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May 23, 1988
UNC-ALO-88-87M

Mr. Edward Hawkins, Chief
Licensing Branch I
Uranium Recovery Field Office
U. S. Nuclear Regualtory Commission
P. O. Box 25235
Denver, CO 80225

MAY 1988 RECEIVED

Dear Mr. Hawkins:

Enclosed for your consideration is UNC's response to NRC's comments on surface water hydrology and erosion protection.

Regarding your additional request of a detailed cost estimate, I refer you to my letter of April 28, 1988 to Mr. Harry Pettengill and a meeting held with Mr. Dale Smith on April 27, in which Mr. Smith agreed that NRC's request for such a cost estimate would be deferred. Additionally, our submittal to Mr. Smith during our meeting contained a cost estimate that provides you with a cost breakdown in yearly increments per activity.

If you have any questions or require additional information do not hesitiate to contact me.

Sincerely yours,

Juan R. Velasquez
Manager, Environmental Affairs

JRV:nlk

cc: Chuck Johnson
Oliver Wesley - Canonie

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RESPONSFS TO NUCLEAR REGULATORY COMMISSION COMMENTS
UNC CHURCH ROCK MILL RECLAMATION PLAN

Comment 1

When tailings are being moved/recontoured in the interim, it is noted that a geotextile fabric cover will be placed over the fine grained tailings. Will there be any long-term detriment to the stability of the cover if/when the geotextile degrades: Provide justification for your conclusion.

Response 1

The geotextile will be used only if needed to help support the tailings sands and construction equipment during the moving of tailings sands over the slimes to provide sufficient support for the movement of the construction equipment. The geotextile fabric will prevent mixing and "pumping" of the slime materials up into the tailings sands by allowing pore water to transfer from the moist slimes into the drier sands as it is loaded over the slimes while keeping the materials segregated. This will result in partial dewatering and associated consolidation of the slimes over a relatively short period of time while the geotextile is still competent. In the long term, when the geotextile begins to degrade, the pore water pressures in the slime materials will have equilibrated with the pore water pressure in the overlying sands. Because of this equilibration, no long-term detriment to the stability of the cover will result.

Comment 2

You indicated that slopes in the tailings range from approximately 10 percent to 1 percent. Also, the earth embankment along the west and south sides of the tailings disposal area will be regraded to a 5:1 configuration. Further, "drainage of precipitation across the slopes will thus be slow and controlled, minimizing infiltration and erosion." Provide the velocities of overland flow and/or channelized flow that were used to estimate how much erosion may occur during a 100-year, 200-year, 1,000-year or PMP event? Discuss how these velocities were estimated. Also, discuss the extent of erosion for each event and why each level of erosion is acceptable in terms of why the pile would not be adversely affected.

Response 2

Overland Flow Velocity Within the Tailings Disposal Area

The revised Figure 7-1 (attached) shows the location of two points (Point 1 and Point 2) where the cover slope will be the steepest. These points are located on the eastern boundary of the tailings within the existing Central Cell. The configuration of the area draining to these points was revised from that shown in the original Reclamation Plan. The slope of the ground surface originally provided in the Reclamation Plan was approximately 10H:1V. The revised slopes are 14 horizontal to 1 vertical (14H:1V) [0.071 feet per feet (ft/ft)] immediately upslope from the points shown.

Overland flow velocities resulting from storms with return periods of 100, 200, 500, and 1,000 years and the probable maximum precipitation (PMP) were calculated at these two points using the unit-width method outlined in NUREG/CR/5620 (Nelson, et al., 1986). The resulting overland flow velocities and depths are provided below:

Return Period (yrs)	1-Hour Storm Amount (inches)	Overland Flow Velocity Point 1 (fps)	Overland Flow Velocity Point 2 (fps)	Overland Flow Depth Point 1 (inches)	Overland Flow Depth Point 2 (inches)
100	1.81	2.25	2.50	0.86	0.98
200	2.03	2.36	2.62	0.92	1.06
500	2.34	2.49	2.77	1.00	1.15
1000	2.56	2.58	2.87	1.06	1.21
PMP	8.46	4.17	4.63	2.17	2.48

These overland flow velocities were compared with maximum permissible velocities (MPV) for vegetated channels. A reasonable MPV for this area would be 3.0 feet per second (fps). This MPV relates to a channel in easily-eroded soils with a slope of five to ten percent and vegetated with a grass mixture (Ree, 1949, as provided in Barfield, et al., 1985). Calculated overland flow velocities were less than 3.0 fps for the 100-, 200-, 500- and 1,000-year return periods. These low velocities indicate that the tailings cover is stable and that no significant amounts of erosion will occur in a 1,000-year period.

Although the overland flow velocity induced by the PMP exceeded 3.0 fps, analysis of the PMP rainfall distribution indicates that this condition (flow velocity greater than 3.0 fps) would last only 22 minutes. Thus, the amount of erosion induced by this short-duration event with its extremely low probability of occurrence within a 1,000-year period is minimal. The tailings cover, at least four feet thick and vegetated with grasses and shrubs, will not be degraded to the extent that tailings are released, consistent with NRC's criteria.

United Nuclear Corporation (UNC) expects that there will be a period of time of perhaps two to three years before vegetation is fully established on the reconfigured tailings area and adjacent areas. Erosion that occurs during this period will be corrected by on-site personnel by regrading affected areas, adding additional cover, and revegetating as needed. The probability of a major storm (greater than or equal to the 100-year storm) occurring during this non-vegetated period is slight and its erosional impact is expected to be minimal even in the absence of such corrective maintenance.

Overland flow velocities were calculated using the unit width method outlined in NUREG/CR-4620 (Nelson, et al., 1986). The rainfall information was derived from extension of base data from the National Oceanic and Atmospheric Administration (NOAA), Atlas 2, Volume IV, New Mexico (NOAA, 1983) and Hydrometeorological Report 49 (HMR-49) (NOAA and Corps of Engineers, 1984).

A Manning's "n" of 0.03 was used to reflect the revegetated condition of the cover and the shallow depths of overland flow. A flow concentration factor of 2.0 was used in the velocity calculations. NUREG/CR-4620 suggests a flow concentration factor of 2.0 to 3.0 for gravel-covered steep embankment slopes. Since the slopes on the tailings cover will be grass-covered and gentle, the lower concentration factor was used. The overland flow velocity calculations are attached.

Overland Flow Velocities on the 5H:1V Embankment

The overland flow velocities on the 5H:1V embankment along the west and south sides of the tailings disposal area were estimated for return periods of 100, 200, 500, and 1,000 years and for the PMP event by the methods described above. The resultant flow velocities and depths are provided below:

Return Period (yrs)	1-Hour Storm Amount (inches)	Overland Flow Velocity (fps)	Overland Flow Depths (inches)
100	1.81	2.51	0.46
200	2.03	2.63	0.48
500	2.34	2.78	0.53
1,000	2.56	2.89	0.56
PMP	8.47	4.66	1.15

Calculated overland flow velocities were less than the MPV of 3.0 fps for storms with return periods of 1,000 years or less. Thus, the 5H:1V embankment slopes are stable. No significant amounts of erosion will occur within a 1,000-year period.

Only the PMP event produced an overland flow velocity greater than 3.0 fps. However, the PMP will not threaten long-term stability or cause the release of tailings because of the short duration of excessive flow velocities (24 minutes) and the location of the occurrence of potential erosion. If erosion during the PMP were to occur, it is expected to occur at or near the bottom of the embankment slope at least 46 feet from the embankment crest. Thus, the tailings material will not be affected by erosion that occurs during the probable maximum flood (PMF).

At the location of the longest embankment slopes, the toe of the slope will be protected by the overbank riprap of the runoff control ditch. This riprap will mitigate the potential for gully formation by providing a stable base at the toe of the slope. Thus, gully formation on the embankment slopes during the PMF will not cause the release of tailings.

A Manning's "n" of 0.03 and a flow concentration factor of 2.5 were used in the overland flow velocity calculations. Due to the steeper slope, a higher flow concentration factor than that applied to the tailings cover calculations was used for the flow velocity calculations of the embankment.

Comment 3

Is the interim soil cover 8 inches, 8-12 inches, or 12 inches? The text is not consistent.

Response 3

The interim soil cover will be 12 inches.

Comment 4

Your flood analysis of Pipeline Arroyo indicates that the drainage area is 16.7 square miles. However, previous studies done for you by Simons, Li and Associates (1980) and Faith Engineering, Inc. (1982) report that the basin drainage area is in excess of 19.1 square miles. Please discuss why the drainage area is smaller in your Reclamation Plan.

Response 4

The previous studies performed by Simons, Li and Associates (SLA) (1980) and Faith Engineering, Inc. (Faith) (1982) used a drainage basin outlet near the southern boundary of the UNC property. The drainage basin described in the Reclamation Plan has its outlet adjacent to the northern edge of the North Cell of the tailings pile. This location is the point at which the Pipeline Arroyo enters the tailings impoundment area.

This location is consistent with the observation of J. D. Nelson in his June 15, 1985 review of the PMF calculations performed by SLA and Faith that ". . .the point of interest at the tailings impoundment is that where the PMF would enter the area and not the point where the PMF would discharge from it. We believe, therefore, that the PMF determinations should be revised to determine the PMF entering the tailings impoundment area. The PMF computation should reflect the appropriate channel length and tributary drainage." Mr. Nelson's observation was acknowledged by Mr. Terry L. Morgan of the New Mexico Environmental Improvement Division in his letter of July 2, 1985, to UNC.

Comment 5

You report a PMF peak flow of 25,000 cfs. Faith Engineering, Inc. reports a peak discharge near 30,000 cfs, while Simons, Li and Associates indicate that the PMF could exceed 90,000 cfs. Why is your estimate lower than the others?

Response 5

Our estimate is lower because neither of the previous calculations by Faith or SLA are appropriate for present conditions. SLA used a drainage basin area of 19.7 square miles and a one-hour PMP of 10.1 inches as derived from the National Weather Service Technical Publication 40. This publication has been superceded by HMR-49 for the western states.

Faith used a drainage basin area of 19.18 square miles and a one-hour PMP amount of 6.8 inches as derived from HMR-49. However, Faith failed to use the elevation correction factor in its PMP determination. A subsequent

PMF hydrograph calculation by UNC used the basin outlet elevation in determining the elevation correction factor. UNC also corrected several procedural and computational errors in Faith's PMF determination. UNC's resulting PMF peak discharge was approximately 30,200 cfs. However, UNC also incorrectly adjusted for elevation because the minimum basin elevation rather than mean basin elevation was used.

The PMF peak flow of 25,000 cfs as described in the Reclamation Plan was the result of 1) a slightly smaller drainage basin area as described in the response to Comment 4, and 2) a reduced PMP amount of 6.2 inches. The reduced PMP amount was a result of the revision to HMR-49 that called for the use of the mean basin elevation instead of the minimum basin elevation for the computation of the elevation correction factor for the local-storm PMP. This revision is provided on the errata sheet of the 1984 edition of HMR-49.

Comment 6

In your PMF analyses, you used an SCS curve number (CN) of 74 for Pipeline Arroyo and 80 for the other areas. Please explain how these values were determined.

Response 6

Page C-2 of Appendix C of the Reclamation Plan indicates that a CN of 79, not 74 as stated in your comment, was used in the PMF calculation for Pipeline Arroyo. The CN of 79 was determined by Faith and provided in its 1981 report to UNC entitled "Design Flood Analysis: North Cell Tailings Embankment." Faith used soil data and soil maps developed by a 1979 Order III soil survey performed cooperatively by the Soil Conservation Service (SCS) and the Bureau of Indian Affairs. Table 1 of the Faith report provides the names, cover types, hydrologic soil groups, CN, and area of each of the five soil associations found within the Pipeline Canyon drainage basin. The area-weighted CN was determined to be 79.

The CN of 80 for the areas draining to the North and South Diversion Ditches was determined by Science Application, Inc. (SAI) and provided in its report to UNC of June 10, 1981, entitled "PMF Determination for the Southeast Diversion Channel and Section 1 Watershed Using SCS Hydrological Techniques." SAI divided the basins into two principal soil associations and developed a weighted CN based on the relative area of the soils, the vegetation type and cover density, and the hydrologic soil classifications. The weighted CN was determined to be 80.

Canonie reviewed both reports and performed a field check of vegetation conditions. Canonie concurs with the CN determinations.

Comment 7

On your PMF analyses, you used procedures from the Bureau of Reclamation's publication, "Design of Small Dams," (DSD) to adjust the PMP from a 1 mi^2 value to a value corresponding to the size of the drainage areas in question. You also used DSD procedures to estimate PMP values for durations of less than 1 hour. Use of DSD procedures results in smaller PMP values than those derived using procedures from Hydrometeorological Report 49 (HMR-49). You should, therefore, use Figure 4.9 in HMR-49 to adjust your 1 mi^2 PMP value of 8.33 inches to correspond to the appropriate drainage areas and Table 4.4 in HMR-49 for determining PMP values for durations of less than 1 hour.

Response 7

The PMF for Pipeline Arroyo was recalculated using the suggested HMR-49 reference to address Comments 4, 5, and 7 which were all directed toward the determination of the PMF. The recalculation was performed to assess the impact that the Nuclear Regulatory Commission's (NRC) recommendations would have on the magnitude of the PMF. The PMF calculation was modified to include moving the discharge point from the location at which Pipeline

Arroyo enters the tailings impoundment area to the location at which Pipeline Arroyo exits the tailings impoundment area. In addition, hydrograph parameters were selected from HMR-49 (NOAA and COE, 1984) as suggested by the NRC in Comment 7, instead of the Design of Small Dams (U.S. Bureau of Reclamation, 1972), which was used in the original calculation.

Table 1 presents a comparison of the two PMF calculations. The peak discharge for the original PMF was estimated as 25,000 cubic feet per second (cfs) while that of the recalculated PMF was estimated as 26,300 cfs. The recalculation produced an increase of only five percent.

The recalculated peak discharge was input into the HEC-2 program to observe the effects of the increase in peak discharge. Table 2 summarizes the effects on channel velocity and water surface elevation. The average increase in flow velocity is 0.16 fps, while the average increase in water surface elevation is 0.4 feet. Thus, the effects of the increase in peak discharge are minimal and can be effectively ignored. Therefore, the original calculations based on a PMF of 25,000 cfs are considered valid and channel designs were not recalculated.

A detailed discussion of the modifications made to the PMF calculation is presented in the following paragraphs.

The original PMF calculation for the Reclamation Plan was based on the following factors:

- o The distribution of rainfall within the one-hour period was taken from the Design of Small Dams (U.S. Bureau of Reclamation, 1977). Rainfall was distributed so that 48 percent fell during the first quarter hour, 71 percent during the first half hour, 88 percent during the third quarter hour, and 100 percent during the entire hour.

- o The areal adjustment factor of 0.74 was taken from Figure 21 of Design of Small Dams (U.S. Bureau of Reclamation, 1977).

- o The drainage basin watershed characteristics were based on a discharge point at the location at which Pipeline Arroyo enters the UNC tailings impoundment area. Figure 7-3 of the Reclamation Plan shows the drainage basin boundary. The basin has its outlet adjacent to the northern edge of the North Cell of the tailings pile. This discharge point results in a drainage area of 16.74 square miles, a water course length of 6.18 miles, and a maximum relief of 785 feet.

The following changes were made in recalculating the PMF:

- o The distribution of rainfall within the one-hour period was taken from HMR-49 (NOAA and COE, 1984). Rainfall was distributed so that 74 percent fell during the first quarter hour, 89 percent during the first half hour, 95 percent during the third quarter hour, and 100 percent during the entire hour.

- o The areal adjustment factor of 0.75 was taken from Figure 4.9 of HMR-49 (NOAA and COE, 1984).

- o The drainage basin characteristics were based on a discharge point at the location at which Pipeline Arroyo exits the UNC tailings impoundment area. As shown on Figure 3 of the Reclamation Plan, drainage basins A1, A2, B, and the unmarked drainage basin northwest of the Pipeline Arroyo were added to the original drainage basin boundary. Drainage basin C was not included because water from this basin drains into the south diversion ditch which discharges into the Pipeline Arroyo south of the UNC tailings area and below the base control structure.

  Thus the watershed has its outlet just upstream of the South Cell discharge point into Pipeline Arroyo. This discharge point results in a drainage area of 18.22 square miles, a water course length of 6.98 miles, and a maximum relief of 819 feet.

An additional factor which affected the decision to use the rainfall distribution and areal adjustment factor from the Design of Small Dams (U.S. Bureau of Reclamation, 1977) was that this is the referenced methodology required by the New Mexico State Engineer's Office. Since UNC must satisfy New Mexico requirements as well as federal requirements, the factors from Design of Small Dams (U.S. Bureau of Reclamation, 1977) were used in all PMF calculations.

The calculations for the original PMF and the recalculated PMF determination as well as the HEC-2 output are attached.

Comment 8

You indicate that PMF velocities within the channel will range from 27.2 to 37.3 fps. Although you expect bank and channel erosion and degradation, you do not expect channel migration into the tailings area. On this basis, you conclude that the Pipeline Arroyo is stable. However, in a previous report by Simons, Li and Associates, the following is indicated:

Simons, Li and Associates (SLA) (1980) concluded that under PMF conditions, the disposal site cannot be considered stable for several reasons. These relate to the stability of the outcrop forming the nickpoint, the fact that the disposal site is located in alluvial material, the potential for high velocity flows to cause the channel to shift laterally, and the fact that the PMF conditions, as determined in their analysis, would cause the tailings embankment to be overtopped. Also, the high velocities which would result under PMF conditions would make the design of a riprap cover difficult. Similar conclusions were drawn for the 500-year flood condition with the exception that the overtopping of the embankment would not necessarily occur. However, for the same reasons as noted above, the site was shown to be unstable.

SLA further indicated that:

A. Stability of the nickpoint outcrop has not been demonstrated. During a flood, discharges would change from subcritical flow above the outcrop to supercritical flow below the outcrop. This increase in velocities would result in a high erosion potential.

B. The lateral extent and continuity of the outcrop was questioned by SLA. We agree with this concern, and note that if the outcrop is faulted or nonexistent at points lateral to the present position of Pipeline Arroyo, there may be a tendency for the stream to migrate around the nickpoint thereby causing the flood to impact upon the tailings impoundment area.

C. SLA noted that because of the sediment deficit in the flow, shifting of the channel under flood conditions would be likely. Furthermore, over long-term periods, the recurrence of multiple floods of smaller magnitudes could cause progressive shifts of the channel which could eventually impact upon the impoundment. As noted by SLA, because the site is underlain by alluvium, the channel could exist at almost any point within the valley.

D. As noted in item "A" above, degradation of the stream channel downstream from the nickpoint could occur where the flow goes from subcritical to supercritical flow. Even under the revised PMF, this condition could occur and cause head-cutting which would migrate upstream and impact on the outcrop.

Since SLA concluded that the site would not be stable for even a 500 year event, it is very likely that the site would also be unstable for your PMF, assuming that SLA's conclusions are valid. You should therefore provide additional information to justify the stability of the site in terms of SLA's concerns stated above.

Response 8

The stability analyses performed by SLA in 1980 considered a much larger PMF (90,000 cfs versus 25,000 cfs) through the existing channel configuration with its unstable nickpoint and steeper channel slopes. Therefore, SLA conclusions are invalid for the reconfigured channel as proposed in the revised Reclamation Plan. Further, it is inappropriate to justify stability in terms of SLA's concerns. Our design is justified in terms of NRC regulatory criteria.

The evaluation performed in the Reclamation Plan was based on the effects of the smaller more realistic PMF (see response to Comment 7) on a reconfigured channel, a deepened, enlarged, and controlled nickpoint, and construction of a base control structure to provide base level control at two locations.

The Pipeline Arroyo stability evaluation described herein considers the ability of the modified channel configuration to prevent the release of tailings within a 1,000-year period or during the occurrence of the PMF. The stability of the channel both upstream and downstream of the nickpoint is addressed.

Pipeline Arroyo can be considered stable for the following reasons:

1. The incision of the nickpoint by approximately 20 feet into competent rock provides both horizontal and vertical stability at this point.

2. The base control structure limits the amount of head cutting that will occur downstream of the nickpoint, will provide both horizontal and vertical stability at this location, and will prevent the migration of head cuts from downstream locations.

3. Meander growth of the channel will not intrude upon the tailings and cause the release of tailings.

4. The modified channel will fully contain the PMF so that no flow impinges upon the tailings embankment.

The existing channel will be reconfigured to a trapezoidal channel with 3H:1V side slopes and a 20-foot bottom width. The channel bottom will be excavated to provide a uniform slope from the north UNC property boundary to the bottom of the incised rock outcrop of the nickpoint. Thus, the channel will be deepened by up to 20 feet in the area adjacent to the tailings impoundment upgradient of the nickpoint. This deepening of the channel performs two important geomorphic functions. First, it contains the PMF within the channel so that no flow impinges upon the tailings impoundment. Second, it creates a large volume of overbank material that must be eroded before the channel can impinge upon the tailings.

Figure 7-5 of the Reclamation Plan illustrates how the incision into the nickpoint will be made. The incision will deepen the nickpoint into less weathered, more competent Zone 3 sandstone than is presently exposed. The depth of the incision will be a minimum of 20 feet and may be greater to ensure that competent material is exposed. The in place rock of the nickpoint and the added riprap will function as a base-level control structure for vertical stability. Since all flows will be directed through the nickpoint via the deepened channel above the nickpoint, its erosion-resistant walls of rock and riprap will provide horizontal stability at this point.

While meander growth will occur upstream and downstream of the nickpoint within the deepened channel, the incision will preclude meander growth in the immediate vicinity of the nickpoint. Meander growth will occur upstream and downstream of the nickpoint as a result of 1) more frequent, smaller magnitude floods such as the 2, 5, 10, and 25 year floods, 2) less-frequent higher magnitude floods such as the 100, 200, 500, and 1,000 year floods, and 3) the PMF.

The effects of the smaller magnitude floods can be demonstrated by observing existing meander patterns. The meander amplitude of the existing channel below the nickpoint is presently 145 feet while that above the nickpoint varied from 50 feet to 170 feet. Given this range of meander amplitude for the widely varying existing channel slopes (0.053 ft/ft for the channel downstream of the nickpoint and 0.0018 ft/ft for the channel upstream), the meander amplitude of the reconfigured channel is expected to be no more than 150 to 170 feet for either channel segment. Thus, the extent of meander growth toward the tailings area will be limited to 75 feet to 85 feet.

Figures 7-1 and 7-2 (attached) indicate that the shortest distance from the reconfigured channel center line to the tailings material is 280 feet. Therefore, such meander growth will not reusult in the release of tailings. This design is in compliance with NRC criteria.

Another approach to estimating meander growth is through the use of a formula by Leopold and Wolman (1957) that relates meander amplitude to channel width at bankfull stage.

The equation is:

$$A = 2.7w^{1.1}$$

Where: A = meander amplitude in feet
W = width at bankfull stage in feet

This formula was derived for channels in alluvial areas. Application of this formula to the area below the nickpoint can be made by using a bankfull width related to the mean annual flood amount. This flood amount was determined to be 150 cfs. The bankfull width was determined to be approximately 40 feet. The meander amplitude predicted by the above equation is 156 feet which compares favorably to the 145 feet of the existing channel.

By extending this formula to include bankfull widths for larger magnitude flood events within the reconfigured channel, the following meander amplitudes can be predicted.

Return Period (yrs)	Peak Discharge (cfs)	Channel Width (ft)	Meander Amplitude (ft)	Potential Movement Toward Tailings (ft)
1,000	7,600	85	360	180
PMF	25,000	125	550	275

Thus, the predicted movement toward the tailings by the channel influenced by the PMF is less than the actual distance to the tailings area.

While this method illustrates the stability of the reconfigured channel, it is also conservative in that it does not account for the large volumes of material that must be eroded between the reconfigured channel and the tailings before tailings would be released. For example, the volume of material between the channel and the tailings at the closest distance is approximately 970 cubic yards (cy) per yard of bank length. This entire volume must be eroded during meander growth or channel movement before tailings will be released. The amount of material in the area below the nickpoint is two to four times greater than this.

While localized scour will develop along the reconfigured channel bottom during flood events, the scoured areas will fill in during the receding phase of the flood. The vertical stability induced by the incised nickpoint and the base control structure will prevent head cutting from affecting the channel configuration.

In consideration of the above evaluations, the reconfigured channel can be considered stable since no tailings will be released during a 1,000-year period or during a PMF event.

Comment 9

In sizing the required riprap, you used the Corps of Engineers procedure report by Maynord (1972). Since this procedure was modified by Maynord (1987), the sizing methodology should reflect the latest changes in riprap design. Discuss how the proposed riprap size (Maynord, 1972) compares to the computed riprap size from the 1987 Maynord procedure. Preliminary estimates by NRC indicate that the riprap proposed for the section within the incised nickpoint in rock (your calculation on page C-5) may be too small.

Response 9

The Corps of Engineers' report concerning Mr. Maynord's modification has not yet been published. However, a copy of Mr. Maynord's dissertation was obtained from the author. The methods proposed in his dissertation were used to recalculate riprap size estimates for the purpose of comparing the proposed riprap size to those estimated by the 1978 Maynord procedure.

Table 3 provides a comparison of the original and recalculated riprap size estimates. The recalculated riprap sizes increased over the original riprap sizes. Also, the thickness of the riprap layer generally increased.

Maynord's 1987 method is a very recent change. It has neither been field tested or accepted as a standard engineering practice. Canonie and UNC believe that it is inappropriate to adopt such a new procedure without extensive evaluation, particularly in light of the significant potential impacts it has on the current design.

Comment 10

You indicate that your HEC-2 routing of the PMF resulted in channel velocities upstream of the nickpoint of 16.2 to 21.2 fps. These high velocities yielded bed degradation of 7.3 feet [please provide the Neill (1973) reference]. Discuss how the nickpoint will be affected by such high velocities. If some degradation is expected at the nickpoint, discuss how this degradation will affect the pile.

Response 10

A review of the bed degradation calculations revealed that the empirical formulae described in Neill (1973) are applicable only to wide alluvial channels where the width of water surface is nearly equal to the width of the channel bottom (i.e., the flow depth is nearly constant across the channel). This condition is not met with the reconfigured channel. Therefore, Neill's formulae are not applicable to this situation. The Neill reference is included in the list of references for this document.

The competent portions of the exposed nickpoint will be only minimally affected by the high velocities of the PMF. Any weathered zones may be affected to a greater extent if not protected by riprap. Because the nickpoint will be excavated to a minimum depth of 20 feet below the existing surface or to the depth of competent rock, only the entrance and exit of the nickpoint might be expected to contain weather zones. However, these sections will be protected by riprap. With this riprap protection in place, degradation at the nickpoint will be minimal, therefore, tailings will be unaffected.

Comment 11

Discuss whether a lowering of the nickpoint would result in head-cutting of the channel that might migrate to the tailings area.

Response 11

Lowering of the nickpoint will not result in head-cutting of the channel because the channel will be excavated to a uniform slope from the northern boundary of the UNC property to the bottom of the incised nickpoint. Minor changes in the elevation of the channel bottom may occur as the channel determines a new dynamic equilibrium. These changes are expected to be less than one foot in magnitude.

Comment 12

You indicate that channel migration during the period 1952-1985, resulted in a change in meander amplitude of 120 feet. What were the magnitudes of the discharges that caused this migration. Could the meander significantly increase with a PMF magnitude event? It may be possible for the base control structure to change the upstream behavior of the channel. Discuss how this structure will affect the channel and ultimately the stability of the pile.

Response 12

Table 7.2 of the Reclamation Plan indicated that the meander amplitude of the channel above the nickpoint increased from 50 feet in 1952 to 170 feet in 1978, then decreased to 150 feet in 1983 and 110 feet in 1985. The natural discharges and sediment loads that produced these changes were not recorded. Mine water discharges were recorded from 1968 to 1986, but the magnitude of these flows (less than 11.5 cfs) was much less than naturally occurring flows. For example, the mean annual flood, which has a recurrence interval of 2.33 years, has an estimated peak discharge of 150 cfs. This estimate was based on precipitation information from NOAA Atlas 2, Volume IV - New Mexico (NOAA, 1973), and the SCS triangular hydrograph method for peak discharge calculations. Flows of this magnitude and greater have been observed, but not recorded, by UNC facility personnel.

The larger natural discharges may have had an overriding effect on the channel morphology depending on the discharge and sediment load of the flood event and the length of time between a flood event and the time the aerial photographs were taken. Because of the lack of information concerning naturally-occurring flows, relating meander amplitude to discharge in Pipeline Arroyo directly is impossible.

The response to Comment 8 provides additional discussion of meander growth in this area.

Comment 13

Will any riprap be placed in the South Diversion Ditch for channel protection or stabilization? If yes, provide the design details of the ditch. Discuss the method used to size the riprap. Include PMF flow, velocities, and any assumptions made in designing the ditch. If not, discuss why flood flows will not affect the pile.

Response 13

Section 7.4 of the Reclamation Plan demonstrates that both the South and North Diversion ditches can safely convey the PMF. It will not be necessary to place riprap in the South Diversion Ditch because the minimum distance from the ditch to the tailings area is 400 feet. At the location of this minimum distance, which is between the South Diversion Ditch and the South Cell Drainage Channel, shallow soil is underlain by Zone 1 sandstone. The sandstone will greatly impede the progress of channel migration. Since the ditch is capable of conveying the PMF without overtopping, the only way that the ditch could impact the tailings areas would be if the ditch migrated 400 feet through the Zone 1 sandstone. This is considered highly unlikely.

During the site visit on April 19 and April 20, 1988, the NRC representatives expressed concern that two curves on the North Diversion Ditch may be the location of increased amounts of erosion that could allow flood flows to pass onto the tailings area. Revised Figure 7-1 shows the locations of the two curves. Cross sections were developed and hydraulic calculations were performed for these locations. Cross Sections DD-DD and EE-EE on Figure 7-9A (attached) show that the curved sections of the North Diversion

Ditch will contain the PMF without overtopping the embankment. In addition, the calculated flow velocities were moderate and the flow was subcritical at both locations (froude number less than 1.0). Thus, the hydraulic calculations indicate that the potential for the North Diversion Ditch to migrate into the tailings pile is minimal. Therefore, it will not be necessary to place riprap into the existing portions of the North Diversion Ditch.

A summary of the hydraulic calculations for the PMF at the two curved sections of the North Diversion Ditch are provided below:

Parameter	Cross Section DD-DD	Cross Section EE-EE
Peak Discharge	1081 cfs	1081 cfs
Flow Velocity	8.0 fps	6.5 fps
Flow Depth	5.1 ft	4.0 ft
Froude Number	0.7	0.7

The calculations for the flow velocity, depth, and froude number are attached.

Comment 14

Will drainage swale(s) be protected from erosion with riprap or rock mulch? If yes, discuss how the riprap was designed and provide the supporting calculations. If no, discuss why riprap is not required in terms of expected velocities.

Response 14

The South Cell Drainage swale will not require protection with riprap or rock mulch because of the shallow channel slope of approximately 0.0012 ft/ft. The peak flow velocity in this swale during the PMF will be approximately 2.5 fps. This velocity is well below the maximum permissible velocity of 3.0 fps for a channel in easily eroded soil with a grass cover.

Due to the addition of the North Cell Drainage Channel, the North Cell Branch swales have been redesigned. Revised Figures 7-1 and 7-2 illustrate the current configuration of the North Cell Branch swales. The slope of the North Cell Branch swales has been reduced from 0.005 ft/ft as described in the Reclamation Plan to 0.002 ft/ft to ensure that they will also not need riprap. The resulting peak flow velocities of the PMF will be 2.4 fps.

Analysis of the shear stress or tractive force induc-. by the concentrated flows within the South Cell Drainage swale and the North Cell Branch swales was performed. Table 4 indicates that runoff produced by the 200-, 500-, and 1,000-year rainfall events will develop tractive forces within the swales that are less than the limiting tractive forces (LTF) for an un-vegetated channel constructed in non-colloidal silt loams. This LTF is 0.110 pounds per square foot (psf) according to Lane (1955, as provided in Barfield, et al., 1985).

Only the PMF produced tractive forces greater than 0.110 psf in both swales. However, this factor is mitigated by the following conditions:

1. The swales will be vegetated with a dense cover of grasses and shrubs that will effectively bind the soil particles with their root mass. Also, the litter from such vegetation will form a mulch in many areas that effectively protects the soil from direct impingement of the erosive forces of the PMF.

2. The duration of the flow for which the tractive forces will be greater than the LTF will be relatively short (17 minutes in the South Cell Drainage swale and 27 minutes in the North Cell Branch swales).

3. The probability of occurrence of the PMF is extremely small.

Thus, the swales will not erode greatly in a 1,000-year period because 1) flow velocities are less than the MPV, and 2) the tractive forces produced by the runoff from the 1,000-year storm are less than the LTF. The occurrence of the PMF will cause minor amounts of erosion, but the vegetative cover and the short duration of the event mitigate the amount of erosion.

The calculations for the PMF and riprap determinations are attached.

The design of the North Cell drainage channel has been changed so that it will be riprapped at the locations shown on the revised Figure 7-2 (attached). The channel will be reconfigured into a trapezoidal ditch with a ten-foot bottom width and 3H:1V side slopes. The channel has been divided into two sections with riprap being sized individually for both the upper and lower channels (see revised Figure 7-2). The riprap size design estimates for the North Cell drainage channel were derived using Maynord's 1978 methods. See Response 9 for additional comments regarding methods and calculations used in determining riprap sizes.

Comment 15

Other than the Universal Soil Loss Equation, an in-depth analysis of cover erosion/degradation is lacking. Have you analyzed the depth and velocity of flow over the cover? Would a shear stress analysis indicate that the cover is stable? Since the average cover slope is approximately 2 percent, what is the steepest slope and where is it located? Did you assume any potential for sheet flow concentration on the cover? Provide justification to show that a 4-foot cover will provide adequate erosion resistance for 1000 years. Also, please address the potential for gullying to occur on the pile or on the steep embankment (5:1) and discuss how gullying will affect the stability of the reclaimed pile.

Response 15

The depth and velocity of flow over the cover has been analyzed and presented in the response to Comment 2. The steepest slopes over the cover are 14H:1V and are located at two points at the eastern boundary of the tailings within the existing Central Cell area. 5H:1V slopes are presented in the design of the outer slope of the reconfigured tailings embankment. Our response to Comment 2 provides additional detailed analyses of the depth and velocity of flow over these areas including sheet flow concentration and gullying potential.

The analyses indicate that overland flow velocities on the cover and the embankment were less than 3.0 fps for 100-, 200-, 500-, and 1,000-year storms. The analyses used flow concentration factors of 2.0 on the cover and 2.5 on the embankment slopes. Thus, the cover and the embankment will experience only minor amounts of erosion during a 1,000-year period and can be considered stable.

The response to Comment 14 includes shear stress or tractive force analyses for the swales of both the North and South Cells where overland flows will be concentrated. The analyses indicated that the tractive forces of overland flows resulting from 200-, 500-, and 1,000-year storms do not exceed the limiting tractive forces of an unvegetated channel construction in easily-eroded soils. Thus, the cover under the swales will be only minimally eroded during a 1,000-year period and can be considered stable.

Since only minimal amounts of erosion will occur on the cover, the four-foot thickness of the cover is more than adequate for a 1,000-year period. Also, the overland flow velocity and tractive force analyses indicate that concentrated flows will not cause gullies to form on either the tailings cover or the embankment slopes. Thus, gullying will not affect the stability of the pile.

Comment 16

The channel modification proposed for Pipeline Arroyo assumes that runoff from the entire 16.7 square mile drainage area will flow into the modified channel. Since the channel of Pipeline Arroyo upstream of the tailings pile is largely undefined consisting of a broad floodplain, the staff is concerned that, during a PMP event, floodwaters will spread across the wide floodplain potentially impacting and eroding the north end of the reclaimed pile which could be affected if a PMF does not remain fully contained in Pipeline Arroyo.

Response 16

The proposed reconfigured channel is designed to convey the entire PMF in those areas adjacent to the west side of the tailings area. It was not assumed that all of the PMF would drain into the channel in the area north of the tailings area. The floodplain in this area will be utilized as part of the flow system.

Figure 7-2 shows that the reconfigured channel will intercept the existing primary flow path within Pipeline Arroyo at the northern UNC property boundary. At channel Cross Section 17 (Figure C-2 of the Reclamation Plan) the reconfigured channel will convey 77 percent of the PMF while the east overbank area will convey 17 percent and the west overbank the remainder. Thus, the greatest portion of the flow will flow within in the channel.

Should a different primary flow path develop upstream of the entrance to the reconfigured channel that allows flow to occur on the floodplain, two mechanisms will occur that would route the PMF away from the reconfigured channel, back to the reconfigured channel. First, once the overbank portion of the PMF enters the reconfigured channel, the larger, steeper, reconfigured channel will effectively "rob" the major portion of the flow from the natural channel. Second, the North Division Ditch will intercept any flow paths in the floodplain and redirect the flow to the reconfigured channel. Thus, even if flow paths other than the existing primary flow path were to develop, no release of tailings would occur because the new flow paths would be directed back to the reconfigured channel. Furthermore, the design of the North Diversion Ditch and the reclaimed tailings area is such as to minimize the potential for the PMF to erode into the northern section of the tailings area and cause the release of tailings. The major mechanisms designed to prevent erosion in this area are listed below:

- o The configuration of the reclaimed tailings area will direct flows into the North Diversion Ditch and away from the tailings.

- o A buffer area approximately 300 feet in length from the base of the reconfigured area to the location of the covered tailings material will protect the tailings from release. This buffer area exists between the PMF floodplain boundary and the tailings boundary.

- o The erosive capacity of the PMF at the floodplain boundary is minimal because this area is in the backwater portion of the floodplain.

Each of these mechanisms is described in the following paragraphs.

Cross Section FF-FF on Figure 7-9A shows the cross section from the tailings area to the North Diversion Ditch and illustrates the downward gradient from the tailings area into the ditch. This design directs water away from the tailings area and therefore minimizes the potential for erosion of the area during the PMF. Furthermore, any secondary channel flow that arises during the PMF will be intercepted by the North Diversion Ditch and routed away from the north tailings embankment.

As shown in the plan view of the site on Figure 7-2, approximately 300 feet of alluvial and tailings cover materials will separate the tailings from the estimated extent of the PMF. The cross section of this area shown on Figure 7-9A further illustrates that this significant buffer area will protect the tailings from erosion volume. Furthermore, the erosive capacity of the PMF against the buffer area is minimal because this area is in the backwater portion of the PMF floodplain. The backwater will have extremely low velocities. Approximately 340 cy of material per yard of bank length must be eroded before tailings are released.

The surface water flow patterns combined with the 300-foot buffer area both inhibit the development of secondary flow paths and minimize the potential for any of these paths to erode into the tailings area.

Comment 17

The reclaimed pile in the vicinity of the borrow pit has slopes that are significantly steeper than the top of the pile. At the point where these steep slopes transition onto the flatter slopes of the pile top, there is a potential for scour of the reclaimed surface and potential exposure of the tailings. Please provide an analysis of the potential for scour at this location. If the conclusion is reached that there could be sufficient scour over a long period to expose tailings, you should modify your reclamation plan to minimize this potential for erosion. This can be accomplished by moving the toe of the steeper slope back away from tailings onto native soil or by providing rip-rap at the critical slope transition locations.

Response 17

The response to Comment 2 indicates that the configuration of the reclaimed pile was adjusted to ensure that overland flow velocities would not cause scouring of the tailings cover. The analyses indicated that overland flow velocities were less than the MPV of 3.0 fps for storms with return periods of 1,000 years and less. Thus, the reclaimed pile will not allow scouring of the cover at the steepest locations and no release of tailings will occur.

Comment 18

An independent evaluation by the staff indicates that a PMP event will result in erosive velocities on the reclaimed outslopes. Consequently, rip-rap erosion protection will be required. Please provide a rip-rap design for the 5H:1V outslopes. Alternately, you may flatten the slopes so that runoff velocities from extreme flood events are reduced and the potential for erosion is minimized. If the selected option is to flatten the slopes, you must further consider the potential for flow concentration and gully formation.

Response 18

The response to Comment 2 indicates that the overland flow velocities induced by the PMP event will cause erosive velocities on the embankment. However, the duration of the period during which these erosive velocities would occur was only 24 minutes. Also, the locations at which gullying would start as indicated by flow velocities greater than 3.0 fps was 46 feet from the crest of the embankment. Thus, only limited amounts of gullying will occur on the embankment slopes and this gullying will not cause the release of tailings.

Comment 19

Modifying Pipeline Arroyo as you propose will alter the hydrology of the stream by changing the slope and reducing the stream length by eliminating meanders. These changes will result in channel instability upgradient of the modified channel. You should therefore discuss how the unstable channel will adjust to reach a condition of equilibrium and how this adjustment will affect your reclamation plan.

Response 19

The response to Comment 8 addressed meander growth in the reconfigured channel upstream of the nickpoint.

The current extent of meandering in the existing channel both upstream and downstream of the nickpoint can be used as a model of the probable extent of meander growth in the reconfigured channel upstream of the nickpoint. Table 7.2 of the Reclamation Plan shows that the meander amplitude for the channel downstream of the nickpoint was 145 feet in 1985 and a maximum of 170 feet upstream of the nickpoint.

New meanders in the channel upstream of the nickpoint are likely to have amplitudes near 170 feet because 1) the slope of the reconfigured channel above the nickpoint will be less than the present channel slope below the nickpoint, but greater than that above the nickpoint, and 2) the reconfigured channel will be incised into the slightly-cemented alluvial material. The slope of the reconfigured channel above the nickpoint will be 0.0075 ft/ft while that of the present channel below the nickpoint is 0.053 ft/ft and the slope above the nickpoint about 0.0018 ft/ft. Thus, the meander amplitude should be between 145 feet and 170 feet.

Also, the depth of the modified channel will inhibit the growth of meanders because of the large volume of bank material that must be eroded. The cementation of the alluvial materials will inhibit the sloughing of bank material and produce nearly vertical channel walls at the outside edge of meanders.

Even using 170 feet as the maximum amplitude of new meanders, the closest the channel would come to the tailings would still be about 195 feet. Thus, the growth of meanders in the reconfigured channel will not affect the tailings.

Comment 20

Because of high velocities in the modified Pipeline Arroyo and the extreme channel widening which is now occurring due to bank collapse, we are concerned that the modifications proposed for Pipeline Arroyo will not result in a stable stream channel. You should therefore provide rip-rap erosion protection for the channel particularly on the east bank which is closest to the tailings pile unless you can conclusively demonstrate that erosion of the Arroyo will not adversely affect the stability of the pile over a 1000 year period.

Response 20

The response to Comment 8 indicates that the reconfigured channel can be considered stable because:

- The incised nickpoint and base control structure provide vertical and horizontal stability at these locations.
- The extent of meander growth in this area will not reach the tailings area.
- The large volume of overbank material that must be eroded slows the rate of meander growth and the extent of channel movement.

Because no tailings will be released within a 1,000-year period or during the passage of the PMF, the channel can be considered stable and no riprap is needed for armoring the channel sides.

MT/klg

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TABLE 1

PARAMETERS USED TO CALCULATE THE PMF
FOR THE PIPELINE ARROYO

	Original Watershed	Revised Watershed
Drainage Area (square miles)	16.74	18.22
Mean Basin Elevation (feet)	7,275	7,275
Water Course Length (miles)	6.18	6.98
Maximum Relief (feet)	785	819
Areal Adjustment		
HMR 49(1)		0.75
Design of Small Dams2	0.74	
PMF (cfs)		
HMR 49(1)		26,300
Design of Small Dams2	25,000	

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(1) Reference, NOAA and COE, 1984

(2) Reference, United States Bureau of Reclamation, 1977

TABLE 2

COMPARISON OF CHANNEL VELOCITIES
AND WATER SURFACE ELEVATIONS

Number	Channel Velocities (fps) Q = 25,000 cfs	Q = 26,300 cfs	Water Surface Elevation Q = 25,000 cfs	Q = 26,300 cfs
1	27.26	27.59	6,885.6	6,886.0
2	22.71	22.97	6,894.3	6,894.8
3	20.61	20.83	6,896.6	6,897.2
4	27.58	27.96	6,894.5	6,894.8
5	29.73	30.16	6,914.1	6,914.4
6	30.37	30.76	6,927.2	6,927.5
7	21.18	21.23	6,935.8	6,936.5
8	20.26	19.61	6,936.7	6,937.7
9	18.80	18.99	6,936.3	6,936.8
10	19.38	19.54	6,936.3	6,936.7
11	20.01	20.41	6,941.8	6,942.1
12	18.60	18.66	6,948.4	6,948.9
13	21.23	21.03	6,950.8	6,951.3
14	16.20	16.18	6,957.4	6,957.7
15	16.39	16.69	6,960.2	6,960.3
16	20.89	21.14	6,964.4	6,964.6
17	19.90	20.05	6,973.1	6,973.3

Note: See Figures C-1 and C-2 in Appendix C of the Reclamation Plan for section locations.

TABLE 3

COMPARISON OF RIPRAP SIZES[1]
BY MAYNORDS 1978 AND MAYNORDS 1987 METHODS[2]

Location	Maynords 1978 Method[1] d_{50} (inches)	Maynords 1978 Method[1] d_{max} (inches)	Maynords 1987 Method[2] d_{50} (inches)	Maynords 1987 Method[2] d_{max} (inches)
Pipeline Arroyo				
Nickpoint	17	22	31	39
Base Control Structure	36	44	56	71
North Diversion Ditch				
Downdrain	13	16	26	32
Runoff Control Ditch	5	6	8.5	11
Runoff Control Ditch Downdrain	23	29	31	39
South Cell Drainage Channel				
Upper Section	15	19	23	29
Lower Section	24	30	36	44
North Cell Drainage Channel				
Upper Section	8	10	14	17
Lower Section	6	8	11	14

Notes: (1) Maynord, Stephen T., 1978, "Practical Riprap Design", Miscellaneous Paper 4-78-7, prepared for Office, Chief Engineers, U.S. Army, Washington, D.C.

(2) Maynord, Stephen T., 1987, "Stable Riprap Size for Open Channel Flows", Ph.D. dissertation, Colorado State University, Fort Collins, Colorado.

TABLE 4

FLOW CHARACTERISTICS FOR THE
SOUTH AND NORTH CELL SWALES

		South Cell Swale			North Cell Branch Swale		
Return Period (yrs)	One-Hr Storm Amount (inches)	Peak Discharge[2] (cfs)	Peak Velocity (cfs)	Tractive Force (psf)	Peak Discharge (cfs)	Peak Velocity (fps)	Tractive Force (psf)
200	2.03[1]	107	1.3	0.048	46.9	1.3	0.059
500	2.34[1]	151	1.4	0.054	65.6	1.5	0.067
1,000	2.56[1]	185	1.5	0.059	85.5	1.6	0.074
PMF	8.47[3]	1,301	2.4	0.122	470	2.4	0.139

(1) Storm amounts derived from extensions of base data from NOAA Atlas 2 - Volume IV, New Mexico.

(2) Peak discharges developed from SCS triangular hydrograph method.

(3) Storm amount derived from HMR-49.

ATTACHMENT

SURFACE WATER HYDROLOGY AND
HYDRAULIC CALCULATIONS

1.0 CALCULATIONS IN RESPONSE TO COMMENT 2

Attachment 1.0 contains the following calculations:

- o Overland flow calculations at the headwaters of the North and South Cell, Point 1, for a return period of 100 years.
- o Overland flow calculations at the headwaters of the North and South Cell, Point 1, for a return period of 200 years.
- o Overland flow calculations at the headwaters of the North and South Cell, Point 1, for a return period of 500 years.
- o Overland flow calculations at the headwaters of the North and South Cell, Point 1, for a return period of 1,000 years.
- o Overland flow calculations at the headwaters of the North and South Cell, Point 1, for the PMP event.
- o Overland flow calculations at the headwaters of the North and South Cell, Point 2, for a return period of 100 years.
- o Overland flow calculations at the headwaters of the North and South Cell, Point 2, for a return period of 200 years.
- o Overland flow calculations at the headwaters of the North and South Cell, Point 2, for a return period of 500 years.
- o Overland flow calculations at the headwaters of the North and South Cell, Point 2, for a return period of 1,000 years.

- Overland flow calculations at the headwaters of the North and South Cell, Point 2, for the PMP event.

- 14H:1V embankment slope calculations to determine what duration of overland flow velocity is greater than 3.0 fps.

- Overland flow calculations at the 5H:1V embankment for a return period of 100 years.

- Overland flow calculations at the 5H:1V embankment for a return period of 200 years.

- Overland flow calculations at the 5H:1V embankment for a return period of 500 years.

- Overland flow calculations at the 5H:1V embankment for a return period of 1,000 years.

- Overland flow calculations at the 5H:1V embankment for the PMP event.

- 5H:1V embankment slope calculations to determine what duration of overland flow velocity is greater than 3.0 fps.

- 5H:1V embankment slope calculations to determine the length of slope for which the PMP overland flow velocity is less than 3.0 fps.

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: NORTH AND SOUTH CELL HEAD WATERS - POINT 1

RUNOFF COEF: 1	RETURN PERIOD: 100 YRS		
SLOPE LENGTH: 296 FT	1-HR PPT AMOUNT: 1.81 INCHES		
AVE SLOPE: 0.069 FT/FT	Tc (calc): 1.745 MIN	EQTN 4.44, NUREG4620	
MANNING'S n: 0.03	Tc (actual): 2.5 MIN		
FLOW CONC: 2	%OF 1-HR PPT: 27.5 %	TABLE 2.1, NUREG 4620	
DRAINAGE AREA: 0.006 ACRES	PPT AMOUNT: 0.497 INCHES		
	PPT INTENSITY: 11.94 IPH		

PEAK DISCHARGE: 0.081 CFS   Q = CiA
CONC. DISCHARGE: 0.162 CFS

DEPTH: 0.072 FT   EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.25 FPS   V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UN' CHURCHROCK 86-060-4
LOCATION: NORTH AND SOUTH CELL HEAD WATERS - POINT 1

RUNOFF COEF: 1	RETURN PERIOD: 200 YRS		
SLOPE LENGTH: 296 FT	1-HR PPT AMOUNT: 2.03 INCHES		
AVE SLOPE: 0.069 FT/FT	Tc (calc): 1.745 MIN	EQTN 4.44, NUREG4620	
MANNING'S n: 0.03	Tc (actual): 2.5 MIN		
FLOW CONC: 2	%OF 1-HR PPT: 27.5 %	TABLE 2.1, NUREG 4620	
DRAINAGE AREA: 0.006 ACRES	PPT AMOUNT: 0.558 INCHES		
	PPT INTENSITY: 13.39 IPH		

PEAK DISCHARGE: 0.091 CFS   Q = CiA
CONC. DISCHARGE: 0.182 CFS

DEPTH: 0.077 FT   EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.36 FPS   V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
	62
15	74
20	82
30	89
45	95
60	100

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OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: NORTH AND SOUTH CELL HEAD WATERS - POINT 1

RUNOFF COEF:	1	RETURN PERIOD:	500 YRS	
SLOPE LENGTH:	295 FT	1-HR PPT AMOUNT:	2.34 INCHES	
AVE SLOPE:	0.069 FT/FT	Tc (calc):	1.741 MIN	EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN	
FLOW CONC:	2	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.006 ACRES	PPT AMOUNT:	0.643 INCHES	
		PPT INTENSITY:	15.44 IPH	

PEAK DISCHARGE: 0.104 CFS   Q = CiA
CONC. DISCHARGE: 0.209 CFS

DEPTH: 0.083 FT   EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.49 FPS   V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: NORTH AND SOUTH CELL HEAD WATERS - POINT 1

RUNOFF COEF: 1	RETURN PERIOD: 1000 YRS		
SLOPE LENGTH: 295 FT	1-HR PPT AMOUNT: 2.56 INCHES		
AVE SLOPE: 0.069 FT/FT	Tc (calc): 1.741 MIN	EQTN 4.44, NUREG4620	
MANNING'S n: 0.03	Tc (actual): 2.5 MIN		
FLOW CONC: 2	%OF 1-HR PPT: 27.5 %	TABLE 2.1, NUREG 4620	
DRAINAGE AREA: 0.006 ACRES	PPT AMOUNT: 0.704 INCHES		
	PPT INTENSITY: 15.89 IPH		

PEAK DISCHARGE: 0.114 CFS   Q = CiA
CONC. DISCHARGE: 0.228 CFS

DEPTH: 0.008 FT   EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.58 FPS   V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: NORTH AND SOUTH CELL HEAD WATERS - POINT 1

RUNOFF COEF:	1	RETURN PERIOD:	PMP YRS	
SLOPE LENGTH:	296 FT	1-HR PPT AMOUNT:	8.46 INCHES	
AVE SLOPE:	0.069 FT/FT	Tc (calc):	1.745 MIN	EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN	
FLOW CONC:	2	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.006 ACRES	PPT AMOUNT:	2.326 INCHES	
		PPT INTENSITY:	55.83 IPH	

PEAK DISCHARGE: 0.379 CFS Q = CiA
CONC. DISCHARGE: 0.758 CFS

DEPTH: 0.181 FT EQTN 4.45, NUREG 4620

FLOW VELOCITY: 4.17 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: NORTH AND SOUTH CELL HEAD WATERS - POINT 2

RUNOFF COEF:	1	RETURN PERIOD:	100 YRS	
SLOPE LENGTH:	375 FT	1-HR PPT AMOUNT:	1.81 INCHES	
AVE SLOPE:	0.071 FT/FT	Tc (calc):	2.071 MIN	EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN	
FLOW CONC:	2	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.008 ACRES	PPT AMOUNT:	0.497 INCHES	
		PPT INTENSITY:	11.94 IPH	

PEAK DISCHARGE: 0.102 CFS   Q = CiA
CONC. DISCHARGE: 0.205 CFS

DEPTH: 0.082 FT   EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.50 FPS   V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: NORTH AND SOUTH CELL HEAD WATERS - POINT 2

RUNOFF COEF:	1	RETURN PERIOD:	200 YRS	
SLOPE LENGTH:	375 FT	1-HR PPT AMOUNT:	2.03 INCHES	
AVE SLOPE:	0.071 FT/FT	Tc (calc):	2.071 MIN	EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN	
FLOW CONC:	2	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.008 ACRES	PPT AMOUNT:	0.558 INCHES	
		PPT INTENSITY:	13.39 IPH	

PEAK DISCHARGE: 0.115 CFS   Q = CiA
CONC. DISCHARGE: 0.230 CFS

DEPTH: 0.088 FT   EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.62 FPS   V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: NORTH AND SOUTH CELL HEAD WATERS - POINT 2

RUNOFF COEF:	1	RETURN PERIOD:	500 YRS	
SLOPE LENGTH:	375 FT	1-HR PPT AMOUNT:	2.34 INCHES	
AVE SLOPE:	0.071 FT/FT	Tc (calc):	2.071 MIN	EQTN 4.44, NUREG 4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN	
FLOW CONC:	2	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.008 ACRES	PPT AMOUNT:	0.643 INCHES	
		PPT INTENSITY:	15.44 IPH	

PEAK DISCHARGE: 0.132 CFS   Q = CiA
CONC. DISCHARGE: 0.265 CFS

DEPTH: 0.096 FT   EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.77 FPS   V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: NORTH AND SOUTH CELL HEAD WATERS - POINT 2

RUNOFF COEF:	1	RETURN PERIOD:	1000 YRS	
SLOPE LENGTH:	375 FT	1-HR PPT AMOUNT:	2.56 INCHES	
AVE SLOPE:	0.071 FT/FT	Tc (calc):	2.071 MIN	EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN	
FLOW CONC:	2	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.008 ACRES	PPT AMOUNT:	0.704 INCHES	
		PPT INTENSITY:	16.89 IPH	

PEAK DISCHARGE: 0.145 CFS Q = CiA
CONC. DISCHARGE: 0.290 CFS

DEPTH: 0.101 FT EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.87 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: NORTH AND SOUTH CELL HEAD WATERS - POINT 2

RUNOFF COEF:	1	RETURN PERIOD:	PMP YRS	
SLOPE LENGTH:	375 FT	1-HR PPT AMOUNT:	8.46 INCHES	
AVE SLOPE:	0.071 FT/FT	Tc (calc):	2.071 MIN	EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN	
FLOW CONC:	2	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.008 ACRES	PPT AMOUNT:	2.326 INCHES	
		PPT INTENSITY:	55.83 IPH	

PEAK DISCHARGE: 0.480 CFS Q = CiA
CONC. DISCHARGE: 0.961 CFS

DEPTH: 0.207 FT EQTN 4.46, NUREG 4620

FLOW VELOCITY: 4.63 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	52
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: 14H:1V EMBANKMENT SLOPES

RUNOFF COEF: 1
SLOPE LENGTH: 375 FT
AVE SLOPE: 0.071 FT/FT
MANNING'S n: 0.03
FLOW CONC: 2
DRAINAGE AREA: 0.008 ACRES

RETURN PERIOD: pmp YRS
1-HR PPT: 8.46 INCHES
Tc (calc): 2.067 MIN EQTN 4.44, NUREG4620
Tc (actual): 22 MIN
%OF 1-HR PPT: 83 % TABLE 2.1, NUREG 4620
PPT AMOUNT: 7.021 INCHES
PPT INTENSITY: 19.15 IPH

PEAK DISCHARGE: 0.164 CFS Q = CIA
CONC. DISCHARGE: 0.329 CFS

DEPTH: 0.109 FT EQTN 4.46, NUREG 4620

FLOW VELOCITY: 3.02 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: 5H:1V EMBANKMENT SLOPE

RUNOFF COEF:	1	RETURN PERIOD:	100 YRS
SLOPE LENGTH:	140 FT	1-HR PPT AMOUNT:	1.81 INCHES
AVE SLOPE:	0.2 FT/FT	Tc (calc):	0.651 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN
FLOW CONC:	2.5	%OF 1-HR PPT:	27.5 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.003 ACRES	PPT AMOUNT:	0.497 INCHES
		PPT INTENSITY:	11.94 IPH

PEAK DISCHARGE: 0.038 CFS Q = CiA
CONC. DISCHARGE: 0.095 CFS

DEPTH: 0.038 FT EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.51 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: 5H:1V EMBANKMENT SLOPE

RUNOFF COEF:	1	RETURN PERIOD:	200 YRS
SLOPE LENGTH:	140 FT	1-HR PPT AMOUNT:	2.03 INCHES
AVE SLOPE:	0.2 FT/FT	Tc (calc):	0.651 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN
FLOW CONC:	2.5	%OF 1-HR PPT:	27.5 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.003 ACRES	PPT AMOUNT:	0.558 INCHES
		PPT INTENSITY:	13.39 IPH

PEAK DISCHARGE: 0.043 CFS Q = CiA
CONC. DISCHARGE: 0.107 CFS

DEPTH: 0.040 FT EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.63 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	[illegible]9
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: 5H:1V EMBANKMENT SLOPE

RUNOFF COEF:	1	RETURN PERIOD:	500 YRS
SLOPE LENGTH:	140 FT	1-HR PPT AMOUNT:	2.34 INCHES
AVE SLOPE:	0.2 FT/FT	Tc (calc):	0.651 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN
FLOW CONC:	2.5	%OF 1-HR PPT:	27.5 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.003 ACRES	PPT AMOUNT:	0.643 INCHES
		PPT INTENSITY:	15.44 IPH

PEAK DISCHARGE: 0.049 CFS Q = CiA
CONC. DISCHARGE: 0.124 CFS

DEPTH: 0.044 FT EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.78 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: 5H:1V EMBANKMENT SLOPE

RUNOFF COEF: 1	RETURN PERIOD: 1000 YRS		
SLOPE LENGTH: 140 FT	1-HR PPT AMOUNT: 2.56 INCHES		
AVE SLOPE: 0.2 FT/FT	Tc (calc): 0.651 MIN	EQTN 4.44, NUREG4620	
MANNING'S n: 0.03	Tc (actual): 2.5 MIN		
FLOW CONC: 2.5	%OF 1-HR PPT: 27.5 %	TABLE 2.1, NUREG 4620	
DRAINAGE AREA: 0.003 ACRES	PPT AMOUNT: 0.704 INCHES		
	PPT INTENSITY: 16.89 IPH		

PEAK DISCHARGE: 0.054 CFS Q = CiA
CONC. DISCHARGE: 0.135 CFS

DEPTH: 0.047 FT EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.89 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	96
50	100

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: 5H:1V EMBANKMENT SLOPE

RUNOFF COEF:	1	RETURN PERIOD:	PMP YRS	
SLOPE LENGTH:	140 FT	1-HR PPT AMOUNT:	8.47 INCHES	
AVE SLOPE:	0.2 FT/FT	Tc (calc):	0.651 MIN	EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	2.5 MIN	
FLOW CONC:	2.5	%OF 1-HR PPT:	27.5 %	TABLE 2.1, NURFG 4620
DRAINAGE AREA:	0.003 ACRES	PPT AMOUNT:	2.329 INCHES	
		PPT INTENSITY:	55.90 IPH	

PEAK DISCHARGE: 0.179 CFS Q = CiA
CONC. DISCHARGE: 0.449 CFS

DEPTH: 0.096 FT EQTN 4.46, NUREG 4620

FLOW VELOCITY: 4.66 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

OVERLAND FLOW CALCULATIONS USING THE UNIT WIDTH METHOD

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: 5H:1V EMBANKMENT SLOPE

RUNOFF COEF:	1	RETURN PERIOD:	PMP YRS
SLOPE LENGTH:	140 FT	1-HR PPT AMOUNT:	8.47 INCHES
AVE SLOPE:	0.2 FT/FT	Tc (calc):	0.651 MIN EQTN 4.44, NUREG4620
MANNING'S n:	0.03	Tc (actual):	24 MIN
FLOW CONC:	2.5	%OF 1-HR PPT:	86 % TABLE 2.1, NUREG 4620
DRAINAGE AREA:	0.003 ACRES	PPT AMOUNT:	7.284 INCHES
		PPT INTENSITY:	18.21 IPH

PEAK DISCHARGE: 0.058 CFS Q = CiA
CONC. DISCHARGE: 0.146 CFS

DEPTH: 0.049 FT EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.97 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

PROJECT: UNC CHURCHROCK 86-060-4
LOCATION: 5H:1V EMBANKMENT SLOPE

RUNOFF COEF: 1	RETURN PERIOD: PMF YRS		
SLOPE LENGTH: 46 FT	1-HR PPT AMOUNT: 8.47 INCHES		
AVE SLOPE: 0.2 FT/FT	Tc (calc): 0.276 MIN	EQTN 4.44, NUREG4620
MANNING'S n: 0.03	Tc (actual): 2.5 MIN		
FLOW CONC: 2.5	%OF 1-HR PPT: 27.5 %	TABLE 2.1, NUREG 4620
DRAINAGE AREA: 0.001 ACRES	PPT AMOUNT: 2.329 INCHES		
	PPT INTENSITY: 55.90 IPH		

PEAK DISCHARGE: 0.059 CFS Q = CiA
CONC. DISCHARGE: 0.147 CFS

DEPTH: 0.049 FT EQTN 4.46, NUREG 4620

FLOW VELOCITY: 2.98 FPS V = Q/FLOW AREA

TABLE 2.1 OF NUREG 4620

RAINFALL DURATION (MIN)	PERCENT OF 1-HR PPT
2.5	27.5
5	45
10	62
15	74
20	82
30	89
45	95
60	100

2.0 CALCULATIONS IN RESPONSE TO COMMENT 7

Attachment 2.0 contains the following calculations:

- o PMF calculation for the original Pipeline Arroyo watershed.
- o PMF calculation for the revised Pipeline Arroyo watershed.
- o Printout of the revised HEC-2 computer model used to determine the limits of the PMF.

Design of Small Dams - Orignal Watershed
PIPELINE ARROYO UNC PROJECT RM86-060-01
26-Apr-88 17:26

ONE-HOUR RAINFALL AMOUNT	9.4	INCHES		
SCS CURVE NUMBER	79		S =	2.66
MEAN BASIN ELEV.	7275	FEET		
DURATION (D)	0.25	HOURS		
WATER COURSE LENGTH (L)	6.18	MILES		0.88068181B
WATERSHED AREA (A)	16.74	SQ. MILES		
MAXIMUM RELIEF (H)	785.00	FEET		
ELEV ADJUSTMENT	0.88625	ADJ. RAINFAL		8.33 INCHES
AREAL ADJUSTMENT (DSD)	0.74	ADJ. RAINFAL		6.16 INCHES
WATERSHED ADJUSTMENT (DSD, TABLE 5, PG 67)	1.04			

ITEM	TIME PERIOD, HRS 0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (DSD,TABLE 2, PG 52)	48	71	88	100
CUMULATIVE RAINFALL	2.96	4.38	5.42	6.16
INCREMENTAL RAINFALL	2.96	1.42	1.05	0.74
SEQUENCE	1.05	1.42	2.96	0.74
P - CUMULATIVE DESIGN RAINFALL	1.05	2.47	5.42	6.16
Q - CUMULATIVE RUNOFF	0.08	0.81	3.17	3.83
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.08	0.73	2.36	0.66

TIME OF CONCENTRATION (Tc)	1.63	HOURS
ADJUSTED Tc	1.70	HOURS
TIME TO PEAK (Tp)	1.14	HOURS
BASE PERIOD (Tb)	3.06	HOURS
UNIT PEAK DISCHARGE	7080	CFS

	TIME	INTERMEDIATE HYDROGRAPHS FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		594.64	5173.16	16681.52	4646.45	
	0.00	0.00				0.00
	0.14	74.33				74.33
	0.29	148.66	0.00			148.66
	0.43	222.99	646.65	0.00		869.63
	0.57	297.32	1293.29	2085.19		3675.80
	0.72	371.65	1939.94	4170.38	0.00	6481.96
	0.86	445.98	2586.58	6255.57	580.81	9868.94
	1.00	520.31	3233.23	8340.76	1161.61	13255.91
	1.14	594.64	3879.87	10425.95	1742.42	16642.88
	1.29	550.13	4526.52	12511.14	2323.22	19911.01
	1.43	305.62	5173.16	14596.33	2904.03	23179.15
	1.57	461.11	4785.95	16681.52	3484.84	25413.42
	1.72	416.60	4398.74	15432.91	4065.64	24313.89
	1.86	372.09	4011.52	14184.29	4646.45	23214.36
	2.00	327.58	3624.31	12935.67	4298.66	21186.23
	2.15	283.08	3237.10	11687.06	3950.87	19158.10
	2.29	238.57	2849.89	10438.44	3603.08	17129.98
	2.43	194.06	2462.67	9189.82	3255.30	15101.85
	2.57	149.55	2075.46	7941.20	2907.51	13073.72
	2.72	105.04	1688.25	6692.59	2559.72	11045.60
	2.86	60.53	1301.03	5443.97	2211.93	9017.47
	3.00	16.02	913.82	4195.35	1864.14	6989.34
	3.15	0.00	526.61	2946.74	1516.36	4989.70
	3.29		139.40	1698.12	1168.57	3006.08
	3.43		0.00	449.50	820.78	1270.28
	3.58			0.00	472.99	472.99
	3.72				125.20	125.20
	3.86				0.00	0.00
	4.01					

HYDROGRAPH CALCULATION FOR ONE-HOUR PMP EVENTS USING THE SCS CURVE NUMBER METHOD
HMR 49 RAINFALL DISTRIBUTION USED

Design of Small Dams - Revised Watershed
PIPELINE ARROYO UNC PROJECT RM86-060-01
13-May-88 14:59

ONE-HOUR RAINFALL AMOUNT	9.4	INCHES	
SCS CURVE NUMBER	79	S =	2.66
MEAN BASIN ELEV.	7275	FEET	
DURATION (D)	0.25	HOURS	
WATER COURSE LENGTH (L)	6.98	MILES	0.880681818
WATERSHED AREA (A)	18.22	SQ. MILES	
MAXIMUM RELIEF (H)	819.00	FEET	
ELEV ADJUSTMENT	0.88625	ADJ. RAINFAL	8.33 INCHES
AREAL ADJUSTMENT (DSD)	0.75	ADJ. RAINFAL	6.25 INCHES
WATERSHED ADJUSTMENT (DSD, TABLE 5, PG 67)	1.04		

ITEM	TIME PERIOD, HRS 0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (DSD,TABLE 2, PG 52)	74	89	95	100
CUMULATIVE RAINFALL	4.62	5.56	5.94	6.25
INCREMENTAL RAINFALL	4.62	0.94	0.37	0.31
SEQUENCE	0.37	0.94	4.62	0.31
P - CUMULATIVE DESIGN RAINFALL	0.37	1.31	5.94	6.25
Q - CUMULATIVE RUNOFF	0.01	0.18	3.62	3.90
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.01	0.17	3.45	0.28

TIME OF CONCENTRATION (Tc)	1.85	HOURS
ADJUSTED Tc	1.92	HOURS
TIME TO PEAK (Tp)	1.28	HOURS
BASE PERIOD (Tb)	3.42	HOURS
UNIT PEAK DISCHARGE	6893	CFS

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		67.72	1153.31	23748.32	1928.13	
	0.00	0.00				0.00
	0.16	8.46				8.46
	0.32	16.93	0.00			16.93
	0.48	25.39	144.16	0.00		169.56
	0.64	33.86	288.33	2968.54		3290.73
	0.80	42.32	432.49	5937.08	0.00	6411.90
	0.96	50.79	576.66	8905.62	241.02	9774.08
	1.12	59.25	720.82	11874.16	482.03	13136.27
	1.28	67.72	864.98	14842.70	723.05	16498.45
	1.44	62.65	1009.15	17811.24	964.06	19847.10
	1.60	57.58	1153.31	20779.78	1205.08	23195.75
	1.76	52.51	1066.98	23748.32	1446.10	26313.92
	1.92	47.44	980.66	21970.75	1687.11	24685.97
	2.08	42.38	894.33	20193.18	1928.13	23058.02
	2.24	37.31	808.01	18415.61	1783.81	21044.74
	2.40	32.24	721.68	16638.05	1639.49	19031.45
	2.56	27.17	635.36	14860.48	1495.16	17018.17
	2.72	22.10	549.03	13082.91	1350.84	15004.88
	2.88	17.03	462.71	11305.34	1206.52	12991.60
	3.04	11.96	376.38	9527.77	1062.20	10978.31
	3.20	6.89	290.05	7750.20	917.88	8965.03
	3.36	1.82	203.73	5972.63	773.56	6951.75
	3.52	0.00	117.40	4195.06	629.24	4941.70
	3.68		31.08	2417.49	484.92	2933.49
	3.84		0.00	639.92	340.60	980.52
	4.00			0.00	196.28	196.28
	4.16				51.96	51.96
	4.32				0.00	0.00
	4.48					

```
1 **************************************************          **************************************
* WATER SURFACE PROFILES                           *          * U.S. ARMY CORPS OF ENGINEERS       *
* VERSION OF NOVEMBER 1976                         *          * THE HYDROLOGIC ENGINEERING CENTER  *
* UPDATED MARCH 1982                               *          * 609 SECOND STREET, SUITE D         *
*                                                  *          * DAVIS, CALIFORNIA 95616            *
* RUN DATE THU, MAY 12 1988   TIME 15:20:59        *          * (916) 440-2105 (FTS) 448-2105      *
**************************************************          **************************************
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X     X XXXXXXX  XXXXX           XXXXX
X     X X       X     X         X     X
X     X X       X                     X
XXXXXXX XXXX    X         XXXXX  XXXXX
X     X X       X               X
X     X X       X     X         X
X     X XXXXXXX  XXXXX          XXXXXXX
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THIS RUN EXECUTED THU, MAY 12 1988 15:20:59

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HEC2 RELEASE DATED NOV 76 UPDATED MAR 1982

ERROR CORR - 01,02,03,04,05

MODIFICATION - 50,51,52,53,54,55

****

T1 ALTERNATIVE 5 - ALTERED CHANNEL CONFIGURATION - Q=26300CFS

T2 UNC PROJECT NO. RM86-060-04 5/12/88

T3 PIPELINE ARROYO SUPERCRITICAL FLOW

J1	ICHECK	INQ	NINV	IDIR	STRT	METRIC	HVINS	Q	WSEL	FQ
	0.	0.	0.	1.	0.007600	0.00	0.0	26300.	6977.090	0.000

NC	0.060	0.060	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	17.000	9.000	539.000	634.000	1000.000	1010.000	1000.000	0.000	0.000	0.000
GR	6975.000	0.000	6970.000	539.000	6959.100	572.000	6959.100	601.000	6970.000	634.000
GR	6970.000	810.000	6968.000	845.000	6970.000	862.000	6975.000	1095.000	0.000	0.000
X1	16.000	20.000	612.000	706.000	1005.000	1015.000	1015.000	0.000	0.000	0.000
GR	6995.000	0.000	6990.000	14.000	6985.000	37.000	6980.000	60.000	6975.000	71.000
GR	6970.000	140.000	6965.000	231.000	6965.000	300.000	6965.000	465.000	6960.000	612.000
GR	6951.400	648.000	6951.400	680.000	6960.000	706.000	6960.000	740.000	6965.000	791.000
GR	6965.000	955.000	6960.700	1180.000	6965.000	1445.000	6970.000	1490.000	6975.000	1508.000
X1	15.000	15.000	621.000	730.000	528.000	522.000	525.000	0.000	0.000	0.000
GR	6975.000	0.000	6970.000	77.000	6965.000	185.000	6960.000	357.000	6960.000	382.000
GR	6960.000	621.000	6943.800	670.000	6943.800	690.000	6957.000	730.000	6958.000	950.000
GR	6957.000	1120.000	6960.000	1831.000	6965.000	1872.000	6970.000	1898.000	6975.000	1933.000
NC	0.060	0.035	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	14.000	10.000	615.000	723.000	473.000	475.000	473.000	0.000	0.000	0.000
GR	6970.000	0.000	6960.000	140.000	6955.000	615.000	6939.800	660.000	6939.800	680.000
GR	6954.000	723.000	6955.000	903.000	6955.000	[illegible]	6960.000	1195.990	6965.000	1450.000
X1	13.000	10.000	578.000	712.000	727.000	722.000	725.000	0.000	0.000	0.000
GR	6970.000	0.000	6960.000	155.000	6955.000	225.000	6950.100	578.000	6936.100	620.000
GR	6936.100	640.000	6950.000	712.000	6954.000	760.000	6961.000	839.000	6965.000	[illegible]
X1	12.000	6.000	80.000	219.000	790.000	795.000	793.000	0.000	0.000	0.000
GR	6950.000	0.000	6950.000	80.000	6930.400	139.000	6930.400	159.000	6950.000	219.000
GR	6952.000	290.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	11.000	4.000	0.000	151.000	760.000	797.000	780.000	0.000	0.000	0.000
GR	6948.000	0.000	6924.500	71.000	6924.500	91.000	6944.500	151.000	0.000	0.000

X1	10.000	4.000	0.500	150.000	130.000	130.000	130.000	0.000	0.000	0.000
GR	6939.000	0.000	6918.500	60.000	6918.500	80.000	6942.000	150.000	0.000	0.000
NC	0.060	0.0[illegible]	0.025	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	9.000	7.000	100.000	231.000	95.000	95.000	95.000	0.000	0.000	0.000
GR	6960.000	0.000	6938.000	100.000	6927.000	133.000	6915.600	150.000	6915.600	170.000
GR	69[illegible].000	177.000	6938.000	231.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	8.000	9.000	122.000	233.000	95.000	105.000	95.000	0.000	0.000	0.000
GR	6950.000	0.000	6942.000	116.000	6939.200	122.000	6935.200	134.000	6914.500	165.000
GR	6914.500	185.000	6928.500	206.000	6937.500	233.000	6938.000	310.000	0.000	0.000
X1	7.000	8.000	143.000	260.000	160.000	127.000	145.000	0.000	0.000	0.000
GR	6950.000	0.000	6945.000	74.000	6943.500	143.000	6938.800	157.000	6913.500	195.000
GR	6913.000	215.000	6935.000	245.000	6940.000	260.000	0.000	0.000	0.000	0.000
NC	0.0[illegible]	0.035	0.030	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	6.000	8.000	143.[illegible]	248.000	610.000	615.000	610.000	0.000	0.000	0.000
GR	6950.000	0.000	6945.300	150.000	6940.000	87.000	6930.000	143.000	6912.400	185.000
GR	6912.400	205.000	6930.000	248.000	6935.000	455.000	0.000	0.000	0.000	0.000
X1	5.000	4.000	0.000	190.000	1049.000	1010.000	1035.000	0.000	0.000	0.000
GR	6938.000	0.000	6900.400	90.000	6900.400	110.000	6927.000	190.000	0.000	0.000
X1	4.000	4.000	0.000	170.000	243.000	245.000	245.000	0.000	0.000	0.000
GR	6900.000	0.000	6880.100	60.000	6880.100	80.000	6910.000	170.000	0.000	0.000
NC	0.0[illegible]	0.035	0.047	0.000	0.000	0.000	0.000	0.000	0.000	0.000
X1	3.000	4.000	0.000	140.000	50.000	50.000	50.000	0.000	0.000	0.000
GR	6910.000	0.000	6875.300	60.000	6875.300	80.000	6910.000	140.000	0.000	0.000
X1	2.000	4.000	0.000	138.000	[illegible]0.000	360.000	290.000	0.000	0.000	0.000
GR	6910.000	0.000	6874.300	60.000	6874.300	80.000	6906.000	138.000	0.000	0.000
NC	0.060	0.035	0.030	0.000	0.000	0.000	0.000	0.000	0.060	0.0[illegible]
X1	1.000	6.000	173.000	330.000	0.000	0.000	0.000	0.000	0.000	0.000
GR	6910.000	0.000	6907.000	173.000	6868.600	239.000	6868.600	259.000	6900.000	330.000
GR	6905.000	475.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
EJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

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1
 THU, MAY 12 1988  15:20:59                                                                      PAGE    3

    SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
    Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA    LEFT/RIGHT
    TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
    SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

 *PROF 1

 *SECNO 17.000
     17.00    14.18  6973.28  6975.08  6977.00  6978.05     4.76     0.00     0.00  6970.00
    26300.    1740.   19796.    4764.     580.     988.    1051.       0.       0.  6970.00
      0.00     3.00    20.05     4.53    0.060    0.030    0.060    0.000  6959.10   185.29
  0.007576       0.       0.       0.        0        9        5     0.00   829.61  1014.90
0
 *SECNO 16.000

 265 DIVIDED FLOW

 3301 HV CHANGED MORE THAN HVINS
     16.00    13.20  6964.60  6966.55     0.00  6970.09     5.49     7.95     0.00  6960.00
    26300.    1228.   20602.    4470.     312.     975.    1133.      58.      18.  6960.00
      0.02     3.94    21.14     3.94    0.060    0.030    0.060    0.000  6951.40   476.63
  0.003329    1000.    1000.    1010.        6        9        0     0.00   755.25  1420.62
0
 *SECNO 15.000

 3301 HV CHANGED MORE THAN HVINS
     15.00    16.49  6960.29  6961.30     0.00  6962.45     3.16     6.64     0.00  6960.00
    26300.      62.   18974.    7264.      79.    1137.    2363.     128.      44.  6957.00
      0.04     0.79    16.69     3.07    0.060    0.030    0.060    0.000  6943.80   346.96
  0.005274    1005.    1015.    1015.        5       16        0     0.00  1486.44  1833.39
0
 *SECNO 14.000
     14.00    17.91  6957.71  6958.56     0.00  6961.01     3.30     2.45     0.00  6955.00
    26300.     679.   20817.    4804.     348.    1286.     899.     165.      58.  6954.00
      0.05     1.95    16.18     5.34    0.060    0.030    0.035    0.000  6939.80   357.99
  0.004155      528     525.     522.        4        8        0     0.00   728.25  1086.24
0
 *SECNO 13.000

 3301 HV CHANGED MORE THAN HVINS
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK      EG       HV       HL       OLOSS   BANK ELEV
   Q         QLOB      QCH       QROB      ALOB       ACH      AROB     VOL      TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL        XNCH     XNR      WTN      ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL     IDC      ICONT    CORAR    TOPWID     ENDST

    13.00     15.22  6951.32  6953.66      0.00  6958.15     6.83     2.86      0.00   6950.10
   26300.       93.   26174.      33.       53.    1245.      10.     186.       63.   6950.00
     0.05      1.74    21.03     3.14     0.060    0.030    0.035    0.000   6936.10    490.24
  0.009558     473.     473.     475.         6        8        0     0.00    237.58    727.82
0

*SECNO 12.000

3301 HV CHANGED MORE THAN HVINS
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    12.00     18.50  6948.90  6948.90      0.00  6954.31     5.41     5.62      3.20   6950.00
   26300.        0.   26300.       0.        0.    1410.       0.     208.       66.   6950.00
     0.07      0.00    18.66     0.00     0.060    0.030    0.035    0.000   6930.40     83.30
  0.006419     727.     725.     722.        20       12        0     0.00    132.35    215.65
0

*SECNO 11.000

3301 HV CHANGED MORE THAN HVINS
    11.00     17.63  6942.13  6943.06      0.00  6948.60     6.47     5.71      0.00   6948.00
   26300.        0.   26300.       0.        0.    1208.       0.     233.       68.   6944.50
     0.08      0.00    20.41     0.00     0.060    0.030    0.035    0.000   6924.50     17.74
  0.008131     790.     793.     795.         4        5        0     0.00    126.15    143.89
0

*SECNO 10.000

3301 HV CHANGED MORE THAN HVINS
    10.00     18.23  6936.73  6937.14      0.00  6942.66     5.93     5.94      0.00   6939.00
   26300.        0.   26300.       0.        0.    1346.       0.     266.       71.   6942.00
     0.09      0.00    19.54     0.00     0.060    0.030    0.035    0.000   6918.50      6.63
  0.007151     760.     780.     797.         3        8        0     0.00    127.68    134.31
0

*SECNO 9.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
```

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1
 THU, MAY 12 1988  15:20:59                                                                 PAGE    5

    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST

      9.00     21.18  6936.78  6936.78     0.00  6942.38      5.60      0.73      0.03  6938.00
    26300.        0.   26300.        0.       0.    1385.        0.      260.       71.   6938.00
      0.09      0.00     18.99      0.00    0.060    0.025    0.035     0.000  6915.60    103.66
  0.004472      130.      130.      130.       20        8        0      0.00    123.67    227.34
0
 *SECNO 8.000
 3685 20 TRIALS ATTEMPTED WSEL,CWSEL
 3693 PROBABLE MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
      8.00     23.22  6937.72  6937.72     0.00  6943.69      5.97      0.42      0.20  6939.20
    26300.        0.   26298.        2.       0.    1341.        4.      263.       71.   6937.50
      0.09      0.00     19.61      0.64    0.060    0.025    0.035 [illegible] [illegible]  126.43
  0.004303       95.       95.       95.       20        8        0      0.00    140.87    267.30
0
 *SECNO 7.000

 3301 HV CHANGED MORE THAN HVINS
 3685 20 TRIALS ATTEMPTED WSEL,CWSEL
 3693 PROBABLE MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
      7.00     23.48  6936.48  6936.48     0.00  6943.48      7.00      0.42      0.14  6943.50
    26300.        0.   26300.        0.       0.    1239.        0.      266.       72.   6940.00
      0.09      0.00     21.23      0.00    0.060    0.025    0.035     0.000  6313.00    160.48
  0.004648       95.       95.      105.       20        5        0      0.00     88.96    249.45
0
 *SECNO 6.000

 3301 HV CHANGED MORE THAN HVINS
      6.00     15.13  6927.53  6933.27     0.00  6942.22     14.69      1.26      0.00  6930.00
    26300.        0.   26300.        0.       0.     855.        0.      270.       72.   6930.00
      0.09      0.00     30.76      0.00    0.060    0.030    0.035     0.000  6917.40    148.90
  0.021776      160.      145.      127.        6        8        0      0.00     93.06    241.96
0
 *SECNO 5.000

 3301 HV CHANGED MORE THAN HVINS
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4.00 7450. .      I     W CL  E R    .   .   .   .   .   .   .   .
     7500. .      I      WC.L E R    .   .   .   .   .   .   .   .
     7550. .     I.      WC. LE R    .   .   .   .   .   .   .   .
     7600. .     I.      WC.  E R    .   .   .   .   .   .   .   .
     7650. .    I .      WC. E LR    .   .   .   .   .   .   .   .
3.00 7700. .    I .       W. E  L    .   .   .   .   .   .   .   .
2.00 7750. .   I  .     WC .E R L    .   .   .   .   .   .   .   .
     7800. .   I  .     W  .ERM L    .   .   .   .   .   .   .   .
     7850. .  I   .    WC   ERML     .   .   .   .   .   .   .   .
     7900. .  I   .   WC   ER ML     .   .   .   .   .   .   .   .
     7950. . I    .  W C   ER ML     .   .   .   .   .   .   .   .
     8000. . I    .  WC    ER  ML    .   .   .   .   .   .   .   .
1.00 8050. . I    . W C    ER  ML    .   .   .   .   .   .   .   .
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THU, MAY 12 1988 15:20:59   PAGE   8

THIS RUN EXECUTED THU, MAY 12 1988   15:21:33

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  HEC2 RELEASE DATED NOV 76 UPDATED MAR  1982
  ERROR CORR -  01,02,03,04,05
  MODIFICATION -  50,51,52,53,54,55
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BOTTOM

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      4900. .         .         .        .I       WMLE      .         .         .         .         .         .
      4950. .         .         .        .I       WMLE      .         .         .         .         .         .
      5000. .         .         .        .I        WLRE     .         .         .         .         .         .
      5050. .         .         .        I       WCLE       .         .         .         .         .         .
      5100. .         .         .        I       WMLE       .         .         .         .         .         .
      5150. .         .         .        I       WMLE       .         .         .         .         .         .
      5200. .         .         .        I       WLRE       .         .         .         .         .         .
      5250. .         .         .        I       WLRE       .         .         .         .         .         .
      5300. .         .         .       I.      WCLE        .         .         .         .         .         .
10.00 5350. .         .         .       I.      WCLE        .         .         .         .         .         .
      5400. .         .         .       I.      WCRE        .         .         .         .         .         .
 9.00 5450. .         .         .      I .      WL.E        .         .         .         .         .         .
      5500. .         .         .      I .        W. E      .         .         .         .         .         .
 8.00 5550. .         .         .     I  .        WL E      .         .         .         .         .         .
      5600. .         .         .     I  .        WMLE      .         .         .         .         .         .
 7.00 5650. .         .         .     I  .       W R E      .         .         .         .         .         .
      5700. .         .         .    I   .      WCL. E      .         .         .         .         .         .
      5750. .         .         .    I   .    W CM .E       .         .         .         .         .         .
 6.00 5800. .         .         .    I   .   WL CM .E       .         .         .         .         .         .
      5850. .         .         .    I   .  W LCM  .E       .         .         .         .         .         .
      5900. .         .         .   I    .  W C M  E        .         .         .         .         .         .
      5950. .         .         .   I    . W  C M E.        .         .         .         .         .         .
      6000. .         .         .  I     . W CLM  E.        .         .         .         .         .         .
      6050. .         .         .  I     .W  CLM E .        .         .         .         .         .         .
      6100. .         .         . I      .W CRLM E .        .         .         .         .         .         .
      6150. .         .         . I      W  CRL E  .        .         .         .         .         .         .
      6200. .         .         .I      W. C RL E  .        .         .         .         .         .         .
      6250. .         .         .I      W.C  RLE   .        .         .         .         .         .         .
      6300. .         .        .I      W .C  RE    .        .         .         .         .         .         .
      6350. .         .        .I      W C   RE    .        .         .         .         .         .         .
 5.00 6400. .         .        I      W C.   EL    .        .         .         .         .         .         .
      6450. .         .        I      W C.  RE     .        .         .         .         .         .         .
      6500. .         .       I.     W C . MEL     .        .         .         .         .         .         .
      6550. .         .       I.     W C . RE      .        .         .         .         .         .         .
      6600. .         .      I .    W C  .ME       .        .         .         .         .         .         .
      6650. .         .      I .    W C  MLE       .        .         .         .         .         .         .
      6700. .         .     I  .   W  C  ME        .        .         .         .         .         .         .
      6750. .         .     I  .   W C  MLE        .        .         .         .         .         .         .
      6800. .         .    I   .  W  C MLE         .        .         .         .         .         .         .
      6850. .         .    I   .  W C  L E         .        .         .         .         .         .         .
      6900. .         .   I    . W  C MLE.         .        .         .         .         .         .         .
      6950. .         .   I    . W C ML E.         .        .         .         .         .         .         .
      7000. .         .  I     . W C L ER.         .        .         .         .         .         .         .
      7050. .         .  I     .W C MLER .         .        .         .         .         .         .         .
      7100. .         . I      .W CML ER .         .        .         .         .         .         .         .
      7150. .         . I      W C L ER  .         .        .         .         .         .         .         .
      7200. .         .I       W CL  ER  .         .        .         .         .         .         .         .
      7250. .         .I      W.CML E R  .         .        .         .         .         .         .         .
      7300. .        .I       W.CL  ER   .         .        .         .         .         .         .         .
      7350. .        .I      W CL  E R   .         .        .         .         .         .         .         .
      7400. .        I       W CL  ER    .         .        .         .         .         .         .         .
```

```
      2300. .        .        .        .        .I     RLWE  M    .        .        .        .        .
      2350. .        .        .        .        .I     RWCE  M    .        .        .        .        .
      2400. .        .        .        .        .I     LWCE K     .        .        .        .        .
      2450. .        .        .        .        I     RLWCE M     .        .        .        .        .
      2500. .        .        .        .        I     RLW.E M     .        .        .        .        .
14.00 2550. .        .        .        .        I     RLW.E M     .        .        .        .        .
      2600. .        .        .        .        I      L WE M     .        .        .        .        .
      2650. .        .        .        .        I     LWCE  M     .        .        .        .        .
      2700. .        .        .        .       I.    RLWCE  M     .        .        .        .        .
      2750. .        .        .        .       I.    L W E  M     .        .        .        .        .
      2800. .        .        .        .       I.    LWC E  M     .        .        .        .        .
      2850. .        .        .        .       I.    LWC E  M     .        .        .        .        .
      2900. .        .        .        .       I.    WC E.  M     .        .        .        .        .
      2950. .        .        .        .      I .   LWC E.  M     .        .        .        .        .
      3000. .        .        .        .      I .   LWC E.  M     .        .        .        .        .
13.00 3050. .        .        .        .      I .   LWC E.  M     .        .        .        .        .
      3100. .        .        .        .      I .   LWC E. M      .        .        .        .        .
      3150. .        .        .        .      I .   W C E.M       .        .        .        .        .
      3200. .        .        .        .     I  .   WC  E.M       .        .        .        .        .
      3250. .        .        .        .     I  .   WC  EM        .        .        .        .        .
      3300. .        .        .        .     I  .   WC E M        .        .        .        .        .
      3350. .        .        .        .     I  .   WC EM.        .        .        .        .        .
      3400. .        .        .        .     I  .   WC EM.        .        .        .        .        .
      3450. .        .        .        .    I   .   WC E .        .        .        .        .        .
      3500. .        .        .        .    I   .   W  E .        .        .        .        .        .
      3550. .        .        .        .    I   .   W ME          .        .        .        .        .
      3600. .        .        .        .    I   .   W ME .        .        .        .        .        .
      3650. .        .        .        .    I   .   WME  .        .        .        .        .        .
      3700. .        .        .        .   I    .   WME  .        .        .        .        .        .
12.00 3750. .        .        .        .   I    .  WL E .         .        .        .        .        .
      3800. .        .        .        .   I    .  WL E .         .        .        .        .        .
      3850. .        .        .        .   I    .  WL E .         .        .        .        .        .
      3900. .        .        .        .   I    .  WL E .         .        .        .        .        .
      3950. .        .        .        .  I     .  WLE  .         .        .        .        .        .
      4000. .        .        .        .  I     . WCLE  .         .        .        .        .        .
      4050. .        .        .        .  I     . WRLE  .         .        .        .        .        .
      4100. .        .        .        .  I     . WRLE  .         .        .        .        .        .
      4150. .        .        .        .  I     . WL E  .         .        .        .        .        .
      4200. .        .        .        .  I     . WL E  .         .        .        .        .        .
      4250. .        .        .        . I      . WCLE   .        .        .        .        .        .
      4300. .        .        .        . I      . WRLE   .        .        .        .        .        .
      4350. .        .        .        . I      . WRLE   .        .        .        .        .        .
      4400. .        .        .        . I      . WRLE   .        .        .        .        .        .
      4450. .        .        .        . I      .WCRLE   .        .        .        .        .        .
      4500. .        .        .        .I       .WC E    .        .        .        .        .        .
11.00 4550. .        .        .        .I       .WC E    .        .        .        .        .        .
      4600. .        .        .        .I       .WR E    .        .        .        .        .        .
      4650. .        .        .        .I       .WRLE    .        .        .        .        .        .
      4700. .        .        .        .I       .WRLE    .        .        .        .        .        .
      4750. .        .        .        .I      WCRLE              .        .        .        .        .
      4800. .        .        .        .I      WCRE               .        .        .        .        .
      4850. .        .        .        .I      WMLE     .         .        .        .        .        .
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PROFILE FOR STREAM PIPELINE ARROYO   SUPERC

PLOTTED POINTS (BY PRIORITY)-E-ENERGY,W-WATER SURFACE,I-INVERT,C-CRITICAL W.S.,L-LEFT BANK,R-RIGHT BANK,N-LOWER END STA

```
ELEVATION 6860.     6880.     6900.     6920.     6940.     6960.     6980.     7000.     7020.     7040.
    SECNO  CUMDIS
    17.00    0.   .         .         .         .         .         I    L WCE.         .         .         .
            50.   .         .         .         .         .        I.    LWCNE.         .         .         .
           100.   .         .         .         .         .        I.    LWCNE.         .         .         .
           150.   .         .         .         .         .        I.  L WCE  .         .         .         .
           200.   .         .         .         .         .        I.  L WCE  .         .         .         .
           250.   .         .         .         .         .        I.  L W E  .         .         .         .
           300.   .         .         .         .         .      I  .  LWC E  .         .         .         .
           350.   .         .         .         .         .      I  . L WC E  .         .         .         .
           400.   .         .         .         .         .      I  . L WCEN  .         .         .         .
           450.   .         .         .         .         .      I  . L WCEN  .         .         .         .
           500.   .         .         .         .         .      I  .  LWC EN .         .         .         .
           550.   .         .         .         .         .     I   . L WC EN .         .         .         .
           600.   .         .         .         .         .     I   . L WC EN .         .         .         .
           650.   .         .         .         .         .     I   . L WCE N .         .         .         .
           700.   .         .         .         .         .     I   . L WCE N .         .         .         .
           750.   .         .         .         .         .     I   .L WC E N .         .         .         .
           800.   .         .         .         .         .    I    .L WC E N .         .         .         .
           850.   .         .         .         .         .    I    .L WC E N .         .         .         .
           900.   .         .         .         .         .    I    .L WCE  N .         .         .         .
           950.   .         .         .         .         .    I    L W E   N .         .         .         .
          1000.   .         .         .         .         .    I    L WC E  N .         .         .         .
    16.00 1050.   .         .         .         .         .    I    L WC E  N .         .         .         .
          1100.   .         .         .         .         .    I    L WC E  N .         .         .         .
          1150.   .         .         .         .         .   I     L WC E  N .         .         .         .
          1200.   .         .         .         .         .   I     L WC E  N .         .         .         .
          1250.   .         .         .         .         .   I     L WCE   N .         .         .         .
          1300.   .         .         .         .         .   I     L WCE   N .         .         .         .
          1350.   .         .         .         .         .   I     L W E   N .         .         .         .
          1400.   .         .         .         .         .  I    RL W E    N .         .         .         .
          1450.   .         .         .         .         .  I    RLWC E    N .         .         .         .
          1500.   .         .         .         .         .  I    RLWC E    N .         .         .         .
          1550.   .         .         .         .         .  I    RLWCE     N .         .         .         .
          1600.   .         .         .         .         .  I    RLWCE     N .         .         .         .
          1650.   .         .         .         .         . I     RLWCE     N .         .         .         .
          1700.   .         .         .         .         . I     RLWCE     N .         .         .         .
          1750.   .         .         .         .         . I     RLW E     N .         .         .         .
          1800.   .         .         .         .         . I     RLW E     N .         .         .         .
          1850.   .         .         .         .         . I     RLWE      N .         .         .         .
          1900.   .         .         .         .         . I     RWCE      N .         .         .         .
          1950.   .         .         .         .         .I      RWCE      N .         .         .         .
          2000.   .         .         .         .         .I      RWCE      N .         .         .         .
    15.00 2050.   .         .         .         .         .I      RWCE      N .         .         .         .
          2100.   .         .         .         .         .I     R WCE    N   .         .         .         .
          2150.   .         .         .         .         .I     R WE     N   .         .         .         .
          2200.   .         .         .         .         .I     RLWE    N    .         .         .         .
          2250.   .         .         .         .         .I     RLWE    N    .         .         .         .
```

SECNO	DEPTH	CWSEL	CRIWS	WSELK	EG	HV	HL	OLOSS	BANK ELEV
Q	QLOB	QCH	QROB	ALOB	ACH	AROB	VOL	TWA	LEFT/RIGHT
TIME	VLOB	VCH	VROB	XNL	XNCH	XNR	WTN	ELMIN	SSTA
SLOPE	XLOBL	XLCH	XLOBR	ITRIAL	IDC	ICONT	CORAR	TOPWID	ENDST
1.00	17.43	6886.03	6889.59	0.00	6897.85	11.82	5.11	0.00	6907.00
26300.	0.	26300.	0.	0.	953.	0.	318.	77.	6900.00
0.12	0.00	27.59	0.00	0.060	0.030	0.035	0.000	6868.60	209.04
0.014888	210	290.	360.	7	8	0	0.00	89.38	298.42

0

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1
 THU, MAY 12 1988  15:20:59                                                                PAGE    6

    SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
    Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA    LEFT/RIGHT
    TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
    SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST

      5.00    13.99  6914.39  6918.90     0.00  6928.51    14.12    13.71     0.00  6930.00
    26300.       0.   26300.       0.       0.     872.       0.     282.      73.   6927.00
      0.10     0.00    30.16     0.00    0.060    0.030    0.035    0.000  6900.40    47.45
  0.023200     618.     610.     605.        5       11        0     0.00   104.64   152.09
0
 *SECNO 4.000

 3301 HV CHANGED MORE THAN HVINS
      4.00    14.66  6894.76  6898.65     0.00  6906.90    12.14    21.61     0.00  6900.00
    26300.       0.   26300.       0.       0.     941.       0.     303.      76.   6910.00
      0.11     0.00    27.96     0.00    0.060    0.030    0.035    0.000  6880.10    15.80
  0.018893    1049.    1035.    1010.        7       11        0     0.00   108.33   124.13
0
 *SECNO 3.000

 3301 HV CHANGED MORE THAN HVINS
 3685 20 TRIALS ATTEMPTED WSEL,CWSEL
 3693 PROBABLE MINIMUM SPECIFIC ENERGY
 3720 CRITICAL DEPTH ASSUMED
      3.00    21.85  6897.15  6897.15     0.00  6903.89     6.74     4.28     0.36  6910.00
    26300.       0.   26300.       0.       0.    1263.       0.     309.      76.   6910.00
      0.11     0.00    20.83     0.00    0.060    0.047    0.035    0.000  6875.30    22.22
  0.016213     243.     245.     245.       20       14        0     0.00    95.57   117.76
0
 *SECNO 2.000

 3301 HV CHANGED MORE THAN HVINS
      2.00    20.47  6894.77  6896.07     0.00  6902.97     8.20     0.92     0.00  6910.00
    26300.       0.   26300.       0.       0.    1145.       0.     311.      76.   6906.00
      0.11     0.00    22.97     0.00    0.060    0.047    0.035    0.000  6874.30    25.60
  0.021203      50.      50.      50.        6        5        0     0.00    91.85   117.45
0
 *SECNO 1.000

 3301 HV CHANGED MORE THAN HVINS
```

3.0 CALCULATIONS IN RESPONSE TO COMMENT 9

Attachment 3.0 contains the following calculations:

- o Riprap calculations for Nickpoint, Pipeline Arroyo using Maynord's 1987 method.
- o Riprap calculations for Base Control Section, Pipeline Arroyo using Maynord's 1987 method.
- o Riprap calculations for North Diversion Ditch downdrain using Maynord's 1987 method.
- o Riprap calculations for Runoff Control Ditch, steep section using Maynord's 1987 method.
- o Riprap calculations for Runoff Control Ditch using Maynord's 1987 method.
- o Riprap calculations for Runoff Control Ditch downdrain using Maynord's 1987 method.
- o Riprap calculations for Section I, South Cell Drainage Channel using Maynord's 1987 method.
- o Riprap calculations for Section J, South Cell Drainage Channel using Maynord's 1987 method.
- o Riprap calculations for North Cell Drainage Channel, Upper Section, using Maynord's 1987 method.

- o Riprap calculations for North Cell Drainage Channel, Lower Section, using Maynord's 1987 method.
- o Riprap calculations for North Cell Drainage Channel, Upper Section, using Maynord's 1978 method.
- o Riprap calculations for North Cell Drainage Channel, Lower Section, using Maynord's 1978 method.

MAYNARD'S (1987) METHOD FOR DETERMINING RIPRAP SIZE FOR OPEN CHANNEL FLOWS   RIPRAP2.WR1

LOCATION:UNC - SECTION WITHIN INCISED NICKPOINT IN ROCK

```
BOTTOM WIDTH =         20 FT
Z (SIDE SLOPE)        1.5
CHANNEL SLOPE =   0.0076
DISCHARGE =        25000 CFS
C =                 0.24
RIPRAP S.W. =        165 PCF
SAFETY FACTOR =     1.00
        Vmax =      1.33 Vavg

D30 (ASSUMED) =    1.550 FT     - SELECT A D30 SIZE
    D60(CALC) =    2.583
            n =    0.046

            d =    26.32 FT     - SELECT A DEPTH OF FLOW
            A =   1565.5 FT^2
            R =    13.63 FT
     Q (CALC) =  25006.6 CFS    - CHECK THIS Q VALUE TO
            v =     16.0 FPS      SEE IF IT MATCHES LISTED
                                  DISCHARGE
         Vmax =   21.245
           Fr =    0.708

   D30 (CALC) =    1.543 FT     - CHECK THIS D30 VALUE TO
         Dmax =    3.215 FT       SEE IF IT MATCHES THE
  TOTAL DEPTH =     3.22 FT       ASSUMED D30 VALUE
```

Reference: Maynord, Stephen T, 1987, Stable Riprap Size For Open Channel Flows, Dissertation, Colorado State University, Fort Collins, Colorado.

MAYNARD'S (1987) METHOD FOR DETERMINING RIPRAP SIZE FOR OPEN CHANNEL FLOWS

RIPRAP2.WR1

LOCATION:UNC - BASE CONTROL SECTION, PIPELINE ARROYO

BOTTOM WIDTH =	20	FT	
Z (SIDE SLOPE)	2		
CHANNEL SLOPE =	0.0185		
DISCHARGE =	25000	CFS	
C =	0.24		
RIPRAP S.W. =	165	PCF	
SAFETY FACTOR =	1.00		
Vmax =	1.33	Vavg	
D30 (ASSUMED) =	2.820	FT	- SELECT A D30 SIZE
D50(CALC) =	4.700		
n =	0.051		
d =	20.60	FT	- SELECT A DEPTH OF FLOW
A =	1260.7	FT^2	
R =	11.24	FT	
Q (CALC) =	25017.9	CFS	- CHECK THIS Q VALUE TO
v =	19.8	FPS	SEE IF IT MATCHES LISTED DISCHARGE
Vmax =	26.393		
Fr =	0.997		
D30 (CALC) =	2.823	FT	- CHECK THIS D30 VALUE TO
Dmax =	5.881	FT	SEE IF IT MATCHES THE
TOTAL DEPTH =	5.88	FT	ASSUMED D30 VALUE

Reference: Maynord, Stephen T. 1987. Stable Riprap Size For Open Channel Flows. Dissertation, Colorado State University, Fort Collins, Colorado.

MAYNARD'S (1987) METHOD FOR DETERMINING RIPRAP SIZE FOR OPEN CHANNEL FLOWS   RIPRAP2.WK1

LOCATION:UNC - NORTH DIVERSION CHANNEL AT EXIT SECTION AT PIPELINE ARROYO

BOTTOM WIDTH =	20	FT	
Z (SIDE SLOPE)	3		
CHANNEL SLOPE =	0.0076		
DISCHARGE =	25000	CFS	
C =	0.24		
RIPRAP S.W. =	165	PCF	
SAFETY FACTOR =	1.00		
Vmax =	1.33	Vavg	
D30 (ASSUMED) =	1.296	FT	- SELECT A D30 SIZE
D50(CALC) =	2.158		
n =	0.045		
d =	20.84	FT	- SELECT A DEPTH OF FLOW
A =	1719.7	FT^2	
R =	11.33	FT	
Q (CALC) =	25027.4	CFS	- CHECK THIS Q VALUE TO SEE IF IT MATCHES LISTED DISCHARGE
V =	14.6	FPS	
Vmax =	19.356		
Fr =	0.745		
D30 (CALC) =	1.296	FT	- CHECK THIS D30 VALUE TO SEE IF IT MATCHES THE ASSUMED D30 VALUE
Dmax =	2.701	FT	
TOTAL DEPTH =	2.70	FT	

Reference: Maynord, Stephen T, 1987, Stable Riprap Size For Open Channel Flows, Dissertation, Colorado State University, Fort Collins, Colorado.

MAYNARD'S (1987) METHOD FOR DETERMINING RIPRAP SIZE FOR OPEN CHANNEL FLOWS

RIPRAP2.WR1

LOCATION:UNC - RUNOFF CONTRCL DITCH - STEEP SECTION

BOTTOM WIDTH =	10 FT	
Z (SIDE SLOPE)	3	
CHANNEL SLOPE =	0.02	
DISCHARGE =	270 CFS	
C =	0.24	
RIPRAP S.W. =	165 PCF	
SAFETY FACTOR =	1.00	
Vmax =	1.33 Vavg	
D30 (ASSUMED) =	0.427 FT	- SELECT A D30 SIZE
D50(CALC) =	0.712	
n =	0.037	
d =	2.19 FT	- SELECT A DEPTH OF FLOW
A =	36.3 FT^2	
R =	1.52 FT	
Q (CALC) =	270.3 CFS	- CHECK THIS Q VALUE TO SEE IF IT MATCHES LISTED DISCHARGE
V =	7.4 FPS	
Vmax =	9.907	
Fr =	1.048	
D30 (CALC) =	0.427 FT	- CHECK THIS D30 VALUE TO SEE IF IT MATCHES THE ASSUMED D30 VALUE
Dmax =	0.889 FT	
TOTAL DEPTH =	0.89 FT	

Reference: Maynord, Stephen T, 1987, Stable Riprap Size For Open Channel Flows, Dissertation, Colorado State University, Fort Collins, Colorado.

MAYNARD'S (1987) METHOD FOR DETERMINING RIPRAP SIZE FOR OPEN CHANNEL FLOWS   RIPRAP2.WR1

LOCATION:UNC - RUNOFF CONTROL DITCH

BOTTOM WIDTH =	10 FT	
Z (SIDE SLOPE)	3	
CHANNEL SLOPE =	0.011	
DISCHARGE =	270 CFS	
C =	0.24	
RIPRAP S.W. =	165 PCF	
SAFETY FACTOR =	1.00	
Vmax =	1.33 Vavg	
D30 (ASSUMED) =	0.276 FT	- SELECT A D30 SIZE
D60(CALC) =	0.460	
n =	0.035	
d =	2.46 FT	- SELECT A DEPTH OF FLOW
A =	42.8 FT^2	
R =	1.67 FT	
Q (CALC) =	270.6 CFS	- CHECK THIS Q VALUE TO
v =	6.3 FPS	SEE IF IT MATCHES LISTED
		DISCHARGE
Vmax =	8.417	
Fr =	0.849	
D30 (CALC) =	0.276 FT	- CHECK THIS D30 VALUE TO
Dmax =	0.575 FT	SEE IF IT MATCHES THE
TOTAL DEPTH =	0.57 FT	ASSUMED D30 VALUE

Reference: Maynord, Stephen T. 1987. Stable Riprap Size For Open Channel Flows. Dissertation, Colorado State University, Fort Collins, Colorado.

MAYNARD'S (1987) METHOD FOR DETERMINING RIPRAP SIZE FOR OPEN CHANNEL FLOWS — RIPRAP2.WR1

LOCATION:UNC - RUNOFF CONTROL DITCH AT DOWNDRAIN INTO SOUTH CELL DRAINAGE

BOTTOM WIDTH =	10	FT	
Z (SIDE SLOPE)	3		
CHANNEL SLOPE =	0.12		
DISCHARGE =	270	CFS	
C =	0.24		
RIPRAP S.W. =	165	PCF	
SAFETY FACTOR =	1.00		
Vmax =	1.33	Vavg	
D30 (ASSUMED) =	1.573	FT	- SELECT A D30 SIZE
D50(CALC) =	2.622		
n =	0.046		
d =	1.54	FT	- SELECT A DEPTH OF FLOW
A =	22.5	FT^2	
R =	1.14	FT	
Q (CALC) =	272.8	CFS	- CHECK THIS Q VALUE TO
v =	12.1	FPS	SEE IF IT MATCHES LISTED
			DISCHARGE
Vmax =	16.113		
Fr =	1.974		
D30 (CALC) =	1.572	FT	- CHECK THIS D30 VALUE TO
Dmax =	3.276	FT	SEE IF IT MATCHES THE
TOTAL DEPTH =	3.28	FT	ASSUMED D30 VALUE

Reference: Maynord, Stephen T. 1987. Stable Riprap Size For Open Channel Flows. Dissertation. Colorado State University. Fort Collins. Colorado.

MAYNARD'S (1987) METHOD FOR DETERMINING RIPRAP SIZE FOR OPEN CHANNEL FLOWS   RIPRAP2.WR1

LOCATION:UNC - SECTION I, SOUTH CELL DRAINAGE CHANNEL

BOTTOM WIDTH =	10	FT	
Z (SIDE SLOPE)	2.5		
CHANNEL SLOPE =	0.03		
DISCHARGE =	1260	CFS	
C =	0.24		
RIPRAP S.W. =	165	PCF	
SAFETY FACTOR =	1.00		
Vmax =	1.33	Vavg	
D30 (ASSUMED) =	1.154	FT	- SELECT A D30 SIZE
D50(CALC) =	1.923		
n =	0.044		
d =	4.79	FT	- SELECT A DEPTH OF FLOW
A =	105.3	FT^2	
R =	2.94	FT	
Q (CALC) =	1262.4	CFS	- CHECK THIS Q VALUE TO
v =	12.0	FPS	SEE IF IT MATCHES LISTED
			DISCHARGE
Vmax =	15.951		
Fr =	1.200		
D30 (CALC) =	1.154	FT	- CHECK THIS D30 VALUE TO
Dmax =	2.405	FT	SEE IF IT MATCHES THE
TOTAL DEPTH =	2.41	FT	ASSUMED D30 VALUE

Reference: Maynord, Stephen T. 1987. Stable Riprap Size For Open Channel Flows. Dissertation, Colorado State University, Fort Collins, Colorado.

MAYNARD'S (1987) METHOD FOR DETERMINING RIPRAP SIZE FOR OPEN CHANNEL FLOWS   RIPRAP2.WR1

LOCATION:UNC - SECTION 3, SOUTH CELL DRAINAGE CHANNEL

BOTTOM WIDTH =	10	FT	
Z (SIDE SLOPE)	3		
CHANNEL SLOPE =	0.058		
DISCHARGE =	1260	CFS	
C =	0.24		
RIPRAP S.W. =	165	PCF	
SAFETY FACTOR =	1.00		
Vmax =	1.33	Vavg	
D30 (ASSUMED) =	1.777	FT	- SELECT A D30 SIZE
D50(CALC) =	2.962		
n =	0.047		
d =	4.06	FT	- SELECT A DEPTH OF FLOW
A =	90.1	FT^2	
R =	2.52	FT	
Q (CALC) =	1262.1	CFS	- CHECK THIS Q VALUE TO SEE IF IT MATCHES LISTED DISCHARGE
v =	14.0	FPS	
Vmax =	18.641		
Fr =	1.526		
D30 (CALC) =	1.776	FT	- CHECK THIS D30 VALUE TO SEE IF IT MATCHES THE ASSUMED D30 VALUE
Dmax =	3.700	FT	
TOTAL DEPTH =	3.70	FT	

Reference: Maynord, Stephen T. 1987. Stable Riprap Size For Open Channel Flows. Dissertation, Colorado State University, Fort Collins, Colorado.

MAYNARD'S (1987) METHOD FOR DETERMINING RIPRAP SIZE FOR OPEN CHANNEL FLOWS   RIPRAP2.WR1

LOCATION:NORTH CELL DRAINAGE CHANNEL, LOWER SECTION

BOTTOM WIDTH =	10	FT	
Z (SIDE SLOPE)	3		
CHANNEL SLOPE =	0.016		
DISCHARGE =	725	CFS	
C =	0.24		
RIPRAP S.W. =	165	PCF	
SAFETY FACTOR =	1.00		
Vmax =	1.33	Vavg	
D30 (ASSUMED) =	0.548	FT	- SELECT A D30 SIZE
D50(CALC) =	0.913		
n =	0.039		
d =	3.86	FT	- SELECT A DEPTH OF FLOW
A =	83.3	FT^2	
R =	2.42	FT	
Q (CALC) =	725.5	CFS	- CHECK THIS Q VALUE TO SEE IF IT MATCHES LISTED DISCHARGE
V =	8.7	FPS	
Vmax =	11.584		
Fr =	0.968		
D30 (CALC) =	0.548	FT	- CHECK THIS D30 VALUE TO SEE IF IT MATCHES THE ASSUMED D30 VALUE
Dmax =	1.141	FT	
TOTAL DEPTH =	1.14	FT	

Reference: Maynord, Stephen T, 1987, Stable Riprap Size For Open Channel Flows, Dissertation, Colorado State University, Fort Collins, Colorado.

MAYNARD'S (COE, 1972) METHOD FOR DETERMINING RIPRAP SIZE FOR STRAIGHT CHANNELS   RIPRAP.WR

LOCATION:UNC - NORTH CELL DREAINAGE CHANNEL, UPPER SECTION

BOTTOM WIDTH =	10	FT	
Z (SIDE SLOPE)	3		
CHANNEL SLOPE =	0.022		
DISCHARGE =	731	CFS	
C =	0.22		
RIPRAP S.G. =	2.45		
D50 (ASSUMED) =	0.679	FT	- SELECT A D50 SIZE
n =	0.0370		
d =	3.51	FT	- SELECT A DEPTH OF FLOW
A =	72.1	FT^2	
R =	2.24	FT	
Q (CALC) =	733.8	CFS	- CHECK THIS Q VALUE TO
v =	10.2	FPS	SEE IF IT MATCHES LISTED
			DISCHARGE
Fr =	0.958		
D50 (CALC) =	0.679	FT	- CHECK THIS D50 VALUE TO
Dmax =	0.848	FT	SEE IF IT MATCHES THE
TOTAL DEPTH =	1.06	FT	ASSUMED D50 VALUE

MAYNARD'S (COE, 1972) METHOD FOR DETERMINING RIPRAP SIZE FOR STRAIGHT CHANNELS   RIPRAP.WR

LOCATION:UNC - NORTH CELL DRAINAGE CHANNEL, LOWER SECTION

BOTTOM WIDTH =	10	FT	
Z (SIDE SLOPE)	3		
CHANNEL SLOPE =	0.016		
DISCHARGE =	725	CFS	
C =	0.22		
RIPRAP S.G. =	2.45		
D50 (ASSUMED) =	0.513	FT	- SELECT A D50 SIZE
n =	0.0353		
d =	3.69	FT	- SELECT A DEPTH OF FLOW
A =	77.7	FT^2	
=	2.33	FT	
Q (CALC) =	727.2	CFS	- CHECK THIS Q VALUE TO
V =	9.4	FPS	SEE IF IT MATCHES LISTED
			DISCHARGE
Fr =	0.858		
D50 (CALC) =	0.513	FT	- CHECK THIS D50 VALUE TO
Dmax =	0.641	FT	SEE IF IT MATCHES THE
TOTAL DEPTH =	0.80	FT	ASSUMED D50 VALUE

4.0 CALCULATIONS IN RESPONSE TO COMMENT 13

Attachment 4.0 contains the following calculations:

- Flow depth calculations - North Diversion Ditch - Section DD.
- Flow depth calculations - North Diversion Ditch - Section EE.

MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS IN TRAPEZOIDAL CHANNELS MANEQT.WR

LOCATION:UNC - NORTH DIVERSION DITCH, SECTION DD

	DISCHARGE =	1081	CFS
	BOTTOM WIDTH =	18	FT
	Z (SIDE SLOPE)=	1.6	
	CHANNEL SLOPE =	0.0033	
	MANNING'S n =	0.0250	

*	d =	5.14	FT	- SELECT A TRIAL DEPTH
*	A =	134.8	FT^2	
CALCS *	R =	3.60	FT	
*	t =	34.448	FT	
*	v =	8.0	FPS	
*	Q (CALC) =	1082	CFS	- CHECK THIS Q VALUE TO SEE IF IT MATCHES LISTED DISCHARGE
*	DIFFERENCE =	0.10	%	

Froude Number =	0.715	
Velocity Head =	1.001	FT
Tractive force =	0.742	PSF

```
MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS        MANEQT.WR
        IN TRAPEZOIDAL CHANNELS


LOCATION:UNC - NORTH DIVERSION DITCH, SECTION EE

           DISCHARGE =      1081 CFS
        BOTTOM WIDTH =        20 FT
       Z (SIDE SLOPE)=      5.43
       CHANNEL SLOPE =    0.0033
         MANNING'S n =    0.0250


      *             d =      4.01 FT      - SELECT A TRIAL DEPTH
      *             A =     167.5 FT^2
CALCS *             R =      2.61 FT
      *             t =   63.5486 FT
      *             v =       6.5 FPS
      *      Q (CALC) =      1083 CFS     - CHECK THIS Q VALUE TO
      *    DIFFERENCE =      0.21 %         SEE IF IT MATCHES LISTED
                                            DISCHARGE

       Froude Number  =    0.702
       Velocity Head =     0.649 FT
       Tractive force =    0.537 PSF
```

5.0 CALCULATIONS IN RESPONSE TO COMMENT 14

Attachment 5.0 contains the following calculations:

- 200-year flood hydrograph calculations for the South Cell Drainage Swale.
- 500-year flood hydrograph calculations for the South Cell Drainage Swale.
- 1,000-year flood hydrograph calculations for the South Cell Drainage Swale.
- PMF hydrograph calculations for the South Cell Drainage Swale.
- Flow depth calculation - South Cell Drainage Swale - 200-year flood.
- Flow depth calculation - South Cell Drainage Swale - 500-year flood.
- Flow depth calculation - South Cell Drainage Swale - 1,000-year flood.
- Flow depth calculation - South Cell Drainage Swale - PMF flood.
- Hydraulic calculations to determine the duration of flow in the South Drainage Swale for which the tractive force is greater than 0.110 psf.
- 200-year flood hydrograph calculations for the North Cell Branch Swale.
- 50C year flood hydrograph calculations for the North Cell Branch Swale.

- o 1,000-year flood hydrograph calculations for the North Cell Branch Swale.

- o PMF hydrograph calculations for the North Cell Branch Swale.

- o Flow depth calculations - North Cell Branch Swale - 200-year flood.

- o Flow depth calculations - North Cell Branch Swale - 500-year flood.

- o Flow depth calculations - North Cell Branch Swale - 1,000-year flood.

- o Flow depth calculations - North Cell Branch Swale - PMF flood.

- o Hydraulic calculations to determ.ne the duration of flow in the North Branch Swale for which the tractive force is greater than 0.110 psf.

- o PMF hydrograph calculations for the North Cell Drainage Channel, Upper Section.

- o PMF hydrograph calculations for the North Cell Drainage Channel, Lower Section.

HYDROGRAPH CALCULATION FOR ONE-HOUR RAINFALL EVENTS USING THE SCS CURVE NUMBER METHOD

SR01HR.WR1

SOUTH CELL DRAINAGE SWALE RM86-060-04
13-May-88 14:34

RETURN PERIOD	200 YRS		
ONE-HOUR RAINFALL AMOUNT	2.03 INCHES		
SCS CURVE NUMBER	77	S =	2.99
MEAN BASIN ELEV.	6970 FEET		
DURATION (D)	0.25 HOURS		
WATER COURSE LENGTH (L)	0.59 MILES		
WATERSHED AREA (A)	0.20 SQ. MILES		
MAXIMUM RELIEF (H)	66 FEET		

AREAL ADJUSTMENT (NOAA ATLAS 2, FIG. 17)	1.000	ADJ. RAINFAL	2.03 INCHES

ITEM	TIME PERIOD, HRS 0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (NOAA ATLAS 2)	57	79	89	100
CUMULATIVE RAINFALL	1.16	1.60	1.81	2.03
INCREMENTAL RAINFALL	1.16	0.45	0.20	0.22
SEQUENCE	0.20	0.45	1.16	0.22
P - CUMULATIVE DESIGN RAINFALL	0.2030	0.6496	1.8067	2.0300
Q - CUMULATIVE RUNOFF	0.0000	0.0009	0.3485	0.4644
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.0000	0.0009	0.3476	0.1159

TIME OF CONCENTRATION (Tc)	0.28 HOURS
WATERSHED ADJUSTMENT (DSD, TABLE 5, PG G7)	1.12
ADJUSTED Tc	0.31 HOURS
TIME TO PEAK (Tp)	0.31 HOURS
BASE PERIOD (Tb)	0.84 HOURS
UNIT PEAK DISCHARGE	308 CFS

SOUTH CELL DRAINAGE SWALE RM86-060-04
13-May-88 14:34

RETURN PERIOD 200 YRS
ONE-HOUR RAINFALL AMOUNT 2.03 INCHES

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		0.0	0.3	107.2	35.7	
	0.00	0.0				0.0
	0.08	0.0				0.0
	0.16	0.0				0.0
	0.24	0.0	0.0			0.0
	0.31	0.0	0.1			0.1
	0.39	0.0	0.1			0.1
	0.47	0.0	0.2	0.0		0.2
	0.55	0.0	0.3	26.8		27.1
	0.63	0.0	0.2	53.6		53.8
	0.71	0.0	0.2	80.4		80.6
	0.78	0.0	0.2	107.2	0	107.3
	0.86	0.0	0.1	91.1	8.9	100.2
	0.94		0.1	75.1	17.9	93.0
	1.02		0.0	59.0	26.8	85.9
	1.10		0.0	43.0	35.7	78.7
	1.18			27.0	30.4	57.3
	1.25			10.9	25.0	35.9
	1.33			0.0	19.7	19.7
	1.41				14.3	14.3
	1.49				9.0	9.0
	1.57				3.6	3.6

HYDROGRAPH CALCULATION FOR ONE-HOUR RAINFALL EVENTS USING THE SCS CURVE NUMBER METHOD

SR01HR.WR1

SOUTH CELL DRAINAGE SWALE RM86-060-04
13-May-88 14:47

RETURN PERIOD	500 YRS		
ONE-HOUR RAINFALL AMOUNT	2.34 INCHES		
SCS CURVE NUMBER	77	S =	2.99
MEAN BASIN ELEV.	6970 FEET		
DURATION (D)	0.25 HOURS		
WATER COURSE LENGTH (L)	0.59 MILES		
WATERSHED AREA (A)	0.20 SQ. MILES		
MAXIMUM RELIEF (H)	66 FEET		

AREAL ADJUSTMENT 1.000 ADJ. RAINFAL 2.34 INCHES
(NOAA ATLAS 2, FIG. 17)

ITEM	TIME PERIOD, HRS 0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (NOAA ATLAS 2)	57	79	89	100
CUMULATIVE RAINFALL	1.33	1.85	2.08	2.34
INCREMENTAL RAINFALL	1.33	0.51	0.23	0.26
SEQUENCE	0.23	0.51	1.33	0.26
P - CUMULATIVE DESIGN RAINFALL	0.2340	0.7488	2.0826	2.3400
Q - CUMULATIVE RUNOFF	0.0000	0.0073	0.4932	0.6420
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.0000	0.0073	0.4859	0.1488

TIME OF CONCENTRATION (Tc)	0.28 HOURS
WATERSHED ADJUSTMENT (OSD, TABLE 5, PG 67)	1.12
ADJUSTED Tc	0.31 HOURS
TIME TO PEAK (Tp)	0.31 HOURS
BASE PERIOD (Tb)	0.84 HOURS
UNIT PEAK DISCHARGE	308 CFS

SOUTH CELL DRAINAGE SWALE RM86-060-04
13-May-88 14:47

RETURN PERIOD 500 YRS
ONE-HOUR RAINFALL AMOUNT 2.34 INCHES

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		0.0	2.3	149.8	45.9	
	0.00	0.0				0.0
	0.08	0.0				0.0
	0.16	0.0				0.0
	0.24	0.0	0.0			0.0
	0.31	0.0	0.6			0.6
	0.39	0.0	1.1			1.1
	0.47	0.0	1.7	0.0		1.7
	0.55	0.0	2.3	37.5		39.7
	0.63	0.0	1.9	74.9		76.8
	0.71	0.0	1.6	112.4		114.0
	0.78	0.0	1.2	149.8	0	151.1
	0.86	0.0	0.9	127.4	11.5	139.8
	0.94		0.6	105.0	22.9	128.5
	1.02		0.2	82.5	34.4	117.2
	1.10		0.0	60.1	45.9	106.0
	1.18			37.7	39.0	76.7
	1.26			15.3	32.2	47.4
	1.33			0.0	25.3	25.3
	1.41				18.4	18.4
	1.49				11.5	11.5
	1.57				4.7	4.7

HYDROGRAPH CALCULATION FOR ONE-HOUR RAINFALL EVENTS USING THE SCS CURVE NUMBER METHOD

SR01HR.WR1

SOUTH CELL DRAINAGE SWALE RM86-060-04

13-May-88 14:48

RETURN PERIOD	1000 YRS		
ONE-HOUR RAINFALL AMOUNT	2.56 INCHES		
SCS CURVE NUMBER	77	S =	2.99
MEAN BASIN ELEV.	6970 FEET		
DURATION (D)	0.25 HOURS		
WATER COURSE LENGTH (L)	0.59 MILES		
WATERSHED AREA (A)	0.20 SQ. MILES		
MAXIMUM RELIEF (H)	66 FEET		

AREAL ADJUSTMENT (NOAA ATLAS 2, FIG. 17) 1.000 ADJ. RAINFAL 2.56 INCHES

ITEM	TIME PERIOD, HRS 0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (NOAA ATLAS 2)	57	79	89	100
CUMULATIVE RAINFALL	1.46	2.02	2.28	2.56
INCREMENTAL RAINFALL	1.46	0.56	0.26	0.28
SEQUENCE	0.26	0.56	1.46	0.28
P - CUMULATIVE DESIGN RAINFALL	0.2560	0.8192	2.2784	2.5600
Q - CUMULATIVE RUNOFF	0.0000	0.0153	0.6053	0.7782
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.0000	0.0153	0.5900	0.1729

TIME OF CONCENTRATION (Tc)	0.28 HOURS
WATERSHED ADJUSTMENT (OSD, TABLE 5, PG 67)	1.12
ADJUSTED Tc	0.31 HOURS
TIME TO PEAK (Tp)	0.31 HOURS
BASE PERIOD (Tb)	0.84 HOURS
UNIT PEAK DISCHARGE	308 CFS

SOUTH CELL DRAINAGE SWALE RM86-060-04
13-May-88 14:48

RETURN PERIOD 1000 YRS
ONE-HOUR RAINFALL AMOUNT 2.56 INCHES

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		0.0	4.7	181.9	53.3	
	0.00	0.0				0.0
	0.08	0.0				0.0
	0.16	0.0				0.0
	0.24	0.0	0.0			0.0
	0.31	0.0	1.2			1.2
	0.39	0.0	2.4			2.4
	0.47	0.0	3.5	0.0		3.5
	0.55	0.0	4.7	45.5		50.2
	0.63	0.0	4.0	91.0		95.0
	0.71	0.0	3.3	136.5		139.8
	0.78	0.0	2.6	181.9	0	184.5
	0.86	0.0	1.9	154.7	13.3	169.9
	0.94		1.2	127.5	26.7	155.3
	1.02		0.5	100.2	40.0	140.7
	1.10		0.0	73.0	53.3	126.3
	1.18			45.8	45.3	91.1
	1.26			18.5	37.3	55.9
	1.33			0.0	29.4	29.4
	1.41				21.4	21.4
	1.49				13.4	13.4
	1.57				5.4	5.4

HYDROGRAPH CALCULATION FOR ONE-HOUR PMP EVENTS USING THE SCS CURVE NUMBER METHOD
DESIGN OF SMALL DAMS RAINFALL DISTRIBUTION USED

SOUTH CELL DRAINAGE SWALE UNC PROJECT K?86-060-01
19-May-88 1?:14

ONE-HOUR RAINFALL AMOUNT	9.4 INCHES		
SCS CURVE NUMBER	77	S =	2.99
MEAN BASIN ELEV.	6970 FEET		
DURATION (D)	0.25 HOURS		
WATER COURSE LENGTH (L)	0.59 MILES		0.880681318
WATERSHED AREA (A)	0.20 SQ. MILES		
MAXIMUM RELIEF (H)	66.00 FEET		
ELEV ADJUSTMENT	0.9015 ADJ. RAINFAL		8.47 INCHES
AREAL ADJUSTMENT (DSD)	1 ADJ. RAINFAL		8.47 INCHES
WATERSHED ADJUSTMENT (DSD, TABLE 5, PG 67)	1.12		

ITEM	TIME PERIOD, HRS 0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (DSD,TABLE 2, PG 52)	48	71	88	100
CUMULATIVE RAINFALL	4.07	6.02	7.46	8.47
INCREMENTAL RAINFALL	4.07	1.95	1.44	1.02
SEQUENCE	1.44	1.95	4.07	1.02
P - CUMULATIVE DESIGN RAINFALL	1.44	3.39	7.46	8.47
Q - CUMULATIVE RUNOFF	0.19	1.35	4.78	5.71
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.19	1.16	3.43	0.93

TIME OF CONCENTRATION (Tc)	0.28 HOURS
ADJUSTED Tc	0.31 HOURS
TIME TO PEAK (Tp)	0.31 HOURS
BASE PERIOD (Tb)	0.84 HOURS
UNIT PEAK DISCHARGE	308 CFS

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		57.24	358.76	1057.64	287.42	
	0.00	0.00				0.00
	0.04	7.15				7.15
	0.08	14.31				14.31
	0.12	21.46				21.46
	0.16	28.62				28.62
	0.20	35.77				35.77
	0.24	42.93	0.00			42.93
	0.27	50.08	44.85			94.93
	0.31	57.24	89.69			146.93
	0.35	52.96	134.54			187.49
	0.39	48.67	179.38			228.05
	0.43	44.39	224.23			268.61
	0.47	40.10	269.07			309.18
	0.51	35.82	313.92	0.00		349.74
	0.55	31.53	358.76	132.20		522.50
	0.59	27.25	331.91	264.41		623.57
	0.63	22.96	305.06	396.61		724.64
	0.67	18.68	278.20	528.82		825.70
	0.71	14.40	251.35	661.02		926.77
	0.75	10.11	224.50	793.23	0.00	1027.84
	0.78	5.83	197.64	925.43	35.93	1164.83
	0.82	1.54	170.79	1057.64	71.85	1301.82
	0.86	0.00	143.94	978.47	107.78	1230.19
	0.90		117.08	899.31	143.71	1160.10
	0.94		90.23	820.14	179.64	1090.01
	0.98		63.37	740.98	215.56	1019.92
	1.02		36.52	661.82	251.49	949.83
	1.06		9.67	582.65	287.42	879.74
	1.10		0.00	503.49	265.91	769.39

```
MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS          MANEQT.WR
         IN TRAPEZOIDAL CHANNELS


LOCATION:UNC - SOUTH CELL DRAINAGE SWALE, 200 YEAR FLOOD

            DISCHARGE =       107 CFS
         BOTTOM WIDTH =         0 FT
        Z (SIDE SLOPE)=        50
        CHANNEL SLOPE =  0.00118
          MANNING'S n =   0.0300


      *             d =      1.30 FT      - SELECT A TRIAL DEPTH
      *             A =      84.5 FT^2
CALCS *             R =      0.65 FT
      *             t =       130 FT
      *             v =       1.3 FPS
      *      Q (CALC) =       108 CFS     - CHECK THIS Q VALUE TO
      *    DIFFERENCE =      0.81 %         SEE IF IT MATCHES LISTED
                                            DISCHARGE

        Froude Number  =   0.279
        Velocity Head =    0.025 FT
        Tractive force =   0.048 PSF
```

```
MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS        MANEQT.WR
        IN TRAPEZOIDAL CHANNELS


LOCATION:UNC - SOUTH CELL DRAINAGE SWALE, 500 YEAR FLOOD

             DISCHARGE =       151 CFS
          BOTTOM WIDTH =         0 FT
       Z (SIDE SLOPE)=        50
         CHANNEL SLOPE =  0.00118
           MANNING'S n =   0.0300


      *              d =      1.48 FT      - SELECT A TRIAL DEPTH
      *              A =     109.5 FT^2
CALCS *              R =      0.74 FT
      *              t =       148 FT
      *              v =       1.4 FPS
      *       Q (CALC) =       152 CFS     - CHECK THIS Q VALUE TO
      *     DIFFERENCE =      0.95 %         SEE IF IT MATCHES LISTED
                                             DISCHARGE

        Froude Number  =   0.285
        Velocity Head =    0.030 FT
        Tractive force =   0.054 PSF
```

```
MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS        MANEQT.WR
        IN TRAPEZOIDAL CHANNELS


LOCATION:UNC - SOUTH CELL DRAINAGE SWALE, 1000 YEAR FLOOD

            DISCHARGE =       185 CFS
         BOTTOM WIDTH =         0 FT
        Z (SIDE SLOPE)=        50
        CHANNEL SLOPE =  0.00118
          MANNING'S n =   0.0300


       *            d =      1.59 FT      - SELECT A TRIAL DEPTH
       *            A =     126.4 FT^2
 CALCS *            R =      0.79 FT
       *            t =       159 FT
       *            v =       1.5 FPS
       *     Q (CALC) =       185 CFS     - CHECK THIS Q VALUE TO
       *   DIFFERENCE =     -0.24 %         SEE IF IT MATCHES LISTED
                                            DISCHARGE

        Froude Number  =  0.289
        Velocity Head =   0.033 FT
        Tractive force =  0.059 PSF
```

MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS IN TRAPEZOIDAL CHANNELS   MANEQT.WR

LOCATION:UNC - SOUTH CELL DRAINAGE SWALE

DISCHARGE =	1000	CFS
BOTTOM WIDTH =	0	FT
Z (SIDE SLOPE)=	50	
CHANNEL SLOPE =	0.00118	
MANNING'S n =	0.0300	

*	d =	3.00	FT	- SELECT A TRIAL DEPTH
*	A =	450.0	FT^2	
CALCS *	R =	1.50	FT	
*	t =	300	FT	
*	v =	2.2	FPS	
*	Q (CALC) =	1003	CFS	- CHECK THIS Q VALUE TO SEE IF IT MATCHES LISTED DISCHARGE
*	DIFFERENCE =	0.32	%	

Froude Number =	0.321	
Velocity Head =	0.077	FT
Tractive force =	0.110	PSF

MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS IN TRAPEZOIDAL CHANNELS   MANEQT.WR

LOCATION:UNC - SOUTH CELL DRAINAGE SWALE, PMP EVENT

```
          DISCHARGE =     1301 CFS
       BOTTOM WIDTH =        0 FT
      Z (SIDE SLOPE)=       50
      CHANNEL SLOPE =  0.00118
        MANNING'S n =   0.0300


       *          d =     3.31 FT     - SELECT A TRIAL DEPTH
       *          A =    547.3 FT^2
CALCS  *          R =     1.65 FT
       *          t =      331 FT
       *          v =      2.4 FPS
       *   Q (CALC) =     1304 CFS    - CHECK THIS Q VALUE TO
       * DIFFERENCE =     0.23 %        SEE IF IT MATCHES LISTED
                                        DISCHARGE

     Froude Number  =   0.326
     Velocity Head  =   0.088 FT
     Tractive force =   0.122 PSF
```

```
MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS        MANEQT.WR
        IN TRAPEZOIDAL CHANNELS


LOCATION:UNC - SOUTH CELL DRAINAGE SWALE

           DISCHARGE =       56 CFS
        BOTTOM WIDTH =        0 FT
       Z (SIDE SLOPE)=       40
       CHANNEL SLOPE =    0.004
         MANNING'S n =   0.0300


      *            d =     0.88 FT      - SELECT A TRIAL DEPTH
      *            A =     31.0 FT^2
CALCS *            R =     0.44 FT
      *            t =     70.4 FT
      *            v =      1.8 FPS
      *     Q (CALC) =       56 CFS     - CHECK THIS Q VALUE TO
      *   DIFFERENCE =     0.22 %         SEE IF IT MATCHES LISTED
                                          DISCHARGE

       Froude Number  =   0.481
       Velocity Head =    0.051 FT
       Tractive force =   0.110 PSF
```

HYDROGRAPH CALCULATION FOR ONE-HOUR RAINFALL EVENTS USING THE SCS CURVE NUMBER METHOD

SR01HR2.WR1

NORTH CELL BRANCH SWALE RM86-060-04

20-May-88 15:06

RETURN PERIOD	200 YRS		
ONE-HOUR RAINFALL AMOUNT	2.03 INCHES		
SCS CURVE NUMBER	77	S =	2.99
MEAN BASIN ELEV.	6985 FEET		
DURATION (D)	0.25 HOURS		
WATER COURSE LENGTH (L)	0.46 MILES		
WATERSHED AREA (A)	0.06 SQ. MILES		
MAXIMUM RELIEF (H)	70 FEET		

AREAL ADJUSTMENT (NOAA ATLAS 2, FIG. 17)	1.000	ADJ. RAINFAL	2.03 INCHES
WATERSHED ADJUSTMENT (DSD, TABLE 5, PG 67)	1.12		

ITEM	TIME PERIOD, HRS 0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (NOAA ATLAS 2)	57	79	89	100
CUMULATIVE RAINFALL	1.16	1.60	1.81	2.03
INCREMENTAL RAINFALL	1.16	0.45	0.20	0.22
SEQUENCE	0.20	0.45	1.16	0.22
P - CUMULATIVE DESIGN RAINFALL	0.2030	0.6496	1.8067	2.0300
Q - CUMULATIVE RUNOFF	0.0000	0.0009	0.3485	0.4644
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.0000	0.0009	0.3476	0.1159

TIME OF CONCENTRATION (Tc)	0.21 HOURS
ADJUSTED Tc	0.23 HOURS
TIME TO PEAK (Tp)	0.26 HOURS
BASE PERIOD (Tb)	0.70 HOURS
UNIT PEAK DISCHARGE	110 CFS

Canonie Environmental

NORTH CELL BRANCH SWALE RM86-060-04
20-May-88 15:06

RETURN PERIOD 200 YRS
ONE-HOUR RAINFALL AMOUNT 2.03 INCHES

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		0.0	0.1	38.3	12.8	
	0.00	0.0				0.0
	0.03	0.0				0.0
	0.07	0.0				0.0
	0.10	0.0				0.0
	0.13	0.0				0.0
	0.16	0.0				0.0
	0.20	0.0				0.0
	0.23	0.0				0.0
	0.26	0.0	0.0			0.0
	0.30	0.0	0.0			0.0
	0.33	0.0	0.0			0.0
	0.36	0.0	0.0			0.0
	0.40		0.0			0.0
	0.43		0.1			0.1
	0.46		0.1			0.1
	0.49		0.1	0.0		0.1
	0.53		0.1	4.8		4.9
	0.56		0.1	9.6		9.7
	0.59		0.1	14.4		14.4
	0.63		0.0	19.2		19.2
	0.66			46.9		46.9
	0.69			44.0		44.0
	0.72			41.2		41.2
	0.76			38.3	0	38.3
	0.79			35.4	1.6	37.0
	0.82			32.6	3.2	35.8
	0.86			0.0	4.8	4.8
	0.89				6.4	6.4
	0.92				15.6	15.6
					14.7	14.7
					13.7	13.7
					12.8	12.8
					11.8	11.8
					10.9	10.9
					0.0	0.0

HYDROGRAPH CALCULATION FOR ONE-HOUR RAINFALL EVENTS USING THE SCS CURVE NUMBER METHOD

SR01HR2.WR1

NORTH CELL BRANCH SWALE RM86-060-04

20-May-88 15:07

RETURN PERIOD	500 YRS		
ONE-HOUR RAINFALL AMOUNT	2.34 INCHES		
SCS CURVE NUMBER	77	S =	2.99
MEAN BASIN ELEV.	6985 FEET		
DURATION (D)	0.25 HOURS		
WATER COURSE LENGTH (L)	0.46 MILES		
WATERSHED AREA (A)	0.06 SQ. MILES		
MAXIMUM RELIEF (H)	70 FEET		

AREAL ADJUSTMENT (NOAA ATLAS 2, FIG. 17)	1.000	ADJ. RAINFAL	2.34 INCHES
WATERSHED ADJUSTMENT (DSD, TABLE 5, PG 67)	1.12		

ITEM	TIME PERIOD, HRS 0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (NOAA ATLAS 2)	57	79	89	100
CUMULATIVE RAINFALL	1.33	1.85	2.08	2.34
INCREMENTAL RAINFALL	1.33	0.51	0.23	0.26
SEQUENCE	0.23	0.51	1.33	0.26
P - CUMULATIVE DESIGN RAINFALL	0.2340	0.7488	2.0826	2.3400
Q - CUMULATIVE RUNOFF	0.0000	0.0073	0.4932	0.6420
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.0000	0.0073	0.4859	0.1488

TIME OF CONCENTRATION (Tc)	0.21 HOURS
ADJUSTED Tc	0.23 HOURS
TIME TO PEAK (Tp)	0.26 HOURS
BASE PERIOD (Tb)	0.70 HOURS
UNIT PEAK DISCHARGE	110 CFS

NORTH CELL BRANCH SWALE RM86-060-04
20-May-88 15:07

RETURN PERIOD 500 YRS
ONE-HOUR RAINFALL AMOUNT 2.34 INCHES

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		0.0	0.8	53.5	16.4	
	0.00	0.0				0.0
	0.03	0.0				0.0
	0.07	0.0				0.0
	0.10	0.0				0.0
	0.13	0.0				0.0
	0.16	0.0				0.0
	0.20	0.0				0.0
	0.23	0.0				0.0
	0.26	0.0	0.0			0.0
	0.30	0.0	0.1			0.1
	0.33	0.0	0.2			0.2
	0.36	0.0	0.3			0.3
	0.40		0.4			0.4
	0.43		1.0			1.0
	0.46		0.9			0.9
	0.49		0.9	0.0		0.9
	0.53		0.8	6.7		7.5
	0.56		0.7	13.4		14.1
	0.59		0.7	20.1		20.8
	0.63		0.0	26.8		26.8
	0.66			65.6		65.6
	0.63			61.6		61.6
	0.72			57.6		57.6
	0.76			53.5	0	53.5
	0.79			49.5	2.0	51.6
	0.82			45.5	4.1	49.6
	0.86			0.0	6.1	6.1
	0.89				8.2	8.2
	0.92				20.1	20.1
					18.9	18.9
					17.6	17.6
					16.4	16.4
					15.2	15.2
					13.9	13.9
					0.0	0.0

HYDROGRAPH CALCULATION FOR ONE-HOUR RAINFALL EVENTS USING THE SCS CURVE NUMBER METHOD

SR01HR2.WR1

NORTH CELL BRANCH SWALE RM86-060-04

20-May-88 15:07

RETURN PERIOD	1000 YRS		
ONE-HOUR RAINFALL AMOUNT	2.65 INCHES		
SCS CURVE NUMBER	77	S =	2.99
MEAN BASIN ELEV.	6985 FEET		
DURATION (D)	0.25 HOURS		
WATER COURSE LENGTH (L)	0.46 MILES		
WATERSHED AREA (A)	0.06 SQ. MILES		
MAXIMUM RELIEF (H)	70 FEET		

AREAL ADJUSTMENT (NOAA ATLAS 2, FIG. 17)	1.000	ADJ. RAINFAL	2.65 INCHES
WATERSHED ADJUSTMENT (DSD, TABLE 5, PG 67)	1.12		

ITEM	TIME PERIOD, HRS 0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (NOAA ATLAS 2)	57	79	89	100
CUMULATIVE RAINFALL	1.51	2.09	2.36	2.65
INCREMENTAL RAINFALL	1.51	0.58	0.26	0.29
SEQUENCE	0.26	0.58	1.51	0.29
P - CUMULATIVE DESIGN RAINFALL	0.2650	0.848[illegible]	2.35[illegible]	2.6500
Q - CUMULATIVE RUNOFF	0.0000	0.0194	0.6532	0.8360
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.0000	0.0194	0.6338	0.1828

TIME OF CONCENTRATION (Tc)	0.21 HOURS
ADJUSTED Tc	0.23 HOURS
TIME TO PEAK (Tp)	0.26 HOURS
BASE PERIOD (Tb)	0.70 HOURS
UNIT PEAK DISCHARGE	110 CFS

NORTH CELL BRANCH SWALE RM86-060-04
20-May-88 15:07

RETURN PERIOD 1000 YRS
ONE-HOUR RAINFALL AMOUNT 2.65 INCHES

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		0.0	2.1	69.8	20.1	
	0.00	0.0				0.0
	0.03	0.0				0.0
	0.07	0.0				0.0
	0.10	0.0				0.0
	0.13	0.0				0.0
	0.16	0.0				0.0
	0.20	0.0				0.0
	0.23	0.0				0.0
	0.26	0.0	0.0			0.0
	0.30	0.0	0.3			0.3
	0.33	0.0	0.5			0.5
	0.36	0.0	0.8			0.8
	0.40		1.1			1.1
	0.43		2.6			2.6
	0.46		2.5			2.5
	0.49		2.3	0.0		2.3
	0.53		2.1	8.7		10.9
	0.56		2.0	17.5		19.4
	0.59		1.8	26.2		28.0
	0.63		0.0	34.9		34.9
	0.66			85.5		85.5
	0.69			80.3		80.3
	0.72			75.1		75.1
	0.76			69.8	0	69.8
	0.79			64.6	2.5	67.1
	0.82			59.4	5.0	64.4
	0.86			0.0	7.6	7.6
	0.89				10.1	10.1
	0.92				24.7	24.7
					23.2	23.2
					21.7	21.7
					20.1	20.1
					18.6	18.6
					17.1	17.1
					0.0	0.0

HYDROGRAPH CALCULATION FOR ONE-HOUR PMP EVENTS USING THE SCS CURVE NUMBER METHOD
DESIGN OF SMALL DAMS RAINFALL DISTRIBUTION USED

BRANCH 1
NORTH CELL BRANCH SWALE   UNC PROJECT   RM86-060-01
20-May-88   14:47

ONE-HOUR RAINFALL AMOUNT	9.4	INCHES		
SCS CURVE NUMBER	77	S =	2.99	
MEAN BASIN ELEV.	6985	FEET		
DURATION (D)	0.25	HOURS		
WATER COURSE LENGTH (L)	0.46	MILES	0.880681818	
WATERSHED AREA (A)	0.06	SQ. MILES		
MAXIMUM RELIEF (H)	70.00	FEET		
ELEV ADJUSTMENT	0.90075	ADJ. RAINFAL	8.47	INCHES
AREAL ADJUSTMENT (DSD)	1	ADJ. RAINFAL	8.47	INCHES
WATERSHED ADJUSTMENT (DSD, TABLE 5, PG 67)	1.12			

ITEM	TIME PERIOD, HRS 0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (DSD, TABLE 2, PG 52)	48	71	88	100
CUMULATIVE RAINFALL	4.06	6.01	7.45	8.47
INCREMENTAL RAINFALL	4.06	1.95	1.44	1.02
SEQUENCE	1.44	1.95	4.06	1.02
P - CUMULATIVE DESIGN RAINFALL	1.44	3.39	7.45	8.47
Q - CUMULATIVE RUNOFF	0.19	1.35	4.77	5.70
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.19	1.16	3.43	0.93

TIME OF CONCENTRATION (Tc)	0.21	HOURS
ADJUSTED Tc	0.23	HOURS
TIME TO PEAK (Tp)	0.26	HOURS
BASE PERIOD (Tb)	0.70	HOURS
UNIT PEAK DISCHARGE	116	CFS

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		21.42	134.43	396.42	107.74	
	0.00	0.00				0.00
	0.03	2.68				2.68
	0.07	5.36				5.36
	0.10	8.03				8.03
	0.13	10.71				10.71
	0.16	13.39				13.39
	0.20	16.07				16.07
	0.23	18.74				18.74
	0.26	21.42	0.00			21.42
	0.30	19.82	16.80			36.62
	0.33	18.22	33.61			51.82
	0.36	16.61	50.41			67.02
	0.40	15.01	67.21			82.22
	0.43	13.41	84.02			97.42
	0.46	11.80	100.82	0.00		112.62
	0.49	10.20	117.62	49.55		177.37
	0.53	8.59	134.43	99.11		242.13
	0.56	6.99	124.37	148.66		280.02
	0.59	5.39	114.30	198.21		317.90
	0.63	3.78	104.24	247.76		355.79
	0.66	2.18	94.18	297.32		393.68
	0.69	0.58	84.12	346.87		431.57
	0.72	0.00	74.06	396.42		470.48
	0.76		63.99	366.75	0.00	430.74
	0.79		53.93	337.08	13.47	404.48
	0.82		43.87	307.41	26.94	378.21
	0.86		33.81	277.73	40.40	351.94
	0.89		23.75	248.06	53.87	325.68
	0.92		13.68	218.39	67.34	299.41
	0.96		3.62	188.72	80.81	273.14
	0.99		0.00	159.04	94.27	253.32
	1.02			129.37	107.74	237.11
	1.05			99.70	99.68	199.38
	1.09			70.03	91.61	161.64
	1.12			40.35	83.55	123.90
	1.15			10.68	75.48	86.16
	1.19			0.00	67.42	67.42
	1.22				59.35	59.35
	1.25				51.29	51.29
	1.28				43.23	43.23
	1.32				35.16	35.16
	1.35				27.10	27.10
	1.38				19.03	19.03
					10.97	10.97
					2.90	2.90
					0.00	0.00

MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS   MANEQT.WR
IN TRAPEZOIDAL CHANNELS

LOCATION:NORTH CELL BRANCH SWALE, 200 YEAR RETURN PERIOD

	DISCHARGE =	46.9	CFS	
	BOTTOM WIDTH =	0	FT	
	Z (SIDE SLOPE)=	40		
	CHANNEL SLOPE =	0.002		
	MANNING'S n =	0.0300		
*	d =	0.94	FT	- SELECT A TRIAL DEPTH
*	A =	35.3	FT^2	
CALCS *	R =	0.47	FT	
*	t =	75.2	FT	
*	v =	1.3	FPS	
*	Q (CALC) =	47	CFS	- CHECK THIS Q VALUE TO SEE IF IT MATCHES LISTED DISCHARGE
*	DIFFERENCE =	0.89	%	

Froude Number = 0.344
Velocity Head = 0.028 FT
Tractive force = 0.059 PSF

```
MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS         MANEQT.WR
        IN TRAPEZOIDAL CHANNELS


LOCATION:NORTH CELL BRANCH SWALE, 1000 YEAR RETURN PERIOD

          DISCHARGE =     85.5 CFS
       BOTTOM WIDTH =        0 FT
       Z (SIDE SLOPE)=      40
      CHANNEL SLOPE =    0.002
        MANNING'S n =   0.0300


      *             d =     1.18 FT      - SELECT NORMAL DEPTH
      *             A =     55.7 FT^2
CALCS *             R =     0.59 FT
      *             t =     94.4 FT
      *             v =      1.6 FPS
      *      Q (CALC) =       87 CFS     - CHECK THIS Q VALUE TO
      *    DIFFERENCE =     1.49 %         SEE IF IT MATCHES LISTED
                                           DISCHARGE

       Froude Number  =   0.357
       Velocity Head =    0.038 FT
       Tractive force =   0.074 PSF
```

MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS   MANEQT.WR
IN TRAPEZOIDAL CHANNELS

LOCATION:NORTH CELL BRANCH SWALE, 500 YEAR RETURN PERIOD

DISCHARGE =	65.6	CFS
BOTTOM WIDTH =	0	FT
Z (SIDE SLOPE)=	40	
CHANNEL SLOPE =	0.002	
MANNING'S n =	0.0300	

*	d =	1.07	FT	- SELECT A TRIAL DEPTH
*	A =	45.8	FT^2	
CALCS *	R =	0.53	FT	
*	t =	85.6	FT	
*	v =	1.5	FPS	
*	Q (CALC) =	67	CFS	- CHECK THIS Q VALUE TO
*	DIFFERENCE =	1.89	%	SEE IF IT MATCHES LISTED DISCHARGE

Froude Number =	0.352	
Velocity Head =	0.033	FT
Tractive force =	0.067	PSF

MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS IN TRAPEZOIDAL CHANNELS MANEQT.WR

LOCATION:NORTH CELL BRANCH SWALE, PMP EVENT, BRANCH 1

```
        DISCHARGE =      470 CFS
     BOTTOM WIDTH =        0 FT
    Z (SIDE SLOPE)=       40
    CHANNEL SLOPE =    0.002
      MANNING'S n =   0.0300


     *            d =     2.23 FT      - SELECT A TRIAL DEPTH
     *            A =    198.9 FT^2
CALCS *           R =     1.11 FT
     *            t =    178.4 FT
     *            v =      2.4 FPS
     *     Q (CALC) =      474 CFS     - CHECK THIS Q VALUE TO
     *   DIFFERENCE =     0.79 %         SEE IF IT MATCHES LISTED
                                         DISCHARGE

    Froude Number  =   0.397
    Velocity Head =    0.088 FT
    Tractive force =   0.139 PSF
```

MANNING'S EQUATION FOR DETERMINING NORMAL FLOW DEPTHS IN TRAPEZOIDAL CHANNELS MANEQT.WR

LOCATION:NORTH CELL BRANCH SWALE.

DISCHARGE =	256	CFS
BOTTOM WIDTH =	0	FT
Z (SIDE SLOPE)=	40	
CHANNEL SLOPE =	0.002	
MANNING'S n =	0.0300	

*	d =	1.77	FT	- SELECT A TRIAL DEPTH
*	A =	125.3	FT^2	
CALCS *	R =	0.88	FT	
*	t =	141.6	FT	
*	v =	2.0	FPS	
*	Q (CALC) =	256	CFS	- CHECK THIS Q VALUE TO SEE IF IT MATCHES LISTED DISCHARGE
*	DIFFERENCE =	-0.07	%	

Froude Number =	0.382	
Velocity Head =	0.065	FT
Tractive force =	0.110	PSF

HYDROGRAPH CALCULATION FOR ONE-HOUR PMP EVENTS USING THE SCS CURVE NUMBER METHOD
DESIGN OF SMALL DAMS RAINFALL DISTRIBUTION USED

UPPER SECTION
NORTH CELL DRAINAGE UNC PROJECT RM86-060-01
19-May-88 11:01

ONE-HOUR RAINFALL AMOUNT	9.4	INCHES		
SCS CURVE NUMBER	77		S =	2.99
MEAN BASIN ELEV.	6980	FEET		
DURATION (D)	0.25	HOURS		
WATER COURSE LENGTH (L)	0.75	MILES		0.880681818
WATERSHED AREA (A)	0.12	SQ. MILES		
MAXIMUM RELIEF (H)	85.00	FEET		
ELEV ADJUSTMENT	0.901	ADJ. RAINFAL		8.47 INCHES
AREAL ADJUSTMENT (DSD)	1	ADJ. RAINFAL		8.47 INCHES
WATERSHED ADJUSTMENT (DSD, TABLE 5, PG 67)	1.12			

	TIME PERIOD, HRS			
ITEM	0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (DSD,TABLE 2, PG 52)	48	71	88	100
CUMULATIVE RAINFALL	4.07	6.01	7.45	8.47
INCREMENTAL RAINFALL	4.07	1.95	1.44	1.02
SEQUENCE	1.44	1.95	4.07	1.02
P - CUMULATIVE DESIGN RAINFALL	1.44	3.39	7.45	8.47
Q - CUMULATIVE RUNOFF	0.19	1.35	4.78	5.71
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.19	1.16	3.43	0.93

TIME OF CONCENTRATION (Tc)	0.34	HOURS
ADJUSTED Tc	0.38	HOURS
TIME TO PEAK (Tp)	0.35	HOURS
BASE PERIOD (Tb)	0.94	HOURS
UNIT PEAK DISCHARGE	165	CFS

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		30.65	192.28	566.96	154.08	
	0.00	0.00				0.00
	0.04	3.83				3.83
	0.09	7.66				7.66
	0.13	11.50				11.50
	0.18	15.33				15.33
	0.22	19.16				19.16
	0.26	22.99	0.00			22.99
	0.31	26.82	24.03			50.86
	0.35	30.65	48.07			78.72
	0.40	28.36	72.10			100.46
	0.44	26.06	96.14			122.20
	0.48	23.77	120.17	0.00		143.94
	0.53	21.48	144.21	70.87		236.55
	0.57	19.18	168.24	141.74		329.16
	0.61	16.89	192.28	212.61		421.77
	0.66	14.59	177.89	283.48		475.96
	0.70	12.30	163.49	354.35		530.14
	0.75	10.00	149.10	425.22	0.00	584.32
	0.79	7.71	134.71	496.09	19.26	657.77
	0.83	5.41	120.32	566.96	38.52	731.21
	0.88	3.12	105.93	524.52	57.78	691.35
	0.92	0.83	91.53	482.09	77.04	651.49
	0.97	0.00	77.14	439.65	96.30	613.09
	1.01		62.75	397.21	115.56	575.52
	1.06		48.36	354.77	134.82	537.96
	1.10		33.97	312.34	154.08	500.39
	1.14		19.57	269.90	142.55	432.02
	1.19		5.18	227.46	131.02	363.66
	1.23		0.00	185.03	119.48	304.51

HYDROGRAPH CALCULATION FOR ONE-HOUR PMP EVENTS USING THE SCS CURVE NUMBER METHOD
DESIGN OF SMALL DAMS RAINFALL DISTRIBUTION USED

LOWER SECTION
NORTH CELL DRAINAGE UNC PROJECT RM86-060-01
19-May-88 11:09

ONE-HOUR RAINFALL AMOUNT	9.4 INCHES		
SCS CURVE NUMBER	77	S =	2.99
MEAN BASIN ELEV.	6980 FEET		
DURATION (D)	0.25 HOURS		
WATER COURSE LENGTH (L)	0.92 MILES		0.880681818
WATERSHED AREA (A)	0.13 SQ. MILES		
MAXIMUM RELIEF (H)	99.00 FEET		
ELEV ADJUSTMENT	0.901 ADJ. RAINFAL		8.47 INCHES
AREAL ADJUSTMENT (DSD)	1 ADJ. RAINFAL		8.47 INCHES
WATERSHED ADJUSTMENT (DSD, TABLE 5, PG 67)	1.12		

	TIME PERIOD, HRS			
ITEM	0-0.25	0.25-0.50	0.50-0.75	0.75-1.00
PERCENT OF 1-HOUR RAINFALL (DSD,TABLE 2, PG 52)	48	71	88	100
CUMULATIVE RAINFALL	4.07	6.01	7.45	8.47
INCREMENTAL RAINFALL	4.07	1.95	1.44	1.02
SEQUENCE	1.44	1.95	4.07	1.02
P - CUMULATIVE DESIGN RAINFALL	1.44	3.39	7.45	8.47
Q - CUMULATIVE RUNOFF	0.19	1.35	4.78	5.71
INCREMENTAL RUNOFF OR EXCESS RAINFALL	0.19	1.16	3.43	0.93

TIME OF CONCENTRATION (Tc)	0.40 HOURS
ADJUSTED Tc	0.45 HOURS
TIME TO PEAK (Tp)	0.39 HOURS
BASE PERIOD (Tb)	1.05 HOURS
UNIT PEAK DISCHARGE	159 CFS

INTERMEDIATE HYDROGRAPHS

	TIME	FIRST	SECOND	THIRD	FOURTH	COMBINED HYDROGRAPH
PEAK DISCHARGE (cfs)		29.52	185.17	546.01	148.39	
	0.00	0.00				0.00
	0.05	3.69				3.69
	0.10	7.38				7.38
	0.15	11.07				11.07
	0.20	14.76				14.76
	0.25	18.45	0.00			18.45
	0.30	22.14	23.15			45.29
	0.35	25.83	46.29			72.12
	0.39	29.52	69.44			98.96
	0.44	27.31	92.59			119.90
	0.49	25.10	115.73	0.00		140.83
	0.54	22.89	138.88	68.25		230.02
	0.59	20.68	162.03	136.50		319.21
	0.64	18.47	185.17	204.75		408.40
	0.69	16.26	171.31	273.00		460.58
	0.74	14.05	157.45	341.26	0.00	512.76
	0.79	11.84	143.59	409.51	18.55	583.49
	0.84	9.63	129.73	477.76	37.10	654.22
	0.89	7.42	115.87	546.01	55.65	724.95
	0.94	5.21	102.01	505.14	74.20	686.56
	0.99	3.01	88.15	464.27	92.74	648.17
	1.04	0.80	74.29	423.40	111.29	609.78
	1.09	0.00	60.43	382.53	129.84	572.81
	1.14		46.57	341.66	148.39	536.62
	1.18		32.71	300.80	137.28	470.79
	1.23		18.85	259.93	126.18	404.95
	1.28		4.99	219.06	115.07	339.12
	1.33		0.00	178.19	103.96	282.15
	1.38			137.32	92.85	230.17

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