | 120 | 85 | 66 | 56 | 47 | 41 | 35 | 31 | 28 | 24 | 22 | 20 | 19 | 17 | 15 | 12 | 0 |
| .50 | 12 | 16 | 22 | 31 | 36 | 44 | 62 | 102 | 176 | 279 | 379 | 438 | 440 | 339 | 218 | 137 | 94 | 71 | 59 | 49 | 42 | 35 | 31 | 28 | 25 | 22 | 21 | 19 | 17 | 15 | 12 | 0 |
| .75 | 10 | 13 | 17 | 24 | 26 | 30 | 35 | 45 | 65 | 106 | 170 | 251 | 326 | 393 | 341 | 245 | 164 | 112 | 81 | 59 | 48 | 39 | 33 | 30 | 26 | 23 | 21 | 20 | 18 | 15 | 12 | 0 |
| 1.0 | 8 | 10 | 13 | 17 | 19 | 21 | 24 | 27 | 31 | 37 | 50 | 75 | 118 | 251 | 360 | 376 | 292 | 205 | 138 | 83 | 60 | 45 | 36 | 32 | 28 | 25 | 22 | 21 | 18 | 16 | 12 | 1 |
| 1.5 | 6 | 7 | 9 | 12 | 13 | 14 | 15 | 17 | 19 | 21 | 23 | 26 | 31 | 56 | 121 | 224 | 311 | 333 | 293 | 192 | 115 | 66 | 45 | 36 | 31 | 28 | 25 | 22 | 19 | 17 | 13 | 4 |
| 2.0 | 4 | 5 | 6 | 8 | 8 | 9 | 10 | 10 | 11 | 12 | 14 | 15 | 16 | 20 | 27 | 43 | 85 | 159 | 243 | 306 | 264 | 154 | 74 | 47 | 37 | 32 | 28 | 25 | 21 | 18 | 14 | 9 |
| 2.5 | 2 | 3 | 4 | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 11 | 13 | 16 | 20 | 27 | 46 | 85 | 184 | 285 | 262 | 147 | 74 | 47 | 37 | 32 | 28 | 22 | 19 | 15 | 11 |
| 3.0 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 10 | 12 | 14 | 17 | 23 | 47 | 109 | 227 | 268 | 160 | 83 | 50 | 38 | 32 | 25 | 21 | 16 | 11 |
| IA/P = 0.30 | | | | | | | | | | | | | * * * TC = 0.4 HR * * * | | | | | | | | | | | | | | | | IA/P = 0.30 | | | |
| 0.0 | 0 | 0 | 0 | 4 | 26 | 113 | 296 | 480 | 495 | 413 | 306 | 234 | 186 | 127 | 100 | 84 | 74 | 67 | 61 | 54 | 49 | 45 | 41 | 37 | 33 | 31 | 29 | 28 | 25 | 21 | 19 | 0 |
| .10 | 0 | 0 | 0 | 0 | 2 | 18 | 81 | 224 | 395 | 462 | 430 | 347 | 272 | 172 | 121 | 96 | 82 | 73 | 66 | 57 | 51 | 46 | 42 | 38 | 34 | 31 | 30 | 28 | 25 | 22 | 19 | 0 |
| .20 | 0 | 0 | 0 | 0 | 2 | 13 | 59 | 169 | 320 | 414 | 424 | 373 | 305 | 196 | 134 | 103 | 85 | 75 | 67 | 59 | 52 | 47 | 43 | 39 | 34 | 32 | 30 | 29 | 25 | 22 | 19 | 0 |
| .30 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 42 | 127 | 255 | 361 | 403 | 383 | 274 | 181 | 127 | 99 | 83 | 73 | 63 | 55 | 48 | 44 | 40 | 36 | 32 | 30 | 29 | 26 | 23 | 19 | 0 |
| .40 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 30 | 94 | 202 | 308 | 372 | 379 | 298 | 203 | 141 | 106 | 87 | 76 | 65 | 56 | 49 | 44 | 40 | 36 | 32 | 31 | 29 | 26 | 23 | 19 | 0 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 21 | 70 | 158 | 258 | 334 | 364 | 270 | 187 | 133 | 102 | 85 | 70 | 60 | 51 | 46 | 41 | 37 | 33 | 31 | 30 | 26 | 23 | 19 | 0 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 30 | 76 | 145 | 219 | 321 | 305 | 241 | 177 | 130 | 102 | 78 | 65 | 55 | 47 | 43 | 38 | 34 | 32 | 30 | 27 | 24 | 19 | 0 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 15 | 42 | 150 | 267 | 308 | 272 | 209 | 154 | 103 | 79 | 62 | 51 | 45 | 41 | 37 | 33 | 31 | 28 | 25 | 19 | 1 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 51 | 136 | 226 | 274 | 263 | 195 | 131 | 85 | 62 | 51 | 45 | 41 | 36 | 33 | 29 | 26 | 20 | 6 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 31 | 86 | 162 | 252 | 239 | 162 | 93 | 64 | 52 | 45 | 41 | 37 | 31 | 28 | 21 | 15 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 33 | 112 | 202 | 235 | 155 | 92 | 64 | 52 | 45 | 41 | 33 | 29 | 23 | 18 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 21 | 76 | 182 | 221 | 148 | 90 | 63 | 51 | 45 | 36 | 31 | 24 | 18 |
| IA/P = 0.50 | | | | | | | | | | | | | * * * TC = 0.4 HR * * * | | | | | | | | | | | | | | | | IA/P = 0.50 | | | |
| 0.0 | 0 | 0 | 0 | 0 | 0 | 7 | 59 | 168 | 245 | 257 | 213 | 186 | 163 | 128 | 109 | 96 | 88 | 81 | 75 | 67 | 62 | 58 | 54 | 50 | 45 | 43 | 41 | 39 | 35 | 31 | 28 | 0 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 41 | 125 | 205 | 240 | 222 | 198 | 154 | 123 | 106 | 94 | 86 | 79 | 71 | 64 | 60 | 56 | 51 | 46 | 43 | 42 | 40 | 36 | 32 | 28 | 0 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 28 | 93 | 168 | 216 | 220 | 205 | 164 | 131 | 110 | 97 | 88 | 81 | 72 | 65 | 60 | 56 | 51 | 46 | 43 | 42 | 40 | 36 | 32 | 28 | 0 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 20 | 69 | 135 | 189 | 209 | 192 | 155 | 126 | 107 | 95 | 86 | 77 | 69 | 62 | 57 | 53 | 48 | 44 | 42 | 41 | 37 | 33 | 28 | 0 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 14 | 50 | 106 | 161 | 193 | 202 | 163 | 133 | 112 | 98 | 89 | 78 | 70 | 62 | 58 | 53 | 48 | 44 | 42 | 41 | 37 | 33 | 28 | 0 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 37 | 83 | 135 | 174 | 194 | 171 | 140 | 117 | 102 | 91 | 80 | 71 | 63 | 58 | 54 | 49 | 45 | 43 | 41 | 37 | 33 | 28 | 0 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 15 | 40 | 76 | 147 | 177 | 169 | 146 | 124 | 107 | 90 | 79 | 68 | 60 | 56 | 51 | 47 | 43 | 42 | 38 | 34 | 28 | 0 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 21 | 78 | 141 | 173 | 167 | 146 | 125 | 101 | 86 | 73 | 63 | 58 | 53 | 48 | 45 | 42 | 39 | 35 | 28 | 1 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 26 | 71 | 121 | 153 | 159 | 139 | 113 | 89 | 72 | 63 | 57 | 53 | 48 | 44 | 40 | 37 | 29 | 7 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 16 | 45 | 86 | 138 | 150 | 125 | 93 | 74 | 64 | 58 | 53 | 48 | 42 | 39 | 31 | 20 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 17 | 59 | 112 | 143 | 121 | 91 | 73 | 63 | 57 | 53 | 45 | 40 | 32 | 26 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 11 | 40 | 101 | 138 | 117 | 90 | 73 | 63 | 57 | 48 | 42 | 34 | 27 |

RAINFALL TYPE = II * * * TC = 0.4 HR * * * SHEET 4 OF 10

## Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL----------HYDROGRAPH TIME(HOURS)----------

| TIME (hr) | 11.3 | 11.9 | 12.1 | 12.3 | 12.5 | 12.7 | 13.0 | 13.4 | 13.8 | 14.3 | 15.0 | 16.0 | 17.0 | 18.0 | 20.0 | 26.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 11.0 | 11.6 | 12.0 | 12.2 | 12.4 | 12.6 | 12.8 | 13.2 | 13.6 | 14.0 | 14.6 | 15.5 | 16.5 | 17.5 | 19.0 | 22.0 |
| IA/P = 0.10 | | | | | | | * * * TC = 0.5 HR * * * | | | | | | | | IA/P = 0.10 | |
| 0.0 | 17 | 23 | 32 | 57 | 94 | 170 | 308 | 467 | 529 | 507 | 402 | 297 | 226 | 140 | 96 | 74 |
| .10 | 16 | 22 | 30 | 51 | 80 | 140 | 252 | 395 | 484 | 499 | 434 | 343 | 265 | 162 | 108 | 80 |
| .20 | 14 | 19 | 25 | 38 | 47 | 69 | 116 | 207 | 332 | 434 | 477 | 449 | 378 | 238 | 149 | 101 |
| .30 | 13 | 18 | 24 | 35 | 43 | 60 | 97 | 170 | 278 | 382 | 446 | 448 | 401 | 270 | 171 | 114 |
| .40 | 12 | 15 | 21 | 29 | 33 | 40 | 53 | 83 | 141 | 233 | 332 | 408 | 434 | 361 | 243 | 157 |
| .50 | 11 | 15 | 20 | 28 | 31 | 37 | 48 | 71 | 118 | 194 | 286 | 367 | 412 | 378 | 271 | 178 |
| .75 | 9 | 11 | 14 | 19 | 21 | 24 | 27 | 31 | 37 | 49 | 74 | 118 | 182 | 319 | 374 | 328 |
| 1.0 | 7 | 9 | 12 | 16 | 17 | 19 | 21 | 24 | 27 | 32 | 40 | 55 | 83 | 188 | 309 | 359 |
| 1.5 | 5 | 7 | 8 | 11 | 12 | 13 | 14 | 15 | 17 | 19 | 21 | 23 | 27 | 43 | 89 | 175 |
| 2.0 | 3 | 4 | 6 | 7 | 8 | 8 | 9 | 10 | 10 | 11 | 12 | 14 | 15 | 18 | 23 | 35 |
| 2.5 | 2 | 3 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 12 | 15 | 18 |
| 3.0 | 1 | 1 | 2 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 8 | 9 | 11 |
| IA/P = 0.30 | | | | | | | * * * TC = 0.5 HR * * * | | | | | | | | IA/P = 0.30 | |
| 0.0 | 0 | 0 | 0 | 1 | 9 | 53 | 157 | 314 | 433 | 439 | 379 | 299 | 237 | 159 | 118 | 95 |
| .10 | 0 | 0 | 0 | 0 | 1 | 6 | 37 | 117 | 248 | 372 | 416 | 391 | 330 | 218 | 150 | 113 |
| .20 | 0 | 0 | 0 | 0 | 1 | 4 | 26 | 87 | 194 | 313 | 382 | 388 | 349 | 244 | 167 | 122 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 19 | 64 | 151 | 259 | 341 | 372 | 316 | 223 | 156 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 13 | 47 | 116 | 211 | 298 | 354 | 328 | 245 | 172 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 34 | 89 | 170 | 255 | 341 | 303 | 225 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 14 | 41 | 89 | 152 | 270 | 305 | 268 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 22 | 98 | 212 | 295 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 30 | 95 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IA/P = 0.50 | | | | | | | * * * TC = 0.5 HR * * * | | | | | | | | IA/P = 0.50 | |
| 0.0 | 0 | 0 | 0 | 0 | 0 | 2 | 26 | 89 | 170 | 217 | 229 | 200 | 179 | 144 | 119 | 104 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 18 | 65 | 135 | 190 | 216 | 205 | 170 | 137 | 115 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 12 | 47 | 106 | 162 | 198 | 203 | 178 | 145 | 121 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 34 | 82 | 135 | 177 | 194 | 168 | 139 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 25 | 63 | 111 | 155 | 189 | 174 | 146 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 18 | 48 | 90 | 133 | 184 | 177 | 152 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 22 | 47 | 80 | 142 | 169 | 164 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 11 | 51 | 112 | 155 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 16 | 50 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| TIME (hr) | 11.3 | 11.9 | 12.1 | 12.3 | 12.5 | 12.7 | 13.0 | 13.4 | 13.8 | 14.3 | 15.0 | 16.0 | 17.0 | 18.0 | 20.0 | 26.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 11.0 | 11.6 | 12.0 | 12.2 | 12.4 | 12.6 | 12.8 | 13.2 | 13.6 | 14.0 | 14.6 | 15.5 | 16.5 | 17.5 | 19.0 | 22.0 |
| 0.0 | 73 | 53 | 47 | 41 | 36 | 32 | 29 | 26 | 23 | 21 | 20 | 19 | 16 | 14 | 12 | 0 |
| .10 | 62 | 55 | 49 | 42 | 36 | 33 | 29 | 26 | 23 | 21 | 20 | 19 | 16 | 14 | 12 | 0 |
| .20 | 101 | 62 | 53 | 45 | 39 | 34 | 30 | 27 | 24 | 22 | 20 | 19 | 17 | 14 | 12 | 0 |
| .30 | 83 | 66 | 56 | 46 | 40 | 34 | 31 | 27 | 24 | 22 | 20 | 19 | 17 | 15 | 12 | 0 |
| .40 | 107 | 79 | 64 | 51 | 43 | 36 | 32 | 28 | 25 | 22 | 21 | 20 | 17 | 15 | 12 | 0 |
| .50 | 119 | 86 | 68 | 53 | 44 | 37 | 32 | 29 | 25 | 23 | 21 | 20 | 17 | 15 | 12 | 0 |
| .75 | 244 | 169 | 117 | 76 | 56 | 43 | 35 | 31 | 28 | 25 | 22 | 21 | 18 | 16 | 12 | 1 |
| 1.0 | 322 | 245 | 172 | 102 | 68 | 49 | 38 | 32 | 29 | 26 | 23 | 21 | 19 | 16 | 12 | 1 |
| 1.5 | 269 | 322 | 309 | 225 | 140 | 77 | 49 | 38 | 32 | 29 | 25 | 23 | 20 | 17 | 13 | 5 |
| 2.0 | 65 | 123 | 202 | 297 | 280 | 181 | 88 | 52 | 39 | 33 | 29 | 26 | 21 | 19 | 14 | 10 |
| 2.5 | 24 | 36 | 66 | 150 | 244 | 278 | 171 | 87 | 52 | 39 | 33 | 29 | 23 | 20 | 15 | 11 |
| 3.0 | 13 | 16 | 20 | 37 | 86 | 198 | 263 | 182 | 96 | 56 | 40 | 33 | 26 | 21 | 16 | 11 |
| IA/P = 0.30 | | | | | | | * * * TC = 0.5 HR * * * | | | | | | | | IA/P = 0.30 | |
| 0.0 | 81 | 71 | 65 | 56 | 50 | 46 | 42 | 38 | 34 | 31 | 30 | 28 | 25 | 22 | 19 | 0 |
| .10 | 92 | 79 | 70 | 60 | 53 | 47 | 43 | 39 | 35 | 32 | 30 | 29 | 26 | 22 | 19 | 0 |
| .20 | 97 | 82 | 72 | 62 | 54 | 48 | 43 | 39 | 35 | 32 | 30 | 29 | 26 | 22 | 19 | 0 |
| .30 | 117 | 94 | 80 | 67 | 58 | 50 | 45 | 41 | 36 | 33 | 31 | 29 | 26 | 23 | 19 | 0 |
| .40 | 127 | 100 | 83 | 69 | 59 | 51 | 45 | 41 | 37 | 33 | 31 | 29 | 26 | 23 | 19 | 0 |
| .50 | 161 | 120 | 96 | 76 | 64 | 54 | 47 | 42 | 38 | 34 | 31 | 30 | 27 | 24 | 19 | 0 |
| .75 | 207 | 155 | 118 | 87 | 70 | 57 | 48 | 44 | 39 | 35 | 32 | 30 | 27 | 24 | 19 | 0 |
| 1.0 | 285 | 237 | 181 | 120 | 88 | 67 | 53 | 46 | 42 | 38 | 34 | 31 | 28 | 25 | 19 | 2 |
| 1.5 | 183 | 249 | 265 | 217 | 152 | 96 | 66 | 53 | 46 | 41 | 37 | 34 | 30 | 26 | 20 | 8 |
| 2.0 | 18 | 59 | 125 | 221 | 245 | 182 | 105 | 69 | 54 | 47 | 42 | 38 | 32 | 28 | 22 | 16 |
| 2.5 | 1 | 5 | 21 | 84 | 174 | 230 | 172 | 103 | 69 | 54 | 46 | 42 | 34 | 30 | 23 | 18 |
| 3.0 | 0 | 0 | 1 | 13 | 56 | 157 | 217 | 163 | 101 | 68 | 53 | 46 | 37 | 31 | 25 | 18 |
| IA/P = 0.50 | | | | | | | * * * TC = 0.5 HR * * * | | | | | | | | IA/P = 0.50 | |
| 0.0 | 93 | 85 | 78 | 70 | 64 | 59 | 55 | 51 | 46 | 43 | 41 | 40 | 36 | 32 | 28 | 0 |
| .10 | 101 | 91 | 83 | 74 | 67 | 61 | 56 | 52 | 47 | 44 | 42 | 40 | 36 | 32 | 28 | 0 |
| .20 | 105 | 94 | 85 | 76 | 68 | 61 | 57 | 52 | 48 | 44 | 42 | 40 | 37 | 32 | 28 | 0 |
| .30 | 117 | 102 | 92 | 80 | 71 | 63 | 58 | 54 | 49 | 45 | 43 | 41 | 37 | 33 | 28 | 0 |
| .40 | 122 | 106 | 94 | 82 | 73 | 64 | 58 | 54 | 50 | 45 | 43 | 41 | 37 | 33 | 28 | 0 |
| .50 | 128 | 110 | 97 | 84 | 74 | 65 | 59 | 55 | 50 | 45 | 43 | 41 | 38 | 33 | 28 | 0 |
| .75 | 144 | 124 | 108 | 91 | 79 | 68 | 61 | 56 | 51 | 47 | 44 | 42 | 38 | 34 | 28 | 0 |
| 1.0 | 166 | 154 | 134 | 109 | 91 | 76 | 65 | 59 | 54 | 49 | 45 | 43 | 39 | 35 | 28 | 2 |
| 1.5 | 97 | 136 | 154 | 145 | 121 | 95 | 75 | 64 | 58 | 54 | 49 | 45 | 41 | 37 | 29 | 10 |
| 2.0 | 18 | 47 | 86 | 134 | 146 | 125 | 94 | 75 | 64 | 58 | 53 | 49 | 42 | 39 | 31 | 21 |
| 2.5 | 0 | 3 | 11 | 44 | 95 | 140 | 127 | 97 | 77 | 65 | 58 | 54 | 45 | 41 | 33 | 26 |
| 3.3 | 0 | 0 | 1 | 7 | 29 | 86 | 135 | 122 | 95 | 76 | 65 | 58 | 49 | 43 | 35 | 27 |

RAINFALL TYPE = II * * * TC = 0.5 HR * * * SHEET 5 OF 10

REFERENCE 4

## Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

| TRVL TIME (hr) | 11.0 | 11.3 | 11.6 | 11.9 | 12.0 | 12.1 | 12.2 | 12.3 | 12.4 | 12.5 | 12.6 | 12.7 | 12.8 | 13.0 | 13.2 | 13.4 | 13.6 | 13.8 | 14.0 | 14.3 | 14.6 | 15.0 | 15.5 | 16.0 | 16.5 | 17.0 | 17.5 | 18.0 | 19.0 | 20.0 | 22.0 | 26.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | HYDROGRAPH TIME(HOURS) | | | | | | | | | | | | | | | | | | | |
| IA/P = 0.10 | | | | | | | | | | | | | * * * TC = 0.75 HR * * * | | | | | | | | | | | | | | | IA/P = 0.10 | | | | |
| 0.0 | 13 | 18 | 24 | 36 | 46 | 68 | 115 | 194 | 294 | 380 | 424 | 410 | 369 | 252 | 172 | 123 | 93 | 74 | 61 | 49 | 41 | 35 | 31 | 27 | 24 | 22 | 20 | 19 | 17 | 15 | 12 | 0 |
| .10 | 13 | 17 | 23 | 34 | 42 | 59 | 97 | 162 | 250 | 337 | 395 | 405 | 381 | 279 | 191 | 135 | 100 | 79 | 65 | 51 | 42 | 36 | 31 | 28 | 25 | 22 | 21 | 19 | 17 | 15 | 12 | 0 |
| .20 | 11 | 15 | 20 | 28 | 32 | 39 | 52 | 82 | 135 | 211 | 295 | 362 | 391 | 351 | 255 | 178 | 127 | 95 | 75 | 57 | 46 | 38 | 32 | 29 | 26 | 23 | 21 | 20 | 17 | 15 | 12 | 0 |
| .30 | 11 | 14 | 19 | 26 | 30 | 36 | 47 | 70 | 113 | 179 | 256 | 326 | 379 | 360 | 277 | 196 | 140 | 103 | 80 | 60 | 48 | 38 | 33 | 29 | 26 | 23 | 21 | 20 | 18 | 15 | 12 | 0 |
| .40 | 10 | 12 | 16 | 22 | 25 | 28 | 33 | 42 | 61 | 96 | 151 | 221 | 291 | 367 | 336 | 255 | 182 | 131 | 98 | 69 | 54 | 42 | 34 | 30 | 27 | 24 | 22 | 20 | 18 | 16 | 12 | 0 |
| .50 | 9 | 12 | 16 | 21 | 24 | 27 | 31 | 39 | 53 | 82 | 128 | 190 | 258 | 358 | 343 | 274 | 200 | 144 | 106 | 74 | 56 | 43 | 35 | 30 | 27 | 24 | 22 | 20 | 18 | 16 | 12 | 0 |
| .75 | 8 | 10 | 13 | 17 | 18 | 21 | 23 | 26 | 31 | 39 | 55 | 82 | 122 | 230 | 314 | 329 | 281 | 217 | 161 | 104 | 72 | 51 | 38 | 33 | 29 | 26 | 23 | 21 | 19 | 16 | 12 | 1 |
| 1.0 | 6 | 8 | 10 | 13 | 14 | 15 | 17 | 19 | 21 | 23 | 27 | 32 | 42 | 89 | 177 | 272 | 319 | 303 | 249 | 163 | 105 | 66 | 45 | 36 | 31 | 27 | 24 | 22 | 19 | 17 | 13 | 3 |
| 1.5 | 4 | 6 | 7 | 9 | 10 | 10 | 11 | 12 | 14 | 15 | 16 | 18 | 20 | 27 | 46 | 90 | 163 | 241 | 295 | 275 | 204 | 119 | 66 | 45 | 35 | 31 | 27 | 24 | 20 | 18 | 13 | 7 |
| 2.0 | 3 | 4 | 5 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 11 | 12 | 13 | 16 | 20 | 28 | 48 | 89 | 151 | 245 | 274 | 213 | 115 | 65 | 44 | 35 | 30 | 27 | 22 | 19 | 14 | 10 |
| 2.5 | 1 | 2 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 8 | 10 | 12 | 14 | 17 | 24 | 37 | 86 | 170 | 260 | 219 | 127 | 71 | 47 | 36 | 31 | 24 | 20 | 16 | 11 |
| 3.0 | 1 | 1 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 6 | 7 | 8 | 10 | 11 | 14 | 17 | 30 | 64 | 157 | 247 | 205 | 122 | 70 | 46 | 36 | 27 | 22 | 17 | 12 |
| IA/P = 0.30 | | | | | | | | | | | | | * * * TC = 0.75 HR * * * | | | | | | | | | | | | | | | IA/P = 0.30 | | | | |
| 0.0 | 0 | 0 | 0 | 0 | 1 | 6 | 30 | 86 | 174 | 266 | 326 | 348 | 328 | 246 | 181 | 138 | 110 | 92 | 79 | 66 | 57 | 49 | 44 | 40 | 36 | 32 | 31 | 29 | 26 | 23 | 19 | 0 |
| .10 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 22 | 65 | 137 | 223 | 292 | 329 | 303 | 228 | 170 | 131 | 106 | 89 | 73 | 61 | 52 | 46 | 41 | 37 | 33 | 31 | 29 | 26 | 23 | 19 | 0 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 15 | 48 | 108 | 185 | 256 | 305 | 321 | 245 | 184 | 141 | 112 | 93 | 75 | 63 | 53 | 46 | 42 | 37 | 34 | 31 | 30 | 27 | 23 | 19 | 0 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 11 | 36 | 84 | 151 | 221 | 277 | 308 | 260 | 199 | 152 | 120 | 98 | 78 | 65 | 54 | 47 | 42 | 38 | 34 | 31 | 30 | 27 | 23 | 19 | 0 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 27 | 65 | 122 | 188 | 286 | 301 | 243 | 187 | 144 | 114 | 87 | 71 | 57 | 48 | 43 | 39 | 35 | 32 | 30 | 27 | 24 | 19 | 1 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 20 | 50 | 98 | 158 | 263 | 292 | 254 | 200 | 155 | 122 | 91 | 74 | 59 | 49 | 44 | 40 | 35 | 32 | 30 | 27 | 24 | 19 | 1 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 23 | 51 | 140 | 231 | 269 | 253 | 211 | 167 | 119 | 90 | 68 | 53 | 46 | 42 | 37 | 34 | 31 | 28 | 25 | 19 | 2 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 29 | 96 | 186 | 249 | 261 | 231 | 169 | 120 | 84 | 61 | 50 | 44 | 40 | 36 | 33 | 29 | 26 | 20 | 5 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 34 | 91 | 163 | 220 | 241 | 197 | 131 | 83 | 61 | 50 | 44 | 40 | 35 | 31 | 27 | 21 | 12 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 11 | 36 | 85 | 174 | 226 | 200 | 127 | 82 | 60 | 49 | 44 | 39 | 32 | 29 | 22 | 17 |
| 2.5 | o | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 37 | 105 | 196 | 214 | 135 | 87 | 62 | 51 | 44 | 36 | 31 | 24 | 18 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 24 | 96 | 205 | 189 | 130 | 85 | 62 | 50 | 39 | 32 | 26 | 18 |
| IA/P = 0.50 | | | | | | | | | | | | | * * * TC = 0.75 HR * * * | | | | | | | | | | | | | | | IA/P = 0.50 | | | | |
| 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 16 | 45 | 92 | 137 | 166 | 185 | 170 | 146 | 125 | 110 | 98 | 89 | 79 | 70 | 63 | 58 | 53 | 48 | 44 | 42 | 41 | 37 | 33 | 28 | 0 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 11 | 34 | 73 | 115 | 149 | 180 | 163 | 141 | 122 | 107 | 96 | 84 | 74 | 65 | 59 | 54 | 50 | 45 | 43 | 41 | 38 | 33 | 28 | 0 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 25 | 57 | 96 | 131 | 173 | 166 | 146 | 126 | 111 | 99 | 86 | 76 | 66 | 59 | 55 | 50 | 46 | 43 | 41 | 38 | 34 | 28 | 0 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 18 | 44 | 79 | 143 | 170 | 160 | 141 | 122 | 108 | 92 | 81 | 69 | 61 | 56 | 52 | 47 | 44 | 42 | 38 | 34 | 28 | 1 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 14 | 34 | 64 | 127 | 166 | 162 | 145 | 127 | 111 | 95 | 82 | 70 | 62 | 57 | 52 | 47 | 44 | 42 | 38 | 34 | 28 | 1 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 10 | 26 | 82 | 138 | 162 | 157 | 140 | 123 | 103 | 88 | 75 | 64 | 58 | 53 | 49 | 45 | 43 | 39 | 35 | 28 | 2 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 12 | 47 | 98 | 139 | 154 | 148 | 135 | 113 | 96 | 80 | 67 | 60 | 55 | 50 | 46 | 43 | 39 | 36 | 29 | 3 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 30 | 73 | 119 | 146 | 151 | 134 | 113 | 91 | 74 | 63 | 58 | 53 | 48 | 45 | 41 | 37 | 29 | 7 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 30 | 66 | 105 | 143 | 143 | 117 | 90 | 73 | 63 | 57 | 52 | 48 | 42 | 39 | 30 | 18 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 11 | 30 | 77 | 121 | 137 | 114 | 88 | 72 | 63 | 57 | 52 | 44 | 40 | 32 | 25 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 19 | 55 | 111 | 132 | 111 | 87 | 71 | 62 | 56 | 47 | 42 | 34 | 27 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 12 | 51 | 112 | 128 | 108 | 86 | 71 | 62 | 51 | 44 | 36 | 27 |

RAINFALL TYPE = II * * * TC = 0.75 HR * * * SHEET 6 OF 10

## Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL-----HYDROGRAPH TIME(HOURS)-----

| TIME (hr) | 11.3 11.0 | 11.9 11.6 | 12.1 12.0 | 12.3 12.2 | 12.5 12.4 | 12.7 12.6 | 13.0 12.8 | 13.4 13.2 | 13.8 13.6 | 14.3 14.0 | 15.0 14.6 | 16.0 15.5 | 17.0 16.5 | 18.0 17.5 | 20.0 19.0 | 26.0 22.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA/P = 0.10 | | | | | | | * * * TC = 1.0 HR * * * | | | | | | | | IA/P = 0.10 | |
| 0.0 | 11 | 15 | 20 | 29 | 35 | 47 | 72 | 112 | 168 | 231 | 289 | 329 | 357 | 313 | 239 | 175 |
| .10 | 10 | 13 | 17 | 24 | 27 | 33 | 42 | 62 | 95 | 144 | 202 | 260 | 306 | 340 | 293 | 222 |
| .20 | 10 | 13 | 17 | 23 | 26 | 30 | 38 | 54 | 82 | 123 | 176 | 232 | 281 | 332 | 303 | 238 |
| .30 | 9 | 12 | 16 | 22 | 24 | 28 | 35 | 48 | 70 | 105 | 152 | 205 | 256 | 323 | 310 | 254 |
| .40 | 8 | 11 | 14 | 19 | 21 | 23 | 27 | 32 | 42 | 61 | 91 | 132 | 181 | 276 | 318 | 294 |
| .50 | 8 | 10 | 13 | 18 | 20 | 22 | 25 | 30 | 38 | 53 | 78 | 114 | 159 | 253 | 311 | 300 |
| .75 | 7 | 8 | 11 | 14 | 16 | 17 | 19 | 21 | 25 | 30 | 38 | 53 | 76 | 146 | 228 | 284 |
| 1.0 | 5 | 7 | 8 | 11 | 12 | 13 | 14 | 16 | 17 | 19 | 22 | 25 | 31 | 57 | 111 | 188 |
| 1.5 | 4 | 5 | 6 | 8 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 17 | 22 | 33 | 59 |
| 2.0 | 2 | 3 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 12 | 15 | 19 |
| 2.5 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 10 | 12 |
| 3.0 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 6 | 7 | 8 |
| IA/P = 0.30 | | | | | | | * * * TC = 1.0 HR * * * | | | | | | | | IA/P = 0.30 | |
| 0.0 | 0 | 0 | 0 | 0 | 1 | 4 | 16 | 42 | 83 | 137 | 195 | 243 | 271 | 292 | 227 | 178 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 12 | 32 | 66 | 113 | 168 | 218 | 279 | 260 | 213 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 9 | 24 | 52 | 93 | 143 | 193 | 271 | 271 | 225 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 18 | 41 | 75 | 120 | 169 | 246 | 264 | 234 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 14 | 32 | 61 | 100 | 190 | 251 | 259 |
| ,50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 10 | 24 | 49 | 83 | 168 | 237 | 254 |
| ,75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 12 | 25 | 76 | 150 | 213 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 15 | 51 | 113 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 18 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IA/P = 0.50 | | | | | | | * * * TC = 1.0 HR * * * | | | | | | | | IA/P = 0.50 | |
| 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 21 | 42 | 71 | 101 | 126 | 160 | 154 | 138 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 15 | 33 | 58 | 87 | 134 | 156 | 149 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 12 | 26 | 48 | 74 | 123 | 153 | 153 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 9 | 20 | 38 | 62 | 111 | 143 | 150 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 6 | 16 | 31 | 75 | 120 | 145 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 12 | 25 | 64 | 109 | 139 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 12 | 39 | 78 | 115 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 26 | 59 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 9 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| TIME (hr) | 11.3 11.0 | 11.9 11.6 | 12.1 12.0 | 12.3 12.2 | 12.5 12.4 | 12.7 12.6 | 13.0 12.8 | 13.4 13.2 | 13.8 13.6 | 14.3 14.0 | 15.0 14.6 | 16.0 15.5 | 17.0 16.5 | 18.0 17.5 | 20.0 19.0 | 26.0 22.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA/P = 0.10 | | | | | | | * * * TC = 1.0 HR * * * | | | | | | | | IA/P = 0.10 | |
| 0.0 | 133 | 103 | 83 | 63 | 50 | 40 | 33 | 29 | 26 | 23 | 21 | 20 | 17 | 15 | 12 | 0 |
| .10 | 126 | 98 | 72 | 56 | 43 | 35 | 30 | 27 | 24 | 22 | 20 | 18 | 15 | 12 | 0 |
| .20 | 136 | 105 | 76 | 59 | 45 | 35 | 30 | 27 | 24 | 22 | 20 | 18 | 16 | 12 | 1 |
| .30 | 146 | 113 | 81 | 61 | 46 | 36 | 31 | 27 | 24 | 22 | 20 | 18 | 16 | 12 | 1 |
| .40 | 181 | 138 | 95 | 70 | 51 | 39 | 32 | 28 | 25 | 23 | 21 | 18 | 16 | 12 | 1 |
| .50 | 195 | 149 | 102 | 74 | 53 | 40 | 33 | 29 | 25 | 23 | 21 | 18 | 16 | 12 | 1 |
| .75 | 256 | 208 | 143 | 99 | 66 | 46 | 36 | 31 | 27 | 24 | 22 | 19 | 17 | 13 | 2 |
| 1.0 | 286 | 272 | 208 | 144 | 90 | 56 | 41 | 33 | 29 | 26 | 23 | 20 | 17 | 13 | 4 |
| 1.5 | 171 | 231 | 268 | 235 | 157 | 88 | 56 | 41 | 33 | 29 | 25 | 21 | 18 | 14 | 8 |
| 2.0 | 44 | 78 | 157 | 231 | 252 | 167 | 96 | 59 | 42 | 34 | 29 | 23 | 20 | 15 | 11 |
| 2.5 | 19 | 27 | 58 | 120 | 214 | 241 | 159 | 94 | 59 | 42 | 34 | 26 | 21 | 16 | 11 |
| 3.0 | 12 | 14 | 22 | 44 | 113 | 214 | 231 | 152 | 91 | 58 | 42 | 29 | 23 | 17 | 12 |
| IA/P = 0.30 | | | | | | | * * * TC = 1.0 HR * * * | | | | | | | | IA/P = 0.30 | |
| 0.0 | 117 | 98 | 79 | 66 | 55 | 47 | 42 | 38 | 34 | 31 | 30 | 27 | 23 | 19 | 0 |
| .10 | 136 | 113 | 88 | 72 | 59 | 49 | 43 | 39 | 35 | 32 | 30 | 27 | 24 | 19 | 1 |
| .20 | 145 | 119 | 92 | 75 | 60 | 50 | 44 | 39 | 35 | 32 | 30 | 27 | 24 | 19 | 1 |
| .30 | 153 | 125 | 96 | 78 | 62 | 51 | 44 | 40 | 36 | 33 | 31 | 27 | 24 | 19 | 1 |
| .40 | 181 | 146 | 109 | 86 | 67 | 53 | 46 | 41 | 37 | 33 | 31 | 28 | 25 | 19 | 2 |
| ,50 | 191 | 155 | 115 | 90 | 69 | 54 | 47 | 42 | 37 | 34 | 31 | 28 | 25 | 19 | 2 |
| ,75 | 228 | 198 | 149 | 112 | 82 | 61 | 50 | 44 | 39 | 35 | 32 | 29 | 26 | 20 | 4 |
| 1.0 | 226 | 234 | 197 | 150 | 104 | 72 | 56 | 47 | 42 | 38 | 34 | 30 | 27 | 20 | 7 |
| 1.5 | 104 | 162 | 220 | 210 | 158 | 102 | 71 | 56 | 47 | 42 | 37 | 31 | 28 | 22 | 13 |
| 2.0 | 20 | 49 | 121 | 187 | 209 | 152 | 100 | 70 | 55 | 47 | 41 | 34 | 29 | 23 | 17 |
| 2.5 | 2 | 7 | 32 | 87 | 171 | 199 | 146 | 98 | 69 | 54 | 46 | 37 | 31 | 24 | 18 |
| 3.0 | 0 | 0 | 2 | 13 | 62 | 158 | 192 | 151 | 103 | 73 | 56 | 41 | 34 | 26 | 18 |
| IA/P = 0.50 | | | | | | | * * * TC = 1.0 HR * * * | | | | | | | | IA/P = 0.50 | |
| 0.0 | 110 | 100 | 87 | 77 | 67 | 60 | 55 | 50 | 46 | 43 | 41 | 38 | 34 | 28 | 1 |
| .10 | 120 | 108 | 93 | 82 | 71 | 62 | 57 | 52 | 47 | 44 | 42 | 38 | 34 | 28 | 1 |
| .20 | 123 | 111 | 95 | 84 | 72 | 63 | 57 | 52 | 47 | 44 | 42 | 38 | 34 | 28 | 1 |
| .30 | 127 | 114 | 98 | 86 | 73 | 63 | 58 | 53 | 48 | 45 | 42 | 39 | 35 | 28 | 1 |
| .40 | 137 | 123 | 106 | 91 | 77 | 66 | 59 | 54 | 49 | 45 | 43 | 39 | 35 | 29 | 2 |
| .50 | 139 | 127 | 108 | 94 | 79 | 67 | 60 | 55 | 50 | 46 | 43 | 39 | 36 | 29 | 3 |
| .75 | 140 | 134 | 117 | 101 | 84 | 70 | 62 | 56 | 51 | 47 | 44 | 40 | 36 | 29 | 4 |
| 1.0 | 125 | 139 | 133 | 117 | 97 | 78 | 66 | 59 | 54 | 49 | 46 | 41 | 37 | 29 | 8 |
| 1.5 | 54 | 86 | 123 | 133 | 119 | 95 | 77 | 66 | 59 | 54 | 49 | 43 | 39 | 31 | 17 |
| 2.0 | 10 | 25 | 64 | 104 | 129 | 116 | 93 | 76 | 65 | 58 | 53 | 45 | 41 | 33 | 24 |
| 2.5 | 0 | 2 | 10 | 34 | 84 | 125 | 117 | 96 | 78 | 66 | 59 | 49 | 43 | 35 | 27 |
| 3.0 | 0 | 0 | 1 | 6 | 32 | 89 | 122 | 114 | 94 | 77 | 66 | 53 | 45 | 37 | 27 |

RAINFALL TYPE = II * * * TC = 1.0 HR * * * SHEET 7 OF 10

REFERENCE 4

## Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution —continued

TRVL----------HYDROGRAPH TIME(HOURS)----------

| TIME (hr) | 11.0 | 11.3 | 11.6 | 11.9 | 12.0 | 12.1 | 12.2 | 12.3 | 12.4 | 12.5 | 12.6 | 12.7 | 12.8 | 13.0 | 13.2 | 13.4 | 13.6 | 13.8 | 14.0 | 14.3 | 14.6 | 15.0 | 15.5 | 16.0 | 16.5 | 17.0 | 17.5 | 18.0 | 19.0 | 20.0 | 22.0 | 26.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA/P = 0.10 | | | | | | | | | | | | | * * * TC = 1.25 HR * * * | | | | | | | | | | | | | | | | IA/P = 0.10 | | | |
| 0.0 | 10 | 13 | 18 | 25 | 29 | 38 | 54 | 81 | 118 | 163 | 213 | 256 | 284 | 311 | 266 | 212 | 163 | 129 | 104 | 78 | 61 | 47 | 37 | 31 | 27 | 24 | 22 | 20 | 18 | 16 | 12 | 1 |
| .10 | 10 | 13 | 17 | 23 | 27 | 34 | 47 | 69 | 102 | 143 | 189 | 234 | 267 | 297 | 274 | 226 | 175 | 138 | 111 | 82 | 64 | 48 | 38 | 31 | 27 | 24 | 22 | 20 | 18 | 16 | 12 | 1 |
| .20 | 9 | 11 | 15 | 20 | 22 | 26 | 31 | 42 | 60 | 88 | 124 | 168 | 212 | 280 | 292 | 261 | 212 | 166 | 131 | 95 | 72 | 53 | 40 | 33 | 28 | 25 | 23 | 21 | 18 | 16 | 12 | 1 |
| .30 | 8 | 11 | 14 | 19 | 21 | 24 | 29 | 38 | 53 | 76 | 108 | 148 | 190 | 263 | 288 | 268 | 224 | 177 | 140 | 101 | 76 | 55 | 41 | 34 | 29 | 25 | 23 | 21 | 18 | 16 | 12 | 2 |
| .40 | 8 | 10 | 13 | 18 | 20 | 23 | 27 | 34 | 46 | 66 | 94 | 130 | 170 | 245 | 282 | 273 | 235 | 188 | 149 | 107 | 80 | 58 | 42 | 34 | 29 | 26 | 23 | 21 | 19 | 16 | 12 | 2 |
| .50 | 7 | 9 | 12 | 16 | 17 | 19 | 22 | 25 | 31 | 41 | 58 | 82 | 114 | 190 | 256 | 279 | 262 | 222 | 178 | 127 | 93 | 65 | 46 | 36 | 31 | 27 | 24 | 22 | 19 | 17 | 13 | 2 |
| .75 | 6 | 8 | 10 | 14 | 15 | 17 | 19 | 21 | 25 | 31 | 41 | 56 | 78 | 139 | 207 | 254 | 265 | 245 | 208 | 152 | 110 | 75 | 51 | 39 | 32 | 28 | 25 | 22 | 19 | 17 | 13 | 3 |
| 1.0 | 5 | 6 | 8 | 10 | 11 | 13 | 14 | 15 | 17 | 19 | 22 | 26 | 33 | 60 | 109 | 173 | 230 | 261 | 255 | 208 | 153 | 100 | 64 | 46 | 36 | 30 | 26 | 24 | 20 | 18 | 13 | 5 |
| 1.5 | 3 | 4 | 5 | 7 | 7 | 8 | 9 | 9 | 10 | 11 | 12 | 13 | 15 | 19 | 27 | 45 | 79 | 130 | 186 | 247 | 239 | 180 | 108 | 68 | 48 | 37 | 31 | 27 | 22 | 19 | 14 | 10 |
| 2.0 | 2 | 3 | 4 | 5 | 6 | 6 | 7 | 7 | 8 | 8 | 9 | 10 | 11 | 13 | 16 | 22 | 35 | 59 | 98 | 171 | 236 | 236 | 156 | 95 | 62 | 44 | 35 | 30 | 23 | 20 | 15 | 11 |
| 2.5 | 1 | 2 | 2 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 6 | 6 | 7 | 8 | 10 | 12 | 14 | 19 | 28 | 58 | 114 | 197 | 226 | 163 | 102 | 65 | 46 | 36 | 26 | 21 | 16 | 11 |
| 3.0 | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 6 | 7 | 9 | 10 | 13 | 19 | 35 | 88 | 184 | 218 | 169 | 109 | 70 | 49 | 31 | 24 | 18 | 12 |
| IA/P = 0.30 | | | | | | | | | | | | | * * * TC = 1.25 HR * * * | | | | | | | | | | | | | | | | IA/P = 0.30 | | | |
| 0.0 | 0 | 0 | 0 | 0 | 0 | 2 | 9 | 25 | 50 | 86 | 130 | 174 | 208 | 253 | 235 | 201 | 164 | 136 | 115 | 92 | 76 | 61 | 51 | 44 | 39 | 35 | 32 | 30 | 27 | 24 | 19 | 1 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 19 | 40 | 71 | 110 | 153 | 217 | 247 | 227 | 191 | 157 | 131 | 103 | 84 | 66 | 53 | 46 | 41 | 36 | 33 | 31 | 28 | 24 | 19 | 2 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 14 | 31 | 58 | 93 | 133 | 202 | 239 | 231 | 199 | 165 | 138 | 108 | 87 | 68 | 55 | 47 | 41 | 37 | 33 | 31 | 28 | 25 | 19 | 2 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 10 | 24 | 46 | 77 | 152 | 210 | 236 | 222 | 190 | 158 | 122 | 97 | 74 | 58 | 49 | 43 | 38 | 34 | 32 | 28 | 25 | 20 | 3 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 19 | 37 | 64 | 134 | 196 | 232 | 225 | 198 | 166 | 127 | 101 | 77 | 59 | 50 | 43 | 38 | 35 | 32 | 28 | 25 | 20 | 3 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 6 | 14 | 30 | 82 | 151 | 206 | 228 | 217 | 189 | 146 | 113 | 85 | 64 | 52 | 45 | 40 | 36 | 33 | 29 | 26 | 20 | 5 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 7 | 15 | 49 | 105 | 164 | 205 | 218 | 205 | 166 | 129 | 95 | 69 | 55 | 47 | 41 | 37 | 33 | 29 | 26 | 20 | 6 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 32 | 77 | 134 | 185 | 214 | 203 | 166 | 120 | 83 | 63 | 52 | 45 | 39 | 35 | 30 | 27 | 21 | 10 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 11 | 33 | 72 | 121 | 184 | 203 | 171 | 117 | 82 | 62 | 51 | 44 | 39 | 32 | 29 | 22 | 15 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 21 | 67 | 132 | 194 | 174 | 123 | 86 | 64 | 52 | 45 | 35 | 31 | 24 | 18 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 13 | 46 | 121 | 187 | 166 | 119 | 84 | 63 | 52 | 39 | 32 | 25 | 18 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 44 | 129 | 180 | 160 | 116 | 83 | 63 | 44 | 35 | 27 | 18 |
| IA/P = 0.50 | | | | | | | | | | | | | * * * TC = 1.25 HR * * * | | | | | | | | | | | | | | | | IA/P = 0.50 | | | |
| 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 13 | 26 | 44 | 68 | 91 | 125 | 142 | 142 | 128 | 117 | 107 | 94 | 83 | 72 | 63 | 57 | 52 | 47 | 44 | 42 | 38 | 34 | 28 | 2 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 10 | 20 | 36 | 57 | 100 | 129 | 140 | 136 | 125 | 114 | 100 | 88 | 76 | 65 | 59 | 54 | 49 | 45 | 43 | 39 | 35 | 29 | 3 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 16 | 30 | 48 | 90 | 122 | 139 | 139 | 127 | 117 | 102 | 90 | 77 | 66 | 60 | 54 | 49 | 45 | 43 | 39 | 35 | 29 | 3 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 12 | 24 | 59 | 98 | 126 | 137 | 134 | 125 | 109 | 96 | 82 | 69 | 61 | 56 | 51 | 46 | 44 | 40 | 36 | 29 | 4 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 10 | 19 | 51 | 89 | 119 | 134 | 136 | 127 | 112 | 98 | 83 | 70 | 62 | 56 | 51 | 47 | 44 | 40 | 36 | 29 | 5 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 15 | 43 | 79 | 112 | 131 | 135 | 129 | 114 | 100 | 85 | 71 | 63 | 57 | 52 | 47 | 44 | 40 | 36 | 29 | 6 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 15 | 39 | 71 | 102 | 123 | 130 | 125 | 112 | 94 | 78 | 67 | 60 | 54 | 49 | 46 | 41 | 37 | 29 | 9 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 17 | 40 | 71 | 101 | 121 | 129 | 121 | 103 | 84 | 71 | 62 | 56 | 51 | 47 | 42 | 38 | 30 | 13 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 10 | 26 | 51 | 92 | 119 | 125 | 105 | 86 | 72 | 63 | 57 | 52 | 44 | 40 | 32 | 23 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 11 | 35 | 72 | 112 | 122 | 103 | 85 | 71 | 63 | 56 | 47 | 42 | 34 | 26 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 24 | 66 | 111 | 119 | 101 | 83 | 71 | 62 | 51 | 44 | 36 | 27 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 23 | 71 | 110 | 116 | 99 | 82 | 70 | 55 | 46 | 37 | 27 |

RAINFALL TYPE = II * * * TC = 1.25 HR * * * SHEET 8 OF 10

## Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL----------HYDROGRAPH TIME(HOURS)----------

| TIME (hr) | 11.3 11.0 | 11.9 11.6 | 12.1 12.0 | 12.3 12.2 | 12.5 12.4 | 12.7 12.6 | 13.0 12.8 | 13.4 13.2 | 13.8 13.6 | 14.3 14.0 | 15.0 14.6 | 16.0 15.5 | 17.0 16.5 | 18.0 17.5 | 20.0 19.0 | 26.0 22.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA/P = 0.10 | | | | | | | * * * TC = 1.5 HR * * * | | | | | | | | IA/P = 0.10 | |
| 0.0 | 9 | 11 | 15 | 21 | 25 | 31 | 41 | 58 | 82 | 112 | 147 | 184 | 216 | 255 | 275 | 236 |
| .10 | 8 | 10 | 13 | 18 | 20 | 23 | 28 | 37 | 51 | 72 | 98 | 131 | 166 | 226 | 265 | 254 |
| .20 | 8 | 10 | 13 | 17 | 19 | 22 | 26 | 33 | 45 | 63 | 87 | 116 | 149 | 212 | 259 | 259 |
| .30 | 7 | 9 | 12 | 16 | 18 | 21 | 24 | 30 | 40 | 55 | 76 | 103 | 134 | 197 | 244 | 255 |
| .40 | 7 | 8 | 11 | 14 | 15 | 17 | 19 | 23 | 28 | 36 | 49 | 67 | 91 | 151 | 208 | 247 |
| .50 | 6 | 8 | 10 | 13 | 15 | 16 | 18 | 21 | 26 | 33 | 43 | 59 | 80 | 136 | 194 | 238 |
| .75 | 5 | 7 | 8 | 11 | 12 | 13 | 14 | 16 | 18 | 21 | 25 | 32 | 42 | 76 | 125 | 179 |
| 1.0 | 4 | 5 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 16 | 18 | 22 | 34 | 59 | 101 |
| 1.5 | 3 | 4 | 5 | 6 | 6 | 7 | 8 | 8 | 9 | 10 | 11 | 12 | 13 | 16 | 22 | 34 |
| 2.0 | 1 | 2 | 3 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 10 | 12 | 16 |
| 2.5 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 6 | 7 | 8 | 9 |
| 3.0 | 0 | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 4 | 5 | 5 | 6 |
| IA/P = 0.30 | | | | | | | * * * TC = 1.5 HR * * * | | | | | | | | IA/P = 0.30 | |
| 0.0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 15 | 31 | 53 | 80 | 112 | 144 | 193 | 225 | 208 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 12 | 25 | 43 | 68 | 97 | 157 | 198 | 219 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 9 | 19 | 35 | 57 | 114 | 168 | 201 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 7 | 15 | 29 | 48 | 100 | 155 | 193 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 12 | 23 | 39 | 87 | 141 | 184 |
| ,50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 9 | 18 | 51 | 101 | 153 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 9 | 30 | 68 | 116 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 20 | 49 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| IA/P = 0.50 | | | | | | | * * * TC = 1.5 HR * * * | | | | | | | | IA/P = 0.50 | |
| .0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 8 | 16 | 27 | 42 | 59 | 92 | 116 | 128 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 6 | 12 | 22 | 35 | 51 | 84 | 110 | 125 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 10 | 18 | 29 | 60 | 91 | 114 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 14 | 24 | 52 | 83 | 108 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | 12 | 31 | 60 | 90 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 9 | 26 | 53 | 83 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 16 | 36 | 62 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 10 | 26 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| TIME (hr) | 13.0 13.4 | 13.8 14.3 | 14.6 15.5 | 16.5 17.5 | 19.0 22.0 |
|---|---|---|---|---|---|
| IA/P = 0.10 | | | | | |
| 0.0 | 198 | 159 | 129 | 98 | 76 |
| .10 | 226 | 187 | 151 | 113 | 86 |
| .20 | 233 | 197 | 160 | 119 | 90 |
| .30 | 238 | 206 | 169 | 125 | 95 |
| .40 | 252 | 230 | 196 | 146 | 109 |
| .50 | 249 | 235 | 204 | 154 | 115 |
| .75 | 222 | 240 | 233 | 193 | 148 |
| 1.0 | 152 | 201 | 236 | 230 | 193 |
| 1.5 | 58 | 95 | 141 | 203 | 226 |
| 2.0 | 22 | 34 | 56 | 110 | 172 |
| 2.5 | 11 | 14 | 18 | 34 | 69 |
| 3.0 | 8 | 9 | 11 | 16 | 27 |
| IA/P = 0.30 | | | | | |
| 0.0 | 186 | 157 | 134 | 108 | 89 |
| .10 | 203 | 178 | 151 | 120 | 98 |
| .20 | 213 | 196 | 171 | 135 | 108 |
| .30 | 210 | 200 | 177 | 140 | 113 |
| .40 | 207 | 202 | 182 | 146 | 117 |
| ,50 | 190 | 205 | 197 | 164 | 131 |
| .75 | 160 | 189 | 197 | 179 | 147 |
| 1.0 | 92 | 138 | 175 | 195 | 178 |
| 1.5 | 21 | 47 | 85 | 145 | 187 |
| 2.0 | 1 | 4 | 13 | 45 | 97 |
| 2.5 | 0 | 0 | 1 | 8 | 31 |
| 3.0 | 0 | 0 | 0 | 1 | 5 |
| IA/P = 0.50 | | | | | |
| .0 | 130 | 121 | 112 | 100 | 90 |
| .10 | 128 | 123 | 114 | 102 | 91 |
| .20 | 126 | 128 | 120 | 108 | 97 |
| .30 | 123 | 126 | 122 | 110 | 98 |
| .40 | 112 | 124 | 126 | 116 | 104 |
| .50 | 106 | 121 | 125 | 118 | 106 |
| .75 | 88 | 108 | 119 | 122 | 112 |
| 1.0 | 49 | 75 | 98 | 118 | 121 |
| 1.5 | 11 | 25 | 45 | 80 | 107 |
| 2.0 | 1 | 4 | 11 | 32 | 63 |
| 2.5 | 0 | 0 | 1 | 4 | 16 |
| 3.0 | 0 | 0 | 0 | 0 | 3 |

| TIME (hr) | 18.0 17.5 | 20.0 19.0 | 26.0 22.0 |
|---|---|---|---|
| IA/P = 0.10 | | | |
| 0.0 | 57 | 43 | 35 | 30 | 25 | 23 | 21 | 18 | 16 | 12 | 1 |
| .10 | 63 | 46 | 37 | 31 | 26 | 23 | 21 | 19 | 16 | 13 | 2 |
| .20 | 66 | 48 | 38 | 32 | 27 | 24 | 22 | 19 | 16 | 13 | 2 |
| .30 | 68 | 49 | 38 | 32 | 27 | 24 | 22 | 19 | 17 | 13 | 2 |
| .40 | 77 | 54 | 41 | 34 | 29 | 25 | 22 | 19 | 17 | 13 | 3 |
| .50 | 81 | 56 | 42 | 34 | 29 | 25 | 23 | 20 | 17 | 13 | 3 |
| .75 | 102 | 67 | 48 | 38 | 32 | 27 | 24 | 20 | 18 | 13 | 5 |
| 1.0 | 135 | 86 | 59 | 44 | 35 | 30 | 26 | 21 | 18 | 14 | 7 |
| 1.5 | 197 | 131 | 84 | 58 | 43 | 35 | 29 | 23 | 20 | 15 | 10 |
| 2.0 | 218 | 187 | 126 | 82 | 57 | 43 | 34 | 25 | 21 | 16 | 11 |
| 2.5 | 141 | 210 | 190 | 133 | 87 | 60 | 44 | 30 | 23 | 17 | 12 |
| 3.0 | 66 | 149 | 204 | 181 | 128 | 85 | 58 | 35 | 25 | 18 | 12 |
| IA/P = 0.30 | | | | | | | | | | | |
| 0.0 | 70 | 56 | 48 | 42 | 37 | 34 | 31 | 28 | 25 | 20 | 2 |
| .10 | 77 | 60 | 50 | 44 | 38 | 35 | 32 | 28 | 25 | 20 | 3 |
| .20 | 84 | 64 | 53 | 46 | 40 | 36 | 33 | 29 | 26 | 20 | 4 |
| .30 | 87 | 66 | 54 | 46 | 41 | 36 | 33 | 29 | 26 | 20 | 5 |
| .40 | 89 | 68 | 55 | 47 | 41 | 36 | 33 | 29 | 26 | 20 | 5 |
| ,50 | 99 | 73 | 58 | 49 | 43 | 38 | 34 | 30 | 26 | 20 | 7 |
| .75 | 110 | 80 | 62 | 52 | 45 | 39 | 35 | 30 | 27 | 21 | 8 |
| 1.0 | 137 | 97 | 72 | 57 | 48 | 42 | 37 | 31 | 28 | 21 | 12 |
| 1.5 | 178 | 133 | 95 | 71 | 57 | 48 | 42 | 34 | 29 | 23 | 16 |
| 2.0 | 162 | 180 | 138 | 99 | 74 | 58 | 49 | 38 | 32 | 25 | 18 |
| 2.5 | 89 | 161 | 174 | 133 | 97 | 72 | 58 | 42 | 34 | 26 | 18 |
| 3.0 | 29 | 98 | 160 | 169 | 129 | 95 | 71 | 48 | 37 | 28 | 19 |
| IA/P = 0.50 | | | | | | | | | | | |
| .0 | 78 | 67 | 60 | 55 | 50 | 46 | 43 | 39 | 35 | 29 | 4 |
| .10 | 79 | 68 | 61 | 55 | 50 | 46 | 43 | 39 | 35 | 29 | 4 |
| .20 | 83 | 71 | 63 | 57 | 52 | 47 | 44 | 40 | 36 | 29 | 5 |
| .30 | 85 | 72 | 63 | 57 | 52 | 48 | 44 | 40 | 36 | 29 | 6 |
| .40 | 90 | 75 | 66 | 59 | 54 | 49 | 45 | 41 | 37 | 29 | 8 |
| .50 | 91 | 77 | 67 | 60 | 54 | 49 | 46 | 41 | 37 | 29 | 8 |
| .75 | 97 | 81 | 69 | 62 | 56 | 51 | 47 | 42 | 38 | 30 | 11 |
| 1.0 | 108 | 90 | 76 | 66 | 59 | 54 | 49 | 43 | 39 | 31 | 16 |
| 1.5 | 118 | 106 | 89 | 75 | 65 | 59 | 53 | 45 | 41 | 32 | 23 |
| 2.0 | 100 | 115 | 104 | 87 | 74 | 65 | 58 | 48 | 42 | 34 | 26 |
| 2.5 | 48 | 94 | 113 | 105 | 89 | 76 | 66 | 53 | 45 | 36 | 27 |
| 3.0 | 15 | 54 | 96 | 111 | 103 | 88 | 75 | 58 | 48 | 38 | 28 |

RAINFALL TYPE = II * * * TC = 1.5 HR * * * SHEET 9 OF 10

## Exhibit 5-II: Tabular hydrograph unit discharges (csm/in) for type II rainfall distribution—continued

TRVL----------HYDROGRAPH TIME(HOURS)----------

| TIME (hr) | 11.0 | 11.3 | 11.6 | 11.9 | 12.0 | 12.1 | 12.2 | 12.3 | 12.4 | 12.5 | 12.6 | 12.7 | 12.8 | 13.0 | 13.2 | 13.4 | 13.6 | 13.8 | 14.0 | 14.3 | 14.6 | 15.0 | 15.5 | 16.0 | 16.5 | 17.0 | 17.5 | 18.0 | 19.0 | 20.0 | 22.0 | 26.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IA/P = 0.10 | | | | | | | | | | | | * * * TC = 2.0 HR * * * | | | | | | | | | | | | | | | | IA/P = 0.10 | | | | |
| 0.0 | 7 | 9 | 12 | 16 | 18 | 21 | 27 | 36 | 49 | 64 | 82 | 104 | 127 | 171 | 201 | 226 | 208 | 193 | 171 | 132 | 105 | 79 | 58 | 45 | 36 | 30 | 26 | 23 | 20 | 17 | 13 | 3 |
| .10 | 6 | 8 | 10 | 14 | 15 | 17 | 20 | 25 | 33 | 43 | 57 | 74 | 94 | 139 | 179 | 204 | 218 | 205 | 188 | 150 | 118 | 88 | 63 | 48 | 38 | 32 | 27 | 24 | 20 | 17 | 13 | 4 |
| .20 | 6 | 8 | 10 | 13 | 14 | 16 | 19 | 23 | 29 | 39 | 51 | 66 | 84 | 128 | 169 | 198 | 213 | 207 | 192 | 157 | 123 | 91 | 65 | 49 | 39 | 33 | 28 | 24 | 20 | 17 | 13 | 4 |
| .30 | 6 | 7 | 9 | 12 | 14 | 15 | 18 | 21 | 27 | 35 | 45 | 59 | 76 | 117 | 159 | 191 | 211 | 208 | 196 | 163 | 128 | 95 | 68 | 51 | 40 | 33 | 28 | 25 | 20 | 18 | 13 | 4 |
| .40 | 5 | 6 | 8 | 11 | 12 | 13 | 15 | 17 | 20 | 24 | 31 | 41 | 53 | 87 | 128 | 167 | 197 | 209 | 205 | 180 | 145 | 106 | 75 | 55 | 43 | 35 | 30 | 26 | 21 | 18 | 14 | 5 |
| .50 | 5 | 6 | 8 | 10 | 11 | 13 | 14 | 16 | 18 | 22 | 28 | 37 | 48 | 78 | 118 | 158 | 190 | 208 | 208 | 185 | 151 | 111 | 77 | 57 | 44 | 36 | 30 | 26 | 21 | 18 | 14 | 5 |
| .75 | 4 | 6 | 7 | 9 | 10 | 11 | 12 | 13 | 15 | 18 | 22 | 27 | 35 | 58 | 91 | 129 | 164 | 191 | 202 | 194 | 167 | 125 | 87 | 63 | 48 | 38 | 32 | 27 | 22 | 18 | 14 | 6 |
| 1.0 | 3 | 4 | 6 | 7 | 8 | 8 | 9 | 10 | 11 | 12 | 14 | 16 | 18 | 28 | 46 | 74 | 110 | 147 | 178 | 201 | 193 | 156 | 108 | 76 | 56 | 43 | 35 | 30 | 23 | 19 | 14 | 8 |
| 1.5 | 2 | 3 | 3 | 5 | 5 | 5 | 6 | 6 | 7 | 8 | 8 | 9 | 10 | 12 | 16 | 23 | 36 | 57 | 86 | 137 | 178 | 195 | 160 | 113 | 79 | 58 | 45 | 36 | 26 | 21 | 16 | 11 |
| 2.0 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 5 | 5 | 6 | 6 | 7 | 8 | 10 | 12 | 16 | 23 | 35 | 67 | 112 | 169 | 190 | 154 | 110 | 78 | 57 | 44 | 30 | 23 | 17 | 11 |
| 2.5 | 0 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 5 | 6 | 7 | 8 | 9 | 12 | 16 | 28 | 52 | 105 | 170 | 185 | 149 | 107 | 76 | 56 | 35 | 26 | 18 | 12 |
| 3.0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 4 | 5 | 6 | 7 | 8 | 12 | 18 | 41 | 99 | 161 | 180 | 152 | 112 | 80 | 45 | 30 | 19 | 12 |
| IA/P = 0.30 | | | | | | | | | | | | * * * TC = 2.0 HR * * * | | | | | | | | | | | | | | | | IA/P = 0.30 | | | | |
| 0.0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 8 | 15 | 25 | 38 | 54 | 74 | 115 | 148 | 168 | 185 | 170 | 159 | 131 | 110 | 89 | 70 | 57 | 49 | 42 | 38 | 34 | 29 | 26 | 20 | 5 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 6 | 12 | 21 | 32 | 47 | 85 | 124 | 153 | 169 | 180 | 168 | 145 | 120 | 96 | 75 | 60 | 51 | 44 | 39 | 35 | 30 | 26 | 20 | 6 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 10 | 17 | 27 | 41 | 75 | 114 | 146 | 165 | 175 | 170 | 149 | 124 | 99 | 76 | 62 | 52 | 45 | 39 | 35 | 30 | 27 | 21 | 6 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 7 | 14 | 23 | 49 | 86 | 122 | 151 | 170 | 174 | 160 | 136 | 107 | 82 | 66 | 54 | 47 | 41 | 37 | 31 | 27 | 21 | 8 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 6 | 11 | 19 | 43 | 77 | 113 | 144 | 165 | 173 | 163 | 140 | 111 | 85 | 67 | 55 | 47 | 41 | 37 | 31 | 27 | 21 | 8 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 4 | 9 | 16 | 37 | 68 | 104 | 136 | 160 | 171 | 165 | 144 | 114 | 87 | 69 | 56 | 48 | 42 | 37 | 31 | 27 | 21 | 9 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 15 | 34 | 62 | 96 | 127 | 152 | 167 | 160 | 132 | 100 | 77 | 62 | 52 | 45 | 40 | 32 | 28 | 22 | 11 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 10 | 24 | 48 | 79 | 111 | 150 | 166 | 153 | 118 | 90 | 71 | 58 | 49 | 43 | 34 | 29 | 23 | 14 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 10 | 24 | 45 | 88 | 130 | 161 | 148 | 115 | 88 | 70 | 57 | 48 | 37 | 31 | 24 | 17 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 10 | 32 | 68 | 122 | 157 | 143 | 113 | 87 | 68 | 56 | 42 | 34 | 26 | 18 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 16 | 51 | 114 | 153 | 144 | 116 | 89 | 70 | 49 | 38 | 27 | 19 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 15 | 59 | 118 | 150 | 140 | 113 | 88 | 57 | 42 | 29 | 19 |
| IA/P = 0.50 | | | | | | | | | | | | * * * TC = 2.0 HR * * * | | | | | | | | | | | | | | | | IA/P = 0.50 | | | | |
| 0.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 8 | 13 | 20 | 28 | 51 | 73 | 92 | 104 | 111 | 112 | 106 | 97 | 86 | 75 | 66 | 60 | 54 | 49 | 46 | 41 | 37 | 30 | 7 |
| .10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 6 | 11 | 17 | 24 | 45 | 68 | 87 | 101 | 109 | 112 | 107 | 98 | 88 | 76 | 67 | 60 | 55 | 50 | 46 | 41 | 37 | 30 | 8 |
| .20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 9 | 14 | 21 | 40 | 62 | 82 | 98 | 107 | 111 | 108 | 100 | 89 | 77 | 68 | 61 | 55 | 50 | 47 | 41 | 37 | 30 | 8 |
| .30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 7 | 12 | 26 | 46 | 67 | 86 | 100 | 108 | 111 | 104 | 93 | 80 | 70 | 63 | 57 | 52 | 48 | 42 | 38 | 30 | 10 |
| .40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 6 | 10 | 22 | 41 | 62 | 81 | 96 | 106 | 110 | 105 | 94 | 81 | 71 | 63 | 57 | 52 | 48 | 42 | 38 | 30 | 11 |
| .50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 4 | 13 | 27 | 46 | 67 | 85 | 99 | 110 | 108 | 98 | 85 | 74 | 66 | 59 | 54 | 49 | 43 | 39 | 31 | 13 |
| .75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 7 | 18 | 33 | 52 | 71 | 88 | 104 | 108 | 102 | 89 | 77 | 68 | 61 | 55 | 50 | 44 | 39 | 31 | 15 |
| 1.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 13 | 25 | 43 | 62 | 87 | 103 | 108 | 97 | 84 | 73 | 65 | 59 | 53 | 45 | 41 | 32 | 20 |
| 1.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 12 | 24 | 48 | 74 | 99 | 106 | 95 | 83 | 72 | 64 | 58 | 48 | 43 | 34 | 25 |
| 2.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 17 | 37 | 69 | 99 | 104 | 94 | 82 | 72 | 64 | 52 | 45 | 36 | 27 |
| 2.5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 27 | 65 | 95 | 102 | 95 | 83 | 73 | 58 | 49 | 38 | 28 |
| 3.0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 | 32 | 68 | 95 | 101 | 93 | 82 | 64 | 52 | 40 | 28 |

RAINFALL TYPE = II * * * TC = 2.0 HR * * * SHEET 10 OF 10

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# Fluid Mechanics

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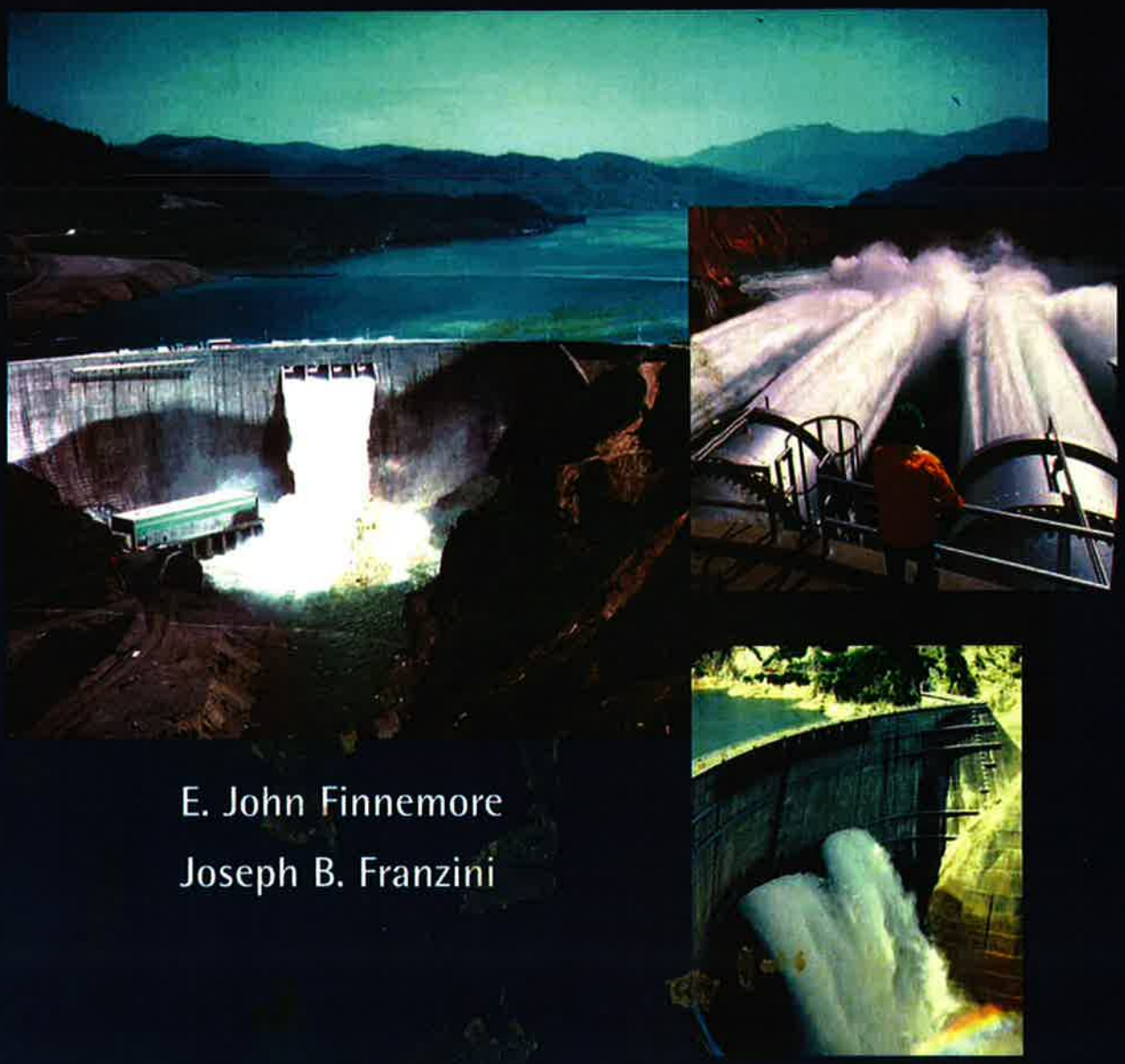

E. John Finnemore

Joseph B. Franzini

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# CHAPTER 10
# Steady Flow in Open Channels

## 10.1 OPEN CHANNELS

An open channel is one in which the stream is not completely enclosed by solid boundaries and therefore has a free surface subjected only to atmospheric pressure. The flow in such a channel is caused not by some external head, but rather only by the gravity component along the slope of the channel. Thus we often refer to open-channel flow as ***free-surface flow*** or ***gravity flow.*** This chapter will deal only with *steady* flow in open channels.

The principal types of open channel are natural streams and rivers; artificial canals; and sewers, tunnels, and pipelines flowing not completely full. Artificial canals may be built to convey water for purposes of water-power development, irrigation or city water supply, and drainage or flood control and for numerous other purposes. While there are examples of open channels carrying liquids other than water, few experimental data exist for such, and the numerical coefficients given here apply only to water at natural temperatures.

For convenience in dealing with large channel systems, we often divide them into reaches. A ***reach*** is a continuous stretch of a waterway, often chosen to have reasonably uniform properties like cross section, slope, and discharge.

The accurate solution of problems of flow in open channels is more challenging than in the case of pressure pipes. Not only are reliable experimental data more difficult to secure, but we meet a wider range of conditions than we do with pipes. Practically all pipes are round, but the cross sections of open channels can be of any shape, from circular to the irregular forms of natural streams. In pipes the degree of roughness ordinarily ranges from that of new smooth metal, on the one hand, to that of old corroded iron or steel pipes, on the other. But with open channels the surfaces vary from smooth timber or concrete to the rough or irregular beds of some rivers. Hence the friction coefficients to be used are more uncertain with open channels than with pipes.

We described uniform flow in Sec. 4.3 as it applies to hydraulic phenomena in general. In the case of open channels uniform flow means that the water cross section and depth remain constant over a certain reach of the channel as well as over time. This requires that the drop in potential energy due to the fall in elevation along the channel be exactly that consumed by the energy dissipation through boundary friction and turbulence.

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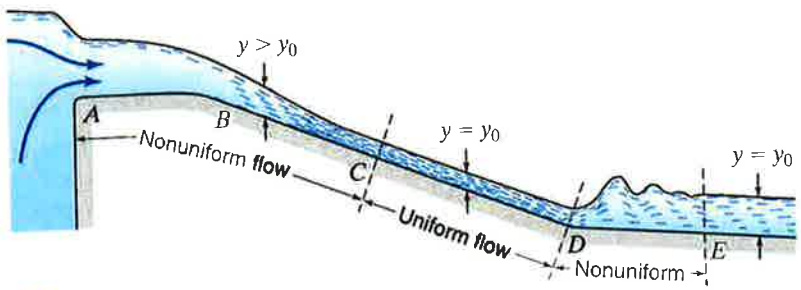


**Figure 10.1**
**Steady flow down a chute or spillway.**

Uniform flow is an equilibrium condition that flow tends to if the channel is sufficiently long with constant slope, cross section, and roughness. We can state this in another way: For any channel of given roughness, cross section, and slope, there exists for a given flow rate one and only one water depth, $y_0$, at which the flow will be uniform. Thus, in Fig. 10.1, the flow is accelerating in the reach from $A$ to $C$, becomes established as uniform flow from $C$ to $D$, suffers a violent deceleration due to the change of slope between $D$ and $E$, and finally achieves a new depth of uniform flow somewhere beyond $E$. Acceleration occurs in the reach from $B$ to $C$ because the gravity component along the slope is greater than the boundary shear resistance. As the flow accelerates, the boundary shear increases because of the increase in velocity, until at $C$ the boundary shear resistance becomes equal to the gravity component along the slope. Beyond $C$ there is no acceleration, the velocity is constant, and the flow is uniform. We commonly refer to the depth in uniform flow as the ***normal depth,*** $y_0$.

Open-channel flow is usually fully rough; that is, it occurs at high Reynolds numbers. For open channels we define the Reynolds number by $\mathbf{R} = R_h V/\nu$, where $R_h$ is the hydraulic radius (Sec. 8.3). Since $R_h = D/4$, the critical value of Reynolds number at which the changeover occurs from laminar flow to turbulent flow in open channels is 500, whereas in pressure conduits the critical value is 2000.

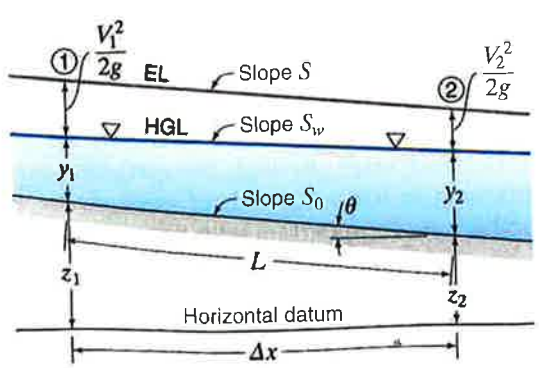


**Figure 10.2**
Open-channel flow—definition sketch.

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In open-channel flow (Fig. 10.2) we refer to the channel ***bed slope*** $S_0$, the ***water surface slope*** $S_w$, and the slope of the energy line or the ***energy gradient*** $S$. It is quite evident that for open-channel flow the hydraulic grade line coincides with the water surface, provided there is no unusual curvature in the streamlines or stream tubes, for if we attach a piezometer tube to the side of the channel, the water will rise in it until its surface is level with the water surface in the channel at that point. We always measure water depth $y$ vertically, and we usually define the distance between sections as the horizontal distance $\Delta x$ between them. As a result, we define the three slopes just mentioned as

$$S_0 = \frac{z_1 - z_2}{\Delta x} = -\frac{\Delta z}{\Delta x} \tag{10.1}$$

$$S_w = \frac{(z_1 + y_1) - (z_2 + y_2)}{\Delta x} = -\frac{\Delta(z + y)}{\Delta x} \tag{10.2}$$

$$S = \frac{h_L}{L} = \frac{(z_1 + y_1 + V_1^2/2g) - (z_2 + y_2 + V_2^2/2g)}{L} \tag{10.3}$$

where $x$, $y$, $\Delta x$, and $L$ are defined in Fig. 10.2. Note that the energy gradient $S$ is defined as the head loss per length of flow path (not per horizontal distance). Also, we usually assume that $\alpha = 1.0$; this assumption is reasonable when the flow depth is less than the channel width. Furthermore, for most practical cases the angle $\theta$ between the channel bed and the horizontal is small; so $L$, the distance along the channel bed between the two sections, is usually almost equal to $\Delta x$, the horizontal distance between the two sections.

## 10.2 Uniform Flow

In uniform flow (Fig. 10.3) the cross section through which flow occurs is constant along the channel, and so also is the velocity. Thus, $y_1 = y_2$ and $V_1 = V_2$ and the channel bed, water surface, and energy line are parallel to one another. Also,

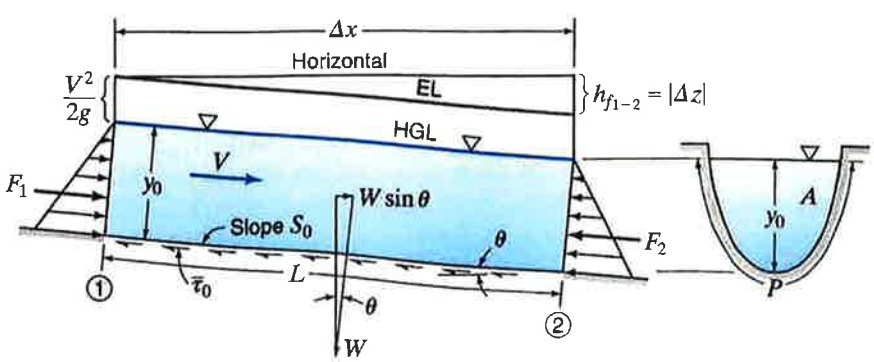


**Figure 10.3**
Uniform flow in open channel.

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$S_w = S_0 = -\Delta z/\Delta x = \tan\theta$, while $S = h_f/L = \sin\theta$, where $\theta$ is the angle the channel bed makes with the horizontal.

In most open channels (rivers, canals, and ditches) the bed slope $S_0$ ($= \Delta z/\Delta x$) falls in the range of 0.01–0.0001. For some chutes, spillways, and sewers it may be larger, and for some large rivers it may be smaller. Because, therefore, usually $S_0 < 0.1$ so that $\theta < 5.7°$, it follows that in most cases $\sin\theta \approx \tan\theta$ (within 0.5%) and $S_0 = S_w \approx S$. In this chapter we will assume that $\theta < 5.7°$ and thus that $S \approx S_0$. In channels where $\theta > 5.7°$ we must make a distinction in the difference between $S$ and $S_0$. Moreover, on such slopes air entrainment and pulsating flow (successions of traveling waves) are common.

In Sec. 8.4 we developed a general equation for frictional resistance in a pressure conduit. The same reasoning may now be applied to uniform flow with a free surface. Consider the short reach of length $L$ along the channel between stations 1 and 2 in uniform flow with water cross section of area $A$ (Fig. 10.3). As the flow is neither accelerating nor decelerating, we can consider the body of water contained in the reach in static equilibrium. Summing forces along the channel, the hydrostatic-pressure forces $F_1$ and $F_2$ balance each other, since there is no change in the depth $y$ between the stations. The only force in the direction of motion is the gravity component, and this must be resisted by the average boundary shear stress $\bar{\tau}_0$, acting over the area $PL$, where $P$ is the wetted perimeter of the section. Thus

$$\gamma AL\sin\theta = \bar{\tau}_0 PL$$

But $\sin\theta = h_f/L = S$. Solving for $\bar{\tau}_0$, we have

$$\bar{\tau}_0 = \gamma\frac{A}{P}S = \gamma R_h S \tag{10.4}$$

where $R_h$ is the hydraulic radius,[1] discussed in Sec. 8.3, and for most slopes (with $\theta < 5.7°$) $S_0$ may be taken as equal to $S$. Substituting the value of $\bar{\tau}_0$ from Eq. (8.10) and replacing $S$ with $S_0$,

$$\bar{\tau}_0 = C_f\rho\frac{V^2}{2} = \gamma R_h S_0$$

We can solve this for $V$ in terms of either the friction coefficient $C_f$ or the conventional friction factor $f$ (Eq. 8.15) to give

$$V = \sqrt{\frac{2g}{C_f}R_h S_0} = \sqrt{\frac{8g}{f}R_h S_0} \tag{10.5}$$

[1] Strictly speaking, we should measure $A$ and $P$ in a plane at right angles to $L$. However, since depth is measured vertically, we calculate values of $A$ and $P$ as those in the vertical plane. The resulting values of $R_h$ are identical regardless of which way we determine $A$ and $P$.

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## The Chézy Formula

Antoine de Chézy (1718–1798), a French bridge engineer and hydraulics expert, proposed in 1775 that the velocity in an open channel varied as $\sqrt{R_h S_0}$. This led to the formula

$$V = C\sqrt{R_h S_0} \tag{10.6}$$

which is known by his name. It has been widely used both for open channels and for pipes under pressure. Comparing Eqs. (10.6) and (10.5), we see that $C = \sqrt{8g/f}$. Despite the simplicity of Eq. (10.6), it has the distinct drawback that $C$ is not a pure number but has the dimensions $L^{1/2}T^{-1}$. This requires that we convert the values of $C$ which are in SI units before we use them with BG units in the rest of the formula.

As $C$ and $f$ are related, the same considerations that are presented in Chap. 8 regarding the determination of a value for $f$ apply also to $C$. For a small open channel with smooth sides, the problem of determining $f$ or $C$ is the same as that in the case of a pipe. But most channels are relatively large compared with pipes, thus giving Reynolds numbers that are higher than those commonly encountered in pipes. Also, open channels are frequently rougher than pipes, especially in the case of natural streams. A study of Fig. 8.11 reveals that, as the Reynolds number and the relative roughness both increase, the value of $f$ becomes practically independent of **R** and depends only on the relative roughness.

## The Manning Formula

One of the best as well as one of the most widely used formulas for uniform flow in open channels is that published by the Irish engineer Robert Manning[2] (1816–1897). Manning had found from many tests that the value of $C$ in the Chézy formula varied approximately as $R_h^{1/6}$, and others observed that the proportionality factor was very close to the reciprocal of $n$, the coefficient of roughness in the previously used, but complicated and inaccurate, Kutter formula. This led to the formula that has since spread to all parts of the world. In SI units, the Manning formula is

In SI units:
$$V(m/s) = \frac{1}{n} R_h^{2/3} S_0^{1/2} \tag{10.7a}$$

The dimensions of the friction factor $n$ are seen to be $TL^{-1/3}$. To avoid converting the numerical value of $n$ for use with BG units, we change the formula itself so as to leave the value of $n$ unaffected. Thus, in BG units, the Manning formula is

In BG units:
$$V(\text{fps}) = \frac{1.486}{n} R_h^{2/3} S_0^{1/2} \tag{10.7b}$$

[2] Robert Manning, Flow of Water in Open Channels and Pipes, *Trans. Inst. Civil Engrs. (Ireland)*, vol. 20, 1890.

REFERENCE 5



where 1.486 is the cube root of 3.28, the number of feet in a meter. Despite the dimensional difficulties of the Manning formula, which have long plagued those attempting to put all fluid mechanics on a rational dimensionless basis, it continues to be popular because it is simple to use and reasonably accurate. Representative values of $n$ for various surfaces are given in Table 10.1.

In terms of flow rate, Eqs. (10.7) may be expressed as

In BG units:
$$Q(\text{cfs}) = \frac{1.486}{n} A R_h^{2/3} S_0^{1/2} \tag{10.8a}$$

In SI units:
$$Q(\text{m}^3/\text{s}) = \frac{1}{n} A R_h^{2/3} S_0^{1/2} \tag{10.8b}$$

**TABLE 10.1 Values of $n$ in Manning's formula**

| Nature of surface | $n$ Min | $n$ Max |
|---|---|---|
| Lucite | 0.008 | 0.010 |
| Glass | 0.009 | 0.013 |
| Neat cement surface | 0.010 | 0.013 |
| Wood-stave pipe | 0.010 | 0.013 |
| Plank flumes, planed | 0.010 | 0.014 |
| Vitrified sewer pipe | 0.010 | 0.017 |
| Concrete, precast | 0.011 | 0.013 |
| Metal flumes, smooth | 0.011 | 0.015 |
| Cement mortar surfaces | 0.011 | 0.015 |
| Plank flumes, unplaned | 0.011 | 0.015 |
| Common-clay drainage tile | 0.011 | 0.017 |
| Concrete, monolithic | 0.012 | 0.016 |
| Brick with cement mortar | 0.012 | 0.017 |
| Cast iron, new | 0.013 | 0.017 |
| Riveted steel | 0.017 | 0.020 |
| Cement rubble surfaces | 0.017 | 0.030 |
| Canals and ditches, smooth earth | 0.017 | 0.025 |
| Corrugated metal pipe | 0.021 | 0.030 |
| Metal flumes, corrugated | 0.022 | 0.030 |
| Canals | | |
| Dredged in earth, smooth | 0.025 | 0.033 |
| In rock cuts, smooth | 0.025 | 0.035 |
| Rough beds and weeds on sides | 0.025 | 0.040 |
| Rock cuts, jagged and irregular | 0.035 | 0.045 |
| Natural streams | | |
| Smoothest | 0.025 | 0.033 |
| Roughest | 0.045 | 0.060 |
| Very weedy | 0.075 | 0.150 |

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Support Material

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## APPENDIX 19.A[a,b]

Manning's Roughness Coefficient, $n$
(design use)

| channel material | $n$ |
|---|---|
| plastic (PVC and ABS) | 0.009 |
| clean, uncoated cast iron | 0.013–0.015 |
| clean, coated cast iron | 0.012–0.014 |
| dirty, tuberculated cast iron | 0.015–0.035 |
| riveted steel | 0.015–0.017 |
| lock-bar and welded steel pipe | 0.012–0.013 |
| galvanized iron | 0.015–0.017 |
| brass and glass | 0.009–0.013 |
| wood stave | |
| small diameter | 0.011–0.012 |
| large diameter | 0.012–0.013 |
| concrete | |
| average value used | 0.013 |
| typical commercial, ball and spigot rubber gasketed end connections | |
| – full (pressurized and wet) | 0.010 |
| – partially full | 0.0085 |
| with rough joints | 0.016–0.017 |
| dry mix, rough forms | 0.015–0.016 |
| wet mix, steel forms | 0.012–0.014 |
| very smooth, finished | 0.011–0.012 |
| vitrified sewer | 0.013–0.015 |
| common-clay drainage tile | 0.012–0.014 |
| asbestos | 0.011 |
| planed timber (flume) | 0.012 (0.01–0.014) |
| canvas | 0.012 |
| unplaned timber (flume) | 0.013 (0.011–0.015) |
| brick | 0.016 |
| rubble masonry | 0.017 |
| smooth earth | 0.018 |
| firm gravel | 0.023 |
| corrugated metal pipe (CMP) | 0.024 (see App. 17.F) |
| natural channels, good condition | 0.025 |
| riprap | 0.035 |
| natural channels with stones and weeds | 0.035 |
| very poor natural channels | 0.060 |

[a] compiled from various sources
[b] Values outside these ranges have been observed, but these values are typical.